



**Asia-Pacific
Economic Cooperation**

Advancing Free Trade
for Asia-Pacific **Prosperity**

APEC Oil and Gas Security Exercise in Chile

Santiago, Chile | 13-15 March 2019

APEC Energy Working Group

December 2019

Produced by:

Asia Pacific Energy Research Centre (APERC)
Institute of Energy Economics, Japan
Inui Building, Kachidoki 11F, 1-13-1 Kachidoki
Chuo-ku, Tokyo 104-0054 Japan
Tel: (813) 5144-8551
Fax: (813) 5144-8555
E-mail: master@aperc.iej.or.jp (administration)
Website: <https://aperc.iej.or.jp/>

For:

Asia-Pacific Economic Cooperation Secretariat
35 Heng MuiKeng Terrace, Singapore 119616
Tel: (65) 68 919 600
Fax: (65) 68 919 690
E-mail: info@apec.org
Website: <http://www.apec.org>

©2019 APEC Secretariat

APEC#219-RE-01.17

Preface

The APEC Oil and Gas Security Exercise (OGSE) is a continuing activity being undertaken by the Asia Pacific Energy Research Centre (APERC) in compliance with the Asia Pacific Economic Co-operation Forum (APEC) Energy Ministers' directives. At the 10th APEC Energy Ministerial Meeting in June 2012 in St. Petersburg, Russia, the APEC Energy Working Group (EWG) and APERC were instructed to pursue a regional cooperation on supply emergency response. Following this, APERC and the EWG have conducted workshops and exercises, such as this one, to assist economies to improve response measures, policies and institutional frameworks dealing with supply disruptions while taking into consideration the economy's domestic circumstances.

APERC, immediately, held two oil and gas security exercises in 2013 – the first was the Joint Southeast Asian Exercise in Bangkok, Thailand and the second was the Indonesian Exercise. In November 2014, APERC officially launched the Oil and Gas Security Initiative (OGSI), an expanded program covering three pillars, one of which is the OGSE, in accordance with the 11th APEC Energy Ministerial Meeting Mandate in Beijing in September 2014.

In 2015, the Philippines hosted the third exercise, which was the first one undertaken under the OGSI. This was followed by the OGSE with: Regional Capacity Building, which took place in Melbourne, Australia. This fourth exercise had participants from four APEC member economies: Indonesia, the Philippines, Thailand and Australia.

In 2017, the OGSE in Peru became the third exercise under the OGSI and the first of these APEC projects to be held in the Americas.

This OGSE, held in Chile, is the fourth one under the OGSI. A so-called “blind” scenario type approach was taken, in which participants were briefed on a simulated energy supply emergency during the exercise, without prior information.

This report presents the outcome of the OGSE in Chile, jointly organised by APERC and the Chilean government through the Ministry of Energy on 13-15 March 2019. The first day was devoted to general presentations on the APEC OGSE, as well as the APEC Exercise Model Procedure (OGS-EMP). In addition, representatives of the Chilean government presented how Risk Management Units work to address the threats and vulnerabilities that Chile has experienced. In the afternoon session, the first hypothetical supply disruption scenario, the oil emergency scenario, was presented by APERC. Participants discussed the possible impacts and actions to be taken and presented them to the Expert Review Team. On the second day APERC presented the gas emergency scenario, which was again discussed by the Chilean participants. After the participants' presentation, the Expert Review Team provided their assessment and recommendations for both scenarios.

Seven invited experts formed the Expert Review Team to assess, comment and provide recommendations to the Chilean participants' responses on the presented emergency scenarios for oil and gas. The Team was composed of experts from the International Energy Agency (IEA), Inter-American Development Bank (IADB), the Latin American Energy Organization (OLADE), the Economic Research Institute for ASEAN and East Asia (ERIA), the Japan Oil, Gas and Metals National Corporation (JOGMEC), the Department of Energy of the United States (DOE) and Gas Energy Latin America.

This report provides the outcome of the exercise, which details the Chilean responses to the two hypothetical emergency scenarios formulated, including the comments and recommendations from the Expert Review Team. The aim is to contribute to the strengthening of Chile's response measures, policies, plans, procedures and communication strategies to better face supply emergency situations.

APERC hopes that those APEC economies who have not yet conducted regular emergency exercises consider conducting an OGSE to strengthen their emergency preparedness system to address and mitigate the impacts of supply disruptions. Response measures must be continuously improved through such exercises to make the system more resilient to all kinds of supply crises. APERC is committed to carry on this activity as long as the Energy Ministers and the APEC economies see the value of this program in improving resilience and mitigating the impact of supply emergencies. APEC economies are also encouraged to hold (or continue to hold) their own supply emergency exercises to further strengthen their policies, institutional arrangements and mechanisms, and response measures on supply disruption.

The Expert Review Team and APERC wish to thank all the participants and delegates who engaged with the team for discussions. Special thanks go to Maria de los Angeles Valenzuela, German Morgado and Corissa Pietro from the Ministry of Energy of Chile, who organised the event, and to Takako Hanon, Hisami Obayashi and Alberto Ramirez Mier, without their support, this report would not have been possible.

Table of contents

Preface	i
Table of contents.....	iii
Abbreviations and acronyms.....	iv
List of figures and tables	vi
Executive summary	vii
1. Background and energy situation in Chile	1
2. First case of oil and gas supply emergency: Oil emergency scenario	25
3. The second case of the oil and gas supply emergency: the gas emergency scenario.	30
4. General observations and recommendations from the expert team.....	34
5. Conclusions	39
References.....	41
Annex I: agenda.....	43
Annex II: list of participants from Chile	45
Annex III: expert review team	47

Abbreviations and acronyms

Abbreviations

Bbl	Barrel
Bbbl	Billion Barrels
Bcm	Billion Cubic Metres
Bcf/y	Billion Cubic Feet per Year
Bcm/y	Billion Cubic Metres per Year
BPO	Business Processing Outsourcing
Cm	Cubic Metre
GWh	Gigawatt-Hour
Kbbl	Thousand Barrel
Kbbl/d	Thousand Barrel per Day
km	kilometre
Kt	Kilo Tonne
KWh	Kilowatt-Hour
Mbbl	Million Barrels
Mbbl/d	Million Barrels per Day
Mboe	Million Barrels of Oil Equivalent
Mmscfd	Million Standard Cubic Feet per Day
Mcm/d	Million Cubic Metres per Day
Mmt	Million Metric Tonnes
Mtoe	Million Tonnes of Oil Equivalent
MW	Mega-Watt
Tcf	Trillion Cubic Feet
Tcm	Trillion Cubic Metres
TWh	Terawatt-Hour

Acronyms

APEC	Asia Pacific Economic Co-operation Forum
APERC	Asia Pacific Energy Research Centre
CCHEN	Comisión Chilena de Energía Nuclear
COSE	Energy Sector Operation Committee
DOE	Department of Energy of the United States
ERIA	Economic Research Institute for ASEAN and East Asia
ENAP	Empresa Nacional del Petróleo
EE	Energy Efficiency
EWG	Energy Working Group
LGSE	General Law of Electric Services
GDP	Gross Domestic Product
HHI	Herfindahl-Hirschman Index

IADB	Inter-American Development Bank
IEA	International Energy Agency
JOGMEC	Japan Oil, Gas and Metals National Corporation
OLADE	Latin American Energy Organization
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LTEP	Long-Term Energy Planning
MEN	Ministry of Energy
CEN	National Electric Coordinator
SEN	National Electricity System
ONEMI	National Emergency Office of the Ministry of Interior
COE	National Emergency Operations Committee
CNE	National Energy Commission
NSCP	National System of Civil Protection
NCRE	Non-Conventional Renewable Energy
OGSE	Oil and Gas Security Exercise
OGS-EMP	Oil and Gas Security Exercise Model Procedure
OGSI	Oil and Gas Security Initiative
OGSN	Oil and Gas Security Network
OGSS	Oil and Gas Security Studies
SEREMIS	Regional Ministerial Secretariats
SEC	Superintendence of Electricity and Fuels
TPES	Total Primary Energy Supply

List of figures and tables

Figures

Figure 1.1: Map of Chile	2
Figure 1.2: Total primary energy supply by fuel, 1990-2016	3
Figure 1.3: Chile’s power generation by source, 2005-16	6
Figure 1.4: Chile’s crude oil supply, 1999-2018 (thousand m ³)	7
Figure 1.5: Chile’s crude oil supply, 1999-2018 (thousand m ³)	8
Figure 1.6: Aconcagua and Biobío refinery, 2010-2018 (thousand m ³)	9
Figure 1.7: Chile’s oil products imports by fuel, 1999-2018 (thousand m ³)	9
Figure 1.8: Chile’s oil products imports by source, 1999-2018 (thousand m ³)	10
Figure 1.9: Chile’s oil products pipeline infrastructure	11
Figure 1.10: Chile’s oil product imports by fuel, 2000-16 (thousand m ³)	12
Figure 1.11: Chile’s oil product imports by fuel, 2000-16 (thousand m ³)	13
Figure 1.12: Natural gas exports and imports, 2005-2016	14
Figure 1.13: Natural gas exports and imports, 2005-2016	15
Figure 1.14: Natural gas demand by sector, 2005-2016	16
Figure 1.15: The Ring of Fire, an area prone to earthquakes and volcanic eruptions	22
Figure 1.16: Earthquakes with a magnitude of 7.0 or higher, 1960 - 2019	24
Figure 2.1: Chile’s oil supply infrastructure.....	25
Figure 2.2: The Concón-Maipú pipeline system (red)	26
Figure 2.3: Simulated video clip showed to the participants during the exercise	28
Figure 3.1: LNG Quintero terminal.....	31
Figure 3.2: Electrogas transport system.....	31
Figure 3.3: Earthquake epicentre and tsunami affected area	32

Tables

Table 1.1: Chile’s action plan on energy efficiency, 2020	19
---	----

Executive summary

Chile joined APEC in November 2014 and is one of the only three Latin American members of APEC. In 2016, Chile's Gross Domestic Product (GDP) reached USD 432 billion (2016 USD purchasing power parity [PPP]), which represents an increase of 3.9% from the 2000 levels. Chile's economic growth is based on solid macroeconomic fundamentals, such as fiscal responsibility, an independent central bank with an explicit inflation target and a floating exchange rate system.

As a consequence of rapid economic growth, Chile's energy demand has been growing steadily since 2000 and is expected to continue following economic expansion. The Chilean economy relies heavily on oil and gas consumption, and demand for these fuels is expected to continue growing at very high rates. In this context, a secure and diversified supply of oil and gas is indispensable for Chile's economic growth and development.

Chile's Total Primary Energy Supply (TPES) increased from 2000 to 2016 from around 25 million tons of oil equivalent (Mtoe) to 38 Mtoe. Oil is the dominant fuel, with gas coming in fourth position after renewables and coal. Chile's oil demand growth has been driven mainly by the transport sector, which represents around 59% of total oil consumption, followed by the industrial and buildings sector with 26% and 11%, respectively.

Despite Chile's geographical diversity and abundant renewable resources (solar, wind, hydro and geothermal), it has very limited fossil fuel resources and is a net importer of crude oil, gas and coal. In 2016, Chile imported virtually all of the crude oil used in its refineries (16 Mtoe) from Brazil (61%) and Ecuador (35%), while domestic production was only 0.26 Mtoe.

Chile has three refineries with a joint capacity of 238 thousand barrels per day (Kbbl/d). Biobío and Aconcagua are the two main refineries of Chile which receive about 92% of their input from oil imports. Chilean refining capacity is not enough to meet domestic oil product demand. As a result, not only does Chile import almost all of its crude oil, but also a substantial share of its oil products. Imports account for around 20% of total gasoline demand, and for 60% and 80% of diesel and LPG demand, respectively. In terms of volume, diesel imports are the largest, making up more than 60% of total oil product imports. Such imports used to be relatively diversified, but dependence on the US has increased rapidly since 2010. Currently, the US is the main source of oil products for Chile, particularly for diesel, supplying more than 95% in the past five years. As Chile has no pipeline interconnections with neighbouring economies for such products, all liquid fuels imports are delivered via tankers to its marine terminals.

In 1995, the Governments of Chile and Argentina signed an agreement for natural gas integration. In 1996, Chile started importing gas from Argentina through the Bandurria pipeline in the extreme south. Since then, seven pipelines were built across the Andes Mountains connecting the two economies. However, in 2004 Argentina began curtailing (and eventually stopping) exports, prompting a group of private and public investors in Chile to work together to build LNG terminals to avoid dependence on only one gas supplier. Since 2010 these have been Chile's main means of

gas supply. Expansion of the Panama Canal reduced the transit time from the Atlantic Ocean and import sources have subsequently become more diversified. In 2016, Chile imported mostly from Trinidad and Tobago (72%) and the United States (17%). A total of 0.28 bcm of this natural gas was re-exported to Argentina by redirecting the Norandino and GasAndes pipelines.

Chile's gas demand has decreased strongly since the supply via pipelines from Argentina stopped. In 2016, gas consumption was 52% less than 2006 levels. Since gas-fired power generation capacity surpassed coal in 2005 to become Chile's second largest source of power (with more than 25% of the power mix), almost half of domestic gas is consumed in this sector. After the curtailment by Argentina, however, investment in gas plants decreased, and the importance of coal has revived.

The Chilean government has a dedicated institutional structure for emergency responses under the coordination of the National Emergency Operations Committee (COE in Spanish) as led by Ministry of Internal Affairs and the Energy Sector Operation Committee (COSE). Moreover, the National Emergency Office of the Ministry of the Interior and Public Security (ONEMI in Spanish), is a key actor on response management. The ONEMI is responsible for mobilising, available resources from both the public and private sector spheres to avoid or mitigate potential impacts in emergency situations, within the parameters established by the State. In addition to this sound institutional framework and clear action protocols, Chile has organised the following exercises in the past:

- 2012: domestic exercise done by the Ministry of Energy (MEN), Superintendence of Electricity and Fuel (SEC) and Companies in the north zone.
- 2013: domestic exercise done by the MEN, SEC and ONEMI in the Biobío Region.
- 2014: domestic exercise done by the MEN, SEC and Companies in the Valparaiso Region.
- 2015: domestic exercise done by the MEN, SEC and ONEMI in 3 regions.
- 2017: communication equipment test exercise

The OGSE in Chile was a 'blind' type exercise, in which participants are briefed about hypothetical supply disruptions without prior notice. The aim is to make the conditions of the exercise more similar to a possible emergency response with limited time and information.

The exercise started with a simulated oil emergency scenario in which an explosion at one of Sonacol's oil product pipelines in the Valparaiso region created a fireball of flame and damaged homes, prompting the evacuation of nearby residents. The explosion occurred at the Concón-Maipú liquid products pipeline. This pipeline transports 99% of liquid fuels consumed in the Santiago Metropolitan region. The repairing of the pipeline and normalisation of operation would take an unknown period.

The first assumption was that the pipeline repairing would take approximately 3 days, with this information, the Chilean participants managed to coordinate and redistribute stocks and logistics capabilities to deal with the emergency. After this, participants were informed by the exercise facilitators that the pipeline damages would actually take around two weeks.

Under the assumption that the pipeline would be offline for more than three days, oil company representatives, especially refuelling station owners, recognised that, in such an event, they did not have the resources to cope with the situation. They asked the government to list priorities and to increase security and policing of fuel stations. The operational committee of the government established priorities considering:

- Keeping fuel supply to strategic and critical infrastructure such as hospitals, ministries, emergency service, firefighters and the police.
- The possibility of imposing demand restriction measures such as suspending schools, promoting remote working and other measures to minimise transportation needs.

Participants also proposed sending fuel to Santiago via the San Fernando-Maipú pipeline, which connects the Biobío refinery with Santiago. However, diverting these flows would affect other cities, mitigating the situation in the capital but creating shortages in other demand centres. The government and companies also agreed to seek international cooperation, such as requesting extraordinary imports of gasoline and diesel, using tanker-trucks while the pipeline is repaired. Finally, participants agreed that in the mid-term it is necessary to develop larger emergency stocks and storage facilities to cope with similar situations.

Based on the responses of the participants, the Expert Review Team provided a series of recommendations. These recommendations included:

- Establish emergency oil stocks (i.e. oil stocks held exclusively for use in a disruption).
- Establish an emergency oil demand management policy.
- Develop a detailed oil crisis response plan, which identifies the specific measures available and procedures to be followed to implement them.

In the second scenario, a gas supply disruption was assumed, independent of the oil disruption scenario. The emergency was initiated by an earthquake of magnitude 8.1 hitting the coast of the Valparaíso Region. The earthquake lasted for 7 minutes, and the epicentre was 40 km deep, about 30 km off the coast of Maitencillo. A possible tsunami alert was issued. Communication systems failed. Only text messages, radios and satellite phones worked. It was confirmed that the earthquake knocked out LNG Quintero importing terminal, leaving it completely out of operation.

Pipeline damage was unknown. Unfortunately, five robotic arms, used to unload the LNG, suffered severe damage and would take two months to be repaired. LNG Quintero supplies 68% of total regasified natural gas volumes in Chile. It should be noted that, during the exercise, the Ministry of Energy emphasized that the earthquake's magnitude in this scenario might be not strong enough to cause such amount of damage, since Chile has experience stronger earthquakes with not major disruption on energy supply, including the 8.8 Concepción earthquake in 2010.

After participants discussed how to solve the crisis for 90 minutes, they were informed that underground pipelines did not suffer any damage and can continue operations, and that the tsunami alert was cancelled.

For the gas scenario, the Expert Review Team made the following recommendations to the participants' answers:

- Establish priorities for consumption and allocation of natural gas supplies across sectors (residential, industry, power generators, etc.).
- Developing a cooperation framework between the Ministry and companies to develop gas storage infrastructure near demand centres. Examples of gas storage facilities that help cope with demand peaks or emergencies are found elsewhere in the APEC region, including Japan, China, the USA and Canada.
- As for the gas exchange protocol between Argentina and Chile, it is recommended to specify the maximum amount that could be exchanged during emergencies, particularly in terms of volumes, duration and seasonal factors.
- Assess the feasibility of transporting LNG via tanker-trucks to Santiago and installing a satellite regasification terminal as the existing one in Permuco.

The Expert Review Team provided other valuable recommendations to enhance Chile's energy security and to improve preparedness for sudden shocks and emergencies in energy supply. The team recommended:

- Share Chile's experience and protocols in the region, because not all economies have the knowledge and experience that Chile has.
- Priority users and priority suppliers should be determined in advance, including their locations.
- Communication and avoiding panic will be important. For example, a maximum limit of purchase amounts could be set at fuel stations. To communicate this, it will be very important to have good communication channels.
- Emergency relationships with neighbouring economies should be specified in prior agreements. Communication among parties and internationally is fundamental.

The exercise participants, namely oil and gas companies, electricity generators and distributors worked cooperatively, effectively coordinating with government ministries and agencies. Institutional capacity is strong, ordered and relatively well-developed. However, Chile's energy infrastructure is relatively vulnerable as it lacks the redundancy and storage capacity to deal with major supply disruptions as evidenced in both scenarios. This kind of experience on disaster management and response could provide lessons to other APEC economies.

While risk management and disaster preparedness plans and actions such as those suggested in the recommendations involve considerable investment, the disaster that could result without such preparedness may incur even higher recovery and emergency costs, in addition to having substantial effects for society. The Expert Review Team highlighted the importance of energy security and recommends the Government consider it a top priority of sustainable and responsible development in Chile. Finally, the Expert Review Team sincerely hoped that this Oil and Gas Security Exercise would contribute positively to energy security in Chile.

1. Background and energy situation in Chile

1.1 Objectives and scope of the exercise

Energy Security has been a serious concern confronting the APEC region where energy demand has been continuously increasing due to economic growth and development. Such concerns are at the forefront of energy cooperation in the region throughout the 21st century.

Against this backdrop, the Eleventh Energy Ministerial Meeting (EMM 11) held in Beijing, China in 2014 gave directions to strengthen capabilities and systems for oil and gas emergency response in APEC member economies. The Ministers also instructed the Energy Working Group, including APERC, to continue cooperation to assist economies in strengthening emergency response measures and policies based on their respective domestic circumstances in collaboration with the International Energy Agency (IEA), Association of South East Asian Nations (ASEAN), the Economic Research Institute for ASEAN and East Asia (ERIA) and other international organisations. In response to the Ministers' directive, the Oil and Gas Security Initiative (OGSI) was launched covering three pillars, namely: the Oil and Gas Security Exercise (OGSE), Oil and Gas Security Network (OGSN), and the Oil and Gas Security Studies (OGSS). The OGSE aims to:

- Investigate domestic systems for emergency preparedness in each APEC economy;
- Develop possible scenarios of oil and gas emergency situations;
- Obtain necessary information and analyses by mobilising capable experts in the APEC region;
- Test the effectiveness of the APEC OGS-EMP.

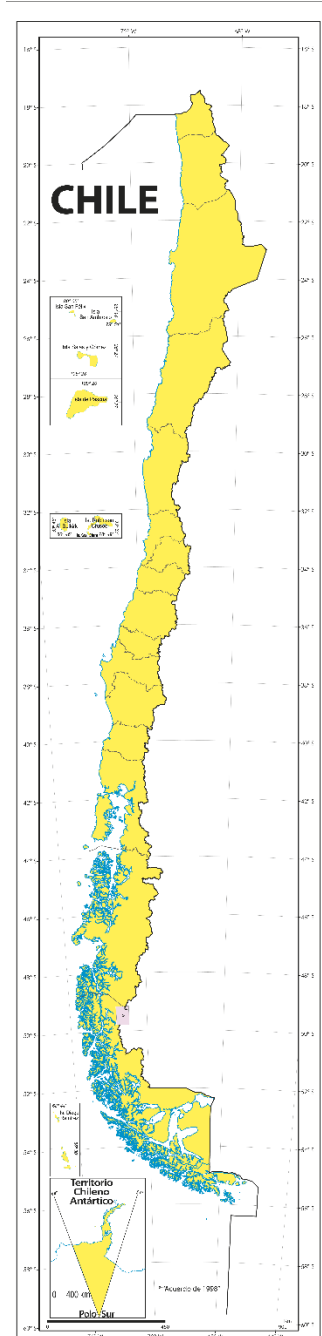
Further, APERC has drafted the APEC OGSE-EMP, which provides a step-by-step approach for oil and gas emergency exercises to promote and guide economies in developing and implementing their respective emergency exercises.

Based on this background, the OGSE in Chile, conducted by APERC and the Ministry of Energy of Chile, covered both oil and gas supply emergency scenarios. Emergency scenarios were presented separately - the first scenario was on oil and the second was on gas. The exercise was conducted in Santiago, Chile, from 13-15 March 2019. The results will be reviewed and evaluated by the APEC Energy Working Group (EWG) at its 58th meeting in Antofagasta, Chile in October 2019.

1.2 Demographic and economic backgrounds

Chile is bordered by Peru to the north, Bolivia to the north-east and Argentina to the east. One of the three Latin American members of the APEC, a member since November 2014, Chile has a land area of 756 102 square kilometres (km²). Its Pacific coastline is 6 435 km long, and its land area has an average width of 175 km. The north is almost entirely desert, and mining drives energy demand in the region, most of which is met with imported fossil fuels despite high solar and wind energy potential. In central and southern Chile, which are colder and wetter, abundant hydro and biomass resources are the main energy sources.

Figure 1.1: Map of Chile



Administratively, Chile has 16 regions headed by president-appointed regional governors. In 2017, the population reached just over 18 million, with 40% residing in the Santiago Metropolitan Region (INE 2017). Chile’s economic growth is based on solid macroeconomic fundamentals, such as fiscal responsibility, an independent central bank with an explicit inflation target and a floating exchange rate system. Chile has increased its GDP per capita by 58% from USD 9 594 in 1990 to USD 24 129 in

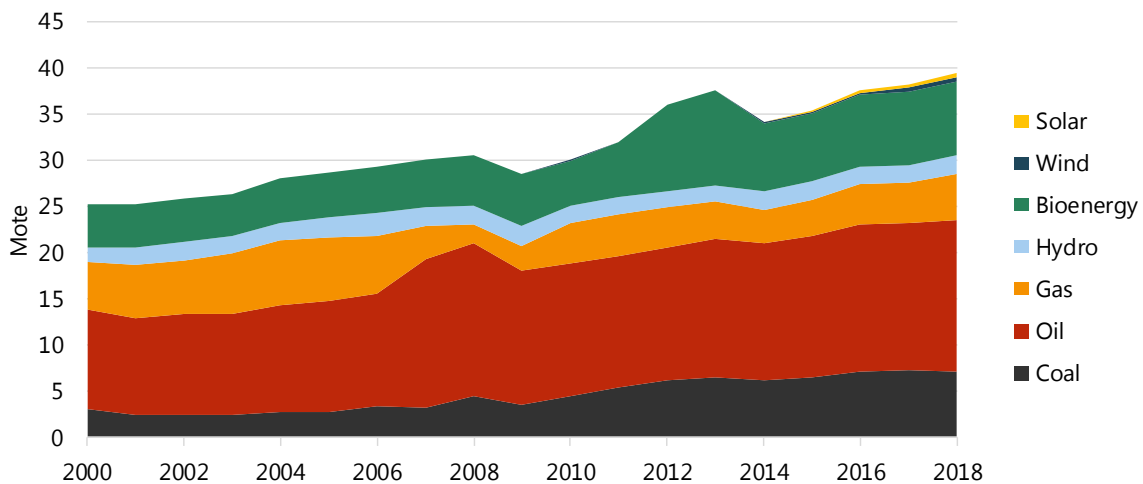
2016 (2016 USD purchasing power parity [PPP]). It is one of the fastest-growing economies in South America, with an average annual growth rate of 3.9% between 2000 and 2016. In 2016, Chile’s GDP reached USD 432 billion (2016 USD PPP), which represents an increase of 3.9% from the 2000 levels.

In 2016, services accounted for 63.6% of GDP, industry for 32.5% and agriculture, forestry and fishery for 3.9%, according to Chile’s Central Bank. Chile’s economy is export driven and its main export goods are commodities. In particular, the economy is the largest copper exporter in the world and changes in global copper prices have a strong impact on the Chile’s economy. Copper prices slumped from 2012 to 2016, falling 40% from 2011, and the contribution of copper mining declined from 14.7% of GDP in 2010 to a still high 7.3% of GDP in 2016. Services have driven Chile’s economic growth in recent years (Banco Central de Chile 2017).

1.3 Total Primary Energy Supply and final energy consumption

Chile largely depends on imports for domestic energy supply as its domestic energy production is only about one-third (33% in 2016) of its total primary energy supply (TPES), which accounted to 38 million tonnes of oil equivalent (Mtoe) in 2016. Given the small domestic production of fossil fuels, the majority is imported. Oil (42% share) is the largest primary energy source, followed by bioenergy (21%) and coal (19%) (APERC 2019).

Figure 1.2: Total primary energy supply by fuel, 1990-2016



Source: (IEA 2019)

Despite Chile’s geographical diversity and abundant renewable resources (solar, wind, hydro and geothermal), it has very limited fossil fuel resources and is a net importer of oil, gas and coal. In 2016, Chile imported all of the oil it used from Brazil (62%) and Ecuador (38%). Natural gas came from Trinidad and Tobago (79%) and Norway (21%), and coal was mostly from Colombia (42%), the US (33%) and Australia (21%) (CNE 2018).

Chile has vast untapped potential for solar power (PV and CSP) as well as for onshore wind, geothermal and hydro energy. Solar PV potential is estimated at 829 GW, CSP at 510 GW, onshore

wind power at 37 GW, geothermal energy at 2 GW and hydropower at 6 GW (Ministerio de Energía 2018). These estimates are based on geo-referencing data and assessments of technical, territorial and environmental constraints.

Chile's fuel mix has historically been dominated by oil, most of which is consumed in the industry and transport sectors. Industry oil use rose in the past decade in response to an energy crisis that occurred when natural gas imports from Argentina suddenly dropped in 2004 and eventually ceased (Chavez-Rodriguez, et al. 2017). Transport is the largest oil consumer, however, and has the second-highest overall energy consumption after industry. As economic growth has improved living standards, the number of private vehicles has increased.

1.4 Chile's Electricity System

The General Law of Electric Services (LGSE—*Ley General de Servicios Eléctricos*), originally enacted in the early 1980s, sets the legal base for the electricity sector. The law privatized the electricity industry; introduced competition into the generation sector; and separated the industry's generation, transmission and distribution segments. Privatisation of the state-owned utilities began in 1986 and was completed by 1998. These principles have remained valid until now despite minor changes. Chile was the first economy in the world to deregulate its power industry, with the incorporation of free market principles (CNE 2018).

The LGSE has been amended several times with different modifications.

- Short Law I, Law 19 940 (*Ley Corta I*) – March 2004: It allows a stronger regulatory approach and the expansion of the transmission of electricity, as well as establishing incentives for non-conventional sources and small generation units.
- Short Law II, Law 20 018 (*Ley Corta II*) – May 2005: Designed to investments in the generation segment through supply bids made by distribution companies.
- Law NCRE (*Ley ERNC*): It establishes short- and long-term policy targets for the share of renewable energy in the total electricity generation mix. The short-term target, initially adopted in 2008 was updated in 2013 up to 20% by 2025. The law, includes its definition of non-conventional renewable energy: biomass, hydropower with capacity less than 20 MW, geothermal, solar, wind, marine energy and “other means of generation” determined by the CNE.
- Transmission Law, Law 20 936–July 2016: It enhances the role of the state in energy planning and the expansion of the transmission system, assuming certain functions that were previously in the hands of the private sector. The law created the National Electric Coordinator (CEN), as the independent system operator. It supports grid expansion and cross-border connections as well as a long-term energy. The law establishes a remuneration scheme for transmission, tolls are completely borne by the consumers and defined by the mechanisms to determinate the cost of capital rate, which could fluctuate between 7% and 10% after taxes.

The regulatory framework for Chile's electricity supply industry is based on the principle of competitive markets for generation and supply. Private companies wholly serve the electricity market, while the government remains a regulator, policy-maker and technical support to identify the requirements to meet the projected demand growth. The Ministry of Energy is the main governmental institution in charge of the energy sector in Chile. The Ministry supports its actions through the CNE and the SEC. The CNE is a technical organisation that acts as a regulator of the Chilean Energy Market, analyses prices, tariffs and technical norms that may affect energy production, generation, transport and distribution, and provides advice to the government through the Ministry of Energy in any field related to the energy sector for its development. SEC monitors the compliance of legal regulatory requirements and technical standards.

Generation companies have the obligation to sell whole production to spot market, and additionally can negotiate a contract with consumers or participate in open energy auctions. The transmission system has open access, giving transmission companies the right to impose the payment of tolls over the available transmission capacity. Finally, the distribution companies operate under a 'distribution public concession regime' with service obligations and regulated tariffs for the regulated customers. Chilean regulation defines regulated customers as those with a connected capacity of below 500 kW. Those who have a connected capacity of over 5 000 kW can negotiate the energy price directly with generation companies. Those who fall in between (500 to 5000 kW) can choose either regulated or unregulated tariffs for periods of no less than four years.

Hydro power has long been a key component of Chile's electricity generation mix and natural gas started to play a leading role in the late 1990s. Chile imported 100% of its natural gas from Argentina from 2000 to 2008 but when Argentina began curtailing exports to Chile in 2003, the use of hydro power, coal and diesel generation rose significantly. Chile's energy transformation has most recently shifted to the adoption of renewable energy. In 2010, only 4% of electricity capacity used URE sources: totalling 532 megawatts (MW) in onshore wind farms, small amounts of solar PV, small hydro, biomass and biogas plants. By 2018, URE sources made up 21% of the total electricity generation mix, with 4 988 MW of installed capacity (47% solar PV, 32% onshore wind farms, 10% small hydro, and the rest in biomass, geothermal and biogas plants) (CNE 2018). New policies, such as a 20% target for renewables by 2025, combined with declining capital costs and outstanding renewable resources have helped transform the market.

In February 2017, the reform to the Law on Gas Services entered into force (Law No. 20,999). Basically, the amendments aim at clarifying issues related to prices of gas distribution, as well as specifying conditions to improve the quality of the service provided by distribution companies, whether they are concessionaires or not. The main changes are:

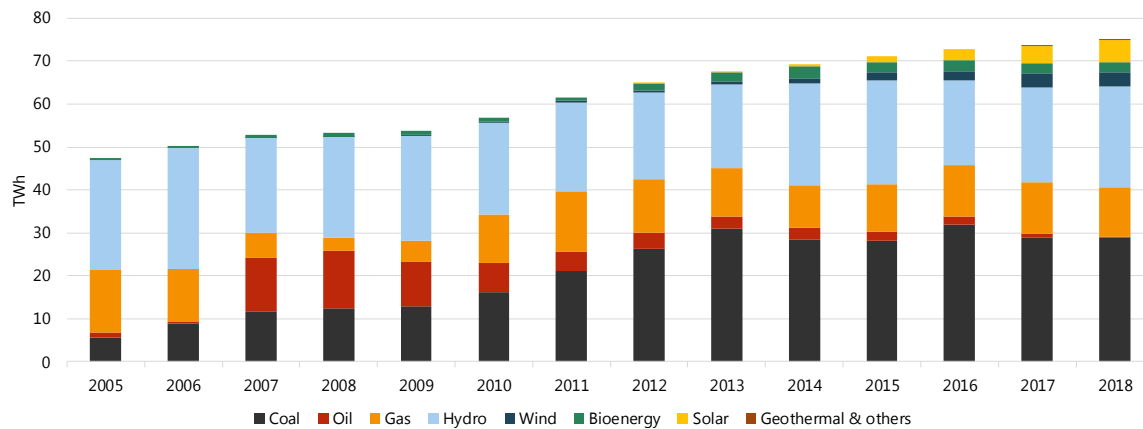
- Reduction of the tolerance margin, over the cost of capital rate, from 5% to 3% for the profitability of gas distribution concessionaires.
- Definition of the necessary conditions to end the free prices regime of a concession zone and its consequent entry into force of the pricing regime, eliminating the mandatory process before the competition authority (TDLC, in Spanish) that was needed to end the free prices regime.

- Elaboration of a procedure for switching providers, both for concession and non-concession networks (the latter usually refers to private networks using an LPG supplier).
- Definition of compensation for customers in case of unauthorized service suspension (15 times the value of the gas not supplied).

Chile main electric system is the National Electricity System (SEN)¹. The system serves the northern, central and southern-central parts of Chile. The desert mining regions in the northern part covers an area equivalent to 25% of Chile’s continental territory, in which about 6% of the population of Chile lives. The central part of the economy reaches about 92% of the population, with more than 70% of customers under a regulated tariff. Its total installed capacity of 22 964 MW, 53% thermal (21% coal, 19% natural gas and 13% diesel), 29% hydro, 9% PV, 7% onshore wind, 2% biomass and one geothermal plant of 48 MW (CNE 2018).

Aside of the main system, Chile has four isolated electric systems; Aysen (63 MW), Magallanes (104 MW), Cochamo (1.7 MW) and Hornopiren (3.3 MW). In 2016, Chile’s total generation was 79 terawatt-hours (TWh), an increase of 51% from 2005. Thermal power plants provided 57% of generation (coal 38%, oil 3.7% and gas 15%), followed by hydro power (30%), bioenergy (7.5%), wind (2.8%) and solar (3.1%). In 2005, solar PV and wind technologies made no contribution to total generation only hydro accounted for a total of 50%, followed by gas (26%). However, the generation from gas has decreased over time reaching level of 23 TWh, decreasing 13% from 2005 levels (Figure 1.3).

Figure 1.3: Chile’s power generation by source, 2005-18



Source: (CNE 2018)

1.5 Oil Supply and Demand

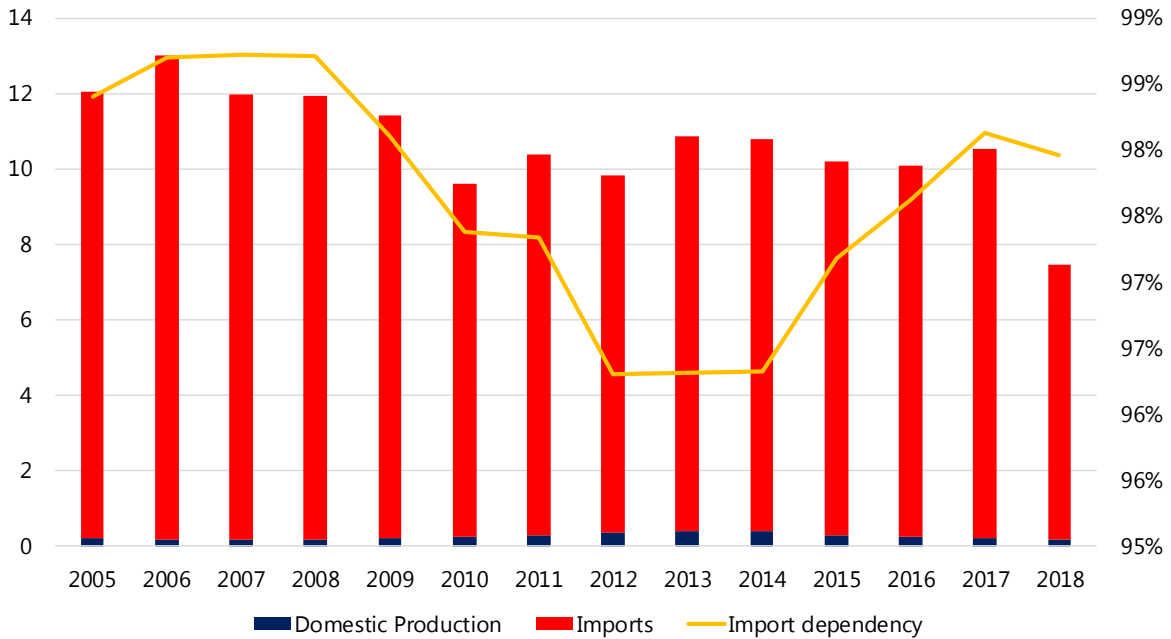
1.5.1 Crude oil Supply

Oil is the major energy source in Chile. In 2016, oil accounted for 42% of TPES. While Chile is a crude oil producer, domestic production stood at only 150 cubic meters (m3) in 2018, equivalent to 956

¹ Map of the electric system of Chile <https://infotecnica.coordinador.cl/>

barrels and very far from total demand which was around 10,500 m3. As a consequence, Chile is a net crude oil importer, with a dependency on imports above 95%. This trend has been true for over 15 years.

Figure 1.4: Chile’s crude oil supply, 1999-2018 (million m³)

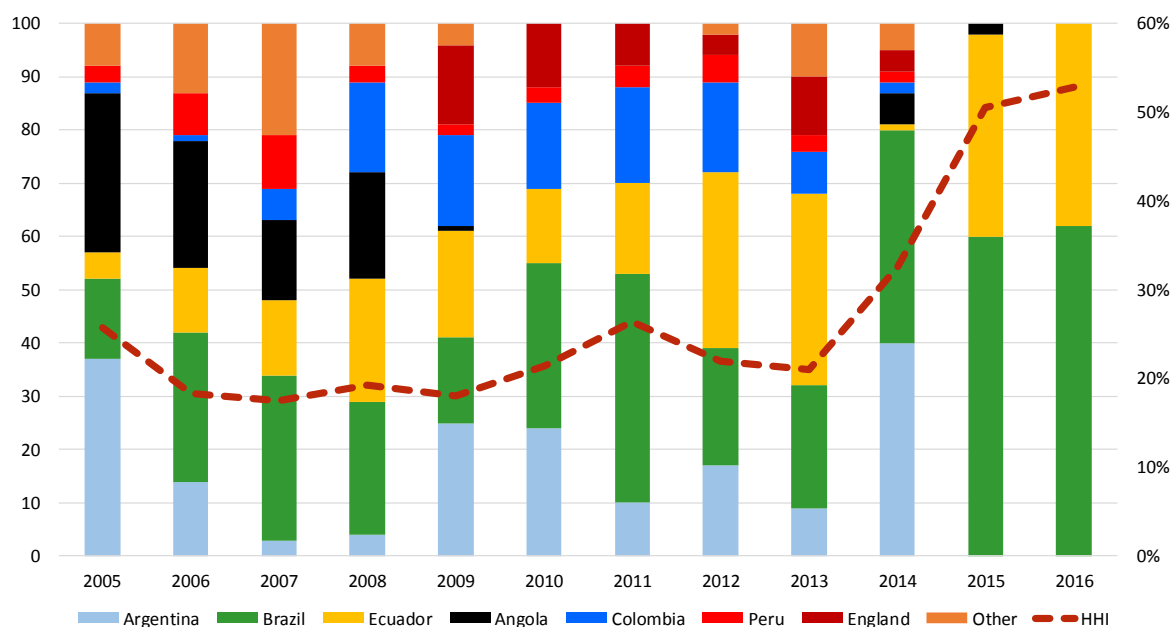


Source: (CNE 2018)

Chile’s crude oil imports used to be heavily dominated by Argentina. However, this trend started decreasing in 2001, due to more competitive volumes from other sources, mostly Brazil and Ecuador, seemingly driven by lower transportation costs and tariff agreements. As a consequence, Chile’s Herfindahl-Hirschman Index (HHI) (Figure 1.5), a common measure of market concentration, increased from 20% in 2013 to almost 60% in 2016, indicating lesser diversification on crude oil importers in recent years.

Chile has two international crude oil pipelines: the Sica-Sica pipeline that takes Bolivian crude oil to an export terminal in the Chilean city of Arica and the Transandino Estenssoro-Pedrales pipeline which connects Argentinean oil deposits of Neuquén province with one of the Chilean refineries (Biobío). However, this pipeline is currently unused because of the lack of exportable surplus in Neuquén. Moreover, imports from Brazil and Ecuador have risen quite fast and since 2015 they dominate Chile’s crude oil imports.

Figure 1.5: Chile's crude oil supply, 2005-2016 (%)



Source: (CNE 2018)

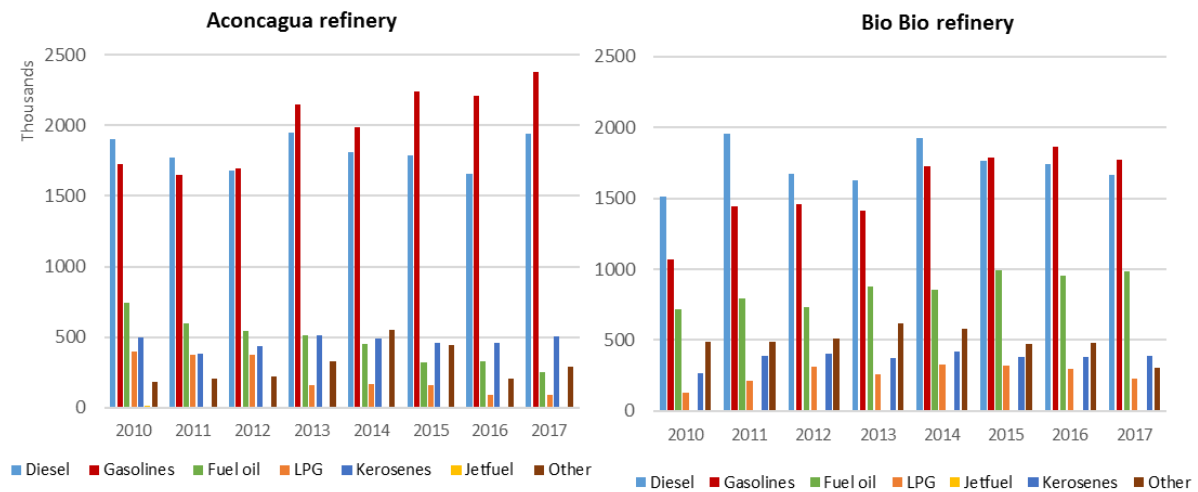
1.5.2 Refining capacity and fuel production

Chile has a total nameplate refining capacity of 238 thousand barrels per day (kb/d), equivalent to 36 000 cubic meters per day (m³/d), distributed among 3 refining complexes along the Chilean territory:

- Aconcagua refinery with a capacity of 104 (kb/d) or 16 500 (m³/d).
- Biobío refinery with 116 kb/d or 18 500 m³/d.
- Gregorio refinery with 18 kb/d or 2 800 m³/d.

The small Gregorio refinery receives virtually the totality of its feedstock from nearby domestic oil and gas production in Southern Chile. While other fuels are also produced, most of Gregorio's refinery production is liquefied petroleum gas (LPG) used for cooking and space-heating. On the other hand, the much larger Aconcagua and Biobío refineries are responsible for most of the domestic fuels production, particularly gasoline and diesel. Historically, more than 95% of these refineries use crude oil imported by tankers from Ecuador or through the Magellan strait, mostly from Brazil.

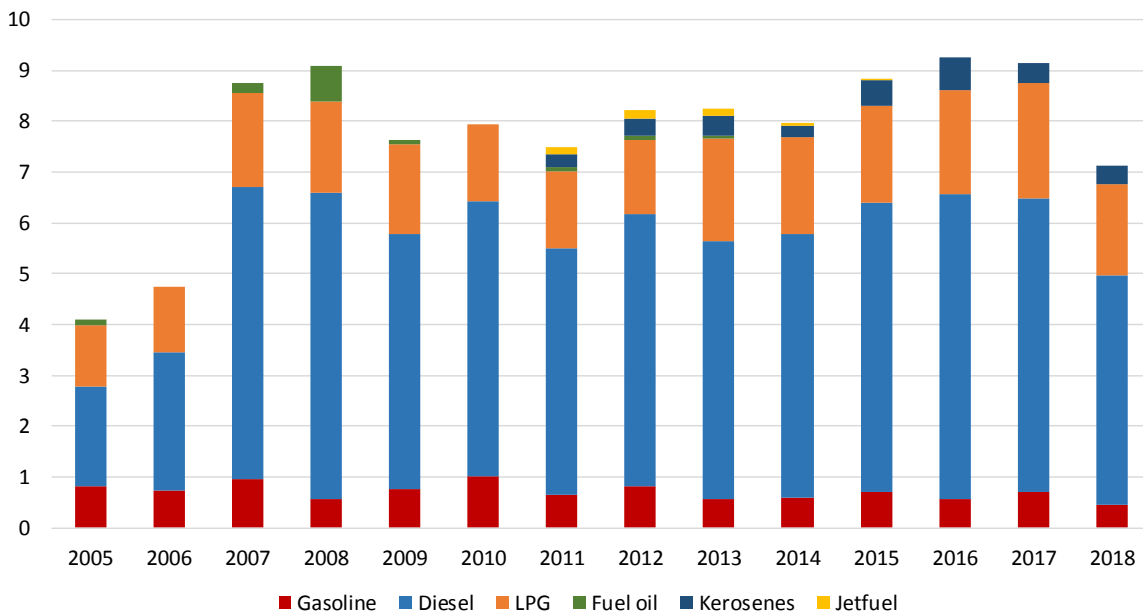
Figure 1.6: Aconcagua and Biobío refinery, 2010-2018 (thousand m³)



Source: (CNE 2018)

While there are no legal barriers to private participation in the oil and gas industry in Chile, all refining capacity has been developed by the state-owned oil company Empresa Nacional del Petróleo (ENAP). However, as domestic refining output is not enough to meet local demand, Chile is a net oil products importer. Gasoline imports account for around 20% of total demand while diesel and LPG imports for 60% and 80%, respectively. In terms of volumes, diesel imports are the largest, accounting for more than 60% of total oil products imports as noted in Figure 1.7.

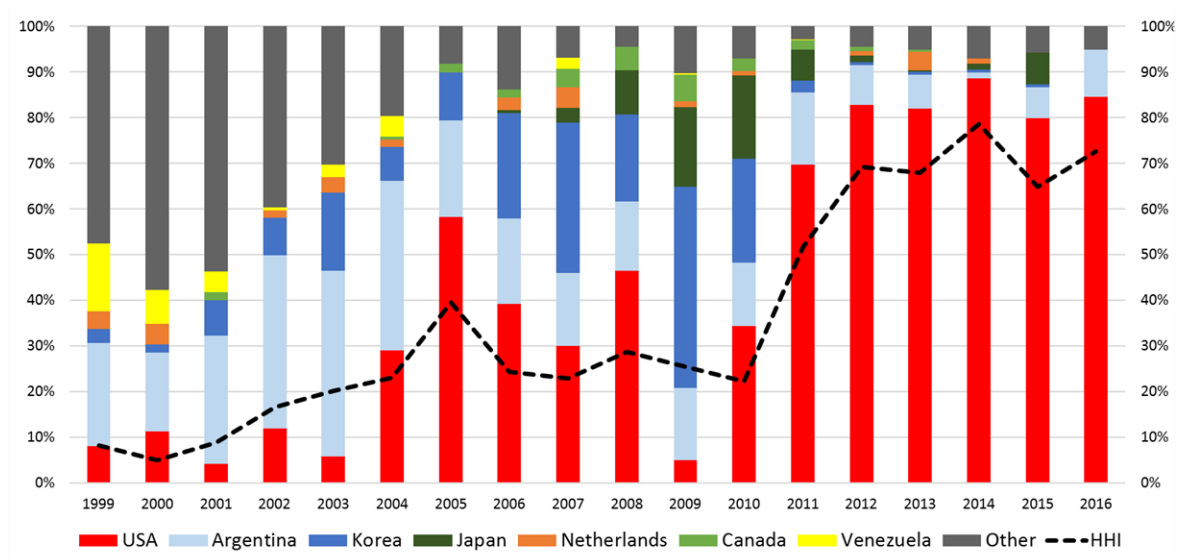
Figure 1.7: Chile’s oil products imports by fuel, 2005-2018 (million m³)



Source: (CNE 2018)

The US is by far the main source of oil product imports for Chile, particularly for diesel, with over 95% of imports in the past five years. Oil product import sources used to be relatively diversified but dependency on US imports has increased rapidly since 2010.

Figure 1.8: Chile’s oil products imports by source, 1999-2018 (thousand m³)

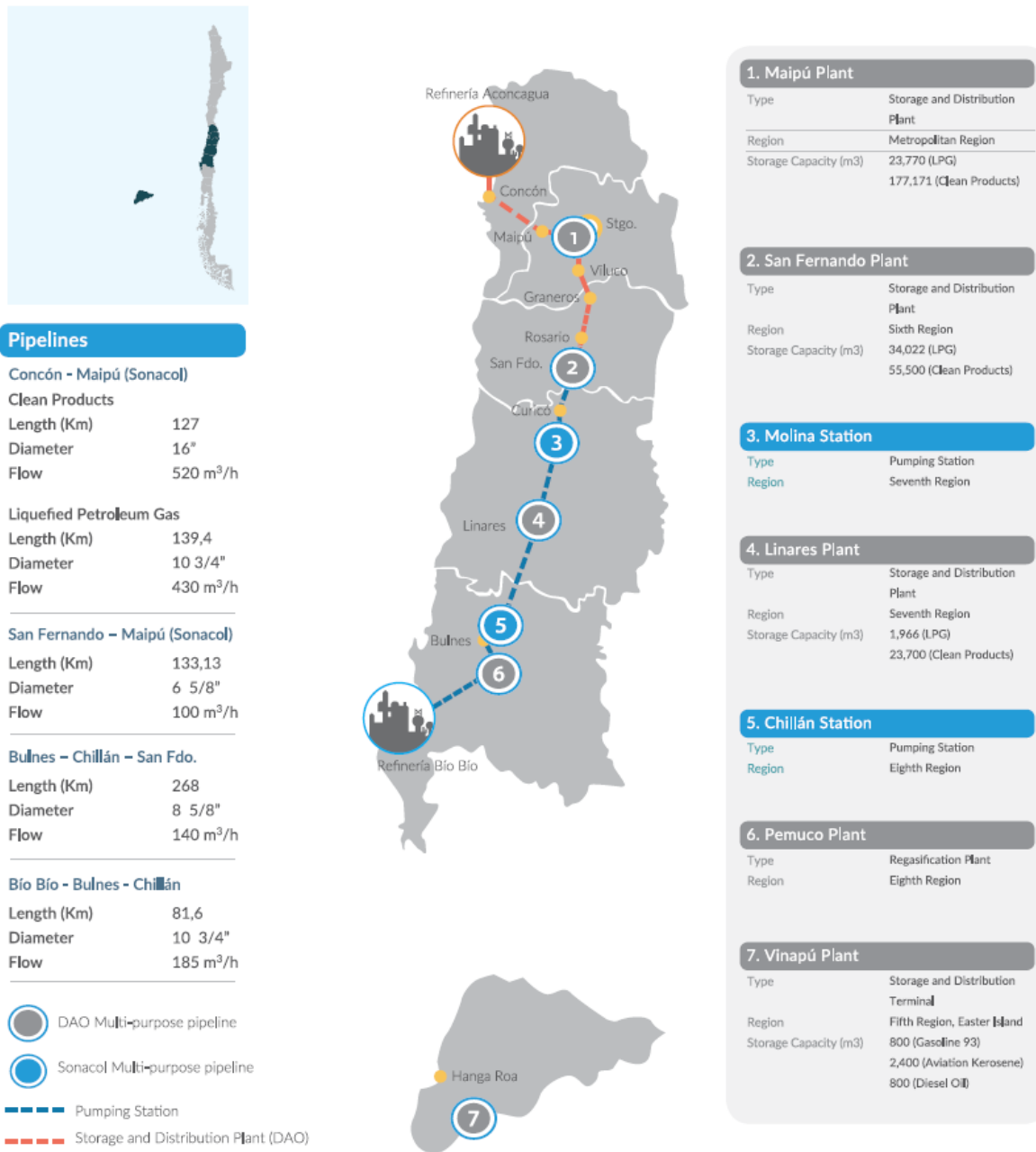


Source: (CNE 2018)

As Chile does not have any international oil product pipelines with neighbouring economies, all oil product imports are received in marine terminals along the coast. Both domestically produced and imported fuels are transported from the two main refineries and receiving terminals to Santiago and other cities via a system of pipelines of around 500 km, as well as truck tankers (Figure 1.9).

Chile’s pipeline network is owned mainly by two companies: state-owned oil company ENAP and Sonacol (a joint-venture between state-owned companies ENAP and Copec with three private companies). For instance, ENAP is the owner of the pipelines between the Biobío Refinery and the city of San Fernando, where it connects with the San Fernando-Maipú pipeline. This last one is owned by Sonacol, as well as the Concón-Maipú oil products pipeline, which has two parallel lines from the Aconcagua refinery to the storage and distribution plant Maipú, on the outskirts of Santiago. One line transports LPG and the other liquid products such as gasoline, diesel, jetfuel and kerosene. The liquid products pipeline has a capacity of 1100 m³/hour and a length of 134 km. The Concón-Maipú liquid products pipeline transports 99% of liquid fuels consumed in the Santiago Metropolitan region.

Figure 1.9: Chile’s oil products pipeline infrastructure



Source: (ENAP 2017)

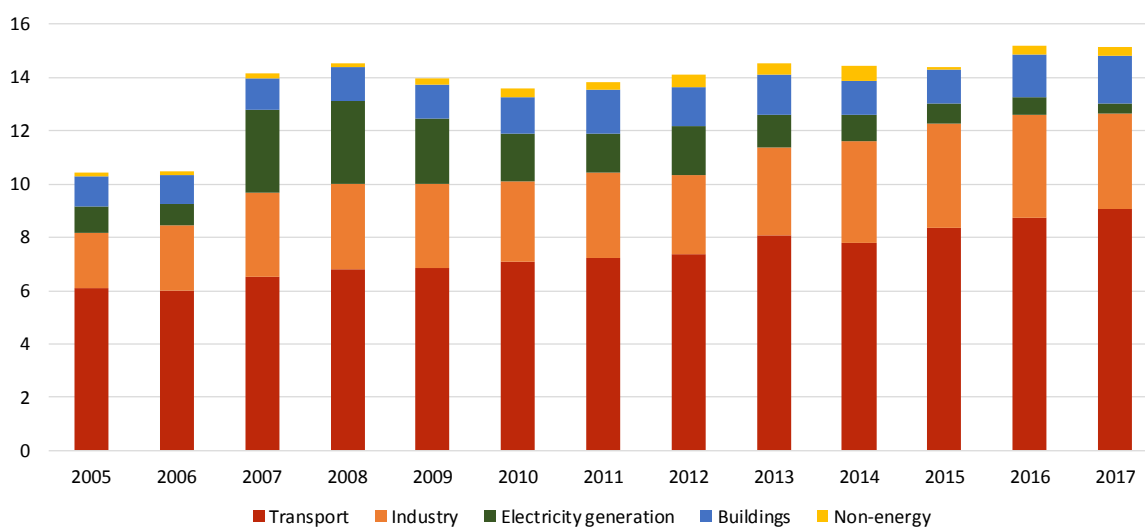
1.5.3 Oil Demand

Chile’s fuel mix has historically been dominated by oil, most of which is consumed in the industry and transport sectors. Transport is the largest oil product consuming sector in Chile, with 54% of the total in 2016, mostly road transport. As economic growth has improved living standards, the number

of private vehicles increased in the past ten years. Around 40% of the vehicle fleet is concentrated in Santiago’s Metropolitan Region.

In contrast to other APEC economies, oil demand in the industrial sector is rising (16% growth in the past decade) in response to the curtailment of natural gas imports from Argentina in 2004, as discussed in section 1.4. Some power plants and industrial users switched from natural gas (a 21% drop from 2000 to 2016), increasing demand for fuel oil and diesel. The buildings sector has also increased its demand for oil products, mainly LPG.

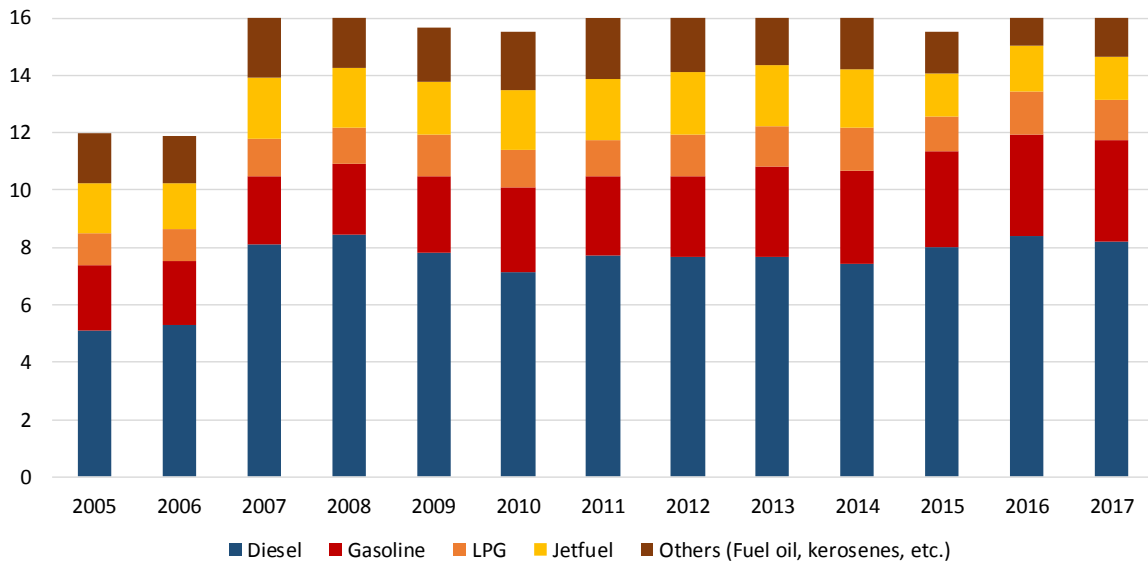
Figure 1.10: Chile’s oil product demand by sector, 2000-16 (million tons of oil equivalent)



Source: (IEA 2019)

Diesel has the largest demand share among oil products in Chile (54%), mainly consumed in transport and industry. Total demand for oil products increased, but the shares of each fuel have remained virtually constant over the past decade.

Figure 1.11: Chile’s oil product demand by fuel, 2000-16 (million tons of oil equivalent)



Source: (IEA 2019)

Crude oil and oil products storage

Altogether, Chile has a storage capacity of around 21 million barrels (bbl) or 3.3 million cubic metres (mcm) for crude oil and oil products. Crude oil takes up over 35% of this capacity and is all managed by ENAP in its three refining complexes. Oil product capacity is located in refineries, marine importing terminals, and storage and distribution facilities across Chile. ENAP owns about 73% of these facilities while other companies, mainly station services owners, own the rest. Companies have a stockholding obligation equivalent to 25 days of average sale or average imports of the previous six months. However, in practice, only ENAP holds emergency stocks (IEA 2018).

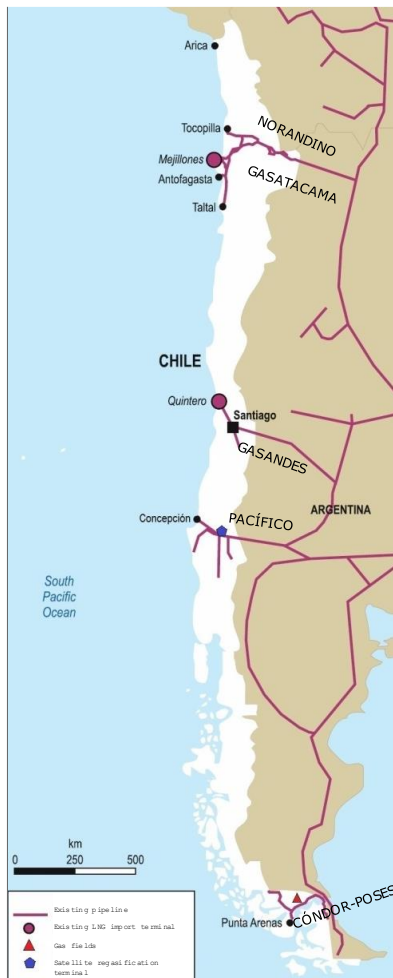
1.6 Gas Supply and Demand

1.6.1 Gas Supply

Natural gas is the fourth dominant fuel used in Chile, accounting for 11% of TPES in 2017. Domestic gas production however, has decreased by around 35% since 2009. Moreover, since domestic gas production accounted for roughly 23% of total gas supply, Chile is a net gas importer (APERC 2019). In fact, Chile heavily relies on LNG imports to satisfy its gas demand, with 73% of imports come from Trinidad and Tobago, followed by the USA (17%) and the rest from other economies (Figure 1.12). With the expansion of the Panama Canal in 2016, transit time from the Atlantic Ocean was reduced and import sources have subsequently become more diversified.

Chile and Argentina are connected by seven gas pipelines, which run from Mendoza in western Argentina to Santiago in central Chile. In 1997, Chile imported exclusively piped gas from Argentina. However, by 2005, gas supply hit a peak of 6.8 Mtoe and fell to a low of 2.0 Mtoe in 2008.

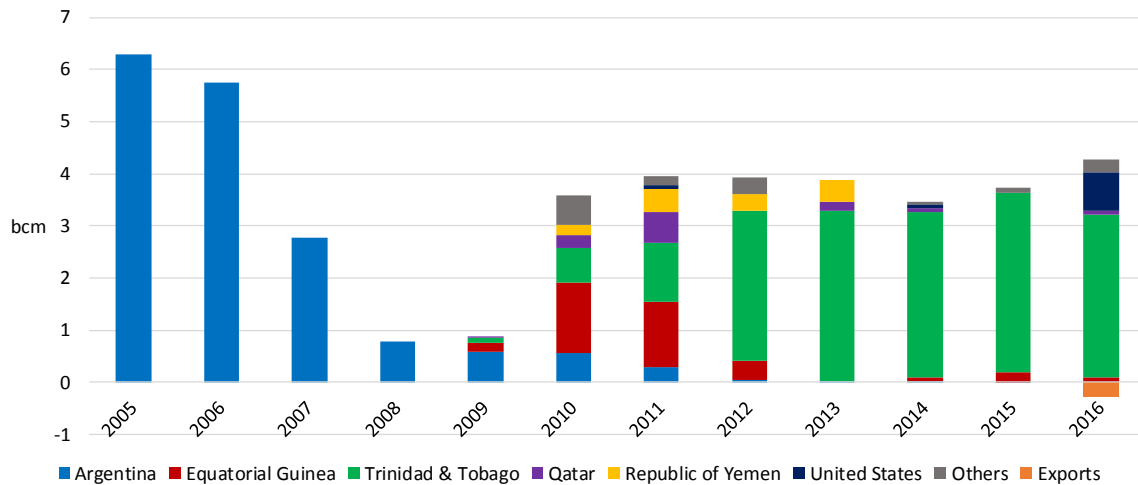
Figure 1.12: Natural gas exports and imports, 2005-2016



Source: (Ministerio de Energia 2018)

Following the aforementioned curtailment of natural gas imports from Argentina that started in 2004, a group of private and public investors in Chile worked together to build LNG terminals to avoid dependence on only one gas supplier. LNG Quintero was built in the Valparaiso region and Mejillones LNG was built in the Antofagasta region. Mejillones LNG has a storage capacity of 175 000 m3 (one tank) with a regasification capacity of 5.5 million m3/d, and LNG Quintero has a storage capacity of 334 000 m3 (two tanks) with a regasification capacity of 15 million m3/d (Ministerio de Energia 2018).

Figure 1.13: Natural gas exports and imports, 2005-2016



Source: (Ministerio de Energia 2018)

Between May 2016 and August 2017, Chile supplied natural gas to Argentina, with a total flow of 360 million cubic metres (mcm). Between May and June, 86 mcm were supplied through the Norandino gas pipeline and another 274 million m3 between June and August through the GasAndes pipeline (Ministerio de Energia 2018). In October 2018, Argentina restarted pipeline exports as a significant step towards regional energy integration.

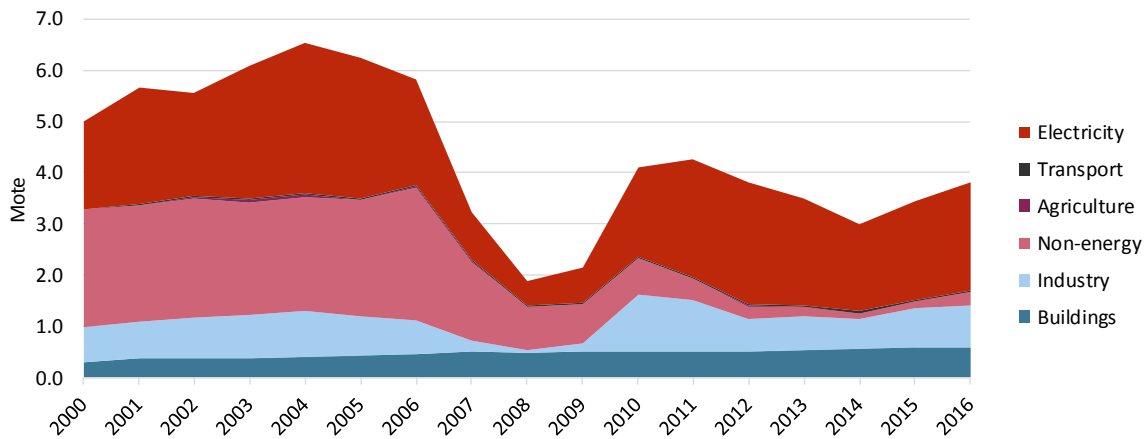
1.4.2 Gas Demand

Natural gas consumption fluctuated widely over the past decade, but demand has not grown back to 2005 levels (6.8 Mtoe). In 2015, Chile’s natural gas consumption was 4.3 Mtoe, 37% less than in 2005. Throughout Chile, the electricity sector is the main consumer of gas. Power generation accounted for over half of total consumption, up from 37% in 2005.

Consumption patterns vary across regions. In the far north, natural gas is mainly used for power generation and is supplied via the Mejillones LNG terminal. In the central and southern regions, natural gas is consumed by both industry and households and supplied via the LNG Quintero terminal. Lastly, the far south region (Magallanes) relies on limited domestic production for power generation, residential heating and the methanol-production industry.

Industry was the second-largest consumer in 2016, at 20% of total gas demand (0.8 Mtoe), followed by buildings at 14% (0.6 Mtoe). Consumption increased in buildings by 30%, due to the population growing at 0.9% CAGR, household numbers increasing (1.8% CAGR), and household sizes becoming larger (1.0% CAGR).

Figure 1.14: Natural gas demand by sector, 2005-2016



Source: (APEREC 2019)

1.5 Energy Policy in Chile

1.5.1 General aspects Chile's Energy Policy

Since the 1980s, Chile has embarked upon developing an economy based on international trade and the rules of the free market. It has reaped various benefits as the economy has significantly grown. From the 1980s to 2014, Chile has more than doubled its income per capita and has been one of the fastest-growing economies in Latin America. In addition, it provides a business environment conducive to foreign investments, given its streamlined administrative processes and simplified tax payments. In line with these principles, Chile's energy policy is based on the development of a free market economy and oriented towards enhancing its economic efficiency and energy security by reducing its vulnerability to supply disruptions and its high dependence on imports.

The Chilean Parliament approved the creation of a Ministry of Energy in November 2009, and the new Ministry of Energy started operations in February 2010. This ministry centralises the functions of developing, proposing and evaluating public policies in this area, including the definition of objectives, regulatory framework and strategies to be applied as well as the development of public policy instruments.

Chile's Ministry of Energy presented the National Energy Policy 2050 in December 2015 to guide long-term energy policy development. The four pillars of Chile's energy policy that will help make its energy sector 'reliable, inclusive, competitive and sustainable' by 2050 are as follows: a) quality and security of supply; b) energy as a driving force for development; c) environmentally friendly energy; and d) energy efficiency and energy education (Ministerio de Energia 2015).

In December 2017, Chile announced an electro-mobility strategy that outlines actions to be taken in the short and medium term to meet the government's goal of having 40% of the private vehicle and 100% of the public transport fleet powered by electricity in 2040. The new strategy's objectives are to establish regulations and requirements to standardise components and promote the efficient development and increased penetration of electric vehicles (EVs), to support research and development and to enhance human capital and knowledge transfer (Ministerio de Energia 2017).

In May 2018, the Ministry of Energy presented an Energy Roadmap to serve as a guideline for government action in energy policy, as well as for leading a people-centred energy modernization during the next four years (2018-2022). It contains short-term commitments based on the following pillars (Ministerio de Energia 2018):

- Energy modernisation;
- Energy for social development;
- Energy development;
- Energy with low emissions;
- Efficient transport;
- Energy efficiency; and
- Energy education and training.

During the joint presentation of the Energy Roadmap, President Sebastián Piñera requested that the Ministry of Energy place special emphasis on 10 'mega-commitments' and included the 11th commitment related to energy integration with neighbouring economies (Gobierno de Chile 2018):

- Create the economy's first map of energy vulnerability, identifying families without electricity and other energy services, with a view to narrowing the existing gaps.
- Modernise the energy institutional framework to increase governmental efficiency and q, specifically the SEC and the Chilean Nuclear Energy Commission (*Comisión Chilena de Energía Nuclear*, CCHEN).
- Reduce the processing time associated with obtaining environmental permits for projects that join the +Energy Plan by 25% with respect to the time taken over the last four years.
- Achieve a fourfold increase in the current capacity of renewable small-scale distributed generation (less than 300 kW) by 2022.
- Achieve a tenfold increase in the number of electric vehicles circulating in Chile.
- Modernise the regulation of electricity distribution through a participatory process, so it allows new circumstances of the energy sector to be identified and facilitates more efficient and competitive implementation.
- Regulate solid biofuels, such as firewood and its derivatives, empowering the Ministry of Energy to establish technical specifications and the regulations for the commercialisation of firewood in urban areas.

- Establish a regulatory framework for energy efficiency that provides the necessary incentives to promote the efficient use of energy in the sectors with the highest consumption (industry and mining, transport and construction) and create a true energy culture in Chile.
- Launch the process of decarbonisation of the energy mix by preparing a schedule for the withdrawal or reconversion of coal-fired power plants, and introducing specific measures for electro-mobility.
- Train 6 000 operators, technicians and professionals, developing skills and competencies for energy management and sustainable energy use in the electricity, fuels and renewable energy sectors, certifying at least 3 000 people.

Chile has no nuclear energy in its electricity mix and it is not considered as a short-term option under the Energy Policy or the current Energy Roadmap 2018-2022, but further research has been proposed to be considered in the next policy review, which will be published by 2020.

1.5.2 Energy efficiency

Energy efficiency (EE) is among Chile's priorities as it works towards achieving its key goal of enhancing its energy security. These efforts also encompass the stabilisation of demand growth through EE measures.

In terms of EE, the Ministry of Energy is responsible for the development of policies and guidelines, including the promotion and enhancement of economy-wide efficient energy use as a means of contributing to the achievement of this goal. Furthermore, in pursuing these objectives, the Ministry of Energy entrusts the Chilean Energy Sustainability Agency, which is responsible for implementing many of these policies by promoting, disseminating and implementing dedicated programmes, opening new markets and exploring opportunities in the field of energy efficiency and developing EE markets to recognise and reward leading EE companies. The current goal is to foster the efficient use of energy as an energy resource. The government has established a 20% savings goal by 2025 after considering the expected growth in energy consumption for the economy.

The Energy Policy defines long-term goals by 2035 and 2050 in EE. These goals are organised in the following 11 alignments:

- Forming a robust market of consultants and enterprises of energy services;
- Applying progressively energy management tools validated by competent entities;
- Using local available resources and exploiting the potential energy in the productive process;
- Efficiently incorporating EE standards in design, construction and conditioning;
- Promoting smart control systems and owning energy production in ways to apply to buildings with efficient solutions;
- Strengthening the efficient edification market and moving towards more productive and efficient local markets;
- Improving EE of vehicles;

- Promoting more efficient transportation alternatives;
- Ensuring the availability of massive and clear information regarding rights and duties of consumers, including alternative energies and methods;
- Designing, implementing and tracking of an energy education strategy jointly with the different initiatives developed by the Ministry of Energy and related institutions;
- Developing professional and technical human capital for the production.

The agenda states short-term concrete activities to encourage EE, which considers measures to extend the development of EE projects, including the continuity of the Action Plan on Energy Efficiency 2020, published in 2012 (Ministerio de Energia 2012). These measures are applicable to industry and mining, transport, buildings, end-use devices and heating.

The government is implementing the Action Plan for Energy Efficiency 2020. Since 2012, the Superintendence of Electricity and Fuels (SEC) certifies security, emission levels and EE standards on firewood home appliances, which have been part of the institutional framework for EE policies owing to the importance of firewood in residential consumption in Chile (Ministerio de Energia 2012). In addition, the Chilean Government approved other EE policy instruments like minimum energy performance standards (MEPS) and labelling.

Table 1.1: Chile’s action plan on energy efficiency, 2020

Industry and mining	<ul style="list-style-type: none"> - Promote energy management systems - Promote energy cogeneration - Encourage efficient technologies - Technical assistance in industry and mining projects
Transport	<ul style="list-style-type: none"> - Improve EE standards for light- and heavy-duty vehicles - Use new transport technologies in heavy-duty vehicles - Promote public transportation - Promote electric vehicles - Technical assistance in transport projects
Buildings	<ul style="list-style-type: none"> - Encourage efficient technologies - Improve thermal insulation in buildings without EE standards - Promote energy management in buildings - Training to relevant actors in the construction chain - Promote building labelling - Promote EE in street lighting
End-use devices	<ul style="list-style-type: none"> - Extend appliance labelling - Establish minimum energy performance standard (MEPS) - Promote minimum lighting efficiency standards through specific programmes focused in low income households
Heating	<ul style="list-style-type: none"> - Encourage new technologies in the use of firewood - Improve firewood quality - Improve the knowledge in the regarding the correct use of firewood and its process

Source: (Ministerio de Energia 2012)

The Energy Efficiency Bill was recently approved in general by the Senate (April, 24, 2019) and continues its discussion in Congress (Bulletin 12058-08). The Law includes measures to be adopted in all productive sectors. The Energy Efficiency Bill proposes changes to the current regulations in six dimensions: 1) institutionalise energy efficiency within the framework of the Council of Ministers for Sustainability; 2) promote the management of energy in large consumers; 3) deliver information to home buyers, regarding the energy requirements in the use of the houses; 4) promote energy management in the public sector; 5) ensure the conditions that facilitate the installation and operation of charging stations for electric vehicles; and 6) promote the renewal of the vehicle fleet with more efficient vehicles, with emphasis on those of electric propulsion.

1.6 Energy Security Policy

The National Emergency Office of the Ministry of the Interior and Public Security (ONEMI in Spanish) is the State's technical agency, created by Decree Law No. 369 of 1974, in charge of planning and coordinating public and private resources for the prevention and care of emergencies and disasters of natural origin or caused by human action, providing ministries, municipalities, governments, municipalities and civil protection organisations at the central, regional, provincial and communal levels, models and permanent management plans for the prevention and management of emergencies, disasters and catastrophes.

Likewise, to comply with its legal mandate, it will be the responsibility of ONEMI to mobilise, within the parameters established by the State, the resources available from both the public and private spheres to avoid or mitigate the potential impact of the occurrence of a risk, emergency or catastrophe situation (ONEMI 2019).

On the other hand, Chile has a National System of Civil Protection (NSCP) that is integrated by public and private organisations, services, academy and organised communities and has two basic principles:

- Mutual help: it is the provision of human, technical and material assistance among member entities of the Civil Protection System, both for joint preventive and reactive actions.
- Escalated use of resources: rational and orderly use of available means for an effective and efficient integral action in Civil Protection. The application of this principle at the time of a destructive event implies the gradual mobilisation of human, and technical resources by the different levels of the System.

The actions of the National System of Civil Protection are executed and developed by each subsystem and each of these is chaired by its respective authority:

- National Level: Minister of Internal Affairs
- Regional Level: Intendant
- Provincial Level: Governor
- Community Level: Mayor

Normally, each subsystem operates under a management platform called the civil protection committee - Communal, Provincial, Regional and National – which is replaced by the emergency operations committee during emergencies.

According to D.S. N° 38/2011, the Ministry of the Interior can constitute the COE when there are emergencies, disasters or catastrophes that cause significant damage to people and/or property, affecting all or part of Chile's territory – or when two or more regions of the economy are involved – or, in the case that those affected are one or more communes of the same region, and that the Minister of the Interior decides that the incident causes a high impact on the population.

The Emergency Operations Committee has the following objectives:

- Coordinate and/or arrange with public and private organisations, the use of human, technical, material and financial resources necessary for emergency or disaster assistance, applying the principles of mutual aid and efficient use of resources.
- Coordinate the necessary tasks to help the affected population, facilitating interaction among the agencies involved.
- Execute the other tasks entrusted by the Minister of Internal Affairs.

The COE is led by the Minister of Internal Affairs and is integrated by the ministries directly related to the developing crisis, as well as the institutions of the Armed Forces and Order and Security, and other specialists, with the advice and support of the National Director of ONEMI. The following National Authorities form the National COE:

- Minister of Internal Affairs
- Minister of National Defence
- Undersecretary of Internal Affairs
- Chief of the Joint Chiefs of Staff
- Minister of Energy
- Minister of Transport and Telecommunications
- Minister of Health
- Minister of Public Works
- General Director of Police of Chile
- General Director of Investigation Police of Chile
- National Director of the National Emergency Office

At a regional level, Regional COEs are established, which are led by the Regional Intendant and conformed of Regional Ministerial Secretariats (SEREMIS) from different areas, Public Services, Armed and Order Forces, Service Companies (water, electricity, gas), Emergency and Volunteer Institutions, among others; who must act in close coordination with ONEMI.

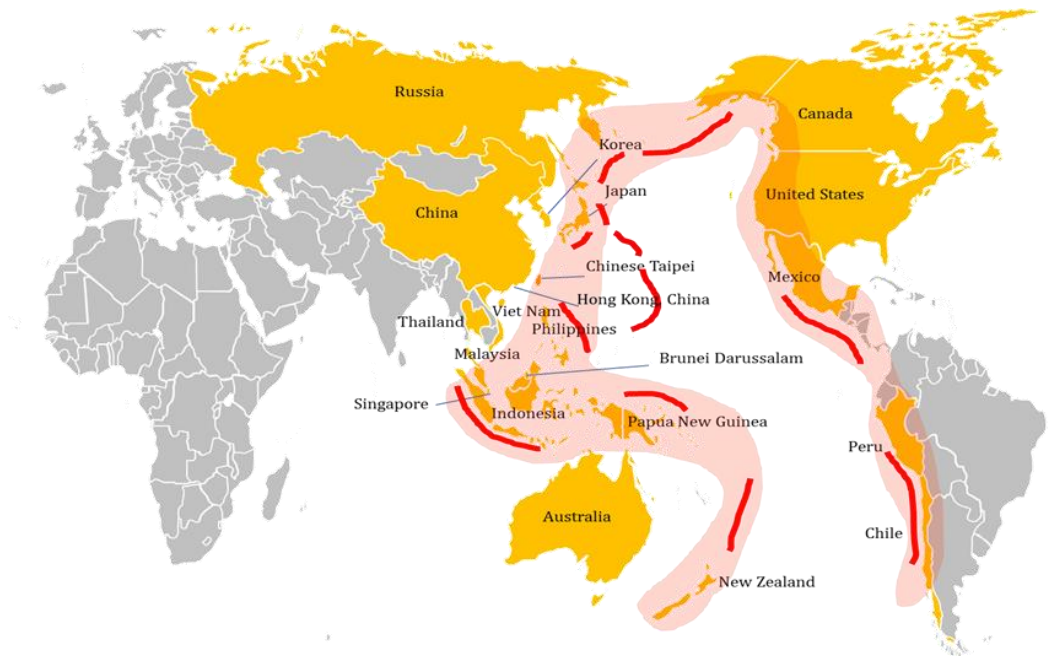
Finally, the Energy Sector Operation Committee (COSE) is composed by high-level energy authorities in Chile's energy sector, including the Ministry of Energy and the SEC. The COSE serves as an instance of information, background collection and coordination between the energy sector authorities, the National COE and the public organizations and companies of the sector involved and / or affected by an energy event. Both the Ministry of Energy and the SEC put at the COSE's disposal all the resources requested to recover the energy supply in the shortest possible time, including: facilities, communication equipment, databases, risk management tools, protocols and expertise.

1.7 Natural disasters in Chile

1.7.1 Earthquakes and tsunamis

More than half of APEC members including Chile, are located in the Ring of Fire – a string of volcanoes and sites of seismic activity around the edges of the Pacific Ocean (Figure 1.14). Roughly 90% of all earthquakes occur along the Ring of Fire, and the ring is dotted with 75% of all active volcanoes on Earth.

Figure 1.15: The Ring of Fire, an area prone to earthquakes and volcanic eruptions



Source: (APERC 2016)

The 1960 earthquake of Chile is the largest earthquake recorded (9.5 magnitude) in the 20th century. Originating off the coast of southern Chile on May 22, 1960, the temblor caused substantial damage and loss of life. It occurred in the afternoon and lasted approximately 10 minutes. This earthquake occurred at a depth of about 32 kilometres.

Since 1960, nine earthquakes – with a magnitude of 7.0 or higher – have struck Chile (Figure 1.15). In February 27, 2010, an earthquake occurred with a magnitude of 8.8 at 3:34 AM. The epicentre was 325 km southwest of Santiago and 35 km deep. It caused widespread damage on land and initiated a tsunami that devastated Maule and Biobío in particular, two first-order administrative districts along Chile’s southern coast.

The effects of the earthquake were concentrated in Valparaiso, Metropolitan and O’Higgins regions. In terms of GDP, Biobío is the second most important region. According to the latest figures released by the Central Bank of Chile (for the year 2006), the share of Biobío in Chile’s total GDP is 10% (surpassed only by the metropolitan area, which accounts for 47 %). The Maule and O’Higgins regions each represent about 4% of total GDP. At the economy level, the damage of this earthquake amounted to 19% of GDP (ECLAC 2010).

At the time of the earthquake, 4 522 MW of power was being dispatched, of which 3000 MW were lost because of the earthquake. In 30 days, 2 257 MW (24 power plants) were back in service. However, 693 MW (16 power plants) would require major repairs; they were disabled for up to six months (UC 2010).

Figure 1.16: Earthquakes with a magnitude of 7.0 or higher, 1960 - 2019



Source: (USGS 2019)

1.6.2 Other natural disasters

Earthquakes and volcanoes are not the only disasters Chile has to cope with—wildfires are getting worse every summer. In the summer (January to March) of 2019, 4 645 fires destroyed 59 122 hectares of woodland, destroying more than 50 homes, killing three and leaving dozens injured or homeless (Bloomberg 2019).

Wildfires have been naturally present in Chile for centuries, but are growing larger and more intense. Temperatures across central-southern Chile have consistently set records in the past three years, prolonging a decade-long drought in parts of the economy (Bloomberg 2019).

2. First case of oil and gas supply emergency: Oil emergency scenario

2.1. Background

Oil is the largest source of energy in Chile, driven mostly by road transport but also by the industrial sector. Chile imports about 95% of the crude oil processed in its three refineries. Despite having two international crude oil pipelines, virtually all of its crude oil imports arrived via tanker to import terminal.

Figure 2.1: Chile's oil supply infrastructure



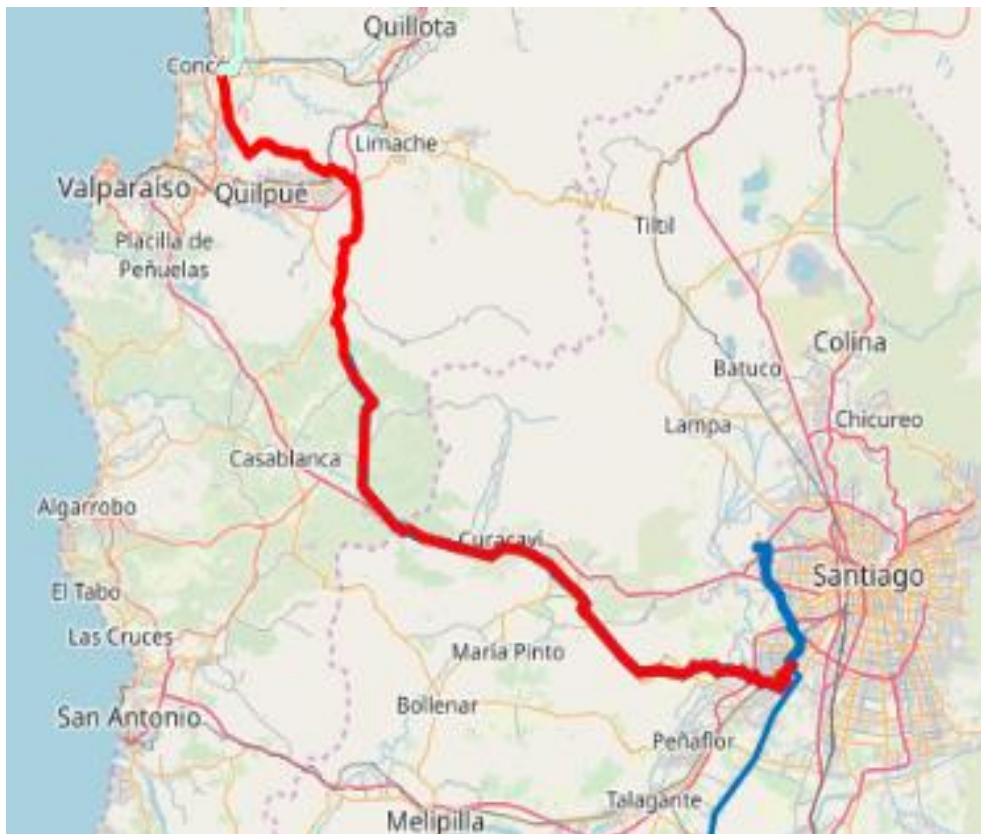
Source: International Energy Agency, 2018.

Moreover, Chile is also an oil product net importer, mostly of diesel and LPG, but also gasoline and other products. All of Chile’s oil product imports arrive via tankers to marine terminals where they are stored and later transported to storage or distribution facilities. In Chile, this is done by two means: oil product pipelines and tanker trucks. However, the oil product pipeline network of around 500 km is limited to Santiago and other cities in central Chile, mainly connecting them with the two main refineries. The rest of the oil supply is distributed by tanker trucks.

2.2 The Concón-Maipú pipeline system

Chile’s pipeline network is owned mainly by two companies: state-owned oil company ENAP and Sonacol (a joint-venture between state-owned companies ENAP and Copec with private companies). The Concón-Maipú systems, owned by Sonacol, has two parallel lines from the Aconcagua refinery to the Maipú storage and distribution plant, in the outskirts of Santiago. One of the lines transports LPG while the other one liquid fuels, mostly gasoline, diesel, jet-fuel and kerosene. The Concón-Maipú liquid products pipeline has a capacity of 1100 m3/hour and a length of 134 km and is vital for oil supply to Chile’s capital as it transports 99% of liquid fuels consumed in the Santiago Metropolitan region.

Figure 2.2: The Concón-Maipú pipeline system (red)



Source: Sonacol, 2019.

2.3 The simulated emergency situation assumptions

It was assumed that the Concón-Maipú liquid products pipeline exploded, creating a severe oil product supply disruption, particularly acute in Santiago and its surroundings. The following details were shared to the exercise participants through a video clip showing a supposed news broadcast.

- An explosion at one of Sonacol's oil product pipelines in the Valparaiso region created a fireball of flame and damaged homes, prompting the evacuation of nearby residents.
- The explosion occurred on the Concón-Maipú liquid products pipeline and the causes of the blast are still unclear, said the intendant of the Valparaiso region.
- Statements included phrases such as "We have reports of flames shooting 25 metres to 60 metres" and "You could see it from 16-24 km away."
- There are reports that two people were injured and two others disappeared. The fire has been contained, but residents near the site have been evacuated.
- The company said in a written statement that it had "immediately started to shut in and isolate that section of pipeline, as well as the parallel LPG line" and was cooperating with authorities in its response.
- With a total and abrupt shutdown of the Concón-Maipú pipeline system, the vast majority of gasoline, diesel, jet fuel and LPG supply to Santiago is interrupted.
- This leaves consumers in Santiago in a very challenging situation, with only Maipú plant stocks and additional volumes that can be transported from the Biobío region via pipelines and truck tankers to depend on.
- This will have very severe consequences since most of domestic transport fuel demand is concentrated in the Santiago Metropolitan region and its surroundings.
- The parallel LPG line has apparently not suffered major damages but was shut down temporarily, as a cautionary measure.
- Repairing of the pipeline and the normalisation of operation will take an unknown period of time depending on the extent of the damage and the authorisation of the regulator and safety agencies.
- Private-vehicle owners and companies will presumably be among the most affected, but some industrial users with significant diesel or fuel oil demand will also be affected.
- Lack of fuel, distribution problems, and panic buying are likely.

After 90 minutes of discussion between participants, they were informed that the pipeline's repairing and safety and quality assessment would take two weeks, before it will be ready for full operation.

Figure 2.3: Simulated video clip showed to the participants during the exercise.



Source: (APERC 2019)

2.4 The Response

The participants assessed the level of supply shortages resulting from the affected pipeline as severe, due to the lack of supply alternatives other than truck tankers, which is not only more expensive and slower, but simply not enough. The Chilean participants acknowledged the almost complete dependency on the Concón-Maipú liquid products pipeline to supply gasoline and diesel to Santiago. Participants agreed that this highlighted a structural problem. First of all, the reliance on a single pipeline and secondly, the fact that companies only have commercial stocks and no emergency stockpiles. In this context, the key question was the duration that the pipeline would be out of operation.

Sonacol, the owner of the pipeline, said, during the exercise, that they could physically repair the pipeline in 3 days. However, the international experience suggests that the required time for normalisation in similar cases is closer to two weeks (Enbridge 2018) (Fell, Fabry and Margolin 2016). Even though the actual repairing process may indeed be a matter of days, it will be followed by lengthy tests, safety assessments and the approval of regulators and government agencies.

Under the assumption that the pipeline would be offline for more than three days, oil company representatives, especially refuelling station owners, recognised that in such an event they did not have resources to cope with the situation. They asked the government to list priorities and to increase security and policing of fuel stations. The operational committee established priorities considering:

- Keeping fuel supply to strategic and critical infrastructure such as hospitals, ministries, emergency service, firefighters and police.

- If necessary, the government could include demand restriction measures like suspending classes, promote remote working and other measures to minimise transportation needs.

Participants also suggested sending fuel to Santiago via the San Fernando-Maipú pipeline, which connects the Biobío refinery with Santiago. Nevertheless, diverting these flows would affect other cities, mitigating the situation in the capital but creating shortages in other demand centres. The government and companies also agreed on seeking international cooperation, mostly through extraordinary imports of gasoline and diesel using truck tankers while the reparation of the pipeline is completed. Finally, participants agreed that in the mid-term it is important to develop larger emergency stocks and storage facilities to cope with similar situations.

3. The second case of the oil and gas supply emergency: the gas emergency scenario.

3.1 Background

More than half of APEC members including Chile, are located in the Ring of Fire – a string of volcanoes and sites of seismic activity around the edges of the Pacific Ocean (Figure 1.14). Roughly 90% of all earthquakes occur along the Ring of Fire, and the ring is dotted with 75% of all active volcanoes on Earth. The 1960 earthquake of Chile is the largest earthquake recorded (magnitude 9.5) in the 20th century. Originating off the coast of southern Chile at a depth of about 32 km on May 22, 1960, the temblor caused substantial damage and loss of life. It occurred in the afternoon and lasted approximately 10 minutes. Since 1960, nine earthquakes – with a magnitude of 7.0 or higher – have struck Chile (Figure 3.1).

3.2 Liquefied natural gas terminal and transportation system

LNG Quintero is the largest regasification terminal of Chile, located in the Valparaiso Region, Quintero. LNG Quintero is the main terminal for central Chile, delivering 52% of natural gas to the power sector, 24% to industrial sector and 14% to residential and commercial sector in 2018 (Ministerio de Energia 2018). Three onshore tanks, with a total storage capacity of 334 000 m³, guarantee continuity of supply. The Terminal's production capacity is 15 million m³ of natural gas per day, to satisfy demand in central Chile. The Terminal operates at an average plant utilization factor of 80% to 90%, figures that are among the highest in the industry. Since 2011, the terminal has operated an LNG Truck Loading Facility that supplies markets in parts of the economy that are not connected by pipeline. As of 2014, following the installation of two new loading bays, the Truck Loading Facility has been able to dispatch 2 500 m³ of LNG per day. The end of the jetty has five arms for unloading LNG from ships. The terminal jetty was built to berth ships with capacities of up to 265 000 m³ of LNG. The jetty arms can unload 12 000 m³ per hour of LNG, which is pumped to the Terminal's storage tanks. By December 2018, the terminal supplied 68% of total natural gas in Chile (GNL Quintero 2019).

Figure 3.1: LNG Quintero terminal



Source: (GNL Quintero 2019)

Electrogas is a company that offers natural gas transportation services in Chile (Figure 3.2). It is engaged in the construction, operation and maintenance of the pipelines. The company is a strategic asset in the supply chain of natural gas in the central zone of Chile, both for residential and industrial customers. Electrogas pipelines consist of two fuel transport systems, the main one consisting of a network of gas pipelines with 165.7 km of ducts between Quintero and Santiago, and a short line to Concón; and the second, consisting of 20.5 km of oil pipelines, to transport diesel oil between Concón and Quillota. The pipelines stretch across different communes of the Metropolitan and Valparaíso regions (ELECTROGAS 2019).

Figure 3.2: Electrogas transport system



Source: (ELECTROGAS 2019)

3.3 The simulated emergency situation assumptions

At 09:00 of March 14, 2019, the coast of the Valparaiso Region was hit by an earthquake of 8.1 magnitude, causing severe losses and damage. The earthquake lasts for 7 minutes with a 40 km depth and the epicentre was about 30 km off the coast of Maitencillo. In addition, a possible tsunami alert was issued. At 09:10, the communication systems failed, only text messages, radios and satellite phones worked. Two minutes later, it was confirmed that the earthquake knocked out LNG Quintero, leaving the terminal completely out of operation. Moreover, underground pipeline damage is unknown. Unfortunately, five robotic arms located in the jetty used to unload the LNG suffered severe damage. By 09:20, reaching the plant has become more difficult due to access routes being critically damaged in the temblor.

Figure 3.3: Earthquake epicentre and tsunami affected area



Source: APERC Scenario

After 90 minutes of discussion between participants, they were informed the tsunami alert had been cancelled and Electrogas has informed that their gas transmission pipeline has not suffered any damage.

3.4 The response

The participants assessed the damage level of the terminal caused by the earthquake. As the central part of Chile relies heavily on gas supply from LNG Quintero, the participants, including private stakeholders (gas companies) and public institutions, worked together to assess the situation and consider solutions.

Participants agreed that the proposed scenario would have a severe impact, due to the magnitude of the earthquake. The damage to LNG Quintero Terminal and the failure of communications could result in a challenge for the economy. That being said, Chilean participants also agreed that the Chilean energy system has faced in the last 10 years at least 3 earthquakes of large magnitude, with minimal consequences in terms of infrastructure damage, and even lower impacts on energy supply. These events include the 8.2 Iquique earthquake in North Chile occurred in 2014, the 8.4 Coquimbo earthquake in central Chile in 2015, and the 8.8 Concepción earthquake that took place in 2010.

Among the responses from the participants were:

- In general, arrangements made by the government to take the lead on centralising information and communication as well as leading coordination with energy companies and other stakeholders.
- Making arrangements to import natural gas via pipeline gas from an Argentina for a determined extraordinary period.
- The government didn't see any legal or policy barrier to address the situation. Other proposals by the government included:
 - › A demand restraint plan to prioritise the residential sector.
 - › Operating the propane/air plant to compensate for the decline in gas supply.
 - › Consider the possibility of bringing LNG from Mejillones LNG Terminal.
 - › Switching to substitute fuels for electricity generation, mostly diesel and fuel oil.

4. General observations and recommendations from the expert team

For this exercise, APERC formed an expert team of seven specialists on energy security. The list of the experts can be found in **Annex III**. Taking Chilean energy sector characteristics into account, the expert team reviewed the participants' responses to both emergency scenarios, and provided the following recommendations:

4.1 Pre-emergency institutional arrangements

1. Emergency arrangements with neighbouring economies should be specified in prior agreements. The gas supply emergency scenario showed the importance of having prior arrangements to make an increase of gas piped imports from Argentina large enough and prompt enough to compensate for temporary shortfalls of gas possible. Communication is fundamental both among domestic parties and internationally.
2. There may be other actors that should participate in future exercises:
 - a. Electric Power: In any scenario in which power may be impacted or in which additional power may be required, a representative from electric utilities should be included. The gas supply scenario is one in which there is a heavy interdependency which may result in cascading impacts.
 - b. Environment/Safety: If regulations exist which require an investigation into environmental impacts and remediation and/or safety practices, it is best to include the appropriate regulatory bodies to understand what needs for investigation and approval to repair impacted assets may occur. It is also important to understand if there is a process for waiving such requirements.
 - c. Investigation/Forensics: If future exercises include terrorist attacks or sabotage situations, it is worthwhile to include law enforcement officials since the disrupted area may require police and forensic investigation. Like environmental or safety requirements, this can delay the start of the recovery process.
3. As far as possible, internal emergency arrangements should be made beforehand. The oil supply emergency scenario showed the necessity of having a comprehensive plan in case of major shortages in Santiago, including rationing measures, designating fuels stations for priority users, and arrangements for planes to refuel in alternative airports.

4.2 Communication strategy

4. It is important to implement a clear, trustworthy, and quick communications strategy. A clear communication strategy to announce information to the public is necessary, so that they can be involved, and panic can be reduced.
5. Concerning communication to the public, it is necessary to design and diffuse protocols about rationing consumption of oil derivatives. It would be more effective to communicate this matter before the emergency, rather than after panic spreads out. Consider employing trusted actors

such as popular sports figures, actors/actresses, or other non-government/non-petroleum company people to help deliver the message.

6. It is necessary to improve formalities around communication protocols. All protocols should be clearly written and widely disseminated to key stakeholders.
7. The contact numbers of relevant persons in cases of emergency must be continuously verified and updated for both public and private sectors.
8. Develop public communication plans for encouraging demand restraint, without inducing panic buying, which would only worsen the emergency.

4.3 Supply measures

4.3.1 Oil supply emergency

The oil supply emergency exercise showed the high risk of relying on a single pipeline to supply most oil liquid fuels to the main consuming urban area in Chile, Santiago, with roughly a third of Chile's consumption, without having sizable security stocks in or around the city. Therefore the Expert Team recommends:

9. Develop plans for additional storage facilities and stockpiling of fuels transported in the Concón-Maipú line.
10. It is recommended that stocks in the private sector should be increased. In addition to the 25 days of operational petroleum stocks which are obligatory at present, there should be 5 more days' worth of stock. The private sector could use this not only for emergencies but for commercial use as well. Two models are proposed do so:
 - a. Setting up a joint oil stockpiling company; in case oil companies cannot accommodate such stockpile increases on their own, they could set up a special joint oil storage company.
 - b. Alternatively, set up an strategic petroleum reserve (SPR to increase stocks without adding excessive burden on the private sector is to set up a government stock,
11. Stockpile or emergency stock information should be improved with public and private cooperation. During the exercise, it was not possible to determine all the remaining stock during the emergency scenario.
12. Accurate assessment/evaluation of impacts is crucial for informed decision-making. It is recommend to keep strengthening data collection and analysis. Detailed and precise information can lead to effective policy measures for both supply side acceleration and demand side restraint.
13. Develop detailed plans for mobilizing personnel, equipment, and materials to quickly repair or bypass a pipeline fracture or emergency situation. If an investigation or environment remediation is required which would delay the repair, consider plans for temporarily bypassing the affected area if possible.
14. In addition to increasing emergency stock, alternatives for strengthening them should be addressed from a regional point of view, rather than independently by each demand centre.
15. Provide further study on the applicability of utilizing tanker trucks to mitigate short term petroleum supply disruptions. Develop plans for existing assets and understand the maximum achievable product flow rates.

16. Designate high priority gas stations may shorten tanker truck resupply trip times and increase flow in case of emergencies.
17. In case of emergencies, presidential decrees can make regulations regarding the quality of fuels more flexible. It would be a good opportunity to create an emergency basket of petroleum derivatives between neighbouring economies.
18. In terms of reduction of diesel and gasoline consumption, one option would be the introduction of bioethanol and biodiesel, if Chile has not yet introduced these biofuels. In particular, there is a high portion of diesel consumption in Chile, so the first priority would be introducing biodiesel fuels.
19. For the case of jet-fuel, develop plans for minimizing supply requirements such as having airlines arrive with return trip fuel.

4.3.2 Gas supply emergency

Given that over half of Chile's gas supply comes from imports received at LNG Quintero and virtually the totality of gas supply to the Santiago region is transported through the Electrogas pipeline, both are key elements of Chile's energy infrastructure.

Currently, the only alternative source of supply to LNG Quintero in the Santiago region is the international pipeline interconnection with Argentina (GasAndes). This would leave any potential gas imports from Argentina subject to availability and only after satisfying first Argentina's domestic market, according to an additional bilateral protocol, signed in 2019 (Energia 2019). Therefore, the simulated scenario in which the LNG Quintero would be left out of line, there would be a direct impact to gas users, particularly to power generators but also to industrial and residential consumers. The Expert Team recommends:

20. Establish priorities for consumption and allocation of natural gas supplies across sectors (residential, industry, power generators, etc.).
21. Developing a cooperation framework between the Ministry and companies to develop gas storage infrastructure near demand centres. Examples of gas storage facilities that help coping demand peak or emergency supplies are found elsewhere in the APEC region, including Japan, China, the USA and Canada.
22. As for the gas exchange protocol between Argentina and Chile, it is recommended to specify the maximum extent that could be exchanged during emergencies, particularly in terms of volumes, duration and seasonal factors.
23. Assess the feasibility of transporting LNG via truck tankers to Santiago and installing a satellite regasification terminal as the existing one in Permuco
24. The electricity sector must be present in every discussion or drill performed about natural gas disruption since it is the principal consumer of LNG. Another missing participant was the industrial sector. Efforts must be made to bridge departments both within the Ministry of Energy and with representatives from the industry and power generators.
25. Evaluate the existing capacities for inter-fuel substitution, as well as the effects on such fuel switching. These effects should be accounts in terms of their mitigations potential to alleviate the supply disruption but also its environmental and financial impacts.

26. Develop a detailed curtailing response plan, which identifies priority users, potential demand restraint measures, interruptible contracts and responsibilities for system operators. This plan should allow the optimal use of available gas supplies in a disruption.
27. Infrastructure, markets and policies framework for natural gas are not homogeneously developed in South American region. Explore the potential for establishing regional arrangements for cooperation and coordination during supply disruptions. This would be particularly useful to start a regional dialogue about the future development for both a sustainable and secure use of energy.

4.4 Regional cooperation

28. Consider establishing Memoranda of Understanding or agreements with neighbouring economies for providing mutual assistance for emergency response in case of supply disruption. These regional agreements are common in other places within the APEC region. For instance, the Association of Southeast Asian Nations (ASEAN) has had 14 sessions of the Energy Security Forum as well as dedicated meetings and workshops for joint oil stockpiling.

4.5 Data

29. Counting with detailed and up to date energy statistics is essential to formulating sound policies and fundamental to taking decision in an emergency response scenario. The Ministry of Energy and National Energy Commission should keep working on strengthening its data collection and analysis systems.
30. Oil data acquisition from the oil industry would best be done weekly, or at least twice a month instead of on a monthly basis. This means that the government can get more precise data on stock levels, import volumes of crude oil and products, refined volumes of each refinery, sales amount, and oil stock levels in each terminal. If the government has such data when supply shortages occur, the government can evaluate the impact on the economy more immediately and precisely, and can set up appropriate countermeasures.
31. The government and/or ONEMI could announce details to the people of Chile about the emergency such as clear, accurate data on supply disruptions, the impact to the public, and reserve levels of petroleum products as well as requesting cooperation in restraining demand if necessary. The purpose of the announcement is to provide assurance to people and let them know there are oil reserves, so there is no need to panic, especially when requesting demand suppression.

4.6 General recommendations

32. Increasing oil and gas transport, storage and distribution infrastructure is key to strengthening energy security and resilience. Although Chile already has stockpiles at refineries and oil stations, more stocks needs to be held at satellite centres to reduce risks of supply disruption to distribution centres. Moreover, one of the common barriers for building storage capacity and stockpiling is who and to which extent will pay for it (government, energy companies, end-consumers, etc.). The international practice worldwide shows that costs are divided to different extents but end-consumers often contribute to such investments indirectly through taxes or levies imposed on final oil and gas consumption.

33. Continue the outstanding efforts that are under way in the areas of risk management and resiliency. Continue enhancing the role of the COSE and the adoption of an Incident Command System, as the one used in other APEC economies (Australia, Japan, US, etc.) , for establishing the roles and responsibilities of players throughout government and industry.
34. Establish priorities for consumers under different scenarios. The priorities for one scenario may have substantial differences depending on the cause (natural disasters, technical problems, etc.) and duration of the emergency.
35. Continue carrying out annual simulation exercises of this nature, to keep participants at ready, and to test protocols and responses to energy emergencies with different sets of companies. Furthermore, such exercises will enhance economy response plans.

5 Conclusions

Chile has taken very relevant measures on responding to emergency situations, in general, and energy supply disruptions in particular, such as the creation of the National Emergency Office of the Ministry of the Interior and Public Security (ONEMI in Spanish), the existence of detailed protocols to face emergency situations and the undertaking of domestic energy security exercises similar to this one. The Chilean participants' response to the exercise was ordered, quick and effective in assessing the situation, engaging public communications and taking decisions.

However, owing to its geographical situation, Chile is exposed to several risks, particular natural disasters, that pose threat to energy security. Some fields some fields of the Chilean energy sector seem to face particularly challenging situations, such as the oil and natural gas transmission pipeline systems, which lack interconnectedness and redundancy. The relevance of energy security and an energy emergency response approach need to be further strengthened in Chile's planning.

In the oil sector, the oil supply emergency exercise showed the high risk of relying on a single pipeline to supply liquid fuels to the main consuming urban area in the economy, Santiago, with roughly a third of Chile's consumption, without having sizable emergency stocks in the city or in its outskirts. Moreover, almost all of Chile's import facilities and refineries are located on the Chilean coast, in which earthquakes and tsunamis are common. Currently Chile has about 25 days of inventory stock as imposed by the government. However, increasing strategic oil stock may need to be considered, such as investing in new storage facilities and increasing the volume ratio compared to those of other APEC economies. Expanding oil product stocks and storage facilities, particularly around Santiago, is a key measure to strengthen energy security in Chile.

Regarding the gas sector, Chile's gas transportation system is regionally disconnected. The central and northern regions are not interconnected via pipeline. This leaves domestic gas supply with no alternatives other than the interconnection with Argentina's gas networks. During the exercise, with the LNG Quintero terminal out of service, which supplies approximately 68% of total natural gas, Chile gas supply to the central region is severely restrained. This would affect residential, industrial, and, particularly, power generators around Santiago. In this context, Chile should have a detailed gas crisis plan, which identifies priority users, potential demand restraint measures, interruptible contracts and responsibilities for system operators. Moreover, a detailed emergency cooperation plan between Chile and neighbouring economies, particularly with Argentina, would contribute to Chile's energy security and resilience.

The participants in the exercise were aware of the existing regulations to deal with emergencies in the energy sector. However, given its condition as net energy importer, Chile has to carefully implement new emergency plans and protocols to deal with supply disruption originated or affecting Chile's sources of crude, oil products and LNG imports. Strengthening cooperation with regional partners has proven to be in the international experiences a more effective way to deal with supply emergency situations. Additionally, it is important to highlight the role of a centralised and effective communication, across energy key stakeholders, and, particularly with the public.

The exercise showed in both scenarios the high risk of relying on limited pipeline transportation systems to supply oil products and gas, respectively. This is especially important, since these systems connect the import terminals in the coast with the main consuming urban area, Santiago, with roughly a third Chile's consumption, without having sizable security stocks in or around the city. Nevertheless, the government and stakeholders made an impressive coordination and showed how COE can arrange the private sector and take lead in coordinating assessment of the impacts and coming up with measures to respond to the disruptions.

In spite of the structural problems in infrastructure detailed before in this report, the Expert Review Team highlights that Chile has actually faced earthquakes of higher magnitude in the last decade, compared to the one presented in the Gas Scenario of this exercise. These events include the 2010 Concepción, the 2014 Iquique and the 2015 Coquimbo earthquakes. Although these quakes' epicentres were not distant from relevant energy infrastructure; in none of these cases, key energy facilities were damaged and did not affect energy supply. This shows a fluid coordination between key energy sector stakeholders in Chile, allowing an efficient use of existing infrastructure and responding to supply emergencies in an ordered and effective way. This joint efforts from previous experiences have been embodied in a series of protocols and sectorial emergency plans between the public and private sectors, allowing allow constant analysis of improvement areas to ensure a better response to energy supply emergencies.

While the recommended measures, as well as other risk management and disaster preparedness plans and actions, involve considerable investment, the disaster that could result without such preparedness may incur even higher recovery and emergency costs, in addition to having substantial effects for society. The benefits of government investing in energy security are translated in a responsible use of public finances, safe access to energy and an improved quality of life.

The Expert Review Team highlights the importance of energy security in Chile and commends the positive steps taken in the right direction for emergency responses with a sound institutional framework and clear action protocols. At the same time, the Expert Review Team acknowledges that relevant challenges still remains and recommends the Government to continue the hard work on having a more sustainable and secure energy system. Finally, the Expert Review Team sincerely hopes that this Oil and Gas Security Exercise contributes positively to further strengthening energy security in Chile.

References

- APERC. 2019. *APEC Energy Demand and Supply Outlook*. 05. Accessed 2019. <https://aperc.iecej.or.jp/publications/reports/outlook.php>.
- APERC. 2016. "Policy Success Factors for Geothermal Electricity Development in The APEC Region." Asia Pacific Energy Research Centre, Tokyo. Accessed 2019. http://aperc.iecej.or.jp/file/2016/2/12/Policy_Success_Factors_for_Geothermal_Electricity_Development_in_the_APEC_Region.pdf.
- . 2019. *Video production*. Accessed 2019.
- Banco Central de Chile. 2017. *Statistics Database*. Accessed 2019. <https://si3.bcentral.cl/Siete/secure/cuadros/home.aspx>.
- Bloomberg. 2019. *After Earthquakes and Volcanoes, Chile Is Threatened by New Natural Disaster*. Daniela Guzman. Accessed 2019. <https://www.bloomberg.com/news/articles/2019-02-25/land-of-earthquakes-and-volcanoes-threatened-by-a-new-scourge>.
- Chavez-Rodriguez, Mauro, Daniela Varela, Fabiola Rodrigues, Javier Bustos Salvagno, Alexandre Koberle, Eveline Vasquez-Arroyo, Ricardo Raineri, and Gerardo Rabinovich. 2017. "The role of LNG and unconventional gas in the future natural gas markets of Argentina and Chile." *Journal of Natural Gas Science and Engineering* (ELSEVIER) 584-585.
- CNE. 2018. *Comision Nacional de Energia*. <https://www.cne.cl/estadisticas/electricidad/>.
- . 2018. *Comision Nacional de Energia*. <http://energiaabierta.cl/visualizaciones/importaciones-y-exportaciones/>.
- . 2018. *Estadisticas*. Accessed 2018. <https://www.cne.cl/estadisticas/electricidad/>.
- . 2018. "Reporte mensual - Diciembre." Santiago, 12. Accessed 2019.
- ECLAC. 2010. *The Chilean earthquake of 27 February 2010: an overview*. Santiago: United Nations publication. Accessed 2019. <https://www.cepal.org/noticias/paginas/4/36404/2010-191-earthquake.pdf>.
- ELECTROGAS. 2019. *Sistema de transporte*. Accessed 2019. <http://www.electrogas.cl/sistema-de-transporte/>.
- ENAP. 2017. Accessed 02 2018. <https://www.enap.cl/>.
- Enbridge. 2018. *Enbridge responds to natural gas transmission pipeline incident north of Prince George, B.C.* <https://www.enbridge.com/media-center/media-statements/prince-george-pipeline-incident>.
- Energia. 2019. *Chile y Argentina reafirman compromisos de integración energética*. <http://www.energia.gob.cl/tema-de-interes/chile-y-argentina-reafirman>.
- Fell, Eric, Erik Fabry, and Rick Margolin. 2016. *Impacts of TETCO's Natural Gas Pipeline Explosion*. <https://www.genscape.com/blog/impacts-tetcos-natural-gas-pipeline-explosion>.
- GNL Quintero. 2019. *Terminal*. Accessed 2019. <http://www.gnlquintero.com/terminal/infraestructura/muelle.htm>.
- Gobierno de Chile. 2018. *President Piñera launches Energy Roadmap with social element and requests that progress be made on 11 mega commitments*. Accessed 2019. <https://www.gob.cl/en/news/president-pinera-launches-energy-roadmap-social-element-and-requests-progress-be-made-11-mega-commitm>.

- IEA (International Energy Agency). 2018. "World Energy Statistics 2016."
- IEA. 2018. *Energy Policies Beyond IEA Countries*. International Energy Agency. Accessed 2018. www.iea.org.
- INE, Instituto Nacional de Estadísticas. 2017. *ww.INE.cl*. Accessed 2018. <http://www.censo2017.cl>.
- Ministerio de Energía. 2018. *Division de Seguridad y Mercados Energeticos*. <http://energia.gob.cl/>.
- . 2015. *Energia 2050*. Accessed 2019. <http://www.energia2050.cl/es/>.
- . 2017. *Estrategia de electromovilidad*. Accessed 2019.
- . 2018. *Ministra de Energía celebra aprobación de proyecto de Generación Distribuida en el Senado que queda listo para ser promulgado ley*. Accessed 2019. <http://energia.gob.cl/tema-de-interes/ministra-de-energia-celebra>.
- . 2012. *Plan de Accion de Eficiencia Energetica 2020*. Accessed 2019. www.amchamchile.cl/UserFiles/Image/Events/octubre/energia/plan-de-accion-de-eficiencia-energetica2020.pdf.
- . 2018. *Planificacion Energetica de Largo Plazo - PELP*. <http://pelp.minenergia.cl/>.
- . 2018. *Ruta Energetica*. Accessed 2019. <http://energia.gob.cl/ruta>.
- ONEMI. 2019. *ONEMI. 7*. <https://www.onemi.gov.cl/presentacion/>.
- Oscar Álamos G. 2019. "Risk Management in the Energy Sector." Santiago, March.
- UC. 2010. *Resiliencia en el Sistema Eléctrico de Chile*. Accessed 2019. <http://hrudnick.sitios.ing.uc.cl/alumno17/resi/desastresnaturales.html>.
- USGS. 2019. *Earthquakes*. Accessed 2019. <https://earthquake.usgs.gov/earthquakes>.

Annex I: agenda

**OIL AND GAS SECURITY EXERCISE IN CHILE
THREE (3) DAYS PROGRAM AGENDA**

Day 1 (Wednesday, 13 March 2019)	
9:00 (30'')	Registration
9:30 (10'')	Welcome Remarks by Chile's Minister of Energy – Mrs. Susana Jiménez Schuster
9:40 (10'')	Opening Remarks by APERC President – Dr. Kazutomo Irie
9:50 (20'')	Introduction of Participants and Experts
10:10 (10'')	Photo Session
Session 1	
10:20 (10'')	Presentation on the whole schedule for the exercise case study by APERC – Mr. Munehisa Yamashiro
10:30 (15'')	Presentation on the Exercise Model Procedure (EMP) – Mr. Diego Rivera Rivota
10:45 (10'')	Q & A
10:55 (15'')	Coffee Break
11:10 (40'')	Presentation on Oil and Gas Security in Chile by the Ministry of Energy – Mr. Oscar Alamos, Head of Energy Risk Management Unit
11:50 (40'')	Q & A
12:30 (60'')	Lunch Break
Session 2	
13:30 (20'')	Introduction of the Oil Supply Emergency Scenario by APERC including Q/A - Mr. Diego Rivera Rivota
13:50 (120'')	Discussion among Chile's Stakeholders on the Response to the Oil Supply Emergency Scenario
15:50 (15'')	Coffee Break
16:05 (45'')	Presentations on the Response to the Oil Supply Emergency Scenario by the Coordination Officials from Chile
16:50 (60'')	Q & A, and Discussion on the Responses to the Oil Supply Emergency Scenario
17:50	Closing of Day 1
Day 2 (Thursday, 14 March 2019)	
8:30 (30'')	Registration
Session 3	
9:00 (5'')	Presentation on the schedule for Day 2 by APERC – Mr. Munehisa Yamashiro
9:05 (20'')	Introduction of the Gas Supply Emergency Scenario by APERC including Q/A - Mr. Juan Ignacio Alarcón
9:25 (120'')	Discussion among Chile's Stakeholders on the Response to the Gas Supply Emergency Scenario
11:25 (15'')	Coffee Break
11:40 (45'')	Presentations on the Response to the Gas Supply Emergency Scenario by the Coordination Officials from Chile
12:25 (60'')	Questions/Answers and Discussion on the response to the Gas Supply Emergency Scenario
13:25 (60'')	Lunch Break

Session 4	
14:30 (40'')	Discussion time to prepare an evaluation by experts and by Chile's Stakeholders.
15:10 (60'')	Tentative Evaluation of the Exercise by Expert Review Team
16:10 (20'')	Questions/Answers and general discussion on the Exercise
16:30 (15'')	Coffee Break
16:45 (20'')	Tentative Evaluation of the Exercise by Chile's Stakeholders
17:05 (20'')	Questions/Answers and general discussion on the Exercise
17:25 (10'')	Final Remarks from Head of International Affairs – Mrs. Paula Estevez
17:35(10'')	Closing Remarks by APERC President – Dr. Kazutomo Irie
Day 3 (Friday, 15 March 2019)	
Site visit Chile LNG Quintero Regasification Plant.	
07:30 (120'')	Meeting and transportation to LNG Quintero
09:30 (30'')	Arrival, registration and security checkpoint.
10:00 (60'')	Presentation of Chile LNG.
11:00 (120'')	Guided tour in the plant.
13:00 (120'')	Transportation from LNG Quintero back to the ICON Hotel.
15:00	Expected arrival in Santiago

Annex II: list of participants from Chile

Participants			
	Name	Organisation	Position
1	Ms. Susana Jiménez S.	Ministry of Energy	Minister of Energy
2	Mr. José Antonio Ruiz F.	Ministry of Energy	Head of the Hydrocarbons Unit, Energy Markets Division
3	Mr. Marco Peirano	Ministry of Energy	Head of the Electricity Unit, Energy Markets Division
4	Mr. Luis Ávila	SEC	Superintendent for Electricity and Fuels
5	Mr. Ricardo Toro	ONEMI	National Director
6	Mr. Oscar Álamos	Ministry of Energy	Head of the Energy Risk Management Unit, Energy Markets Division.
7	Mr. Germán Morgado	Ministry of Energy	Professional from the Energy Risk Management Unit, Energy Markets Division.
8	Mr. Luis González	Ministry of Energy	Professional from the Energy Risk Management Unit, Energy Markets Division.
9	Mr. Alejandro Lemus	SEC	Head of the Fuel Engineering Division
10	Ms. Maricel Lavin	SEC	Head of the Technical Unit of liquid fuels
11	Ms. Marta Cabeza	SEC	Chief Dept. General Secretariat.
12	Ms. Hilda Cabello	SEC	Chief Dept. Fuels Systems
13	Ms. Margarita Martínez	ONEMI	Head of the Simulation Unit
14	Miss Helia Vargas	ONEMI	Head of Community Prevention Department
15	Mr. Camilo Grez	ONEMI	Chief of staff
16	Mr. Miguel Ortiz	ONEMI	Chief of the Early Warning Centre
17	Mr. Carlos Vega	Under Secretary of the Interior	UGRE professional
18	Mr. José Alejandro Álvarez	COPEC	Operations Manager
19	Mr. Leonardo Canales	ENAP	Operations Manager
20	Mr. Francisco Guzmán B.	ENEX	Commercial Operations Manager
21	Mr. Patricio Arriagada	ESMAX	Plant manager
22	Mr. Iván Roa	SONACOL	Chief of Operations

23	Ms. Ana Retamal	ABASTIBLE	Supplies Vice-Manager
24	Mr. Alfredo Ramón	ABASTIBLE	Chief Operations Officer
25	Mr. Cristian Valenzuela V.	GASCO GLP	Head of Gas Transportation Services
26	Mr. Patricio Lara	LIPIGAS	Chief Operations Officer
27	Mr. Rodrigo Vivallos	GASMAR	Supply Manager
28	Mr. Alejandro Bizama	GASMAR	Corporate Manager Occupational Health and Safety
29	Mr. Rafael González	GNL CHILE	Head of Distribution and Deposits
30	Mr. Alejandro Amorín	GNL Quintero	Supply Manager
31	Mr. Eduardo Vargas	GNL Mejillones	Operations Manager
32	Mr. José Ubiergo	GasValpo	Supply Manager
33	Mr. Francisco Arrieta	Electrogas	Supply Engineer
34	Mr. Luis Villalba	GasAndes	National Emergency Chief
35	Mr. Roger Serrat	Metrogas	National Chief Security
Organising team			
1	Ms. Ma. de los Ángeles Valenzuela	Ministry of Energy	Hydrocarbons Unit Professional, Energy Markets Division
2	Miss Carmen Gloria Guerra	Ministry of Energy	Hydrocarbons Unit Professional, Energy Markets Division
3	Ms. Paula Estevez	Ministry of Energy	Head of the International Relations Office
4	Ms. Corissa Petro	Ministry of Energy	International Relations Office Professional
5	Miss Adelaida Baeriswyl	Ministry of Energy	International Relations Office Professional
6	Mr. Pablo Romero Z.	DIRECON	Professional of the Department of Energy, Commerce and Sustainable Development

Annex III: expert review team

Name	Organisation	Position
Experts from APEC and non-APEC economies		
Mr. Gabriel Bauza	Gas Energy Latin America	Managing Partner
Mr. Carlos Sucre	Inter-American Development Bank (IADB)	Consultant, Extractive Sector Initiative
Dr. Han Phoumin	Economic Research Institute for ASEAN and East Asia (ERIA)	Energy Economist
Mr. Patrick Willging	United States Department of Energy (DOE)	Logistics Management Specialist
Mrs. Sylvia Marcela Reinoso	Latin American Energy Organization (OLADE)	Capacity Building Specialist
Mr. Jason Elliot	International Energy Agency (IEA)	Senior Energy Analyst at the Energy Policy and Security Division
Mr. Hiroaki Maruyama	Japan Oil, Gas and Metals National Corporation (JOGMEC)	Project Director
APERC		
Dr. Kazutomo Irie	APERC	President
Mr. Munehisa Yamashiro	APERC	Vice President
Mr. Juan Ignacio Alarcón	APERC	Researcher
Mr. Diego Rivera Rivota	APERC	Researcher