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FOREWORD

Following the instruction from 11th APEC Energy Ministers' Meeting (EMM11) held in Beijing, China in September 2014, APERC has started implementing the Oil and Gas Security Initiatives in November 2014. Among the overarching pillars of OGSI is the conduct and publication of the Oil and Gas Security Studies (OGSS).The first six reports of OGSS was published in November 2015, which were circulated to the Energy Working Group (EWG) members and uploaded in the APEC and APECR websites. OGSS continues to undertake research activity and produce reports including this one.

The primary objective of the OGSS is to provide useful information to APEC economies on significant developments and vital issues related to oil and gas security, including individual economy's policies to address and enhance oil and gas security measures. I am hopeful that APEC economies will learn something from these OGSS research studies and will serve as an impetus for them to re-examine their policies, plans and programs to further strengthen their respective oil and gas supply security measures. The information from these studies may offer plausible approaches and options which the APEC economies could consider as an individual member in addressing any magnitude of supply disruptions or emergencies, as well as how APEC could deepen cooperation for possible region-wide energy security framework.

I would like to express my sincere gratitude to the authors and contributors for the OGSS for spending time and efforts in doing relevant research studies. However, I would like to emphasize that the contents and views in these independent research projects only reflect those of the authors and not necessarily of APERC. The contents and information from these studies might change in the future due to unforeseen external events, and the changes or improvements in the individual economy's policy agenda and framework on oil and gas security.

Finally, rest assured that APERC will continuously conduct OGSS to serve its purpose of aiding the governments and policymakers in APEC in addressing the oil and gas security issues in the region.

Takato OJIMI
President
Asia Pacific Energy Research Centre

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Abbreviation and Acronyms

Abbreviation

Bbbl	billion barrel
Bbbl/d	billion barrel per day
Bcm	billion cubic metre
Bcm/y	billion cubic metre per year
Bcf/d	billion cubic feet per year
BT	billion tonne
Cm	cubic metre
GW	gigawatts
Ktoe	kilotonne of oil equivalent
Km^2	square kilometre
Mmbbl	million barrel
Mmbbl/d	million barrel per day
Mcm/d	million cubic metre per day
Mcm/y	million cubic metre per year
Mtoe	million tonnes of oil equivalent
Mtpy	million tonne per year
Kbbl/d	thousand barrel per day
Tcf	trillion cubic feet
Tcm	trillion cubic metre
Toe	tonne of oil equivalent
USD	US Dollar

Acronyms

APEC	Asia-Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Centre
APSA	ASEAN Petroleum Security Agreement
APG	ASEAN Power Grid
ASEAN	Association of Southeast Asian Nations
BAU	Business-as-usual
CBM	Coalbed Methane
CAGP	Central Asian Gas Pipeline

CRED	Centre for Research on the Epidemiology of Disasters
DBR	Doing Business Report
DMO	Domestic Market Obligation
EIA	Energy Information Administration
EMM	Energy Ministerial Meeting
ENAP	National Petroleum Company
ESI	Energy Security Initiative
EWG	Energy Working Group
GPS	Global Petroleum Survey
HHI	Herfindahl-Hirschman Index
ICC-IMB	International Chamber of Commerce – International Maritime Bureau
IEA	International Energy Agency
IEEJ	Institute of Energy Economics Japan
IEP	International Energy Program
INDCs	Intended Nationally Determined Contributions
JBIC	Japan Bank for International Cooperation
JODI	Joint Organisations Data Initiative
JPDA	Joint Petroleum Development Area
LNG	Liquefied Natural Gas
LPI	Logistics Performance Index
MENA	Middle East and North Africa
ND-GAIN	Notre Dame Global Adaptation Index
PEMEX	Petróleos Mexicanos
PESTLE	Political, Economic, Social, Technical, Legal and Environmental
PMB	Pulau Muara Besar
PPP	Purchasing Power Parity
RGT	Regasification Terminals
R/P	Reserves-Production
RTEIS	Real Time Emergency Information Sharing Initiative
SEA	Southeast Asia
TPES	Total Primary Energy Supply
UAE	United Arab Emirates
UN	United Nations
UN SE4ALL	United Nation Sustainable Energy for All
UN Comtrade	United Nations Commodity Trade Statistics Database
UNDP	United Nations Development Program

US	United States
WB	World Bank
WGI	World Governance Index

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Executive Summary

OIL AND GAS SECURITY INDEXATION

Energy security has been one of the highest priorities for all governments in the Asia-Pacific Economic Cooperation (APEC) region, even though the concept is subject to various interpretations and setting a clear definition remains a challenge. In 2001, the APEC Leaders endorsed the Energy Security Initiative (ESI) in order to strengthen regional energy security, emphasizing longer-term policy responses that address the broad challenges facing the region's energy supply by focusing on actions that are practical in a policy context and acceptable in a political context.

In order to gauge the supply security risk for oil and gas, the study established six indicators based on PESTLE analysis – political, economic, social, technical, legal and environmental. A total of 59 sub-indicators were assigned in these indicators and grouped into internal and external factors (please see Figure 1.2 in Chapter 1). In addition to PESTLE, the study made further analysis on major import sources for crude oil, petroleum products and natural gas (including liquefied natural gas [LNG]) for APEC and in each economy. The key findings of the indexation are divided into two energy resources – oil and gas.

APEC's overall result showed low to moderate-low risk[1] on oil and gas supply security. Oil and gas had almost equal supply security risk in 2013. However, the oil security index exhibited improvement compared with the 2000 level, a 3.0 percentage point risks reduction. On the other hand, gas supply security risk remained at the same level.

Oil Supply Security Index

In 2013, the APEC region imported 1,287 Mtoe (9.5 billion barrels) of crude oil (including intra APEC oil imports). According to the United Nations Commodity Trade Statistics Database (UN Comtrade), nearly every year from 2000-2013, half of the crude oil imports came from five main suppliers. Saudi Arabia had been the largest supplier, accounting for around one-fifth of total imports, followed by Canada and the United Arab Emirates (UAE) with an average share of 10% and 8.0%, respectively. Canada exported most of its oil production to the United States. On the other hand, Russia saw a steady increase in its oil exports to other APEC economies over the study period, and became one of the top five exporters to the APEC region in 2011.

[1] For this study, the index used ranges from 1.0% to 100.0% such that a lower index means less vulnerable to any oil/gas supply disruption/crisis. An index of 20% and below is considered having low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

Among the APEC members, 10 economies showed improvement in their oil supply security index (with a difference of more than 1.0 percentage point from 2000-2013). Six economies remained at similar levels as in 2000 (with a difference of less than 1.0 percentage point). Meanwhile, four economies – Australia; China; Papua New Guinea; and Thailand – demonstrated a deterioration in their respective oil security index (higher index score) (please see Figure 3.2 in Chapter 3).

Three indicators contributed to APEC's oil security index improvement – technical/technology, economic and environmental indicators. Among the major factors that triggered the improvement were: (1) the reclassification of oil reserves (oil sands) in Canada from probable to proven reserves (which subsequently improved the APEC's Reserves-Production [R/P] ratio by 50%); (2) reduction of the overall APEC oil intensity from 63.8 toe/million 2010 USD in 2000 to 42.4 toe/million 2010 USD in 2013; and, (3) higher readiness and lower vulnerability towards climate change threats

However, the absence of an oil emergency supply agreement in eight APEC members prevented the supply security index score from going down further, while the social indicator showed a slight uptick resulting from an increase in APEC's oil consumption per capita, from 0.78 toe/person in 2000 to 0.80 toe/person in 2013. The other sub-indicator that needs some attention is the piracy threat in the political indicator. Piracy incidents in the APEC region recorded a sharp increase from 69 incidents in 2008 to 148 incidents in 2014. The increase of piracy in the APEC region added another 6.0% of risk to the political indicator.

Gas Supply Security Index

APEC members generally have been dependent on two regions for LNG supply, which are the Middle East and North Africa (MENA) and Southeast Asia, with each region supplying 40% and 28% of LNG demand, respectively. If Australia is added to the equation, the share of these regions and economies as import sources reaches more than 80%. One of the advantages of LNG producers from the APEC region is the absence of chokepoints (even Russia plans to export LNG to East Asia through the Artic Sea route).

Five economies have constantly appeared as top natural gas import sources (pipeline and LNG) for the APEC region, namely: Canada; Indonesia; Malaysia; the United States; and Qatar. In 2000, these major exporters supplied around 80% of the region's gas demand, but significantly dropped to about 60% in 2013. The reduction in the share reflected a better diversity of import sources from 0.25 in 2000 to 0.09 Herfindahl-Hirschman Index (HHI)[2] in 2013.

APEC registered a better gas security index than oil, with a relatively stable index at around 28%. The index recorded the lowest risk in 2009, partly because of weaker gas demand due to the global economic

[2] The study measures import diversity by applying the Herfindahl-Hirschman Index (HHI) to assess whether a given economy is particularly dependent on one particular fuel (details on HHI is discussed in Annex I: Methodology).

crisis that occurred in 2008-2009. Of the six indicators, only two of them – social and technical/technology indicators, displayed an upward security index (increasing risk). The rest of the indicators either improved or remained unchanged.

The study found that 10 economies showed a worsening gas supply security index (with a difference of more than 1.0 percentage point from 2000-2013), while the others improved (please see Figure 3.8 in Chapter 3). Mostly, the increase in security index occurred in economies that recorded high growth in gas demand, and from the economies that started to import gas. Although some economies are net gas producers, such as Malaysia, supply security risk still exists as production areas are located far from demand centres, which subsequently forces these economies to import gas.

A significant reduction on the risk was realised from a higher preparedness level as more APEC members have already established policies, such as allowing gas to be imported in LNG form or having gas storage in place, and built new infrastructure (most new infrastructure was built to cater to demand and help improve supply security). Import source diversity also contributed to the overall improvement on risk. In 2000, APEC economies imported gas from 17 economies (including from APEC economies) and by 2013, the number of import sources more than doubled to 36 economies.

There are only seven Association of Southeast Asian Nations-APEC (ASEAN-APEC) members that have a regional agreement on gas supply for emergencies, which is covered under the ASEAN Petroleum Security Agreement (APSA). As a number of economies have no agreements on gas supply security, the risk for this sub-indicator is higher compared with oil. Theoretically, if all APEC members were covered by such agreements, it would lower the political indicator index score by 15 percentage points. Chokepoint risk for gas is lower than oil as 47% of gas was imported through pipelines, and at the same time, most LNG imports in APEC came from East Asia, which contributed to lowering chokepoint risk.

CHAPTER 1
INTRODUCTION

The Asia-Pacific Economic Cooperation (APEC) region is home to around 2.8 billion people. In 2013, it represented around 57% of the global gross domestic product (GDP) and 47% of global trade. Since 1989, the year of APEC inception, the GDP doubled from USD 16 trillion to USD 31 trillion in 2013. Over the same period, economic development boosted per-capita income by 45%, lifting millions out of poverty and creating a growing middle class (APEC, 2015).

Energy security has been one of the highest priorities for all governments in APEC, even though the concept is subject to various interpretations and setting a clear definition remains a challenge. Long-term energy security typically addresses the need for timely investments to ensure energy supply in line with economic development goals and sustainable environmental commitments. Short-term energy security focuses on the ability of the energy system to react promptly to sudden changes in the supply-demand balance.

APEC has not set a specific definition of energy security, but recognizes that energy supply disruptions can have negative impacts on economic and social development. In 2001, APEC Leaders endorsed the Energy Security Initiative (ESI) in order to strengthen regional energy security, emphasizing longer-term policy responses that address the broad challenges facing the region's energy supply by focusing on actions that are practical in a policy context and acceptable in a political context (EWG APEC, 2001). Over the years, the ESI evolved and expanded; by 2008, there were 13 on-going initiatives under the Energy Working Group (EWG), including the Joint Organisations Data Initiative (JODI), the Real Time Emergency Information Sharing Initiative (RTEIS) and a program for Energy Emergency Responses. In 2014, the Energy Ministerial Meeting (EMM) officially recognized four elements that are vital for energy security and sustainable development in this region: diversified energy supply and stable demand, safe energy transportation routes, innovation in energy technologies and effective fora to discuss energy policy. (APEC, 2014)

Improving access to data through JODI has been one of the key achievements under the ESI. Recognizing that the lack of transparent and reliable oil market data aggravates price volatility, the EMM took steps to address this issue. Physical integration or connectivity of energy flow as a mechanism for energy security in APEC has also been at the top of the agenda for the EMM. Several existing sub-regional power interconnections in APEC, such as the ASEAN Power Grid (APG) and North America interconnections, will help economies to have more options for obtaining energy supply.

Recent events in oil and other markets have brought the issue of energy security to the forefront. High and volatile prices raise concerns about short-term risks to economic growth and about longer-term

ability to acquire sufficient energy to support the development goals. While achieving energy security, will mean different things to different economies, there is a strong common interest in ensuring the world can produce enough energy at reasonable costs to support sustainable use, thereby ensuring a high quality of life for the people.

The Asia Pacific Economic Research Centre (APERC) has released the APEC Energy Demand and Supply Outlook 6th Edition which comprises energy forecast up to 2040. Under the same Outlook, APERC established an energy security indicators for each economy consisting of two main energy security indices. The first represents fuel diversity in total primary energy supply (TPES) and in fuel input for electricity. The second assesses the level of an economy's energy production self-sufficiency. The logic behind this combination is that some economies have a high concentration for one particular fuel (for primary supply and/or electricity) – i.e., low diversity – but a high level of self-sufficiency for that said fuel. In such a situation, high self-sufficiency reduces the risk of low diversity. By contrast, some economies have a very diverse fuel supply that is mostly imported, reflecting a lack of indigenous resources.

APERC measures fuel diversity by applying the HHI to assess whether a given economy is particularly dependent on one fuel (details on HHI methodology can be found in Annex I). The HHI is widely used in the industry as a means of tracking monopolies. In Global Tracking Framework 2013, which was prepared for the United Nation Sustainable Energy for All (UN SE4ALL) program, the World Bank (WB) uses the HHI to assess levels of primary fuel diversity around the world, including in APEC economies (WB, 2013). The HHI could also be applied to determining changes for the Outlook period.

APERC also assesses the energy security of APEC members based on projections of primary energy production over primary energy demand. This reveals the level of self-sufficiency of an economy and overall future import level needed to sustain adequate supply to meet demand.

In the APEC 6th Energy Outlook, APERC did not pursue an in-depth assessment of energy supply security that should cover assessment on risk exposure linked to other factors, such as geopolitical issues and trading route chokepoints, etc. Therefore, this study will dive deeper into other indicators in order to provide a more comprehensive study of risk to energy supply.

Defining Energy Security: An Ongoing Global Discussion

The attempt to define energy security has prompted endless discussions among policymakers, academics and industry players, and led to different organisations proposing a range of definitions (Table 1). Most organisations define energy security as encompassing four common dimensions: availability, affordability, accessibility and acceptability.[3] Availability is closely related to the diversification of supply,

[3] Other indicators can also be explored, such as the effect of global oil prices on supply security, the relation of poverty reduction to energy security, and other social-energy security relationships.

while affordability is closely related to the type of fuel chosen and price volatility. In terms of accessibility, infrastructure readiness plays an important role. Acceptability is linked to issues such as environmental friendliness and social objectives.

Table 1: Definitions of energy security

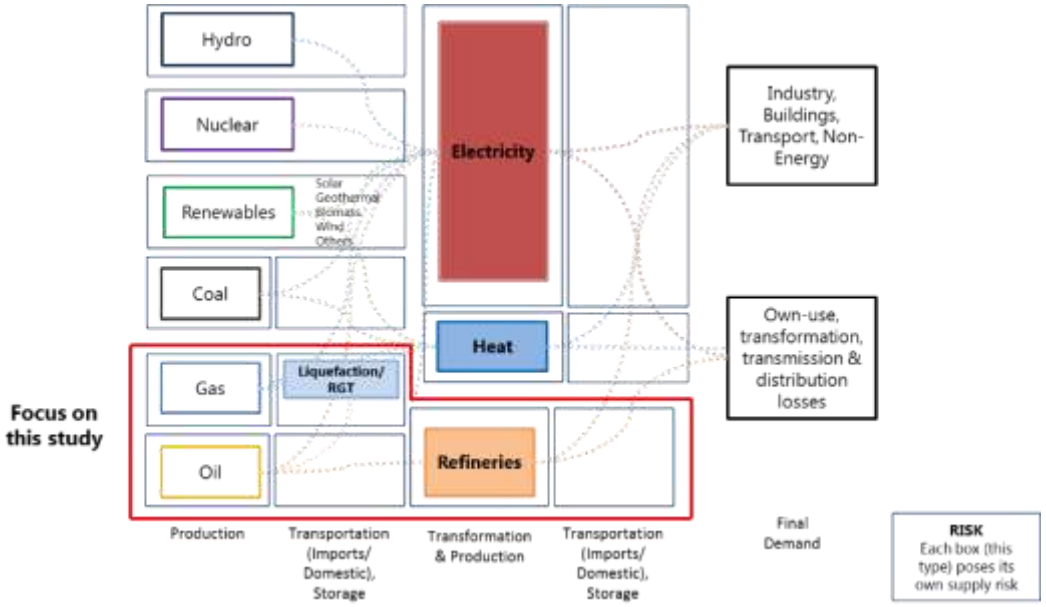
Organization	Definition
International Energy Agency	Uninterrupted physical availability of energy at a price that is affordable, while respecting environmental concerns.
Asia Pacific Energy Research Centre	Adequate energy supplies at reasonable and stable prices to sustain economic performance and growth. APERC assess energy security in terms of availability, accessibility, acceptability and affordability.
World Bank	Sustainable production and use of energy at reasonable costs in order to facilitate economic growth and improve the quality of people's lives.
United Nations Development Program (UNDP)	Continuous availability of energy in varied forms, in sufficient quantities and at reasonable prices.
Institute of Energy Economics, Japan	Energy security means to secure adequate energy at reasonable prices necessary for the people's lives, and economic and industrial activities of the economy.

Sources: IEA (2011); APERC (2007); WB (2005); UNDP (2000) and IEEJ (2012).

In 2007, APERC published "A Quest for Energy Security in the 21st Century," which focused on the energy security dimensions stated above and included indicators created to assess the situation at that time. For the APEC 6th Outlook, APERC analysed three interrelated factors: primary energy fuel diversification, fuel input diversification for the electricity sector, and total primary energy supply self-sufficiency. APERC's intention in creating the indicators was to support the assessment of the level of energy security, not to judge the level of energy security for any particular economy or compare whether one economy is less secured than the other. APERC recognises that energy security issues are unique for each economy (Figure 1.1).

The energy supply chain is highly complex and its future is uncertain due to unexpected changes and contrasting values. The complexity of the system may be defined by, for example, changing political environment, technologies, finance and demographics. As challenging as it may be, establishing an energy security indexation can help policymakers, industry players and even the public to better understand the energy supply situation. Decisions must be made with existing information. Therefore, techniques like scenario analyses are useful for gathering this type of disparate information.

Figure 1.1: Energy Supply Chain and Risks



Sources: APERC analysis

Indexation Building Blocks

Before an energy security index can be established, it is necessary for us to understand factors that can influence energy security. In terms of time span, it can be divided into short-, middle- or long-term. Since the energy supply system is complex, many uncertainties and factors may affect supply security, for example, risks of political instability, technical/technology limitations and economics.

There are a few studies available on energy security indexation. Among notable studies available are the "Global Energy Architecture Performance Index" published by the World Economic Forum (WEF, 2016). The report focused on the "energy trilemma" consisting of economic growth and development, environmental sustainability, and energy security and access. The Institute of Energy Economics, Japan (IEEJ) has published a few studies on energy security indexation, such as the study on "An Analysis of Major Countries Energy Security Policies and Conditions," which examined the seven main indicators of energy security (IEEJ, 2011).

In order to have a better understanding of the underlying risk on energy security supply, PESTLE analysis has been chosen so that the analysis would be able to cover almost all aspects of risk factors. The PESTLE acronym represents political, economic, social, technical, legal and environmental (each PESTLE element will be called indicator) (CIPD, 2015). The reason PESTLE analysis was chosen is because this methodology can give a helicopter view on the risk of energy supply as it covers most of the major concerns lingering around energy security. There are a few papers that have been published based on PESTLE analysis to assess the energy security supply, which one of the notable papers was published by the UK Energy

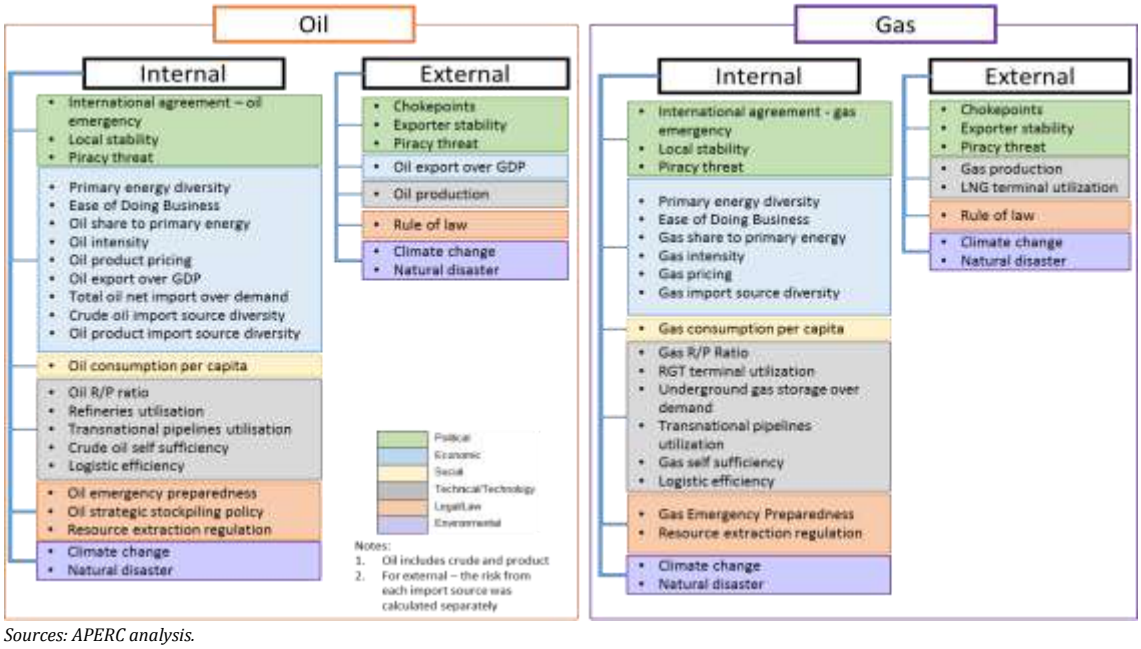
Research Centre titled "An investigation into future energy system risks: An industry perspective" (UKERC, 2014).

However, the challenge of using PESTLE analysis is to identify and define sub-indicators that can be assigned to each indicator. APERC is aware that to get all indicators and apply them to energy security risk may take a longer time. Likewise, the expertise in assessing some of these indicators does not directly rest with APERC, and that some indicators could be considered sensitive for governments. Therefore, this study made use of well-established and publicly available global indices like the World Governance Index (WGI) and "Ease of Doing Business" released by the World Bank, and the Global Petroleum Survey (GPS) by Fraser Institute, among others.

List of Sub-Indicators

In formulating the index, APERC tried to gather as much data related to energy security as possible and used them to form the indices for the PESTLE indicators and sub-indicators. As mentioned above, some of the data were from external sources, and therefore, some modifications were made in order to turn them into indices. Based on PESTLE analysis, APERC identified a combination of 44 sub-indicators for both oil and gas (some of the sub-indicators are applied to both oil and gas). In order to evaluate the risk further, APERC divided the indicators into two groups, the internal and external factors (Figure 1.2). However, it must be stressed that these indicators are a non-exhaustive list and the selection of these indicators is subject to data availability.

Figure 1.2: Sub-indicators used in energy security index

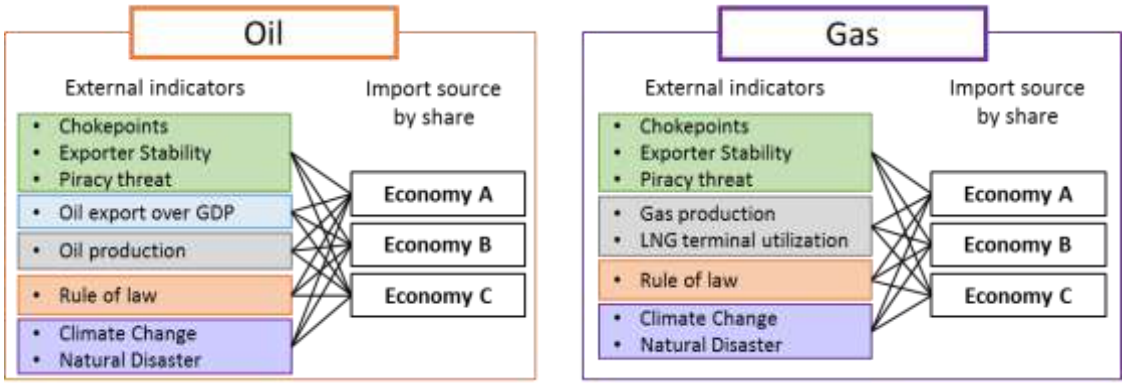


Sources: APERC analysis.

Internal and External Factors

Sub-indicators were assigned to PESTLE indicators and grouped into internal and external factors. This section will briefly explain the internal and external factors. A total of 24 and 22 internal sub-indicators for oil and gas were assessed, respectively (Figure 1.3). APERC did not assign any weight to this grouping, thus, both factors will have an equal risk. A detailed explanation on indicator selection is discussed in Annex I (Methodology).

Figure 1.3: Sub-indicators used in external group



Sources: APERC analysis.

Internal indicators are assumed to be issues that are within one's economic control, such as local stability (political stability), end-user energy pricing and emergency preparedness. These indicators can be used as guidance for policymakers and industry players in improving energy security in each economy.

In order to form the external indicators, APERC utilised the UN Comtrade for crude oil and oil product trade data, and the Cedigaz database for natural gas trade data. The UN Comtrade, a repository of official trade statistics, has a series of Harmonised Commodity Description and Coding Systems (known as HS Code) that categorize the type of goods (UN Comtrade, 2016).[4] From these databases, APERC managed to list all import sources and applied the external indicators risks to each import source.

APERC carried out risk analysis on each economy that exports crude oil, oil products and natural gas based on external sub-indicators (Figure 1.3). For example, from 2000 to 2013, UN Comtrade listed 79 crude oil import sources (economies) for China. In order to have a better picture of the external risk, APERC conducted risk analysis for each of 79 sources based on shares to total imports.

[4] UN Comtrade does not have specific records on Chinese Taipei trade data for political reasons. Chinese Taipei trade data is classified as "Other Asia," not specified elsewhere" (UN Stats, 2010). Therefore, the Study utilised crude oil import data from the Ministry of Economic Affairs, Bureau of Energy (BOE, 2016).

Indexation and Indicator Usage Suggestion

APERC recognizes that each economy has its own set of challenges in ensuring supply security. Due to differences in needs and characteristics, APERC would like to list a few suggestions for economies that wish to adopt this indexation. Based on APERC observation, energy security indexation needs to be flexible but should not stray from the objective to gauge the strength (or weakness) in assessing supply security. As today's world needs to adapt to a fast-changing environment and technology advances, APERC tried to establish an indexation that is flexible enough for policymakers, industry players and the public to better understand the underlying energy supply security risk in their respective economies.

This study applied several sub-indicators grouped into internal and external factors to establish and evaluate the oil and gas supply security index for all APEC economies. However, in reality, some economies do not need all the sub-indicators to be part of the indexation and some economies may need other sub-indicators to be included in the indexation. By using the same methodology, economies can add other sub-indicators or remove and replace them based on their economy context.

Using this index hopefully will help governments to prioritize issues that need immediate attention and at the same time monitor other indicators. For instance, some economies may think that natural disaster does not pose a significant threat to the energy supply, therefore can be dropped from the security index. On the other hand, some economies with enough supply reliability/supply interruption data should add this as a sub-indicator in the security index.

As discussed earlier, APERC did not put weights on any indicators, sub-indicators or groupings (internal and external factors). However, some economies may consider adding weights to the indicators, sub-indicators and groupings. For example, some economies may see that external issues are something that the government needs to focus on since most of the energy sources are imported. Therefore, by giving higher weight to the external factors may amplify and change the supply security index results. However, the application of weights must not skew the numbers or scores toward unrealistic results.

Although the index was created mainly for energy security and importers, energy exporters can utilise this index to improve their domestic conditions, which in turn could help lower the supply risk for importers and also be a selling point for exporters.

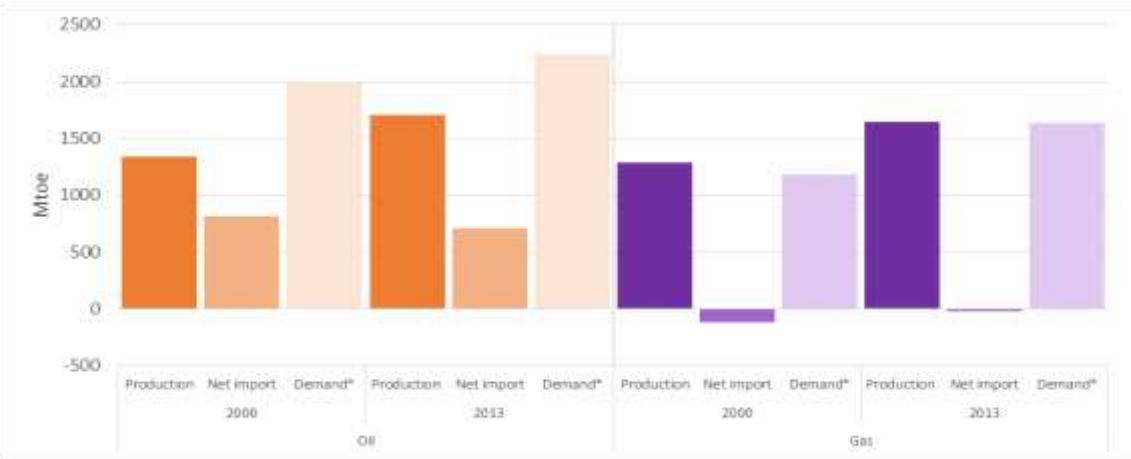
CHAPTER 2

APEC FUEL IMPORT SOURCES ANALYSIS

APERC conducted an analysis focusing on the top five exporters to APEC for each fuel, as well as the share of intra-APEC energy imports (APEC economies importing from others APEC economies). The study also did the same analysis for each APEC economy, which is discussed in Chapter 4 (APEC Economy Chapter). The analysis will help energy importers understand the short-term and long-term risk associated with major crude oil import sources, and at the same time, help exporters to understand barriers that may hamper them from being more competitive.

APEC's net oil imports as a whole declined from 815 Mtoe in 2000 to 707 Mtoe in 2013. Most of the reduction occurred in the United States as oil production in this economy increased because of availability of unconventional oil. However, net gas imports fell from 120 Mtoe in 2000 to 25 Mtoe in 2013, as a result of growing gas demand in APEC (Figure 2.1).

Figure 2.1: Production, Net Imports and Demand, 2000-2013



Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

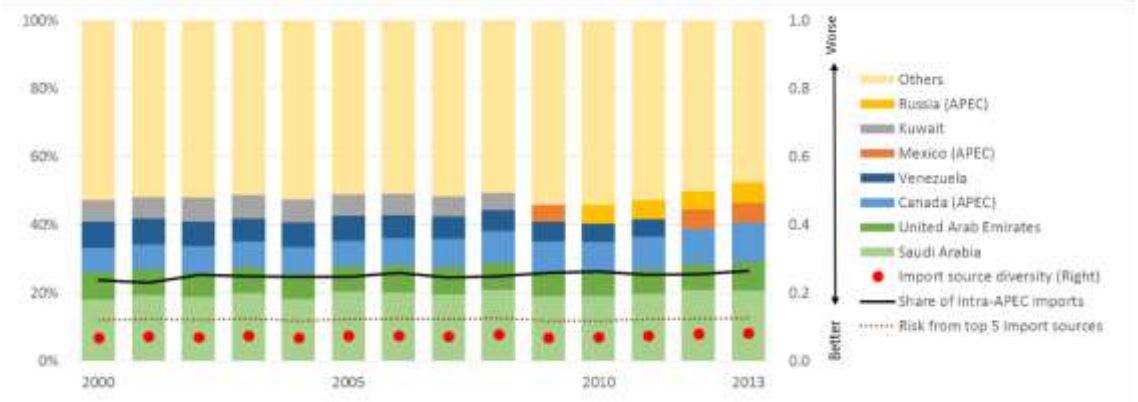
Crude Import Sources

In 2013, APEC imported 1,287 Mtoe of crude oil, up from 1,184 Mtoe in 2000 (including intra-APEC oil imports and exports), equal to an average annual growth rate of 0.6% (IEA, 2015 and EGEDA, 2015). Data gathered from UN Comtrade showed that from 2000-2013, about half of APEC's crude oil imports came from the five main exporters. Saudi Arabia has consistently supplied around one-fifth of total imports, while Canada and the United Arab Emirates contributed average shares of 10% and 8.0%, respectively. Canada exported most of its oil production to the United States. Russia had been steadily

increasing its oil exports to APEC members over the 2000-2013 period and became one of the top five exporters to the APEC region in 2011 (Figure 2.2). Venezuela was also a major exporter of crude oil to the region. Despite the large share of oil imports from Saudi Arabia, APEC's crude oil imports are relatively well-diversified with HHI of 0.07-0.08 HHI (lower HHI represents better diversity).

In terms of intra-APEC energy imports, the share stays almost the same throughout the historical period, ranging between 24% to 27%. Most of the intra-APEC trade occurred between the United States and Canada-Mexico, which accounted for nearly two-thirds of all intra-APEC crude oil imports. Even though there are APEC economies considered to be large crude oil producers (by global standards), a lot more needs to be done to improve energy trade between APEC members.

Figure 2.2: Crude Oil Import Sources, 2000-2013



Source: APERC analysis and UN Comtrade, 2016.

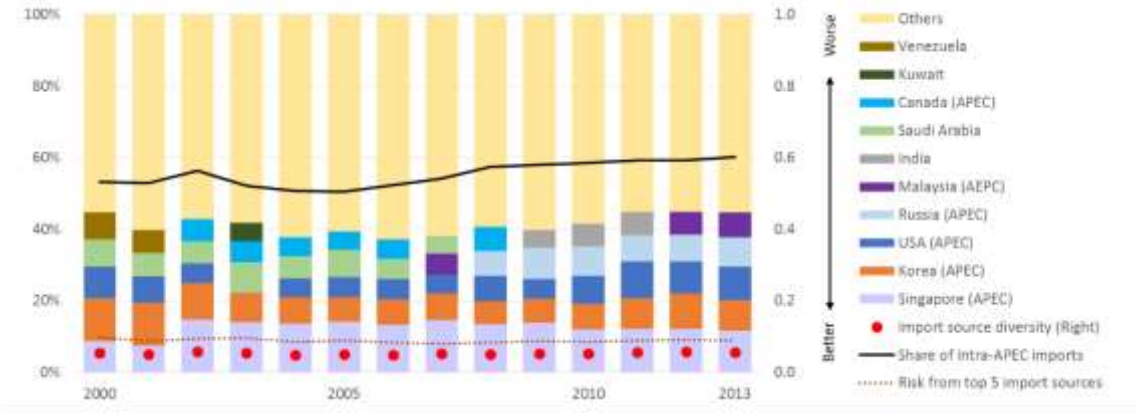
The study established the external factor risks from crude oil exporters that cover risks (sub-indicators) on chokepoints, exporter's stability,[5] piracy risk,[6] exporter's oil exports over GDP,[7] exporter's oil production level,[8] exporter's "rule of law" (derived from WGI), exporter's readiness and vulnerability in facing climate change impact[9] and natural disaster risk. Based on this methodology, APEC crude oil import risk (from the top five sources) remained stable for most years (historical period), averaging about 12%. However, a deeper analysis showed that the index scores for three sub-indicators – chokepoints, exporter's stability and oil exports over GDP, increased by 1.0%, 10% and 4.0%, respectively, while the index on exporter's readiness and vulnerability to climate change impacts, and exporter's oil production level sub-indicators declined.[10]

[5] The study adopted the Worldwide Governance Indicators (WGI) - Political Stability and Absence of Violence/Terrorism sub-index (published by the World Bank) in order to establish exporter's stability sub-indicator and chokepoint risk. The Study also made of the WGI "rule of law" sub-index to establish the exporter's "rule of law" sub-indicator (WB, 2016).
[6] The index was derived based on Piracy and Armed Robbery against Ships Report 2015 published by the International Chamber of Commerce - International Maritime Bureau (ICC-IMB, 2015).
[7] The index was derived from IMF's World Economy Outlook 2013 data (IMF, 2013).
[8] The index was derived from EIA data on global oil production (EIA, 2016a).
[9] The index was derived from Global Adaptation Index data focusing on the level of readiness and vulnerability of all economies in the world toward climate change impact (ND-GAIN, 2016).
[10] The exporter's risk analysis consists of piracy threat, chokepoint risk, exporter's stability, oil export over GDP, rule of law risk, climate change risk and natural disaster risk.

Oil Product Import Sources

Oil product import sources for the APEC region are more diversified than crude oil with 0.05-0.06 HHI. About 40%-45% of oil product imports came from the top five exporters (Figure 2.3). Singapore and Korea continuously provided an aggregate average share of around 20% of total oil product imports in the region over the historical period. The United States was also one of the top five oil product exporters for most of the years with its share almost doubling in 2011 (10%) compared with 2009 (6.0%). In addition to these three economies, the other top oil product exporters to APEC varied almost every year. This shows how competitive the industry is compared with crude oil trade.

Figure 2.3: Oil Product Import Sources and Diversity Index, 2000-2013



Source: APERC analysis and UN Comtrade Database.

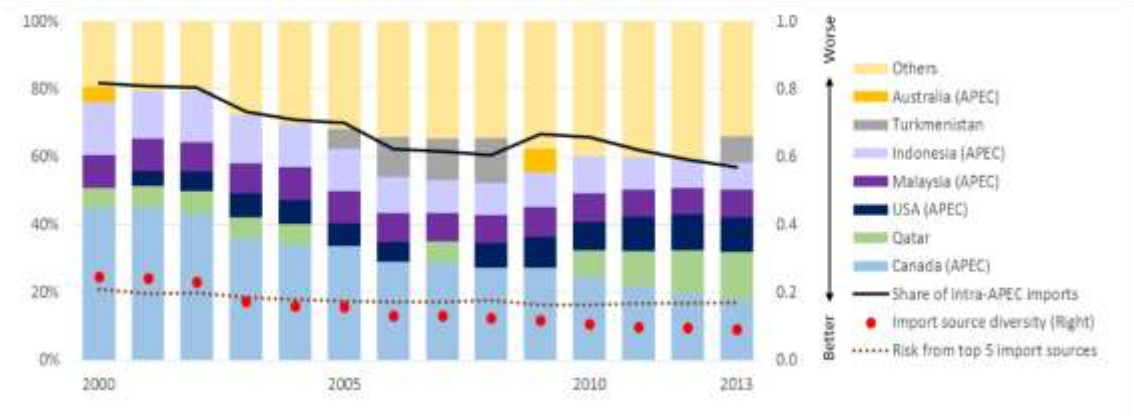
Most APEC members have built refineries for their own consumption and exports (Hong Kong, China is the only economy without a refinery). Therefore, it is expected that intra-APEC imports for oil products to be higher than crude. Intra-APEC trade reached its highest point in 2013 with a 60% share to total oil product imports, an increase of 8.0 percentage points from the 2000 level. In terms of top five exporters' risks, oil products had a lower index than crude oil: 10% in 2000, down to 9.0% in 2013, mainly driven by lower chokepoint risk, better exporter's stability, and a higher degree of "rule of law" for exporters.

Gas Import Sources

The study utilised the Cedigaz database to determine the major source of gas imports, which covered imports of natural gas through pipelines and LNG imports. Five economies almost constantly appeared as top import sources for the APEC region – Canada; Indonesia; Malaysia; the United States; and, Qatar (Figure 2.4). In 2000, these major import sources supplied around 80% of gas demand, but gradually dwindled to 60% in 2013, which also resulted in a decrease in the intra-APEC trade (57% in 2013 from 82% in 2000). Such reduction in share of the major import sources reflected a better diversity of import sources, from 0.25 in 2000 to 0.09 HHI in 2013.

Shares of LNG exports from Indonesia and Malaysia have been declining over the years due to the increasing LNG production from Qatar and Australia and the entry of new LNG producers, such as Papua New Guinea, in the market. Both economies provided an aggregate share of 26% to the region's total import demand in 2000, dropping to 16% in 2013 with increasing share of Qatar gas. The contribution from Qatar expanded to 14% of total gas imports in 2013 from only 6.0% in 2000. Following the shale gas revolution, the United States expanded its gas export share in APEC as one of the top gas exporters and managed to increase gas exports to Canada; Mexico; and, even to Asia.

Figure 2.4: Natural Gas Import Sources and Diversity Index, 2000-2013



Source: Cedigaz database and APERC analysis.

Although Turkmenistan also appeared to be one of the top gas exporters to the APEC region, most of the gas was recorded as exports to Russia, which served as a transit point before the gas was delivered to Europe. With the completion of the Central Asia-China Gas Pipeline that connects Turkmenistan, Uzbekistan and Kazakhstan gas fields to China, Turkmenistan became a major gas exporter to the region (CNPC, 2016).

The risks associated with the major gas exporters (top five exporters) showed a decreasing trend, from 21% in 2000 to 17% in 2013 with increasing shares of low-risk exporters to total APEC gas imports, such as the United States. Better exporter's stability and higher production level contributed to the declining risk. The exporter's stability sub-indicator improved by 6.0 percentage points (from 56% in 2000 to 50% in 2013), while the exporter's gas production sub-indicator dropped to 6.0% in 2013 (from 21% in 2000) due to increasing gas production output from exporters.[11]

[11] The gas import source risk analysis consists of piracy threat, chokepoint risk, exporter stability, LNG terminal utilisation, gas production, "rule of law," climate change and natural disaster risks.

CHAPTER 3

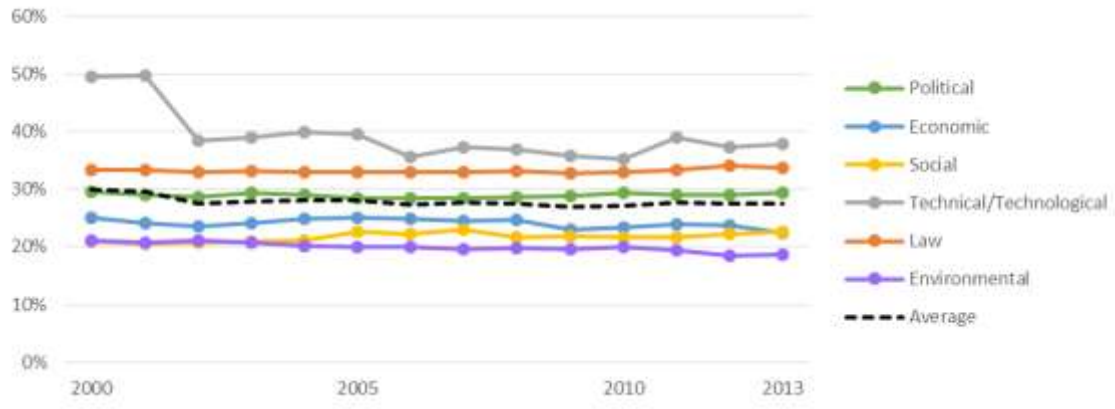
OIL AND GAS SECURITY INDEXATION

This chapter discusses the results of the indexation based on PESTLE analysis – the Oil Security Index and the Gas Security Index. The indexation is intended to examine supply security risk that could affect and disrupt oil and gas supply in APEC and its member economies. The study used a scale of 0% to 100% for each indicator, **where 0% means no risk, while 100% has the highest risk.** For the diversity index using HHI, the scale used is **0.0 to 1.0 where lower HHI means highly diversified**.

Oil Security Index

Several sub-indicators were included in PESTLE analysis to assess the supply security risks, either derived from well-established indices or data that are publicly available[12]. In order to establish the security index for the total APEC region, the study summed up the APEC economies' crude and oil product production, demand, reserves, technical capacities, and import sources. Likewise, a few indices for total APEC were generated by taking the average index of all member economies, such as the international emergency supply agreements on oil and gas, and the readiness and vulnerability towards climate change. A simple average was used to come up with the overall index score (without assigning any weights to indicators, sub-indicators and groupings into internal and external factors).

Figure 3.1: APEC Oil Security Index 2000 – 2013



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any gas supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

[12] Cedigaz (for gas security indexation) is the only data that was used from subscription service.

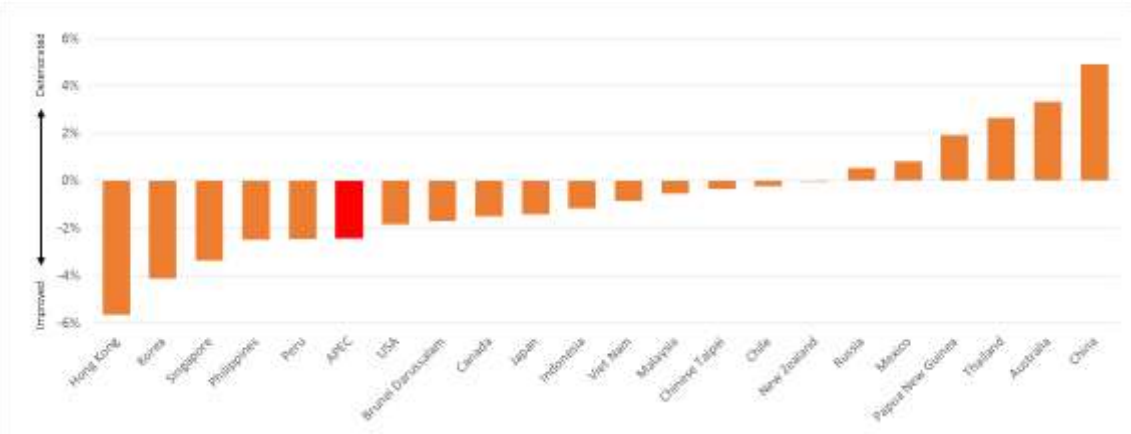
APEC is a huge region with relatively stable political environment. Thus, the results showed that most of the indicators obtained steady index over the historical period (2000-2013) with the exception of technical and social indicators. On average, APEC oil supply security risk improved from 30% in 2000 to 27% in 2013 (Figure 3.1).

Three indicators contributed to the improvement – technical/technology indicator, economic indicator and environmental indicator. The reclassification of oil reserves (oil sands) in Canada from probable to proven reserves (which subsequently improved APEC's reserves-production [R/P] ratio by 50%), the declining overall APEC oil intensity from 63.8 toe/million 2010 USD in 2000 to 42.4 toe/million 2010 USD in 2013, and the higher readiness and lower vulnerability towards climate change threats were the driving factors for the improvement in the overall oil security index for the APEC region. Theoretically, even if the Canada's oil reserves reclassification was removed from the indicators, oil security index still showed an improvement of 2 percentage points.

However, the social indicator showed a slight increase from 28% in 2000 to 30% in 2013 because of a rise in APEC's oil consumption per capita, from 0.78 toe/person in 2000 to 0.80 toe/person in 2013. Other indicators, such as political and law indicators, are relatively unchanged.

From 2000 to 2013, there were 10 economies that displayed improvements in their oil supply security index (with a difference of more than 1.0 percentage point), followed by seven APEC members that had relatively the same condition as in 2000 (with a difference of less than 1.0 percentage point). Four economies – Australia; China; Papua New Guinea; and, Thailand – exhibited a deterioration in their oil security index (higher index) (Figure 3.2).

Figure 3.2: Oil Supply Security Index Changes, 2000 to 2013



Sources: APERC analysis.

Political

In the political indicator, APEC earned relatively stable results. Under this indicator, six sub-indicators were considered and divided into internal and external factors (three sub-indicators each). The average index of political indicator remained steady at around 30% (for the 2000-2013 period). Although the international agreement on oil emergency sub-indicators showed a reduction (due to the inclusion of Korea under the International Energy Agency-International Energy Program [IEA-IEP] in 2003) and the improved chokepoint risk (as economies surrounding chokepoints became more stable). On the other hand, the index for the internal piracy threats and exporter's stability increased (Table 2).

Table 2: Oil Supply Security Index: Political indicator, 2000-2013

Risk	Political sub-indicators	2000	2005	2010	2013
Internal	Local stability	46%	47%	49%	46%
	Piracy	5%	2%	2%	6%
	International agreement on oil emergency	50%	48%	48%	48%
External	Piracy	2%	1%	1%	2%
	Chokepoints	11%	11%	11%	10%
	Exporter's stability	39%	38%	45%	44%
Political index		30%	28%	29%	29%

Source: ACE (2015), WB (2016a), ICC-IMB (2015), IEA (2015), UN Comtrade Database (2016) and APERC analysis.

Eight APEC economies have no existing regional or multilateral agreement on oil supply security. Only 13 economies have entered into regional oil security policy – six economies under the IEA-IEP, and seven ASEAN-APEC economies (Brunei Darussalam; Indonesia; Malaysia; Philippines; Singapore; Thailand and Viet Nam) covered by the ASEAN Petroleum Security Agreement (APSA)[13].

Under IEA policy, all members are committed to undertake joint measures in the event of supply emergencies, and agree to share information, coordinate their energy policies, as well as cooperate in the development of rational energy programs. Each IEA member is likewise required to contribute in collective action based on its assessed share to total IEA oil consumption. Holding of oil stocks equivalent to 90 days of the prior year's net imports is also set as an obligation for IEA members (IEA, 2015).

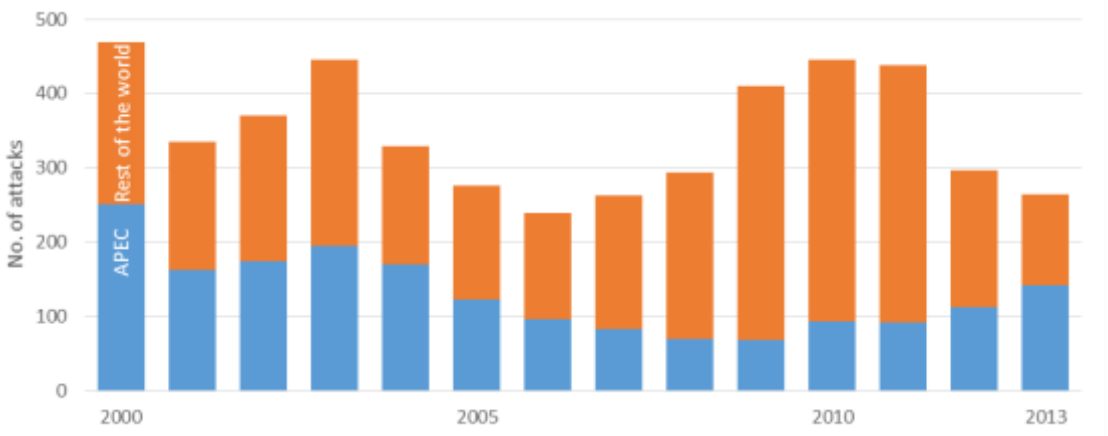
The APSA–Coordinated Emergency Response Measure (CERM) stipulates that all member states must endeavour to supply petroleum to an ASEAN Member State in Distress at an aggregate amount equal to 10.0 percent of the Normal Domestic Requirement of said member state for a continuous period of at least 30 days. However, the member state in distress must first implement short-term measures to reduce oil demand before requesting assistance under CERM (ACE, 2015).

[13] APSA is a regional agreement that was signed in 2009 by all 10 ASEAN member states. APSA covers both oil and natural gas in case a supply emergency occurs.

The study adopted the Worldwide Governance Indicators (WGI)[14] published by the World Bank in order to establish the local and exporter's stability sub-indicator (WB, 2016a). The study assigned the risk derived from WGI to both internal and external factors, whereby for external risk, each import source will have a different risk value. Based on the average index derived from WGI, the APEC local stability risk increased in 2010 to 49% and fell to 46% in 2013 (same level in 2000). At the same time, exporter's stability (based on share) increased from 39% in 2000 to 44% in 2013.

The other sub-indicator is the piracy threat, for which the data were obtained from the International Chamber of Commerce – International Maritime Bureau (ICC-IMB). The ICC-IMB is a non-profit organization, established in 1981 to act as a focal point in the fight against all types of maritime crime and malpractice. One of the IMB's principal areas of expertise is in the suppression of piracy that led to the creation of the IMB Piracy Reporting Centre in 1992. This organization produced an annual *Piracy and Armed Robbery against Ships Report* that contains the number of attacks that occurred, type of ships that were attacked, and the location of the attack (ICC-IMB, 2015).

Figure 3.3: Shares of Piracy Incidents in APEC and the Rest of the World, 2000-2013



Sources: ICC-IMB, 2015 and APERC analysis.
Note: ICC-IMB recorded incidents that occurred in economy and international waters. APERC only considers incidents occurring among APEC members as per the ICC-IMB report, plus incidents that occurred along the Straits of Malacca since all economies that border the straits are APEC members.

From the ICC-IMB data, 54% (251 incidents over a total of 469 piracy incidents) of all piracy incidents around the world occurred within APEC members' water boundaries in 2000, and by 2013, the share increased to 60% (148 incidents in APEC out of 245 worldwide incidents) (Figure 3.3). However, a closer look at the data revealed that there was a huge improvement that occurred from 2008 to 2011, where the share of piracy incidents recorded in the APEC region dropped below 25%. The lowest number of piracy incidents in APEC was in 2009 with 68 out of 410 incidents worldwide, which subsequently improved the political security risk by more than 1.0%. The attacks reduced significantly in 2008/09 because of the

[14] WGI consist of six sub-indices, namely: (1) Voice and Accountability; (2) Political Stability and Absence of Violence/Terrorism; (3) Government Effectiveness; (4) Regulatory Quality; (5) Rule of Law; and, (6) Control of Corruption. The Study adopted the WGI's "Political Stability and Absence of Violence/Terrorism indicator" published by the World Bank in order to establish the local stability indicator (WB, 2016).

cooperation between Malaysia; Indonesia and Singapore in combating pirates. A concerted and well-coordinated action by regional governments can prevent pirate attacks on commercial shipping (Time, 2009).

Economic

In the economic indicator, 9 of the 10 sub-indicators were considered under internal factor, and one sub-indicator as an external factor. Five of the sub-indicators displayed improvement – "Ease of Doing Business," oil share to total primary energy, oil intensity, oil product pricing for end-users, and total oil net import over demand. As a result of these improvements, the economic indicator index fell to 22% in 2013 from 25% in 2000 (Table 3).

For the "Ease of Doing Business" sub-indicator, the study made use of the Doing Business Report (DBR) published by the World Bank Group (WB, 2016b) in order to establish the index for each APEC economy. The intention to include this sub-indicator is to show how prepared governments are in facilitating investment in their own respective economy, including investment for energy sector. The index for the "Ease of Doing Business" sub-indicator decreased by 7.0 percentage points, from 34% in 2000 to 27% in 2013.

Table 3: Oil Supply Security Index: Economic Indicator, 2000-2013

Risk	Economic sub-indicators	2000	2005	2010	2013
Internal	Primary energy diversity	25%	26%	26%	27%
	Ease of Doing Business	34%	33%	30%	27%
	Oil share to primary energy	28%	27%	25%	25%
	Oil intensity	75%	64%	59%	55%
	Oil product pricing	38%	38%	38%	33%
	Oil exports over GDP	0%	0%	0%	0%
	Total net oil imports over demand	41%	39%	38%	32%
	Crude oil import source diversity	7%	7%	7%	8%
	Oil product import source diversity	5%	5%	5%	6%
External	Oil exports over GDP	17%	20%	18%	19%
Economic index		25%	25%	23%	22%

Source: IMF (2013), WB (2016b), IEA (2015 and 2016), ICC-IMB (2015), UN Comtrade Database (2016) and APERC analysis.

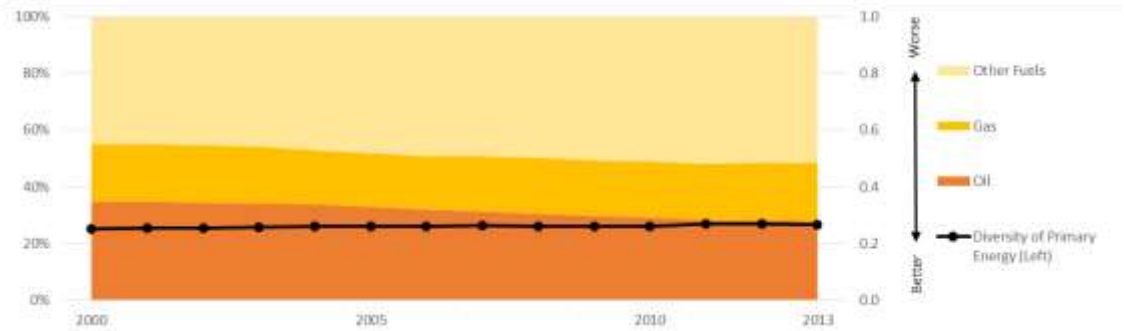
The oil share to total primary energy and oil intensity in APEC showed some improvements. Over the historical period, the APEC oil share to total primary energy sub-indicator went down to 25% in 2013 from 28% in 2000. Meanwhile, oil intensity improved from a high of 63.8 toe/million 2010 USD in 2000 to 42.4 toe/million 2010 USD in 2013, which resulted in a decline in the oil intensity sub-indicator score from 75% in 2000 to 55% in 2013. It should be noted that in determining the index for oil intensity, the study compared the oil intensity levels among APEC economies (highest and lowest level), and treated the highest oil intensity level as having the highest risks (this calculation method is used in order to establish the highest and lowest benchmark in APEC. The index also looked at the changes in economy's oil intensity levels over the historical period (highest oil intensity level recorded from 2000-2013). Further explanation is available in Annex I (Methodology).

As a number of APEC economies have begun to remove or rationalise energy subsidies, it improved the oil product pricing sub-indicator index score from 38% in 2000 to 33% in 2013. Theoretically, if APEC economies with energy subsidies remove all such subsidies, it would further push down the economic indicator index score by another 2.0 percentage points.

Three sub-indicators showed an upward trend in index, which offset some of the gains made by other sub-indicators. Although the import sources of crude oil and oil product imports were considered very diverse, the diversity index rose slightly, from 0.07 HHI in 2000 to 0.08 HHI in 2013 for crude oil, and from 0.05 HHI in 2000 to 0.06 HHI in 2013 for oil product import sources. On the other hand, primary energy diversity became less diversified with coal taking a larger share in the primary energy mix, which subsequently pushed the diversity level from 0.25 HHI in 2000 to 0.27 HHI in 2013 (Figure 3.4).

Figure 3.4: Oil and gas share in primary energy and diversity of energy mix, 2000-2013

Sources: APERC analysis and IEA World Energy Statistics 2015.



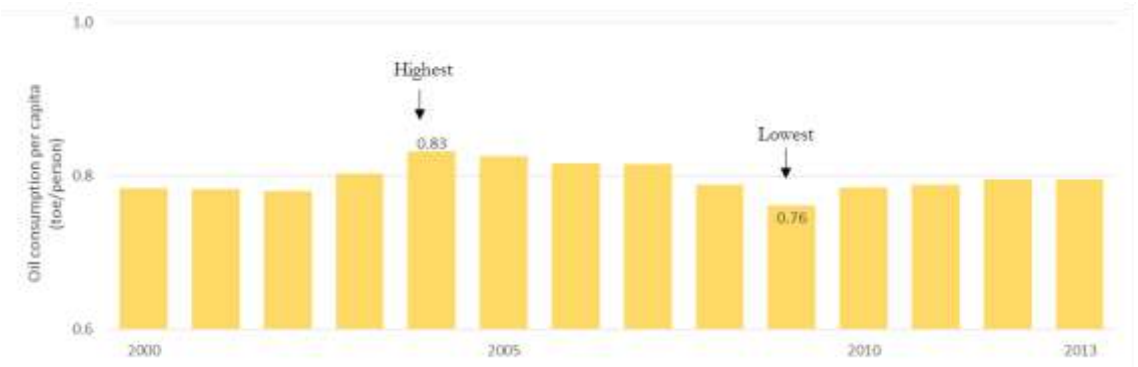
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

Social

Only one sub-indicator was considered in the social indicator – the oil consumption per capita. Similar methodology in getting the index for oil intensity was applied to determine the index for oil consumption per capita sub-indicator. APEC recorded the highest oil consumption per capita in 2004, and the lowest in 2009 because of the financial and economic crisis that occurred in 2008 (Figure 3.5). APEC oil consumption per capita increased modestly post 2009 with nearly flat growth seen in 2012-2013.

Other sub-indicators that could potentially be part of this indicator, including energy affordability and human resources constraint in the oil and gas industry (this sub-indicator can be part of the technical/technology sub-index too). However, as most APEC members don't keep track of human resources constraint in the oil and gas industry (with exception of few big economies such as the United States), the social index will only covers oil consumption per capita.

Figure 3.5 • APEC oil consumption per capita in toe/person, 2000-2013



Sources: APERC analysis and IEA World Energy Statistics 2015.

Technical and Technology

This indicator showed a huge improvement, particularly in 2002-2003. As mentioned earlier, the reclassification of oil reserves (oil sands) in Canada from probable to proven reserves, which subsequently expanded the APEC's Reserves-Production (R/P) ratio by 50%, led to the decline in the index from 51% in 2000 to 7% in 2005 (Table 4). Although APEC crude oil production increased by 27% in 2013 (from the 2000 level), oil reserves rose by 137%, much higher than oil production growth rate. This made APEC's oil R/P ratio jump from 14.8 years in 2000 to 27.2 years in 2013.

The logistics efficiency sub-indicator, which was derived from the Logistics Performance Index (LPI) published by the World Bank, is used as part of the technical/technology indicator. The LPI covers six sub-indicators, namely: (1) customs, (2) infrastructure, (3) international shipments, (4) logistics quality and competence, (5) tracking and tracing, and (6) timeliness (WB, 2016c)[15]. The LPI is a survey-based index which

[15] Details on logistics efficiency can be found in Annex I: Methodology

has both qualitative and quantitative results. The study chose LPI as part of the sub-indicators for energy security because an efficient logistics system can be one of the criteria to overcome energy supply disruptions, particularly oil product supply disruptions[16]. Transferring oil products in massive quantities during shortages can be a nightmare for economy without good pipelines infrastructure. On average, the APEC logistics efficiency sub-indicator slightly improved from 32% in 2000 to 31% in 2013.

Table 4: Oil Supply Security Index: Technical/technology Indicator, 2000-2013

Risk	Technical/technology sub-indicator	2000	2005	2010	2013
Internal	Logistics efficiency	32%	32%	32%	31%
	Oil reserves/production ratio	51%	7%	10%	10%
	Refinery Utilisation	89%	92%	89%	85%
	Trans-border pipeline Utilisation	100%	84%	55%	90%
	Crude oil self-sufficiency	36%	35%	34%	31%
External	Oil production rate	15%	10%	10%	5%
Technical/technology index		49%	40%	35%	38%

Source: EIA (2016), IEA (2015), WB (2016c), BP (2015), UN Comtrade Database (2016), CNPC (2015), OGJ (2015) and APERC analysis.

In 2000, APEC had total refinery capacity of about 45 million barrels per day (Mmbbl/d). By 2013, the refinery capacity increased to 55 Mmbbl/d, with most of the new capacity built in China (BP, 2015). Despite the increase in refinery capacity, APEC refinery capacity utilisation rate remained at around 85%-90% level for most of the years. The study considered that the higher utilisation rate of refineries means higher risk for economies.

The APEC overall crude oil self-sufficiency rate improved by about 5.0% (Figure 3.6). From 2000-2013, nearly a quarter of APEC members (Brunei Darussalam; Canada; Malaysia; Mexico; Russia; and, Viet Nam) continued to enjoy a self-sufficiency level of 100%, while Australia; China; Indonesia; New Zealand; Papua New Guinea; and, Peru displayed some reduction in self-sufficiency level. On the other hand, four economies exhibited improvement in this sub-indicator, led by the United States (because of increased production in unconventional oil), followed by the Philippines; Thailand; and, Chile.

Constraints on oil pipelines could also be considered as a supply security concern. Although the study plans to include both cross border and domestic pipeline constraints, data on pipeline reliability for each economy is hard to get. With this, the study only focused on the trans-border oil pipeline. China opened up oil pipelines from Kazakhstan in 2006. The trans-border pipeline utilisation rate already reached 100% in 2013, up from 16% in 2006 (Xinhua, 2013 and CNPC, 2015). This pushed the index for overall APEC trans-border oil pipeline utilisation rate sub-indicator to go up to 90% in 2013 from 55% in 2010.

[16] For this sub-indicator, the study managed to retrieve data for all APEC members except Brunei Darussalam. Thus, the study utilised Singapore data as a proxy for Brunei Darussalam due its comparable land size and GDP per capita

As for external risk, the study used the lowest crude oil production of exporters (recorded between 2000-2013) as benchmark to determine the production risk (having the highest supply disruption risk). The study utilised oil production data retrieved from the Energy Information Agency (EIA) in order to formulate the index. For example, Saudi Arabia had been consistently supplied around 20% of total crude oil imports to APEC over the historical period, and based on the oil production record from 2000-2013, Saudi Arabia recorded the lowest oil production in 2002, which subsequently produced the highest risk in the period of 2000-2013.

Figure 3.6: APEC crude oil self-sufficiency, in %, 2000-2013

	2000	2013
Brunei Darussalam	100	100
Canada	100	100
Indonesia	100	85
Malaysia	100	100
Mexico	100	100
Russia	100	100
Viet Nam	100	100
Papua New Guinea	100	60
Australia	93	62
China	76	43
Peru	68	43
USA	41	54
New Zealand	36	32
Thailand	20	29
Chile	4	5
Korea	1	0
Philippines	0	10
Japan	0	0
Chinese Taipei	0	0
Hong Kong, China	0	0
Singapore	0	0
APEC	64	69

Sources: APERC analysis and IEA World Energy Statistics 2015.

Law

Four sub-indicators were used to form the law indicator index. The study utilised WGI's "rule of law" sub-index data as one of the sub-indicators, as well as the data retrieved from Global Petroleum Survey (GPS) 2007-2014 produced by the Fraser Institute (WB, 2016a and FI, 2016). The law indicator showed a stable index, an average of around 33% (Table 5). Three internal sub-indicators and one external sub-indicator considered in the law indicator.

Table 5: Oil Supply Security Index: Law Indicator, 2000-2013

Risk	Law sub-indicators	2000	2005	2010	2013
Internal	Resource extraction regulations	37%	36%	35%	40%
	Oil emergency preparedness	0%	0%	0%	0%
	Strategic stockpiling (in days)	58%	58%	58%	58%
External	Rule of law	38%	37%	38%	37%
Law index		33%	33%	33%	34%

Source: WB (2016a), FI (2016), APERC (2016), UN Comtrade Database (2016) and APERC analysis.

The GPS Report was used to establish the resource extraction regulations as part of the indicator. The report, which consists of survey feedback from professionals, company chairmen, specialists and managers in the oil and gas sector, is utilised to gauge the resource extraction (oil and gas) regulations. The GPS Report consists of four sub-indices which are: (1) all-inclusive composite index/policy perception index; (2) commercial environment index; (3) regulatory climate index; and, (4) geopolitical risk index.[17] For the law indicator purposes, the study only just made use of the regulatory climate index. However, the survey does not cover Hong Kong, China; Korea; Singapore; and Chinese Taipei, all of which do not produce oil and gas or only produce very limited amounts. Since the data from the report started in 2007, the study used a moving average to determine the index for 2000-2006. The idea of having this indicator is to help understand the legal barriers in extracting oil and gas, which can be the deciding factor for investors to invest in oil and gas production. APEC's average index on regulatory barriers inched up slightly, from 37% in 2000 to 40% in 2013. Chile obtained the lowest resource extraction regulation index at 27% followed by New Zealand at 30% and the United States at 31%.

The study on Oil Supply Security and Emergency Policy in the APEC region published by APERC in 2015 was also made as a reference. This study looked into the policies as well as challenges faced by APEC members in preparing for oil supply disruption, which covered discussions on the level of strategic oil stockpiling.by APEC economies. The data and information on oil stockpiling from this study was taken to establish the strategic stockpiling policy sub-indicator[18] (APERC, 2015). APEC overall oil strategic

[17] The study only utilised the Regulatory Climate Index which covers the regulatory aspects of petroleum extraction (FI, 2016).
[18] The study used the highest level of oil stockpiling within APEC (both Japan and Korea maintained huge oil stocks) as the baseline.

stockpiling risk stands at 65% in 2013 (the calculation for the index is based on the highest stockpiling level among APEC members). The risk can be considered high due to missing information or no oil stockpile in at least four economies, as well as low oil stockpiling level in most APEC members compared with APEC-IEA member economies such as Japan; Korea; and, the United States. Since the data available is limited, the study applied the 2013 oil stockpiling data down to 2000 (Table 6).

Table 6: Oil stockpiling in APEC, 2013

	Oil Stockpile (Days)[19]
Australia	52 days of net imports
Brunei	31 days of oil demand (industry)
Canada	53 days of oil demand (industry)
Chile	25 days of sales
China	30-60 days of domestic demand
Hong Kong, China	30 days of retained imports
Indonesia	22 days of domestic demand
Japan	157 days of net imports
Korea	233 days of net imports
Malaysia	No Information
Mexico	No Information
New Zealand	97 days of net imports
PNG	No Information
Peru	15 days of domestic supply
Philippines	30 days for refiners & 15 days for marketers
Russia	No Information
Singapore	50 days (refiners); 60 days (power generation)
Chinese Taipei	90 days of net imports
Thailand	50 days of domestic demand
United States	251 days of net imports
Viet Nam	47 days of domestic demand

Sources: APERC (2015)
Note: The information was gathered through feedback from economy representatives that attended the Oil and Gas Security Forum in 2015 and 2016.

[19] IEA members' Oil Stockpile (only for Australia; Japan; Korea; New Zealand; and the United States) is as of Dec. 2014. Based on IEA methodology, oil stockpiles of IEA-APEC economies covered both public and industry stocks and the stock level in days is computed from the previous year's net imports. The portion of total days of net imports covered by industry stocks, which includes stocks held for commercial and operational purposes, as well as stocks held by industry to meet minimum economy's stockholding requirements (including stocks held for this purpose in other economies under bilateral agreements). On the other hand, the portion of total days of net imports by government-owned stocks is held for emergency purposes (including stocks held in other economies under bilateral agreements). In the case of Canada, the oil stockholdings are industry stocks held for commercial purposes based on domestic demand.

As for external risk, the "rule of law" sub-index of WGI was included with the intention to reflect perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts (WB, 2016a). Although APEC oil import sources from within the region had increased, the exporter's (based on their export shares) "rule of law" still remained almost at a stable rate, at around 37%-38%, for most of the years[20]. A deeper analysis at the economy level will show the effect of this sub-indicator.

Environmental

The environmental indicator included two sub-indicators – the readiness and vulnerability to climate change,[21] and natural disaster risk (Table 7). Although most of all importing economies will not see immediate impact on supply disruption as climate change impact on supply can only be seen in long-term, it will be useful if these sub-indicators are part of the indexation.

Table 7: Oil Supply Security Index: Environmental Indicators, 2000-2013

Risk	Environmental sub-indicators	2000	2005	2010	2013
Internal	Climate change	42%	41%	38%	37%
	Natural disaster	1%	1%	3%	2%
External	Climate change	39%	36%	35%	33%
	Natural disaster	0.2%	0.3%	0.7%	0.2%
Environmental index		21%	20%	20%	19%

Source: ND-GAIN (2016), CRED (2016), UN Comtrade Database (2016) and APERC analysis.

As for readiness and vulnerability towards climate change, the study utilised the Notre Dame Global Adaptation Index (ND-GAIN), which summarises an economy's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience (ND-GAIN, 2016). Based on ND-GAIN data, the overall supply disruption risk due to climate change for both internal and external factors improved by 5.0 and 6.0 percentage points from 2000-2013, respectively. The readiness sub-index contributed much to the improvement. Despite the progress made on climate change sub-indicator, APEC economies should still pursue low carbon efforts and green growth as the risk of climate change are expected to grow.

Natural disaster sub-indicator was calculated based on number of people affected by natural disasters over the total population. Data used for this sub-indicator was generated from the International Natural Disaster Database established by the Centre for Research on the Epidemiology of Disasters (CRED)

[20] The Study utilised data gathered from WGI – "Rule of Law" sub-index. Rule of law is used as an indicator to determine, among other factors, the level of fulfilling contract obligations and property rights (WB, 2016).

[21] The vulnerability index was given on a scale of 0 to 1 where a low index means less vulnerable, while the readiness index uses the same scale where a high index means higher level of readiness.

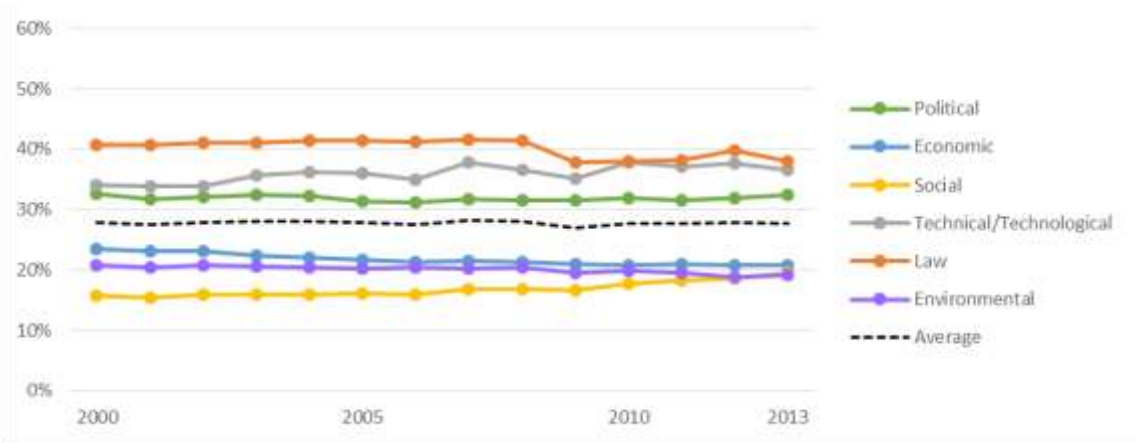
(CRED, 2016). Some may argue that natural disasters are events that cannot be predicted and something beyond one's control. However, natural disasters are something that APEC economies have constantly prepared for and the occurrence of natural disasters, depending on the impact, may create disruption in the energy supply, not only to the economy where the natural disaster occurred, but also to energy importers. .

The year 2010 actually marked the highest impact to natural disaster in APEC (based on population affected). There were three economies – Chile; China and Thailand – that were badly hit by earthquakes and big floods that year. In 2011, other natural disasters hit the APEC region – the great earthquake in Japan that triggered a tsunami, which led to the Fukushima nuclear incident, and Typhoon Washi (local name Typhoon Sendong) that affected the Philippines (GMA News, 2012).

Gas Security Index

The study also came out with a separate security index for gas using the same methodology as the oil security index. The gas security index (covering both piped gas and LNG) included 22 sub-indicators, 14 sub-indicators subject to internal factors, and the remaining influenced by external factors.

Figure 3.7: APEC Gas Security Index 2000 – 2013



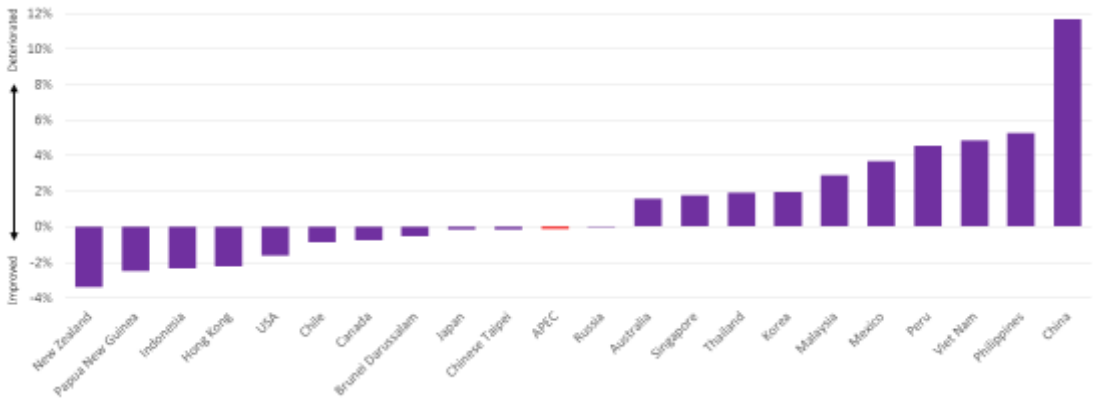
Sources: APERC analysis.
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any gas supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

On average, the gas supply in the APEC region exhibited a better security level compared to oil, with relatively stable security index of around 28%. The index recorded the lowest risk in 2009, partly because of weaker gas demand following the global economic crisis during 2008-2009. Among six indicators, only two – social and technical/technology indicators – displayed an upward index. The rest of the indicators improved or were relatively unchanged (Figure 3.7).

Both the economic and law indicators demonstrated decreases in their indices by 3.0 percentage points each during the historical period, while the index for environmental indicator dropped by 2.0 percentage points. On the other hand, the social indicator rose by 4.0 percentage points caused by higher gas consumption per capita level in the APEC region, which offset some of the risk reductions gained from the economic and law indicators.

Import source diversity sub-indicator helped improve the overall economic indicator index. Gas import sources of the APEC region more than doubled in 2013 reaching 36 economies (including from APEC economies) from only 17 economies in 2000. Meanwhile, the gas emergency preparedness sub-indicator provided most of the risk reduction in the law indicator as more APEC economies already established policies such as allowing underground gas storage and importing gas in the form of LNG, and built new infrastructure to cater to growing demand and improve supply security.

Figure 3.8: Gas Supply Security Index Changes, 2000 – 2013



Sources: APERC analysis.

The results revealed that 10 economies obtained an increase in gas supply security risk, while the rest unchanged or improved (Figure 3.8). Much of the increase was recoded in economies with high growth in gas demand, as well as from the economies that started to import gas. Although some economies are net gas producers, such as Malaysia, supply disruption risk still remains as production areas are far from demand centres which subsequently forces these economies to import gas. A deeper analysis on domestic pipeline reliability will show a more accurate risk index.

Political

The political indicator assigned six sub-indicators, three sub-indicators each for internal and external factors (Table 9). The piracy sub-indicator (both internal and external factors) received an increasing index over the historical period. As discussed earlier in the oil security, the number of piracy attacks in the

APEC region more than doubled from its lowest annual number reported (APEC recorded the lowest level of piracy in 2009 with 68 reported incidents, and then increased to 148 incidents in 2013). However, according to the ICC-IMB report, there were seven pirate attacks on LNG tankers from 2000-2013 around the world.[22]

Table 8: Gas Supply Security Index: Political Indicator, 2000-2013

Risk	Political sub-indicators	2000	2005	2010	2013
Internal	Local Stability	46%	47%	49%	46%
	Piracy	5%	2%	2%	6%
	International agreement on gas emergencies[23]	60%	60%	60%	60%
External	Piracy	6%	3%	2%	5%
	Chokepoints	3%	4%	5%	6%
	Exporter's stability	56%	50%	51%	51%
Political index		33%	31%	32%	32%

Source: ASCOPE (2013), WB (2016a), ICC-IMB (2015), IEA (2016) and APERC analysis.

Only seven ASEAN-APEC members have a regional agreement on gas supply security covered under APSA. Due to the limited number of economies with such kind of security agreement on gas emergencies, a high index for this sub-indicator was obtained compared with oil. However, if all APEC members have entered into gas supply security agreements, it would lower the political indicator index further by 15 percentage points.

Chokepoint risk for gas was also lower than oil, as a significant amount of gas imports are received through pipelines. In 2013, there were 32 economies that exported gas to APEC economies (including intra-APEC) with a total volume of 437 billion cubic metre (Bcm). About 53% of the gas imports was in the form of LNG, and the rest through pipelines, mainly in the US; Canada; Mexico; and, China. However, gas had higher exporter's stability risk compared with oil. Among the reasons identified that resulted in higher risk was the higher concertation of import sources compared with oil. In 2013, nearly 60% of gas imports came from the top five exporters, while for oil, the top five exporters only supplied 50% of crude oil imports. Thus, the lower diversity of import sources could make the exporter's stability sub-indicator skewed towards the major gas exporters.

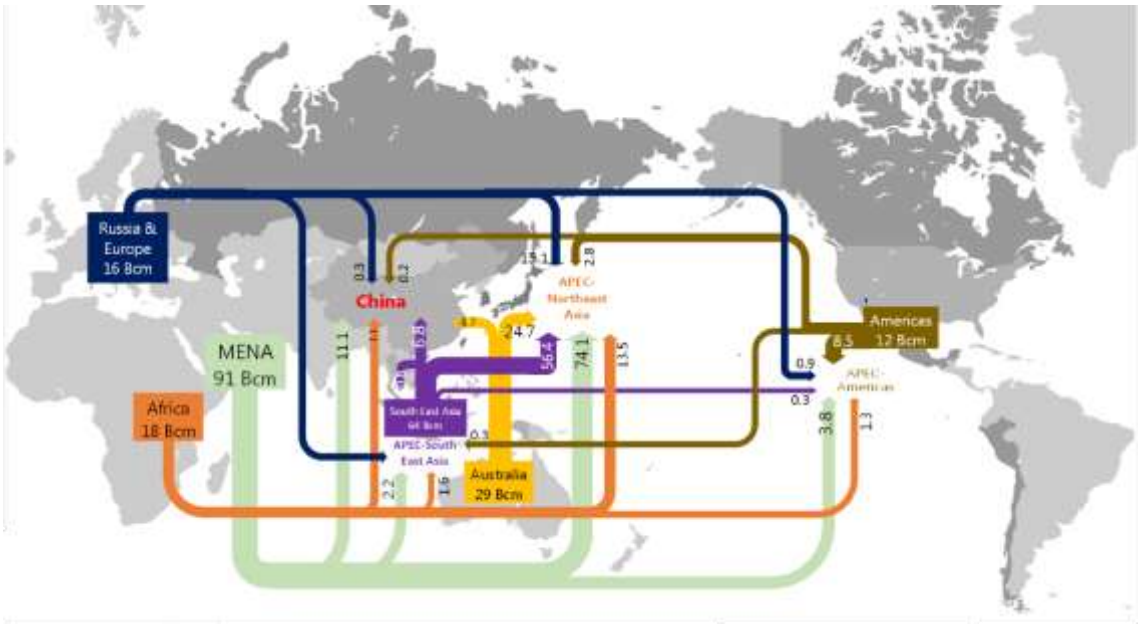
Generally, APEC economies have been dependent on two regions for LNG supply, the Middle East and North Africa (MENA) and the Southeast Asia regions supplying around 40% and 28% of LNG demand, respectively. If Australia is added to the equation, the share of these regions and economies as

[22] The ICC-IMB report does not provide data on whether these attacks occurred in the APEC region or specific regions in the world.

[23] Under normal circumstances, the study assigned the risk at 100% for economies that do not have an agreement on gas supply during emergencies. However, there are a few economies that do not have such agreements, but have produced surplus gas. For these economies, the study assigned the risk at 50% only. These economies are Australia; Canada; Mexico; PNG; Russia and the United States.

import sources could reach more than 80% (Figure 3.9). Among the advantages that LNG producers from the APEC region have is the lack of chokepoints (even Russia plans to export LNG to East Asia through the Artic Sea route) (LNG Producer-Consumer Conference, 2016).

Figure 3.9: APEC LNG Import Sources in Bcm, 2013



Sources: APERC analysis and Cedigaz database.
Note:

- *APEC members that import LNG are: Malaysia; Singapore; and, Thailand (APEC Southeast Asia); and Japan; Korea; and, Chinese Taipei (APEC Northeast Asia); Canada; Chile; Mexico; and the U.S. (APEC Americas).*
- *APEC LNG import sources: Algeria, Egypt, Oman, Qatar, UAE and Yemen (MENA region); Nigeria and Equatorial Guinea (Africa region); Norway, Belgium, Spain, United Kingdom and Russia (Europe region); Brunei Darussalam; Malaysia; and, Indonesia (Southeast Asia); Canada; Peru; Trinidad and Tobago; and, the U.S. (Americas region). Other economies that re-export LNG or at a very small quantity have been excluded in this figure.*

Economic

The economic indicator covered six sub-indicators all covering internal factors. The same sub-indicators were used as in the oil security index with the exception of oil exports over GDP sub-indicator. The economic sub-indicator index improved from 23% in 2000 to 21% in 2013. The reduction in security risk was partly contributed to by a better index in the "Ease of Doing Business" (as discussed in the oil security index section), improvement in gas import source diversity, and a slight decrease in gas intensity (Table 10).

Gas maintained its share to total primary energy at around 20% for most of the years. However, gas intensity decreased from 37.7 toe/million 2010 USD in 2000 to 31.1 toe/million 2010 USD in 2013, which led the indicator to fall from 57% in 2000 to 55% in 2013. In the gas pricing sub-indicator, the study used the data from the IEA energy subsidy database, of which, in 2013, six APEC members – Brunei Darussalam; China; Indonesia; Malaysia; Chinese Taipei; and, Thailand – have at least some form of gas

subsidy. Since the database only provided 2012-2014 data, the study assumed that the gas subsidy was introduced even before that and stretched the assumption to start in 2000. In terms of gas import source diversity, APEC managed to improve the sub-indicator index from 0.25 HHI (diversity based on share) in 2000 to 0.09 HHI in 2013.

Table 9: Gas Supply Security Index: Economic Indicator, 2000-2013

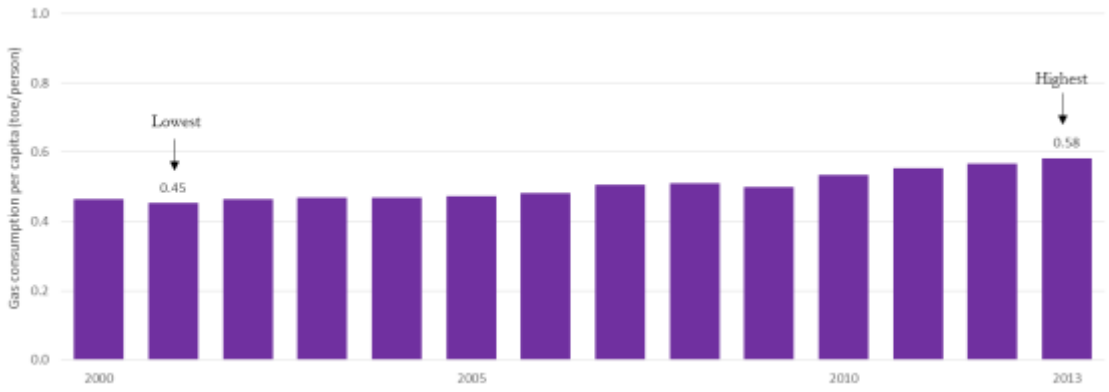
Risk	Economic sub-indicators	2000	2005	2010	2013
Internal	TPES Diversity (HHI)	25%	26%	26%	27%
	Ease of Doing Business	34%	33%	29%	27%
	Gas share to primary energy	20%	19%	20%	20%
	Gas intensity	57%	52%	54%	55%
	Gas pricing	36%	36%	36%	36%
	Gas import source diversity	25%	16%	11%	9%
Economic index		23%	22%	21%	21%

Source: WB (2016b), IEA (2015 and 2016), ICC-IMB (2015), Cedigaz database (2016) and APERC analysis.

Social

The gas consumption per capita sub-indicator, the only sub-indictor under the social indicator, displayed a steady increase in index over the historical period, from 16% in 2000 to 20% in 2013. A similar methodology was utilised as in the oil security index in determining the index for this sub-indicator. The lowest gas consumption per capita was recorded in 2001, while the highest occurred in 2013 (Figure 3.10).

Figure 3.10: APEC gas consumption per capita, 2000-2013, toe/person



Sources: APERC analysis and IEA World Energy Statistics 2015.

From the 2000-2013 period, APEC gas consumption per capita increased by 26% as demonstrated by a gradual and steady increase over the years, with the exception in 2009 because of the global financial and economic crisis. gas consumption per capita showed a stronger rebound post-2009 as gas demand increased

rapidly in China, Japan (triggered by Fukushima incident that prompted Japan to switch from nuclear to LNG), Russia and the United States (both Russia and the U.S. are major gas producers and consumers).

Technical and Technology

The technical/technology indicator exhibited a slight increase in index, 28% in 2013 from 25% in 2000 (Table 11). The APEC region produces more gas than it consumed, which makes APEC a net gas exporter. However, further production disaggregation between economies revealed a different picture stark contrast can be seen for resource energy poor economies, such as Japan and Korea, and energy resource rich economies, such as Russia and Australia.

Table 10: Gas Supply Security Index: Technical/technology Indicator, 2000-2013

Risk	Technical/technology sub-indicator	2000	2005	2010	2013
Internal	Logistics efficiency	32%	32%	32%	31%
	Reserves/production for gas	2%	4%	5%	6%
	RGT terminal utilisation	49%	50%	44%	39%
	Underground gas storage over demand	90%	90%	89%	87%
	Trans-border pipeline utilisation of gas	29%	46%	60%	58%
	Gas self-sufficiency	0%	0%	0%	0%
External	LNG Utilisation	49%	53%	61%	65%
	Gas production	21%	14%	12%	6%
Technical/technology index		25%	26%	28%	28%

Note: Gas Self-Sufficiency shows 0% risk as APEC as a whole is a net gas exporter.
Source: EIA (2016), IEA (2015), WB (2016c), BP (2015), Cedigaz database (2016) and APERC analysis.

The APEC gas R/P ratio decreased from 41.6 years in 2000 to 39.6 years in 2013. The decrease in R/P ratio caused the index for gas reserves/production sub-indicator to rise from 2.0% in 2000 to 6.0% in 2013. With huge reserves available in some members, APEC is expected to continue to be self-sufficient in the near future. However, each economy has a different R/P ratio.

In 2013, seven APEC economies had natural underground gas storage facilities. The United States owned more than half (56%) of the capacity, followed by Russia with 29%. Underground gas storage usage is closely related to seasonal variations and usually gas will be withdrawn from storage during the winter season[24]. In 2014, the year of the Polar Vortex, the United States had sharply "drawn down" natural gas from its storage facilities as a result of higher than normal demand (API, 2016). From the data on storage capacities, the study established the underground gas storage over demand sub-indicator as storage could be utilised during emergencies.

[24] Since underground gas storage is closely related to seasonal variations, a closer examination of gas demand during winter can help to better understand the risk posed on gas supply.

In 2000, only four APEC members had regasification terminals (RGT) (Japan; Korea; Chinese Taipei and the United States) with a total combined capacity of 288 Bcm. By 2013, the number of economies with regasification terminals increased to 12 with a total capacity of 690 Bcm (about 70% of global regasification capacity). The increase in total capacity for regasification could help reduce gas supply security risk (although a further examination for each economy may show a different result) (Figure 3.11). Due to the increase in the number of RGT in APEC, the utilisation rate sub-indicator index decreased from 49% in 2000 to 39% in 2013.

Figure 3.11: APEC regasification terminal utilisation rate, in %, 2000-2013

	2000	2013
USA	63	1
Chinese Taipei	60	100
Korea	42	40
Japan	33	47
Chile	No RGT	64
Canada	No RGT	9
China	No RGT	50
Indonesia	No RGT	36
Malaysia	No RGT	40
Mexico	No RGT	30
Thailand	No RGT	28
Singapore	No RGT	27
APEC	36	34

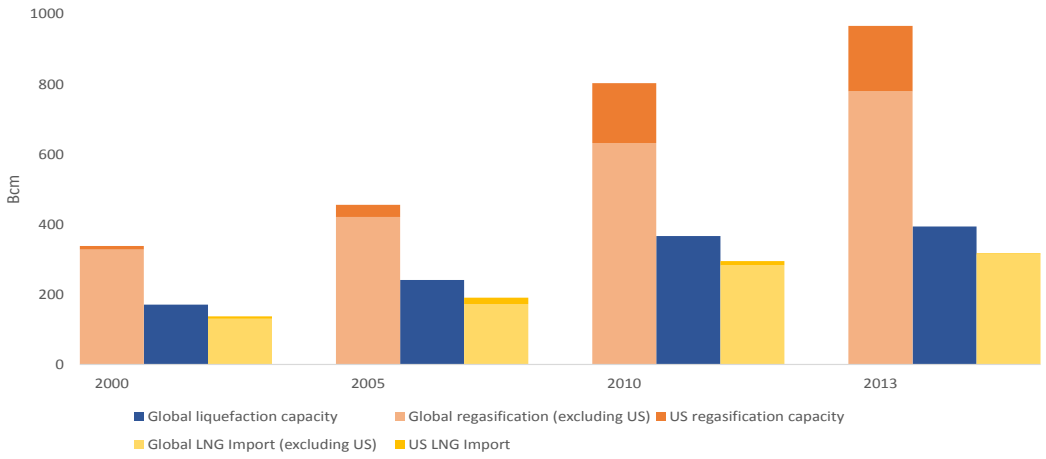
Note: RGT = Regasification terminal
Sources: APERC analysis and Cedigaz Database (2016).

One of the interesting findings from this indicator is the regasification utilisation rate in Japan. Before the Fukushima accident in March 2011, the utilisation rate stood at 39% (in 2010). It increased to 44% in 2011 and 48% in 2012 as gas demand increased due to nuclear power plants shutdown. Looking at the rate itself shows that Japan can actually import more LNG as the capacity to regasify the LNG is available especially during the year when Fukushima incident occurred. Several factors may contribute to the low regasification utilisation rate in Japan such as limited liquefaction capacity that is available around the world, thus there is not enough LNG that can be sent to these regasification terminals and/or the lack of pipeline integration that connects major supply and demand centres that can carry gas across Japan. Some of the regasification terminals located in the west of Japan could not be fully utilised due to this missing link during the Fukushima accident, which eventually led to an energy supply crisis.

As for external risk, the study assigned the lowest gas production of exporters (recorded between 2000-2013 periods) with the highest supply disruption risk (using the same methodology as in the oil security

index). Since the shale gas revolution that occurred around the mid-2000s, the production risk index fell from 21% in 2000 to 6.0% in 2013 (which means that gas exporters have the capacity to increase gas production). On the other hand, as liquefaction capacity had become more constrained, the liquefaction utilisation rate increased from 49% in 2000 to 64% in 2013 (Figure 3.12).

Figure 3.12: Global liquefaction/regasification capacity and LNG imports, 2000-2013



Sources: APERC analysis and Cedigaz Database (2016).
Note: The US is mentioned specifically due to the shift of being an LNG importer (in the early and mid-2000s) to an LNG exporter (post 2010)

However, with many LNG projects that are expected to be fully on-line by 2020, the risk of limited liquefaction capacity to meet LNG demand is expected to be reduced, although the bigger question posed by many energy analysts is the liquefaction capacity post 2020. At present, 25 of 26 liquefaction terminals under construction globally are located in APEC economies, while dozens of new LNG liquefaction projects have been proposed in Australia; Canada; the United States; Malaysia; Indonesia; and, Russia (IGU, 2015).

Law

Three sub-indicators formed the law indicator, two covers internal factors and one external factor. As with in the oil security index, the GPS and WGI were used to establish the resource extraction regulations sub-indicator and the "rule of law" sub-indicator.

From the results, the law indicator improved due to better gas emergency preparedness as mentioned earlier in this chapter (Table 12). The emergency preparedness indicator index fell by 13 percentage points, from 50% in 2000 to 37% in 2013, as a result of the introduction of regasification terminals in most APEC members (12 APEC members had regasification terminals in 2013 compared with only four in 2000), as well as existing policies to handle gas supply disruption (some economies, such as

Malaysia, don't have a policy explicitly for gas, but it is embedded under the power supply disruption policy). As for the exporter's rule of law sub-indicator, gas displayed a slightly lower index compared with oil in early 2000. However, in 2013, both oil and gas had the same index of 37%.

Table 11: Gas Supply Security Index: Law Indicator, 2000-2013

Risk	Law sub-indicators	2000	2005	2010	2013
Internal	Resource extraction regulations	37%	36%	35%	40%
	Emergency preparedness	50%	50%	43%	37%
External	Rule of law	34%	37%	35%	37%
Law index		41%	42%	38%	38%

Source: WB (2016a), FI (2015), APERC (2016), Cedigaz database (2016) and APERC analysis.

Environmental

Under the environmental indicator, two sub-indicators were included (similar to the oil security index) – the readiness and vulnerability to climate change impact and natural disaster both assigned as internal and external factors. For the internal factor, same index as in the oil security index was used. Meanwhile, the external factor posed a slightly higher risk than oil at 36% in 2013 compared with 33% for oil due to fewer import sources (Table 13). Despite the increase from external risk, the overall environmental index decreased from 21% in 2000 to 19% in 2013 owing to a higher readiness level and lower vulnerability in facing climate change. The exporter's natural disaster risk demonstrated a very minimal impact as most gas producing economies, such as those from the Middle East, are located far from natural disaster areas.

Table 12: Gas Supply Security Index: Environmental Indicators, 2000-2013

Risk	Environmental sub-indicators	2000	2005	2010	2013
Internal	Climate change	42%	41%	38%	37%
	Natural disaster	1%	1%	3%	2%
External	Climate change	38%	38%	35%	36%
	Natural disaster	0.1%	0.0%	0.1%	0.1%
Environmental index		21%	20%	20%	19%

Source: ND-GAIN (2016), CRED (2015), Cedigaz database (2016) and APERC analysis.

Conclusions and Policy Recommendations

- In general, APEC is divided into three main categories – (1) economies with abundant oil and gas resources that will continue to be net energy exporters, (2) economies that have significant resources but because of high oil and gas demand will become net energy importers, and (3) economies that are energy resource poor. However, given that APEC is relatively stable region with higher degree of "rule of law," the APEC economies should try to expand intra-APEC trade.

- APEC's overall results showed that oil and gas had low to moderate risk exposure to supply disruption over the 2000-2013 period. Oil used to have a higher supply disruption risk than gas in 2000 because of lack of oil reserves in some APEC members, but because of the reserves changes, it supply risk decrease. The results also revealed that the region held low levels of oil stockpiling (higher index) since some economies only maintained small amounts of stock, except those APEC-IEA members with obligatory requirement to have at least 90 days stock based on net imports. Few economies (non-IEA members) were able to establish high level of stocks, such as Chinese Taipei, while others like China started to build more stockpiling facilities to expand storage capacity for both crude oil and oil products.

  Given the limited resources (such as funds) and availability of storage facilities, some economies could not secure larger amounts of oil stockpiling, thus presence of risk could be high in the event of a supply disruptions. However, APEC could consider formulating a strategy for possible joint stockpiling among and between member economies, which could improve the region's overall risk on supply disruptions.

  APEC economies with insufficient oil stockpiling could also consider entering into bilateral agreements with other members holding large amounts of oil stocks to source a portion of such stockholding in the event of domestic supply emergencies. With this agreement in place, member economies (with no strategic oil stocks) could enhance their supply security level with the possibility of securing oil supply (through bilateral agreements with those member economies with huge strategic oil stockpiling) to fill a portion of the supply gap during emergencies.

- Reducing oil demand or oil intensity will help improve supply security, as demonstrated by some of the APEC economies (such as New Zealand). Thus, APEC economies need to push further on energy efficiency agenda in their respective energy policies.

- Although gas had better security than oil initially because of higher self-sufficiency levels, the supply security risk does not getting better over the years because of increasing demand recorded in most APEC members. Likewise, most economies have built or have plans to build new infrastructure

providing option(s) to source imports either through pipelines or in the form of LNG, as well as gas storage, to meet growing gas demand. Such gas infrastructure is critical to enhancing the emergency preparedness of member economies.

- As a stable oil and gas import source is important for APEC economies, expanding intra-APEC trade for both oil and gas could reduce the political stability and chokepoint risks. Besides these risks, APEC economies should cooperate to address piracy issues that have been on the rise, particularly along Straits of Malacca, which is a major route for oil and LNG imports.

- Currently, only 14 economies have entered into international oil security agreements, and seven economies have regional gas security agreements. As the presence of international/multilateral agreement contributes to reducing the supply security risks, APEC may consider developing its own oil and gas security framework agreement covering supply sharing in the event of domestic or regional supply emergencies. The framework agreement may also include other security measures such as strengthening domestic economies' emergency policies and response strategies.

Chapter 4

Oil and Gas Security Indexation

By

APEC Member Economies

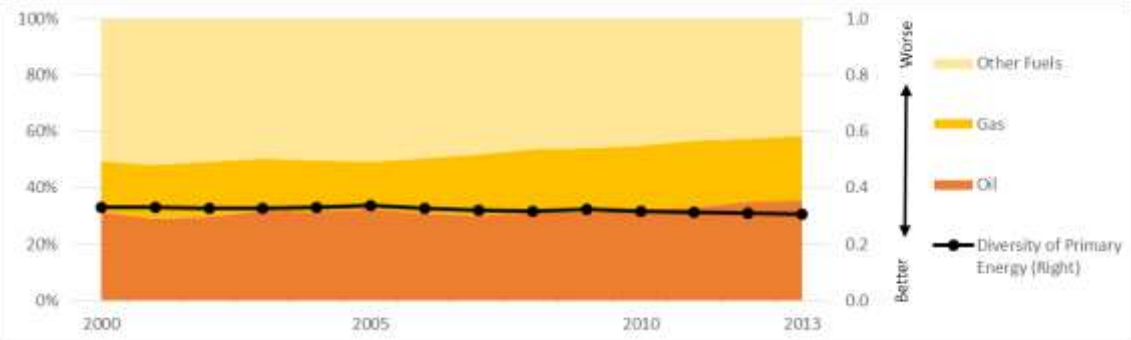
AUSTRALIA

Economy-Energy Overview

Australia is the largest island economy in the world occupying a total land area of 7.7 million square kilometres (km2), and with a total population of 23 million in 2013. In the same year, the economy's gross domestic product (GDP) reached USD 936.9 billion (USD 2010 Price and Purchasing Power Parity [PPP]), exhibiting an annual growth rate of 3.0% in the last 13 years (2000-2013) (WB, 2015; EDMC, 2015).

The economy is an energy producer ranked as the 8th largest in the world, contributing 2.4% to global energy production. It is one of the largest exporters of coal (providing around 27% of total coal exports in 2014), as well as a major exporter of uranium and liquefied natural gas (LNG), accounting for about 10% of global LNG exports. In 2013-14, the economy's energy production in terms of energy content was comprised of coal (66%), uranium (13%), gas (13%), crude oil 5% (including condensate and naturally occurring liquefied petroleum product) and renewable energy 2.0% (OCE, 2016).

Figure 4.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original > 25. A higher HHI means a high concentration in one or a few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

The economy's primary energy supply requirement in 2013 stood at 129 million tonnes of oil equivalent (Mtoe), which grew by 19% from the 2000 level (108 Mtoe) translated to an annual increase of 1.4%. About 60% of the total was sourced from oil (35%) and gas (25%), while coal supplied 34% and renewables, such as hydro, solar, wind, biomass and wastes, represented 6.0% (IEA, 2015). The economy's primary energy mix could be considered as having a diversified mix with a 0.32 HHI, a moderate-low concentration of energy sources (Figure 4.1).

The economy's oil supply requirement had been increasing annually at 2.3% per year, reaching 46 Mtoe in 2013 from 34 Mtoe in 2000. Its share to energy mix grew to 36% in 2013 from 32% in 2000. With

modest proven oil reserves, compared with global oil producers, estimated at 4.0 billion barrels (BP, 2015), the economy is a net importer of crude oil, as well as oil products. The economy's oil supply requirement is projected to increase at 0.4% per year until 2040 (APERC, 2016).

Meanwhile, its natural gas supply requirement rose annually at 3.4%, from 19 Mtoe (21 billion cubic metres [Bcm]) in 2000 to 30 Mtoe (33 Bcm) in 2013. This is translated to more than a 50% increase in natural gas supply requirement (IEA, 2015). The share of gas to primary energy mix in 2013 was about one-fourth, from less than 20% in 2000. Gas has become an important energy source for the economy not only to meet its domestic demand, but also as one of the major sources of export earnings. It was reported that the estimated proven gas reserves of the economy in 2013 stood at 3.7 trillion cubic metres (Tcm) (BP, 2015). The economy's gas supply requirement is projected to increase annually at 2.1% (APERC, 2016).

In 2013, energy intensity stood at 137.8 tonnes of oil equivalent (toe) per USD million GDP (toe/USD million) based on primary energy supply requirement, a drop of 19% from the 2000 level. On the other hand, primary energy per capita was stable, at about 5.6 toe/person from 2000-2013 (EGEDA, 2015).

Oil Security

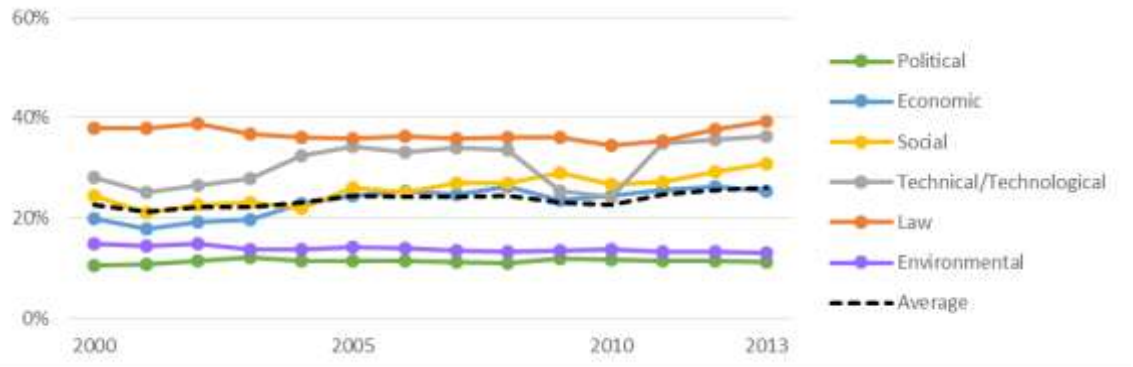
Looking at the six oil security indicators used in this study, Australia has low vulnerability to oil supply disruption with an overall supply security index of 26% in 2013, which could be translated to having a moderate-low exposure (low index means lower risk on supply disruption) (Figure 4.2). Although it could be observed that the security index had demonstrated a steady increase from 23% in 2000.

Among the indicators, the social and technical/technology indicators were the major causes of such increase in security risk. For the social indicator, with only one sub-indicator (oil consumption per capita), the gradual rise in oil consumption per capita from 1.8 toe/person in 2000 to 2.0 toe/person in 2013 triggered the increase. The index was determined based on the highest and lowest oil consumption per capita level among the APEC economies, and the historical changes in the economy's per capita level (highest recorded). The APEC average oil consumption per capita was 50% lower than the economy's per capita, only 0.80 toe/person in 2013 (0.78 toe/person in 2000).

The technical/technology indicator, which consists of six sub-indicators (one is an external factor), recorded an increase in risk by 8.0 percentage points, from 28% in 2000 to 36% in 2013. The economy's oil reserves-production (R/P) ratio had been going down due to declining reserves, while the oil self-sufficiency level was on a downward trend resulting in a higher import dependency level. Both these sub-indicators caused the technical/technology indicator to go up. The sudden drop in the technical/technology index during 2009-2010 was attributed to additional oil reserves declared in those years. On the other hand, with no additional refineries being built, import dependency on oil products is likely to accelerate in the future (APERC, 2015). As such, the economy's refinery utilisation rate is already high at 95% causing a higher index

for this sub-indicator. Additional refinery facilities may improve the refinery utilisation rate sub-indicator, and thus the technical/technology indicator. When it comes to external factors in the technical/technology indicator, the oil production rate sub-indicator of crude oil exporters (import sources) also had an increasing index, reaching 22% in 2013 from 16% in 2000. This means that some exporters of crude oil to the economy could have higher risks to fulfil their export obligations because of the decreasing production rates.

Figure 4.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economy received a high result in the law indicator (highest risk), which is made up of four sub-indicators (one is an external factor). However, the index for this indicator remained relatively stable at around 38%-39% over the historical period. In the resource extraction regulation sub-indicator, the economy obtained a 40% index, an increase from 20% in 2000. Since the index value doubled, perceptions of investors on regulations governing upstream oil and gas deteriorated with New South Wales, Tasmania, Victoria and even Queensland having the highest perception that existing regulations could deter investment. South Australia gained a lower index having the most attractive policy for upstream investment. The resource extraction regulation sub-indicator made used of the Regulatory Climate Index of the Global Petroleum Survey (GPS), which covers perceptions on costs of regulatory compliance, uncertainties on anticipated changes in environmental regulations, the enforcement of regulations, legal system fairness and transparency, etc. As the economy does not maintain a public oil stockpile and no minimum stockholding obligation for oil companies, the index in the strategic oil stockpiling sub-indicator is high, about 80% in 2013 (APERC, 2015). As of December 2013, the economy oil stock level was 52 days of net imports (IEA, 2014a). Increasing the oil stockpile would reduce the risk under the law indicator. Under the International Energy Agency (IEA) agreement, all members are required to maintain oil stocks equivalent to at least 90 days of net oil imports (IEA, 2014b). As for oil emergency preparedness, the economy has put in place emergency policy and measures to address potential supply disruption, thus attaining a lower index in the emergency preparedness sub-indicator.

The economic indicator, composed of 10 sub-indicators (one is an external factor), exhibited an increased risk at 25% in 2013 from 20% in 2000. The primary reason for the increase was the rise in oil import share to total oil supply (covering both crude oil and oil products). The import share significantly rose mainly because of the big increase in oil product imports. The increase in the economic indicator index was also caused by escalating diversity index for oil product import sources, from 13% in 2000 to 29% in 2013 (please see discussions below on Imports and Sources Section). The index for "Ease of Doing Business" from the World Bank (WB) as a sub-indicator also went up over the historical period, and thus had an effect on the economic indicator. The decrease in oil intensity sub-indicator index from 67% in 2000 to 57% was not enough to offset the increases in other sub-indicators. The economy's oil intensity dropped by 8.0% over the historical period, 49 toe/million 2010 USD in 2013 from 53 toe/million 2010 USD in 2000. It should be noted that same methodology used in oil consumption per capita was applied in estimating the index for oil intensity.

The economy received the lowest index (lowest risk) in political and environmental indicators. On the political sub-indicator (with six sub-indicators), the lowest index are in piracy and international agreement as internal factors for the economy. The economy being a member of the International Energy Agency (IEA) could solicit assistance through collective or joint actions of IEA member economies under the International Energy Program (IEP) in the event of oil supply emergency situations (IEA, 2014b). But in the local stability sub-indicator, the economy earned an increasing index (lower index means higher stability) from the World Governance Indicators (WGI) of WB, 25% in 2000 to 30% in 2013. WGI measures the quality of governance such as government effectiveness, accountability and political stability. As for external factors in the political sub-indicators, the major sources of imports (exporters) for both crude oil and oil products have low risks in terms of piracy and chokepoints, as well as having a relatively stable political landscape.

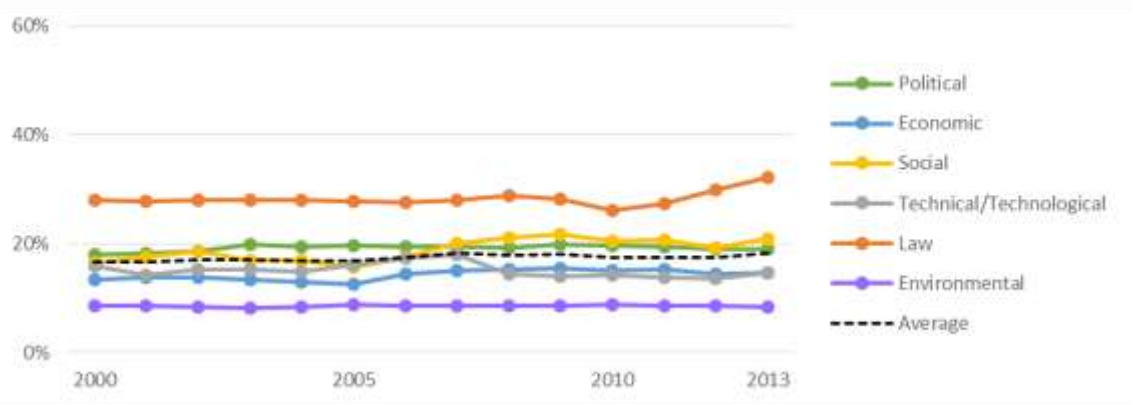
For the environmental indicators covering risks related to climate change and natural disaster as sub-indicators (both as internal and external factors), the Notre Dame Global Adaption Index (ND-GAIN) revealed relatively a low result for the economy with an index value of 23% (moderate-low exposure) on the climate change sub-indicator covering categories on adaptive capacity, exposure, and readiness. As for the oil import sources (external factor), the average ND-GAIN index was 34% in 2013. The economy had a low index in the natural disaster sub-indicator using the Centre for Research on the Epidemiology of Disasters (CRED) indicator in terms of population affected by natural calamities in both internal and external (sources of imports), with an index value of less than 1.0% over the historical period.

Gas Security

Overall, Australia's gas supply security is within the low exposure with an index of 18% in 2013, from 17% in 2000 (Figure 4.3). The gas security index went up a bit in 2007 as social indicator increased by 3.0 percentage points from 2000 level. Although Australia recorded gas import from Timor Sea from the Joint Petroleum Development Area (JPDA), this study does not consider such import in estimating external risk as gas from JDPA is mainly for re-export (in LNG form).

The law indicator received the highest risk recorded at 32% (2013), which is already under the category of mid-low exposure. Similar to oil security, the high index was attributed to the resource extraction regulation sub-indicator for the economy.

Figure 4.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In gas security index (1.0% to 100.0%), a lower index means less vulnerability to any gas supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

In the technical/technology indicator, a slight uptick was recorded in 2007 due to depleting reserves reported on that year. However, in total, the gas R/P ratio sub-indicator index went down as gas reserves almost doubled (1.8 times) in 2013 (2.2 Tcm) from its 2000 level of 1.2 Tcm. This sub-indicator may improve in the near term with gas reserves in Greater Gordon Field, which has estimated reserves of 1.1 Tcm (40 trillion cubic feet [Tcf]) and is expected to produce 26.9 billion cubic metres per year (Bcm/y) of gas (equivalent to 950 billion cubic feet per year [Bcf/d]). Other gas upstream projects that are already in the pipeline are the Wheatstone Project and Browse Basin Development Program, etc. (IEA, 2014). The economy is also exploring coalbed methane (CBM) and shale gas as other potential gas resources. Energy Information Administration (EIA) estimates showed that the economy has vast technically recoverable gas reserves of around 12.4 Tcm (437 Tcf) (EIA, 2014).

The steady growth in the gas supply requirement led to the increase in the economy's gas consumption per capita which triggered the social indicator to move upward from 17% in 2000 to 21% in 2013. Gas consumption per capita went up to 1.3 toe/person in 2013 from 1.0 toe/person in 2000. The

economy's gas consumption per capita was higher than the APEC average of 0.58 toe/person in 2013 and 0.46 toe/person in 2000.

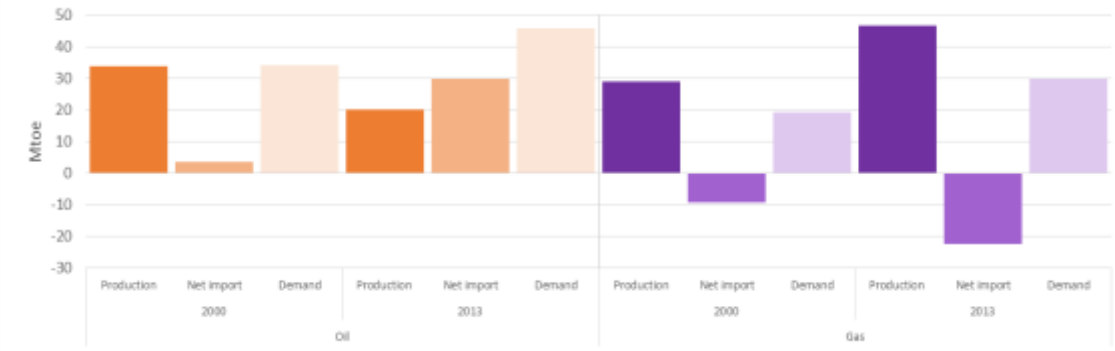
On the other hand, the economic indicator (covering six sub-indicators) increased by 6.0 percentage points, from 13% in 2000 to 15% in 2013 because of expanding gas share to primary energy supply and increasing gas intensity (as sub-indicators). The share of gas to primary energy supply reached 23% in 2013 from 18% in 2000, while gas intensity slightly increased to 32 toe/million 2010 USD in 2013 (from 30 toe/million 2010 USD in 2000), thus earning an increase in index at 51% in 2013 (from 47% in 2000).

In the political indicator index, the absence of international/multilateral agreements on gas supply security push the index slightly higher. Right now, the IEA agreement does not yet cover gas security, but could be included in the future if the global and regional gas supply situations warrant its inclusion. However, with huge gas reserves, the economy could be accorded with an index of 50% (economies with no resources and no international agreement were given 100% risk).

Imports and Sources

Australia's crude oil production has been decreasing since 2000 at a rate of 4.0% per year due to maturing oil fields. And as most of the economy's crude oil production is located off the northwest coast, which is far from the refineries situated in the east, a significant portion of its crude oil is exported to other Asian economies (EIA, 2014). Over the historical period, crude oil imports grew annually at 1.0%, on average. With this, the economy's dependency on crude oil imports went up from about 8.0% in 2000 to 37% in 2013 in terms of refinery demand. This was despite the economy's decreasing oil refinery capacity, which stood at 674 thousand barrels per day (kbbl/d) in 2013 from 847 kbbl/d in 2000, a 20% cut in capacity. Oil refinery capacity was further reduced in 2015 with the retirement of two refineries from six refineries operating in 2013, bringing down the capacity to 412 kbbl/d (OGJ 2000-15 & IEA, 2015a).

Figure 4.4: Production, Net Imports and Demand, 2000-13



Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

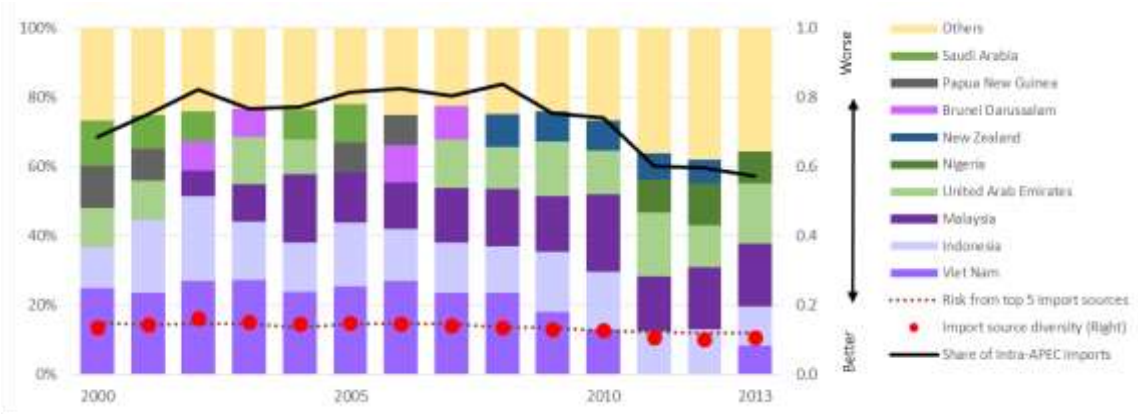
As the economy's refinery capacity dwindled, oil product imports significantly surged reaching almost half of domestic demand in 2013, from only 12% in 2000. On average, oil product imports exhibited a 13% growth rate per year during the historical period. It should be noted that the economy's refinery facilities are nearly at their full capacity. With declining domestic oil refining capacity, crude oil imports are expected to decrease in the future, which will be offset by increasing oil product imports (APERC, 2015). If no additional refinery capacity will be added in the coming years, oil product imports will rise in the future. Total oil net imports (crude oil and oil products) registered an eightfold increase to 29.7 Mtoe in 2013 from only 3.6 Mtoe in 2000 (Figure 4.4).

Crude Import Sources

Over the historical period, the diversity index of crude import sources was at a low level with an average index of 0.13 HHI (0.11 HHI in 2013), which is translated to a low concentration or well-diversified sources (Figure 4.5). Consistent major exporters of crude oil to Australia were Indonesia; Malaysia; Viet Nam; and, the United Arab Emirates (UAE). The economy started to import from Nigeria in 2009, which further improved its diversity index. Before, the economy sourced a significant amount of crude oil from New Zealand; Saudi Arabia; Brunei Darussalam; and, Papua New Guinea.

In terms of risk associated with the major import sources, it declined somewhat from 15% in 2000 to 12% in 2013. This could be attributed to risks associated with the previous sources of imports in the sub-indicator related to exporter's stability (local stability). Although importing from Nigeria had accompanying risks, these were offset by a reduction of imports from Viet Nam and Indonesia, which also had identified risks.

Figure 4.5: Crude Oil Import Sources, 2000-13



Sources: APERC analysis and UN Comtrade, 2016.

The share of intra-APEC imports was recorded at 57% of total crude oil imports, from a high of more than 80% between the periods of 2005 to 2008 as the major crude oil suppliers were within the region. In 2005-2006, the top five crude oil suppliers were Brunei Darussalam; Indonesia; Malaysia; Papua New

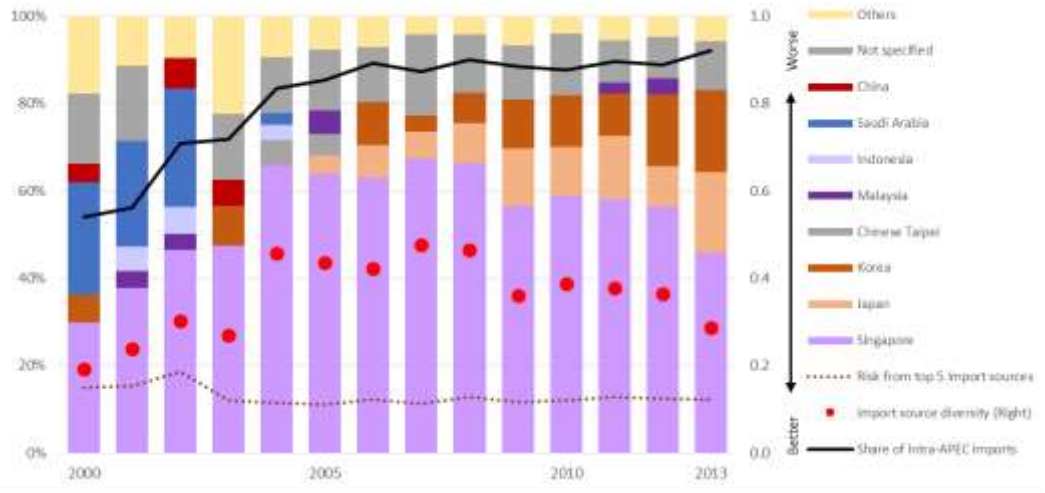
Guinea; and, Viet Nam. Crude oil from New Zealand came in 2008 until 2012. When the economy sourced crude oil again from UAE in 2007, it replaced the oil from Papua New Guinea and Brunei Darussalam. The increased volume of crude oil from UAE led to the decline of intra-APEC import share, and was further reduced with the entry of Nigerian crude displacing some amount of imports from Indonesia and Viet Nam.

Oil Product Import Sources

Singapore has been the main source of oil product imports for the economy, from 30% in 2000 to 47% in 2013 of total imports. The share of Singapore imports was high from 2004 to 2008, around 65% on average. As such, the diversity index was at the highest, 0.45 HHI on average, during those years where two-thirds of imports were coming from Singapore (Figure 4.6). Other major sources of imports were Japan; Korea; and, Chinese Taipei. Increasing imports from Japan and Korea led to a decreased import share from Singapore. During the early years, the economy even imported from China; Indonesia; Malaysia; and, Saudi Arabia.

Risk associated with the major oil product import sources was low compared with the risk from crude oil imports. The level of risk was on a decreasing trend from 11% in 2000 to 8.0% in 2013. The risk gradually came down as the economy started to import from Japan; Korea; and, Chinese Taipei. Meanwhile, the intra-APEC import share was high, reaching 92% of total imports in 2013 from only 54% in 2000. A low level of intra-APEC share was recorded when the economy was still importing from Saudi Arabia, accounting for about 25% of total imports, on average.

Figure 4.6: Oil Product Import Sources, 2000-13



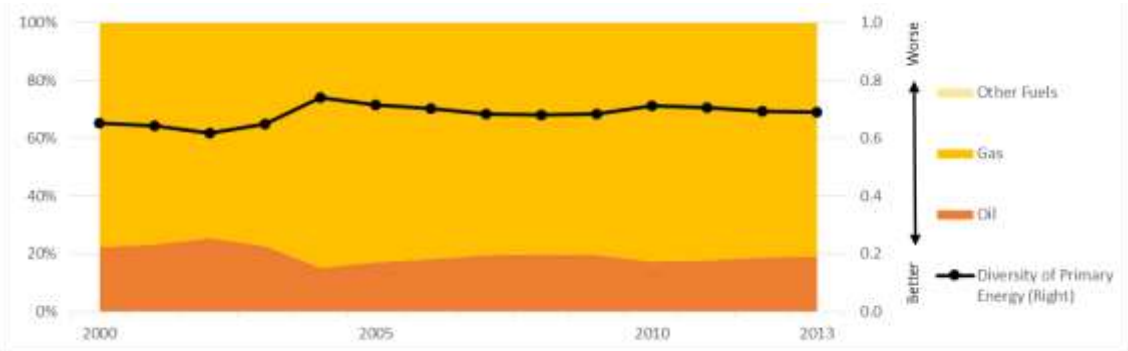
Sources: APERC analysis and UN Comtrade, 2016.

BRUNEI DARUSSALAM

Economy-Energy Overview

Brunei Darussalam is one of the Asia-Pacific Economic Cooperation (APEC) economies located in Southeast Asia covering a total land area of around 5,765 square kilometres (km2) and with small population of about 411,000. In 2013, the economy's gross domestic product (GDP) stood at USD 28.4 billion (2010 Price and Purchasing Power Parity [PPP]), growing annually at an average rate of 1.2% (2000-13). The economy's GDP per capita of USD 69,108 (2010 USD PPP) is among the highest in the APEC region (WB, 2015; EDMC, 2015).

Figure 5.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or a few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

Brunei is a producer of both oil and gas. Most of the oil produced is exported with only a small amount being refined at the Brunei Shell Refinery. Likewise, 90% of gas produced is exported as liquefied natural gas (LNG), and the remainder is utilised locally for power generation and town gas. These sectors contribute more than 60% to the economy's GDP and generate about 90% of government revenues and export earnings (IBT, 2013).

In 2013, the economy's primary energy supply requirement reached 3.0 million tonnes of oil equivalent (Mtoe), up by 28% from the 2000 level of 2.4 Mtoe, and growing annually at 1.9%. The economy relies heavily on oil and gas as the main energy resources – 81% was sourced from gas, 19% from oil, and less than 1% from renewables specifically from solar (IEA, 2015). As such, the diversity index using HHI showed a moderate-high concentration having an index of 0.70 (Figure 5.1).

Brunei's oil supply requirement registered an average annual increase of less than 1.0% in the last 13 years, from 0.53 Mtoe in 2000 to 0.58 Mtoe in 2013, while its crude oil production level has been declining

in recent years due to maturing oil fields, decelerating at 7.0% annually (from 2008 to 2013) (APERC, 2015). The economy has estimated proven oil reserves of 1.1 billion barrels (Bbbl) (BP, 2015). The economy's oil supply requirement is projected to exhibit a modest increase of 1.2% annually until 2040 (APERC, 2016).

The economy's natural gas supply requirement rose by more than 30% in 2013 from its 2000 level of 1.8 Mtoe (2.0 billion cubic metres [Bcm]), an annual increase of 2.2%. Its annual production only expanded at a rate of 0.6% over the 13-year period, which affected export quantity (in the form of LNG) to slowly decline since 2009 following growing domestic demand. The economy's estimated proven gas reserves are placed at 276 Bcm (BP, 2015). Gas supply requirement is estimated to grow annually at a rate of 2.0% (until 2040) (APERC, 2016).

Energy intensity (primary energy supply) of the economy in 2013 was recorded at 107.0 tonnes of oil equivalent (toe) per USD million GDP (toe/USD million), higher by 8.6% from the 2000 level of 98.5 toe/USD million. Primary energy per capita was about 7.4toe/person in 2013, a negligible increase of 0.2% (from the 2000 level) (EGEDA, 2015).

Oil Security

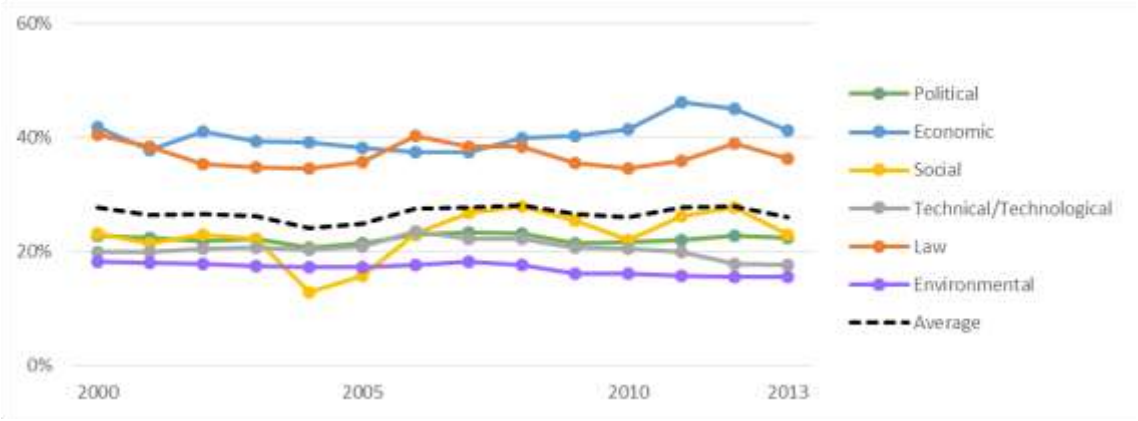
From the different supply security indicators used for this study, Brunei earned a 26% index with a category of moderate low-exposure, a modest improvement from the 2000 index of 28% (Figure 5.2). A low security index means lower supply disruption risk.

The economic indicator, which considered 10 sub-indicator (one is an external factor), received the highest risk, among the indicators, with an average value of 42% over the historical period. Contributing factors for the high index are the presence of subsidy in oil pricing and oil intensity. Price subsidies pose a risk to the economy as consumers have limited or no incentive to use oil efficiently given its low price. On the other hand, oil intensity obtained more than a 50% index within the historical period, and the highest was recorded at 68% in 2012. The economy's oil intensity in 2013 stood at 20.6 toe/USD million, an improvement of 6.8% from 22.1 toe/USD million in 2000. It should be noted that the index for this sub-indicator is computed based on the highest and lowest intensity levels from APEC economies, as well as the recorded changes (highest level) in the intensity level of the economy over the historical period. This sub-indicator could be improved in the future with the announcement of Brunei during the United Nations (UN) Climate Summit in September 2014 to reduce total energy consumption by 63% in 2035 through intensified energy efficiency measures (RTB News, 2014).

The oil product diversity sub-indicator under the economic indicator had realised improvement, from 100% in 2000 as imports mainly came from Malaysia, and then progressively falling to 49% in 2013 with the entry of other sources. For crude oil, the economy started importing in 2010 from Malaysia, although still at small volumes. The economy's crude oil production is more than sufficient, even without imports, to meet

its domestic crude demand. For the "Ease of Doing Business" sub-indicator from the World Bank (WB), the economy showed a minor decline in 2013 at 38% (from 41% in 2000).

Figure 5.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The law indicator, covering four sub-indicators (one is an external factor), exhibited a decreasing index (improvement in risk) at 36% in 2013 from 41% in 2000. Such a trend is due to the "rule of law" sub-indicator as an external factor, for which the index decelerated to 27% in 2013 (44% in 2000). The rising imports of oil products from Singapore rather than Malaysia pushed down the result of the "rule of law" sub-indicator. The "rule of law" is part of the indices generated in the World Governance Index (WGI), which evaluates the quality of contract enforcement, etc. In the strategic oil stockpiling sub-indicator, the economy only imposes an obligatory stockholding level for oil products equivalent to 31 days for industry (IEA, 2014). However, the stockholding level is still considered small compared with other APEC economies. The resource extraction regulation sub-indicator had a relatively stable result at 36%, although it went up to 53% in 2012. This sub-indicator used the Regulatory Climate Index of the Global Petroleum Survey (GPS), which looks at the cost of regulatory compliance including the legal system's transparency and fairness.

A steady index for the political indicator was observed for the economy, an average of 23% over the historical period. This indicator is made up of six sub-indicators (three each for internal and external factors. The local stability sub-indicator displayed a moderate increase from 25% in 2000 to 28% in 2013 (lower index means higher stability), and still under the category of moderate-low exposure. The local stability sub-indicator is generated from the WGI that evaluates the possibility of an unstable political climate. Meanwhile, the exporter's stability declined (35% in 2013 from 49% in 2000) with increasing imports from Singapore having a lower local stability index. Being a member of the Association of Southeast Asian Nations (ASEAN), the economy is a party to the ASEAN Petroleum Security Agreement (APSA). Although APSA has been ratified by all member states of ASEAN, how effective the provisions of the agreement have not yet

to be tested in actual supply disruption or emergency situation. However, it still contributes to lowering the supply risk.

Initially, the social indicator (with only one sub-indicator) demonstrated a downward trend from 23% in 2000 to 13% in 2003, but rose afterward to reach 23% again in 2013. The economy's oil consumption per capita in 2013 stood at 1.4 toe/person, a 12% reduction from the 2000 level. Similar to oil intensity, the result for this sub-indicator is assessed relative to the highest and lowest per capita level from APEC economies, and also reflected the changes (highest recorded) in the economy's per capita level over the historical period. The economy's oil consumption per capita was higher by 57% than APEC average of 0.80 toe/person in 2013.

The technical/technology indicator showed a decreasing index from 20% in 2000 to 18% in 2013 based on the six sub-indicators, one of which is an external factor. Mainly, the oil reserves-production (R/P) ratio sub-indicator influenced the improvement in the index of technical/technology indicator. The sub-indicator index went down to 0% in 2013 (16% in 2000) caused not by an increase in oil reserves, but a reduction in production. At the current production rate and level of reserves, production could be sustained for 22 years. The economy has set out a strategic action for a more sustainable energy sector which includes a target in intensifying the upstream and downstream oil and gas activities to maintain the reserves replacement ratio[25] to be at least above 1. The economy intends to expand oil and gas production from about 372,000 barrels per day (bbl/d) in 2013 to 650,000 bbl/d in 2035 (EIDPMO, 2015). Given limited refinery capacity, the economy's refinery utilisation rate (sub-indicator) is already at full capacity, thus earning a higher index for this sub-indicator.

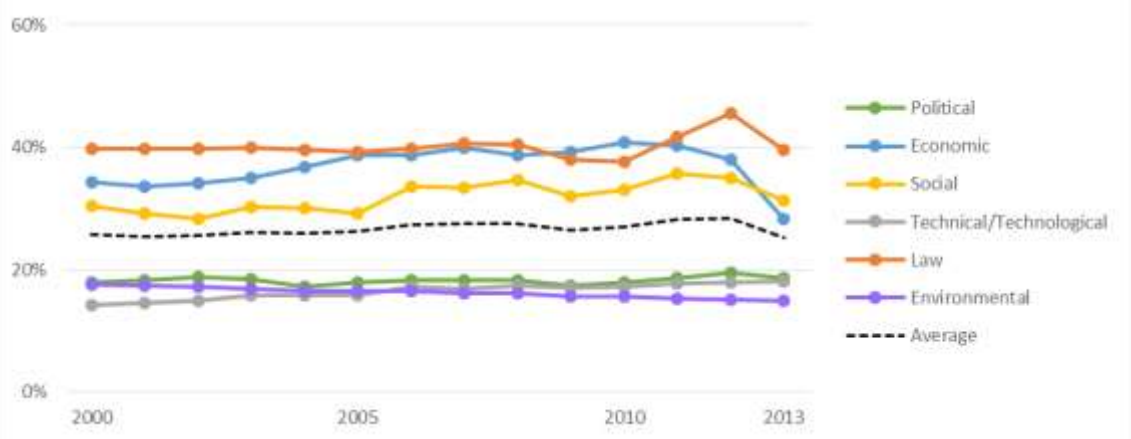
The environmental indicator index modestly decreased (16% in 2013 and 18% in 2000). These indicators covered the risks from climate change and natural disaster as sub-indicators (both applied as internal and external factors). The reduction in risk in this indicator could be attributed to the improvement in the economy's climate change sub-indicator, down to 42% in 2013 (49% in 2000). The climate change sub-indicator adopted the Notre Dame Global Adaption Index (ND-GAIN) covering exposure, adaptive capacity and readiness in terms of climate change impact. The climate change sub-indicator for exporters (as an external factor) had a low index, primarily contributed to by Singapore and Malaysia with better (lower) ND-GAIN index.

[25] It measures the amount of proven reserves added to a company's reserve base during the year relative to the amount of oil and gas produced. The ratio must be at least 1 for the company to sustain its business in the long-term.

Gas Security

Brunei's gas supply security index had been stable at an average of 27% over the historical period (Figure 5.3). The law indicator (composed of three sub-indicators with one as an external factor) gained the highest index (highest risk) at 40% in 2013 triggered mainly by the economy's gas emergency preparedness sub-indicator in the absence of regasification terminals (RGT) and underground storage. Although the economy is highly self-sufficient as the current gas production is three times its domestic demand, the absence of these facilities could also pose a security risk for the economy when a domestic supply disruption occurs.

Figure 5.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The social indicator had an index of 31% in 2013, from an initially increasing index, which reached 36% in 2011 (from 30% in 2000). This was influenced by the economy's gas consumption per capita, which fell to 6.0 toe/person in 2013 from a high of 8.0 toe/person in 2011. The economy's gas consumption per capita is significantly higher than other major gas producers in the APEC region, such as Russia with 2.8 toe/person and the United States with 1.9 toe/person (both recorded in 2013), which is attributed to higher share of gas in the primary energy supply mix, about 80% of the total in 2013. Similar methodology used in oil consumption per capita was applied to determine the index for gas consumption per capita sub-indicator.

The index for the economic indicator dropped to 28% in 2013, from 34% in 2000 and 41% in 2010. This indicator took into account six sub-indicators. The major factor for the decrease was the abrupt fall in the gas intensity sub-indicator in 2013, to about 86.4 toe/USD million from 111.1 toe/USD million in 2011 caused by the lower gas supply requirement recorded for the said year compared with the past three (3) years (2010-2012). Same methodology applied in oil intensity was used to determine the index for gas intensity sub-indicator. On the other hand, the gas share to primary energy supply had been increasing,

resulting in a rising index for this sub-indicator (81% in 2013, 78% in 2000). Government subsidies on gas pricing also contributed to the economic indicator index as already explained in the oil security.

As for the political indicator (same sub-indicators as in oil security), it earned a stable index of 18%, on average. The economy's local stability and international/multilateral agreements on supply security as already discussed above (oil security) mainly contributed to the political indicator index. APSA may cover gas supply security, thereby the economy received the same index (equivalent to the oil security) for the international/multilateral agreements on gas security.

On the other hand, the technical/technology indicator index gradually increased to 18% in 2013 from 14% in 2000. This indicator included eight sub-indicators (two are under external factors) to determine the risks. The gas R/P ratio sub-indicator caused such an increase as the economy's gas reserves slowly declined at a rate of around 2.0% annually over the historical period, while production had still been going up annually at 0.6%. In 2013, the economy's gas reserves were recorded at 276 Bcm from 366 Bcm in 2000 (BP, 2015). Current gas reserves can still cover the current level of production for 24 years.

Import and Sources

Although Brunei's crude oil production has been declining, the output is still more than sufficient to cover domestic refinery demand. However, the economy's crude exports decreased by around 34% in 2013 (6.4 Mtoe) from the 2000 level (9.7 Mtoe). A small amount of imports from Malaysia began in 2010, which stood at 0.014 Mtoe, and only 0.010 Mtoe in 2013. Meanwhile, oil refinery output also dwindled causing oil product imports to rise sharply, a seventeen-fold increase reaching 298 Mtoe in 2013 from only 17 Mtoe in 2000. This resulted in an upswing in the import dependency level, reaching 53% in 2012 (3.0% in 2000), but fell to 30% due to a drop in the oil product supply requirement of the economy. The economy has limited refinery capacity to meet its domestic oil demand, but is expected to expand with the construction of a refinery and aromatics cracker plant project on Pulau Muara Besar (PMB) Island with a capacity of 175,000 barrels per day. The additional refinery capacity is scheduled to be in operation by 2019 (BB, 2016). With this expansion, there would be a shift in the economy's exports, consuming more crude oil and increasing oil product exports (EIA, 2016). Overall, total oil net imports (crude and oil products) remained negative, but exhibited a 37% decline. Net imports in 2013 stood at -6.1 Mtoe from -9.7 Mtoe in 2000 (Figure 5.4).

Despite a steady increase in domestic gas demand, and with gas production only growing at 0.6% annually, Brunei could still export around 80% of its production output, on average. The economy has been exporting LNG to Korea and Japan, and expanded its market to include other Asian consumers such as China; India; Malaysia; and Chinese Taipei. As the economy's domestic demand for natural gas is increasing, specifically for the power and petrochemical sectors, more of its gas production could be utilised locally and thus compete with LNG exports (EIA, 2016) (Figure 5.4).

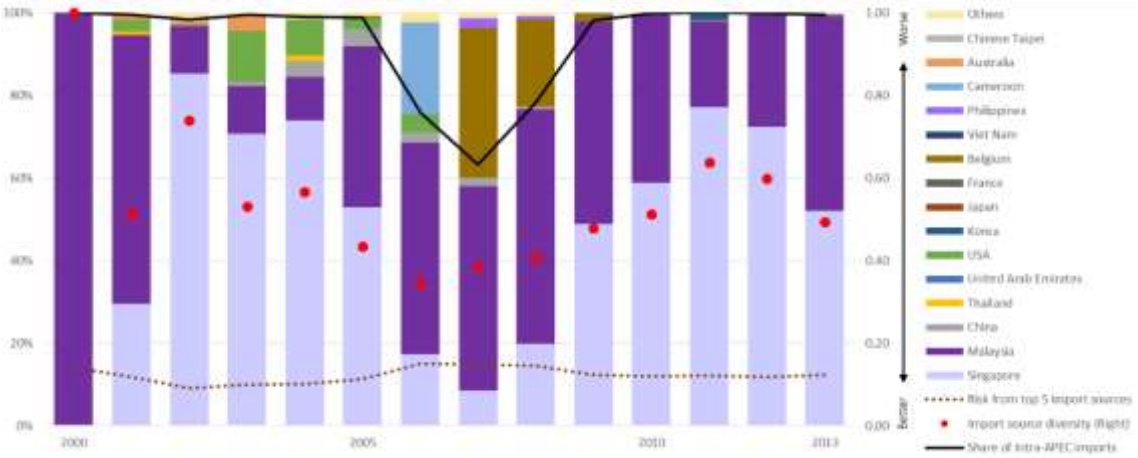
Figure 5.4: Production, Net Imports and Demand, 2000-13

Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Oil Product Import Sources

Both Malaysia and Singapore had been major sources of oil product imports for the economy with a combined share of 99% in 2013. During that year, Singapore's import share was 52% and Malaysia's at 47%. At the beginning of the historical period, the economy was heavily dependent on Malaysian imports, which provided 100% of the domestic import requirements. Eventually, the share of Malaysia to total imports began to fall as imports from Singapore and from other sources started to come in 2001.

Figure 5.5: Oil Product Import Sources, 2000-13



Sources: APERC analysis and UN Comtrade, 2016.

The risks associated with major import sources improved, reaching 12% in 2012 from 14% in 2000, following rising imports from Singapore, which received relatively lower risk result. As the major exporters came from the APEC region, intra-APEC was almost 100% throughout the historical period except in the years 2007 to 2009 with imports outside the region coming from economies such as Belgium and Cameroon (Figure 5.5).

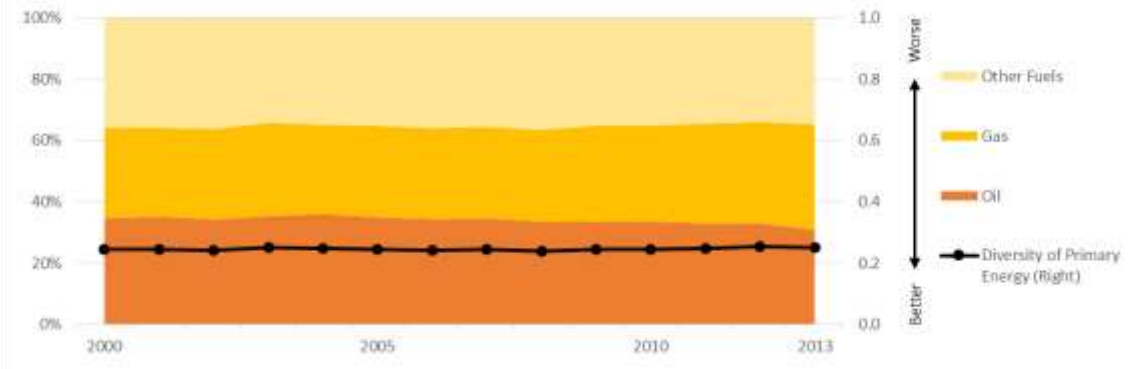
CANADA

Economy-Energy Overview

Canada is the second largest economy in the world in terms of land area with a total population of 36.3 million (2016). The economy's gross domestic product (GDP) had grown modestly at 2.0% annually, which stood at USD 1,458.0 billion (USD 2010 Price and Purchasing Power Parity [PPP]) in 2013 from USD 1,127.9 billion in 2000 (WB, 2015 and EDMC, 2015).

Canada is a net energy exporter endowed with abundant energy resources, both fossil fuel and renewable energy. The economy is the fourth largest energy producer in the Asia-Pacific Economic Cooperation (APEC) region and the sixth largest in the world (IEA, 2016). The economy is an exporter of crude oil, natural gas, coal, uranium and electricity (IEA, 2015). In 2015, the energy sector contributed about 11% to the economy's GDP (NRCan, 2016).

Figure 6.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

The economy's primary energy supply requirement in 2014 reached 283 million tonnes of oil equivalent (Mtoe), an increase of 11% from the 2000 level of 252 Mtoe, due mostly from coal, natural gas, and crude oil and natural gas liquids. Almost 35% of the economy's energy supply requirement was provided by natural gas, expanding its share from 30% in 2000. Oil contribution declined to 30% from 35% during the same period, while coal's share decreased to 8.0% (from 13%). Nuclear had a 10% share, while the aggregate contribution of renewable was slowly picking up providing 18% to the energy supply mix, of which 66% was hydro resources. From this energy mix, the economy had a diversity index of 0.25 HHI (moderate-low concentration) for its primary energy supply (Figure 6.1).

The oil supply requirement of the economy started to decline in 2004 reaching 78 Mtoe in 2013, from 95 Mtoe (2004) due to decreased utilisation from oil-based power plants. Oil demand for other sectors still exhibited an upward trend, 1.2% annually over the last 13 years. It is projected that the oil supply requirement will peak in 2027 and then decline, translating to only a 5.0% increase from 2013 until 2040 (APERC, 2016). The economy has the third largest proven oil reserves of 169.9 billion barrels (Bbbl), about 97% of which is oil sands (NRCan 2016). Likewise, the economy ranked fourth in global crude oil production. In 2014, its crude oil production stood at 153 Mtoe, translated to an annual increase of 3.1% in the last 14 years. This resulted in crude oil exports doubling at 124 Mtoe in 2014, and import volume decreasing at 1.1% annually (IEA, 2016). Most crude oil exports went to the United States.

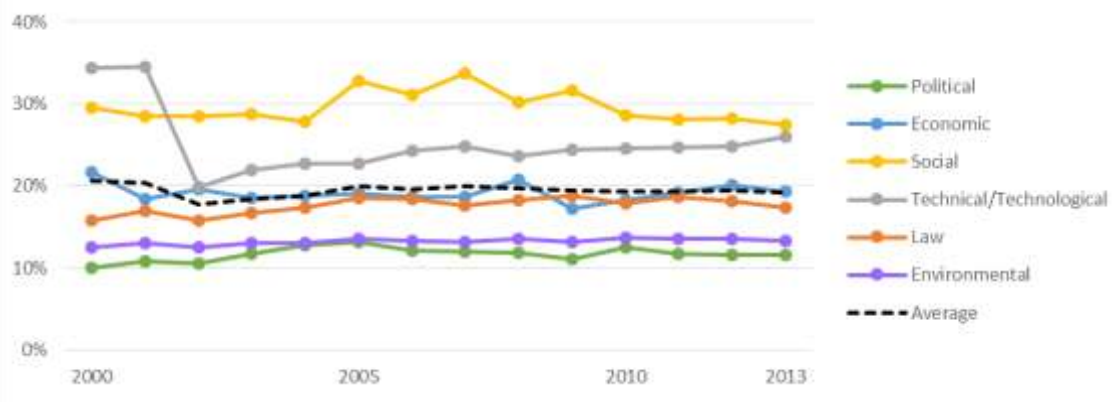
On the other hand, the economy's natural gas supply requirement grew at 1.2% annually, 97 Mtoe (108 billion cubic metres [Bcm]) in 2014 from 74 Mtoe (82 Bcm) in 2000, as demand increased for additional natural gas-fired generation capacity. The gas requirement is seen to rise at 1.5% annually to 2040, largely for growing consumption of electricity (APERC, 2016). The economy has substantial proven reserves of natural gas estimated at 2.0 trillion cubic metres (Tcm) (70 trillion cubic feet [Tcf]), 1.1% of total global gas reserves. Although the economy has a small share of global gas reserves, the economy ranked fifth in dry natural gas production and was the fourth largest exporter in the world. However, the economy's gas production declined 1.0% annually from 2000- 2014, with exports falling 1.6% annually. Almost all of its gas exports were sent to the United States via pipeline. The reduction in gas production was due to declining exports.

The energy intensity of the economy fell by 22% in 2013, 173.7 tonnes of oil equivalent (toe) (primary energy) per USD million GDP (toe/USD million) from 223.0 toe/USD million in 2000. Primary energy per capita was about 7.2 toe/person in 2013 from 8.2 toe/person in 2000 (EGEDA, 2015).

Oil Security

Canada's oil security index had been stable over the 13-year period (2000-13), an average of 19% index (low exposure to risk) (Figure 6.2). A low index is translated to having lower risk on supply disruption. The social indicator, which only included one sub-indicator, had the highest risk but at a decelerating trend, 27% in 2013 from 30% in 2000. The index was caused by high oil consumption per capita, third highest in the APEC region after Singapore and the United States. The economy's oil consumption per capita in 2013 stood at 2.2 toe/person from the 2000 level of 2.8 toe/person. The peak in the social indicator's index noted in the period of 2005-2009 was a result of the historical changes (highest recorded) in the economy's oil consumption per capita relative to the highest and lowest per capita level of other APEC economies.

Figure 6.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The technical/technology indicator earned an index of 26% in 2013, from a high of 35% in 2000. This indicator covered six sub-indicator, one of which is an external factor. The drop in the technical/technology indicator index in 2002 was due to the improvement in the oil reserves-production (R/P) ratio from 97% in 2001 to 0% in 2002 as a result of an increase in reserves (180 Bbbls) after oil sands resources were reclassified as proven reserves, and thus technically and economically recoverable (EIA, 2015). However, the index gradually rose (increased risk) as reserves slightly declined on a year-on-year basis over the historical period. But with the technology breakthroughs in oil exploration and development, such as horizontal drilling, hydraulic fracturing and pad drilling, the economy's shale resources could be harnessed and increase the oil reserves to over 300 Bbbls. In Alberta, oil sands accounted for 97% of proven reserves comprised of in-situ recoverable reserves of 133 Bbbls through non-conventional mining and 32 Bbbls by the conventional method (NRCan, 2016). At the current production rate, the proven reserves could satisfy domestic oil demand for about 140 years, which could grow significantly with potential shale reserves (NRCan, 2015a).

The biggest contributor to the technical/technology indicator is the refinery utilisation rate sub-indicator with the economy's refinery facilities already operating nearly at full capacity. The economy has 17 refinery facilities with a total capacity of 1.96 million barrels per day (Mmbbl/d) (OGJ, 2000-15). The additional refinery capacity of 50 thousand barrels per day (kbbl/d) expected to come online in 2017 will improve the index (reducing the risk) for this sub-indicator (IEA, 2015a). With this refining capacity, the economy is also a net exporter of oil products, registering an increase of 4.0% annually (IEA, 2015). Meanwhile, the economy's logistics efficiency sub-indicator obtained a low index of 22% based on the Logistics Performance Index (LPI). LPI evaluates infrastructure and logistics quality and competence.

In the economic indicator (with nine sub-indicators under internal factor, and one sub-indicator as external factor), the economy also showed slight improvement (lowering of risk) at 19% in 2013 from 22% in

2000. Improvements were observed in the oil share to primary energy and oil intensity sub-indicators. The index for the oil share to primary energy sub-indicator decelerated to 31% from 35%, and oil intensity to 49% from 71% over the historical period. In determining the index for oil intensity, the same methodology used in oil consumption per capita was applied. Likewise contributing to the economic indicator is the crude oil import sources sub-indicator as the diversity index went down (improvement) from 48% to 10%. However, the diversity index for oil product import sources worsened from 30% to 51% (please see discussion on import sources below).

The law indicator is relatively stable and with a low historical average index of 18%. This indicator is made up of four sub-indicator, one of which is an external factor. From the different sub-indicators, the resource extraction regulations received a high average index of 34%. Based on the Regulatory Climate Index of the Global Petroleum Survey (GPS), investors' perception on policy regulations and quality, specifically in Quebec and New Brunswick, had a high index in mild to strong deterrent to investment. Meanwhile, being an oil exporter, the economy is exempted from the International Energy Agency (IEA) 90-day oil stockpile based on net imports (IEA, 2014). In 2013, it was reported that the economy had industry-held stock equivalent to around 53 days of oil demand, comprised of crude (65%) and oil products (35%) (APERC, 2015). Likewise, the economy has established an institutional structure and response measures (including policies) to deal with emergencies such as oil supply disruptions (APERC, 2015). Given these facts, the economy obtained the lowest indices (lowest risk) in the oil stockpiling and emergency preparedness sub-indicators. Using the World Governance Indicators (WGI), the "rule of law" sub-indicator, as an external factor, displayed an upward trend in index, from 28% in 2000 to 35% in 2013. This could be attributed to higher index in "rule of law" from Algeria and Iraq among the sources of crude oil imports.[26] This sub-indictor looks at the quality of contract enforcement, among other factors.

The economy received the lowest index in environmental and political indicators with an average of 13% and 12%, respectively. The environmental indicator is composed of two sub-indicators (applied both for internal and external factors) – the exposure and readiness to climate change, and natural disaster. On internal risk related to the climate change sub-indicator under the environmental indicator, the economy obtained 24% (average index) from the Notre Dame Global Adaption Index (ND-GAIN) covering exposure, adaptive capacity and readiness. External risk on climate change from import sources also had an increasing and higher index of 33% in 2013 from 29% in 2000. Higher climate change risks were noted for Algeria, Iraq and Mexico. The highest climate change risk from import sources was recorded at 36% to 37% when the economy was still importing from Angola and Russia for crude oil and from Peru for oil products. With respect to the natural disaster indicator, the economy received less than a 1.0% index for both internal and external (import sources). The natural disaster sub-indicator used the Centre for Research on the Epidemiology of Disasters (CRED) indicator based on the number of population affected by natural disaster.

[26] The study recognized that there are many rational reasons considered in the decision to import fuel, such as cost, proximity and regional integration objective. However, as energy self-sufficiency is always at the top of most government agenda, once the economy sought to import fuel, it means the supply risk will be subject to external factors that may be beyond the economy's control.

In the political indicator (with six indicators, three each for internal and external factors), the local stability sub-indicator slightly increased from 28% in 2000 to 29% in 2013 (low index means higher stability), although the highest reached 34% in 2005 but started to go down afterward. The local stability sub-indicator is based on WGI that evaluates the quality of governance and political stability of the different economies. Improvement in the local stability sub-indicator means that the economy has been perceived to have a better political climate. Also under the political indicator is the existence of international/multilateral agreements on oil security, for which the economy earned a low result being a member of IEA with huge oil reserves. The economy could seek assistance from IEA members through collective or joint actions during oil supply disruptions (IEA, 2014). On the other hand, the exporter's stability sub-indicator (external factor) for import sources showed a higher index (higher risk) of 35% in 2000 and increased further to 47% in 2013, and the highest was at 50% (average) for the period of 2003 to 2008 with increased crude oil imports from Algeria and Iraq. Also affecting the political indicator is the chokepoint from import sources, specifically for Iraq crude oil.

Gas Security

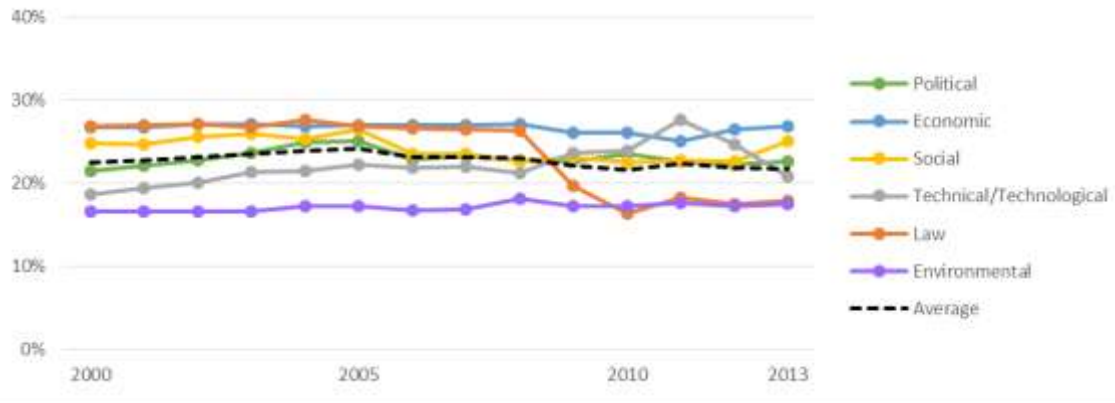
Canada received a much higher security index for gas compared with oil, although still low at 22% (moderate-low) in 2013 (Figure 6.3). The index was relatively stable over the historical period with the highest index recorded at 24%. Among the indicators, the social indicator (with only one sub-indicator) registered the highest index (highest risk) at 25%, historical average, which measures gas consumption per capita. The economy's gas consumption per capita in 2013 reached 2.5 toe/person from 2.4 toe/person in 2000. Similar to oil, the gas consumption per capita index is affected by the changes (highest and lowest gas consumption per capita level) relative to other APEC economies, as well as the changes in the economy's per capita level (highest recorded) over the historical period.

The economic indicator (composed of six sub-indicators all under internal factor) had an index value of 27% mainly contributed to by gas intensity, gas share to primary energy, and gas import diversity. The gas intensity sub-indicator was 54% in 2013, a negligible improvement from 55% in 2000. Meanwhile, the gas share to primary energy had been increasing, from 30% in 2000 to 34% in 2013. As discussed above, the gas supply requirement grew annually at 1.2% with increasing demand from power generation. Although the economy sends almost all of its gas exports to the United States, the economy also sources nearly all of its gas import requirements from the United States. In 2013, the United States provided 96% of the economy's gas imports, from 100% in 2000 until 2008. The remaining gas imports came from Qatar and Trinidad and Tobago.

The political indicator (same sub-indicators in oil security) 23% in 2013 (from 21% in 2000). The exporter's stability sub-indicator from WGI showed an increasing index for the economy with the entry of Trinidad and Tobago as a gas supplier. As IEA does not have an agreement yet on gas supply security, but

since the economy has a huge amount of gas reserves, the index in the international/multilateral agreement sub-indicator was set at 50% (half risk). In the future, the index for this sub-indicator could improve once an IEA agreement covering gas is implemented. The economy's local stability sub-indicator is also a contributing factor (as already explained in oil security).

Figure 6.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The technical/technology indicator exhibited an increasing trend (increasing risk) from 19% in 2000 to 28% in 2011 and then suddenly dropped to 21% in 2013. This indicator considered eight sub-indicators, two are under external factor. The reason behind the decline is the gas R/P ratio sub-indicator, which was rising due to depleting reserves, but with additional reserves considered in 2013, the ratio declined. It was reported that a total of about 300 Bcm of additional reserves were added in 2013 from the 2007 level27 (total of yearly increase in reserves) (CAPP, 2015). This sub-indicator may improve further in the future with the economy's significant deposits of unconventional gas from coalbed methane (CBM), shale gas and tight gas, which could potentially expand gas reserves. According to the US Energy Information Administration (EIA), the economy has unproven technically recoverable shale gas resources of around 16.2 Tcm (or 572 trillion cubic feet) (EIA, 2015). Most shale gas resources are found in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick and Nova Scotia. There is now drilling and production in the Montney and Horn River shale basins located in the northeast of British Columbia (NRCan, 2012). At the current gas reserves, the economy's gas production could be sustained for about 15 years.

Another sub-indicator affecting the technical/technology indicator is natural gas storage capacity over demand, which had a utilisation rate of around 25% (historical average), while the sub-indicator on regasification terminals had a decreasing utilisation rate, from 8.0% in 2008 to 4.0% in 2013. The decline was caused by a decrease in LNG imports from Trinidad and Tobago. The economy's only regasification terminal

[27] CEDIGAZ reported the increase in reserves only in 2013.

(RGT), the Canaport LNG Terminal in Saint John, New Brunswick, which began receiving LNG imports in 2009, has a total capacity of 34 million cubic metres per day (Mcm/d) (Canaport, 2015). As most of the gas exports and imports were transported through pipelines, the economy also had an increasing utilisation rate of its trans-border pipelines, which stood at 63% in 2013 from only 5.0% in 2000. The economy has the largest network of gas pipeline systems, which is highly interconnected with the United States' pipeline system (EIA, 2015). In terms of the external factor in the technical/technology indicator, the gas production rates (as sub-indicator) of gas exporters had intensified, with largest improvement seen for Qatar.

The law sub-indicator, consisting of three indicators (one is an external factor), demonstrated a declining trend from 27% in 2000 to 18% in 2013. The main contributor to the decline was the improvement in the emergency preparedness sub-indicator as a result of building a regasification terminal in 2009, which provides an alternative or option in receiving gas imports. The resource extraction regulations had the highest index (as discussed in oil security), while the "rule of law," as an external factor, had a 20% average index since the economy relied heavily on gas imports from the United States. The United States received a lower WGI for enforcement of contract and property rights.

The environmental indicator (same sub-indicators in oil security) had been stable at 18% over the historical period. The climate change sub-indicator (external factor) for exporters remained relatively unchanged despite the entry of Trinidad and Tobago with a higher index in climate change from ND-GAIN. This was due to the still huge share of the United States in total imports (the U.S. has a lower climate change index). As explained above, the economy had a stable climate change index (internal factor).

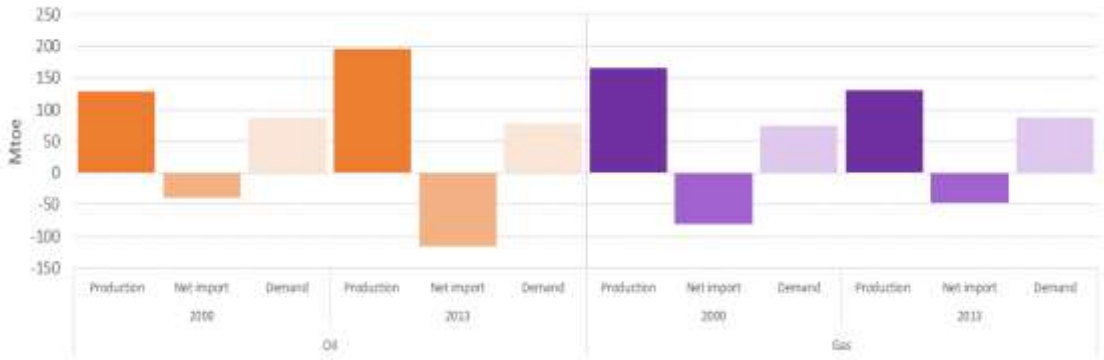
Imports and Sources

As Canada's crude oil production has been increasing over the historical period, about 3.3% annually, export volume increased, while imports decreased. Both crude oil and oil product exports had picked up annually at 4.5% and 4.0%, respectively. Meanwhile, crude oil imports went down by 21% from 2000 to 2013, translating to an annual reduction of 1.8%. However, oil product imports accelerated, an increase of 41% for the same period, or a 3.0% annual growth rate. As mentioned above, the economy's refinery facilities are operating at full capacity, and additional capacity is seen to come in 2017. Overall, total oil imports were down by 12% (same period). With this, net imports fell by almost three times reaching -116 Mtoe in 2013 from -39 Mtoe in 2000 (Figure 6.4).

On the other hand, despite the reported expansion of gas reserves during the latter part of the historical period, the economy's gas production was cut by 12% in 2013 from 2000 production level, a 1.0% annual decline. Gas production started to diminish in 2007, from 183 Bcm to 145 Bcm in 2013. This caused gas exports to decrease by 17% in 2013 (from the 2000 level), while imports built up significantly, a seventeen-fold increase in 2013. As such, net imports (although still negative) increased by 47%, - 47 Mtoe

(52 Bcm) in 2013 from - 89 Mtoe (99 Bcm) in 2000 (Figure 6.4). It may be noted that gas pipeline exports to the United States were decreasing as a result of increasing U.S. production of unconventional gas (from shale gas). With this, the United States has become more self-sufficient in natural gas (NRCan, 2015b).

Figure 6.4: Production, Net Imports and Demand, 2000-13



Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

With this development, the economy is intending to diversify its gas market by exporting in the form of LNG. Such a plan would require LNG export terminals. Currently, the economy has no operating LNG export terminals. There are a significant number of applications for LNG facilities. In October 2015, the National Energy Board (NEB) already approved 22 applications for LNG export licenses. Most of the LNG projects are located in British Columbia, with some in Nova Scotia, New Brunswick and Quebec (NEB, 2016). However, NEB noted that the issuance of licenses is not an assurance that the LNG facilities will be built as this is determined by market conditions.

Crude Import Sources

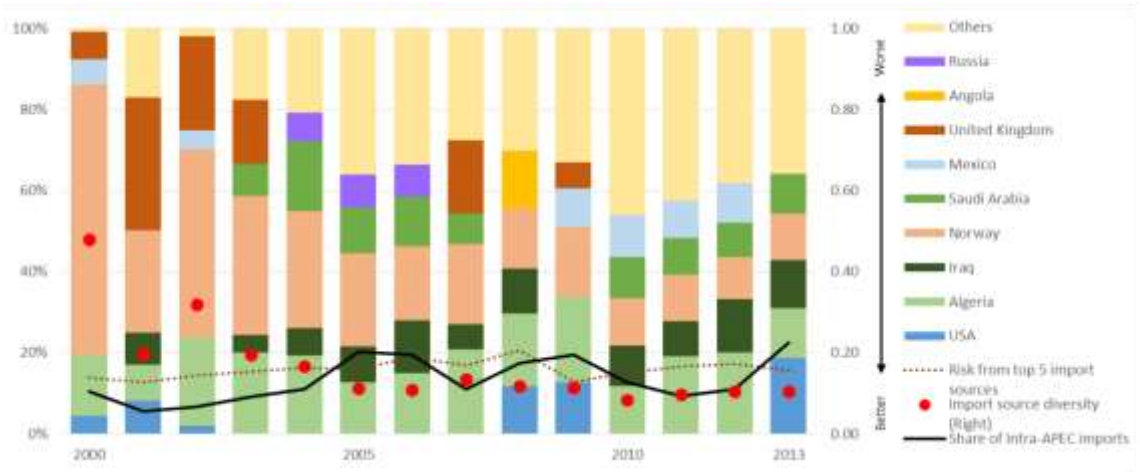
Canada's diversity index for crude import sources was at 0.10 HHI (low concentration) in 2013, thus having very diversified import sources (Figure 6.5). The index was initially at 0.48 HHI in 2000 when the economy was getting a significant amount of its crude oil imports from Norway. The share of Norway's crude oil to total supply dwindled to 11% in 2013 with the entry of other sources such as, Iraq, the United Kingdom, Saudi Arabia, Mexico, etc. In 2013, the United States was the largest supplier of crude oil imports to the economy providing about 20% of the total. Other major sources were Algeria (12%), Iraq (12%), Norway (11%) and Saudi Arabia (10%).

The risk associated with major import sources was still considered low at 16%. Although there is high risk importing from Algeria and Iraq (exporter's stability and "rule of law" sub-indicators), the overall risk was offset by imports from low-risk sources such as Norway and the United States.

As the economy sourced a huge portion of its crude oil imports outside the APEC region, the intra-APEC import share remained at a low level during the historical period. In 2013, the intra-APEC import share was only 23% of the total crude oil imports, which was largely contributed to by a higher share

of crude from the United States.

Figure 6.5: Crude Oil Import Sources, 2000-13



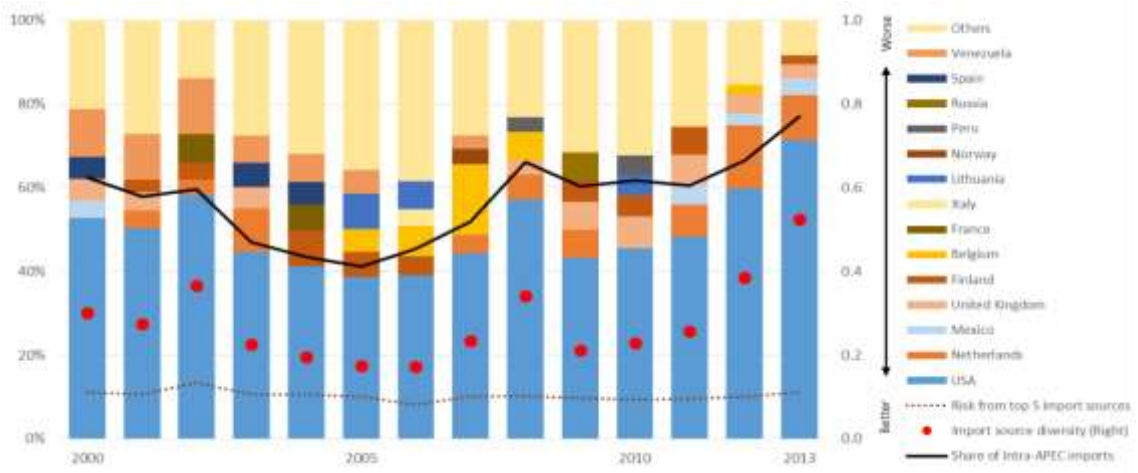
Sources: APERC analysis and UN Comtrade, 2016.

Oil Product Import Sources

The United States has been the major source of oil product imports providing more than two-thirds of the oil product imports during the historical period. Initially, the United States only contributed about half of the oil imports in 2000, and increased to 70% in 2013. As the economy relied heavily on imports from the United States, the diversity index was high at 0.52 HHI from 0.30 HHI in 2000 (Figure 6.6). The remaining import requirements in 2013 were met by the Netherlands (9.0%), Mexico (3.0%), the United Kingdom (3.0%) and Finland (2.0%). The increased imports from the United States displaced a portion of imports coming from other sources. Within the historical period, the economy also imported oil products from other European economies such as Belgium, France, Italy, Lithuania and Norway. At some point, Peru and Russia also contributed to the import requirement of the economy.

The level of risk from oil product major exporters was still low at 11% as sources were from low-risk economies in Europe and the United States. Meanwhile, the intra-APEC import share was high at 77% in 2013 from 62% in 2000, which was basically contributed to by the huge import volume from the United States.

Figure 6.6: Oil Product Import Sources, 2000-13

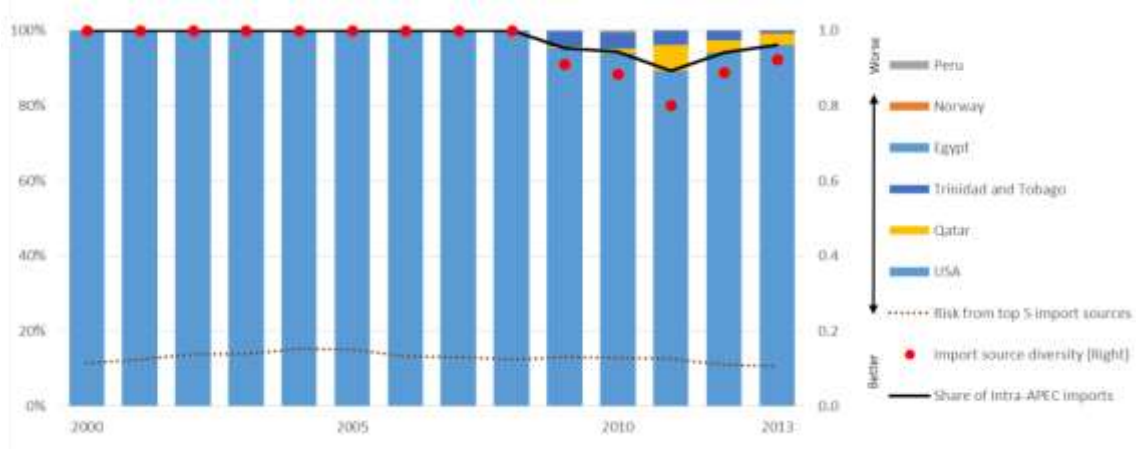


Sources: APERC analysis and UN Comtrade, 2016.

Gas Import Sources

As the economy is heavily dependent on the United States for gas imports, the diversity index in 2013 was high at 0.96 HHI from a high of 1.0 HHI in 2000 until 2008 (Figure 6.7). The index modestly declined when gas imports came in from Trinidad and Tobago in 2009, and the following year from Qatar. Risk from gas exporters was low at 11% due to the large share of the United States to total gas imports, despite the high risks associated with Trinidad and Tobago. With a large portion of gas imports coming from the United States, the intra-APEC import share was also high at 96%.

Figure 6.7: Natural Gas Import Sources, 2000-2013



Sources: APERC analysis and Cedigaz 2016.

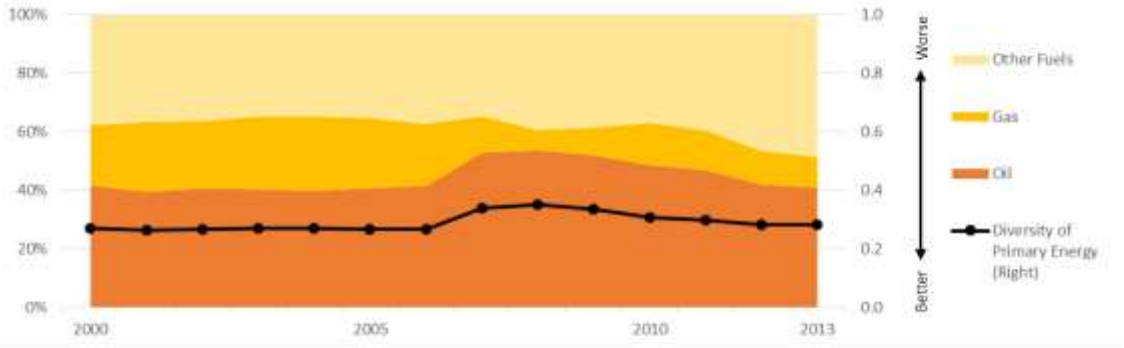
CHILE

Economy-Energy Overview

Chile is one of the two Asia-Pacific Economic Cooperation (APEC) member economies in South America, and the only member of the Organization of Economic Cooperation and Development (OECD) in this sub-region. The economy occupies a land area of 756,000 square kilometres (km2) with a total population of only 18 million in 2013. In the same year, gross domestic product (GDP) was registered at USD 361.4 billion (USD 2010 Price and Purchasing Power Parity [PPP]), which grew at a rate of 4.3% annually from the 2000 level (WB, 2015; EDMC, 2015).

Having limited energy resources, Chile is heavily dependent on energy imports. In 2013, total energy imports accounted for about two-thirds of the 38.7 million tonnes of oil equivalent (Mtoe) total primary energy supply of the economy. The bulk of its primary energy supply requirement was oil at 41%, coal at 17%, gas at 10%, and renewables at 31%, mostly biomass (80%) and hydro (17%). From the primary energy supply mix, the diversity index of the economy in 2013 was at 0.28 HHI (moderate-low concentration). Said index went up in 2007 following a sharp increase (40%) in oil supply requirement, specifically for power generation (Figure 7.1).

Figure 7.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

The economy's oil supply requirement expanded reaching 15.8 Mtoe in 2013 from 10.5 Mtoe in 2000, a yearly increase of 3.2%. Oil maintained a stable share of 40% to primary energy supply for the period 2000-2006, before going up to 54% in 2007, and then gradually declined to reach 40% share level again 2013. The economy's proven oil reserves were placed at 150 million barrels (mmbbl), which allowed a small amount of oil production, an average of 3.7 mmbbl (0.5 Mtoe) annually from the historical period (EIA, 2015; IEA,

2015). As such, the economy relies heavily on oil imports. The oil supply requirement is projected to increase at 1.7% annually until 2040 (APERC, 2016).

Natural gas supply requirements displayed a downward trend, declining at a rate of 1.9% in the last 13 years, due to decreasing demand for power generation and a portion on non-energy application. Historically, gas demand for power had been dwindling as a result of displacement by coal generation. The economy also has modest gas reserves estimated at 96.3 billion cubic metres (Bcm) (3,400 billion cubic feet [Bcf]) (EIA, 2015). In the APEC Energy Outlook, gas demand of the economy is expected to grow much higher than oil at 2.7% annually due to the expected increase in demand from industry and residential sectors (APERC, 2016).

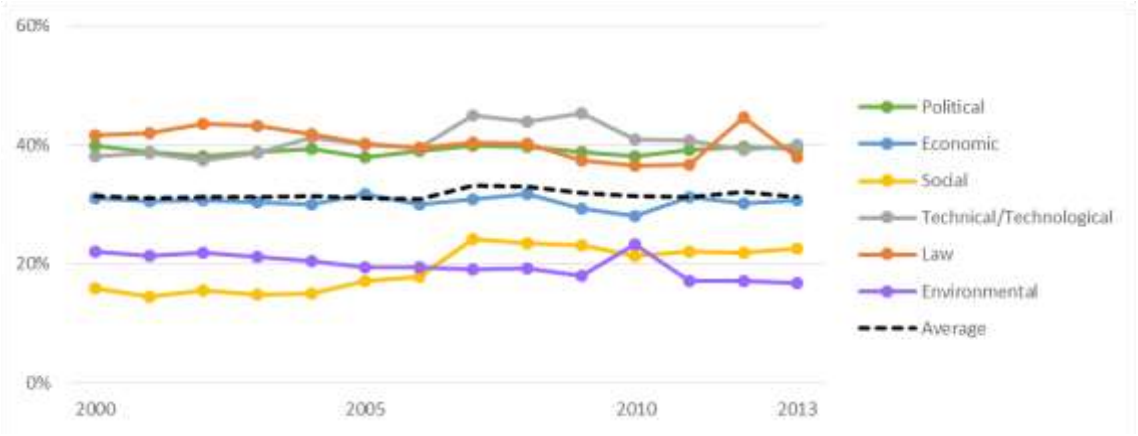
The economy's energy intensity was 107.1 tonnes of energy (toe) per USD million GDP (toe/USD million) in 2013, an improvement of 9.4% from the 2000 level of 118.2 toe/USD million in 2013. Meanwhile, primary energy per capita increased by 32% in 2013, 2.2 toe per person (toe/person) from 1.7 toe/person in 2000 (EGEDA, 2015).

Oil Security

Chile's oil security index is considered as having a moderate-low exposure with a historical average index of 32% (Figure 7.2). A low index means lower risk on supply disruption. A slight increase in the index (33%) was observed in 2007 and 2008. Among the supply security indicators, the political and technical/technology indicators obtained the highest risk at 40% each in 2013.

Under the political indicator (with three sub-indicators each under internal and external factors), the local stability sub-indicator received a 39% index in 2013 (high index means lower stability) based on the World Governance Index (WGI) by the World Bank (WB) on the likelihood of having an unstable political environment. At the beginning of the historical period, the indicator showed a declining trend from the 2000 level (42%) down to 33% in 2003, and afterward gradually rising until 2013. On the other hand, the exporter's stability (external factor) sub-indicator demonstrated an improvement, 45% in 2013 from 53% in 2000. The economy has been dependent on crude oil imports from its neighbouring economies within South America, of which some of them earned a higher index in their respective local stability index (likelihood of political instability). With the entry of other sources of crude oil such as the United Kingdom and Canada, the dependency on crude oil from South America slowly decreased over the historical period, to around 70% in 2013 from a high of more than 80% in 2000, which caused the sub-indicator index to fall. This was also contributed to by increasing oil product imports from the United States, 90% of total imports in 2013, displacing imports from Peru; Argentina; and, Korea. The United States benefits from a better local stability situation compared with other oil product exporters.

Figure 7.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

Although already a member of OECD since 2010, the economy is not yet covered by the International Energy Program (IEP) under the International Energy Agency (IEA) Agreement, which contains regional oil supply security agreement. As such, the economy had a high index in the international/multilateral agreements on oil security sub-indicator (political indicator). This sub-indicator is expected to improve as the economy is a candidate member of IEA, and when membership has been granted, will be included in the IEA-IEP (APERC, 2015).

The technical/technology indicator moved up to a high of about 45% index value between the period 2007-2009 from 38% in 2000, and then slowly went down to 40% in 2013. This indicator included five sub-indicator under internal and one as an external factor. Such a trend was caused by the refinery utilisation rate sub-indicator, which was initially at 87% in 2000, and progressively reached full capacity (100%), and decelerated in 2010 until 2013, which stood at 86%. The decline in refinery utilisation rate was offset by an increase in oil product imports and a decrease in crude oil imports during these periods. Another contributing factor is the oil reserves-production ratio sub-indicator. The index for this sub-indicator significantly rose beginning in 2007 at around 40% from 18% in 2000 as the economy expanded its crude oil production even with no additional oil reserves findings. As the economy has limited oil resources, the oil self-sufficiency sub-indicator had the highest index (among the sub-indicators for technical/technology indicator), around 93% to 97% (high index means lower self-sufficiency level), over the historical period. Given its minimal oil and gas findings, the economy has intensified its promotion for oil and gas exploration and production through the National Petroleum Company (ENAP) to double hydrocarbons production by 2020. The economy has increased exploration investment through ENAP with a budget of around USD 800 million annually until 2020 (ENAP, 2014 & 2015).

The law indicator (consisted of four sub-indicator, one is an external factor) saw a slight decline in index, 38% in 2013 from 41% in 2000. Under this indicator, the oil stockpiling sub-indicator received the

highest index at 88%. The economy does not hold any strategic oil stocks, but there is obligatory stock for oil industry participants, equivalent to 25 days of sales based on the past six months (APERC, 2015). As for the resource extraction regulation sub-indicator, the economy had a relatively low index of 27% in 2013 using the Regulatory Climate Index of the Global Petroleum Survey (GPS) that assesses regulatory quality such as cost of regulatory compliance, and transparency and fairness of the legal system. As for external factors, the "rule of law" sub-indicator improved to 37% in 2013 from 53% in 2000. This could be attributed to increased crude imports from other sources outside South America and the expanding oil product imports from the United States. The "rule of law" is one of the indices in the WGI covering the quality of contract enforcement, property rights, etc.

The economic indicator, which covered 10 sub-indicators, gained a historical average of 31%. The economy, being highly dependent on imported oil (total oil supply), reported the highest index value in the oil net imports over demand sub-indicator, nearly 100%, among the sub-indicators. However, the oil intensity sub-indicator displayed a decreasing trend, down to 58% in 2013 from 67% in 2000. This sub-indicator is assessed relative to the oil intensity level (highest and lowest intensity level) of other APEC economies, and the historical changes (highest recorded) in the economy's oil intensity level. In 2013, the economy's oil intensity improved by 11% from 49.2 toe/USD million in 2000 to 43.8 toe/USD million in 2013. In terms of the diversity index, the crude oil diversity sub-indicator declined over the historical period due to the entry of other import sources, while the oil product import diversity rose with heavy reliance on U.S. imports. The "Ease of Doing Business" sub-indicator by WB showed improvement at 28% in 2013 (45% in 2000).

The economy's increasing oil consumption per capita resulted triggered the social indicator displayed an upward trend (increasing risk) reaching 23% in 2013 from 16% in 2000. Initially, the economy's oil consumption per capita in 2000 was at 0.69 toe/person and slowly went up to 0.90 toe/person in 2013, a little above the APEC average of 0.80 (2013). The oil intensity is based on other APEC economies' oil consumption per capita level, and the historical changes in the economy's per capita level.

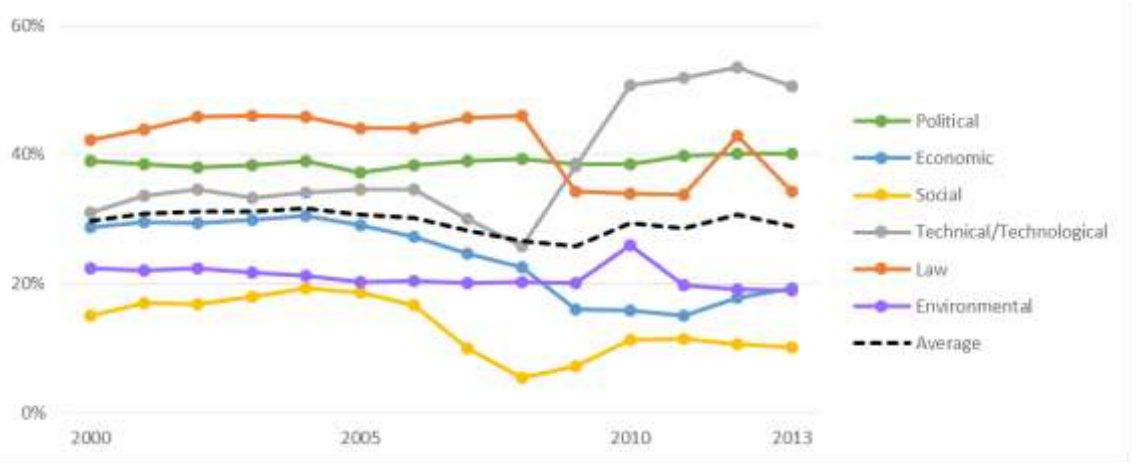
On the other hand, the environmental indicator exhibited a downward trend (declining risk) having the lowest index value among the other security indicators, only 17% in 2013 (22% in 2000). This indicator included exposure and readiness to climate change, and natural disaster as sub-indicators applied both as internal and external factors. The main contributor for the decline is the climate change sub-indicator for both internal and external factors. The economy's climate change indicator was down by eight percentage points, 34% in 2013, which means there was significant progress noted on the economy's adaptive capacity and readiness for climate change impact. The climate change sub-indicator for external factors (import sources) also made improvement with imports from the US; Canada and the United Kingdom. The climate change index is based on the Notre Dame Global Adaption Index (ND-GAIN).

Gas Security

Chile gained nearly the same level of risk (as in the oil security) in gas supply security with a historical average index of 31%, which is under the moderate-low exposure category (Figure 7.3). The technical/technology indicator obtained the highest risk at 51% in 2013 (under mid-exposure category). This indicator is made up of eight sub-indicators, of which two are under external factor. The index showed an increasing trend (increasing risk) reaching 51% in 2013 (31% in 2000). One factor affecting this indicator is the gas self-sufficiency sub-indicator, which deteriorated over the historical period rising to 80% in 2013 from 69% in 2000 as domestic gas production and reserves declined. This was despite the decrease in the economy's gas supply requirement. However, gas self-sufficiency may improve in the near term with the development of the economy's Magallanes shale basin in the southern region of Tierra del Fuego, with an estimated initial flow rate of 119 million cubic metres per day (Mcm/d) (4.2 billion cubic feet per day [Bcf/d]) of shale gas (EIA, 2015).

The expanding utilisation rate of regasification terminals (RGT), as a sub-indicator, also contributed to the increase in the technical/technology indicator. The RGT utilisation rate went up significantly, from 18% in 2010 to 64% in 2013. The economy operated its first RGT in 2009 with a capacity of 3.7 billion cubic metres per year (Bcm/y), and in succeeding years added 2.0 Bcm/y. Through the RGT, the economy was able to begin importing LNG from Trinidad and Tobago, Yemen and Qatar, and in previous years from Equatorial Guinea (EIA, 2015). Having developed LNG import facilities coupled with declining gas imports from Argentina via pipeline, which were drastically reduced to only 1.0% in 2013. This led to a decrease in the trans-border gas pipeline utilisation rate to less than 1.0%.

Figure 7.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

As for external factors in the technical/technology indicator, the gas production rate of exporters as a sub-indicator improved to 4.0% in 2013 from 19% in 2000 with the diversification of gas import sources. However, the LNG export terminal utilisation rate of LNG exporters was nearly at full capacity in 2013, thus leading to a high index for this sub-indicator.

The political indicator (same indicators as in oil security) recorded a stable index at 39%, on average, over the historical period. In the absence of international/multilateral agreements on gas security, the economy received a high index in this sub-indicator. Similar to oil security, the economy has a pending application to be a member of IEA. Although the IEA-IEP does not yet cover gas, with the growing share of gas in the global supply mix, it may be considered later on in the program. The exporter's stability sub-indicator (external factor) using the WGI on the possibility of an unstable political situation ramped up to 53% in 2013 (49% in 2000) with the entry of Yemen LNG, but somehow soften by Trinidad and Tobago and Qatar with better local stability. As the share of Middle East gas increased, the chokepoint sub-indicator also pushed up.

On the law indicator, composed of three sub-indicators (one is an external factor), the index dropped (decreased risk) to 34% in 2013 from 42% in 2000. The primary contributor for the decline is the economy's gas emergency preparedness, which improved with the introduction of RGT in 2010. The index for the "rule of law" sub-indictor (external factor) of the gas exporters only modestly moved up, 56% in 2013 from the 2000 level of 54%, despite the gas coming from Yemen, which received the highest index (under rule of law) among the gas exporters (but offset by the gas imports from Trinidad and Tobago and Qatar).

On the other hand, the economic indicator (with six sub-indicators) also showed a decreasing trend (19% in 2013; 29% in 2000). The dwindling gas intensity is one of the factors for the falling economic indicator. The economy's gas intensity displayed an improvement of 54%, from 24.2 toe/USD million in 2000 to 11.2 toe/USD million in 2013. Similarly, the gas share to primary energy supply diminished to 10% in 2013 (21% in 2000). The gas import diversity sub-indicator also realised an improvement from initially 100% (with one source of gas imports), down to 24% in 2011 and started to go up again with a rise in LNG imports from Trinidad and Tobago.

The environmental indicator (same sub-indicators as for oil security) went down by three percentage points in 2013 (19%) from the 2000 level. The factor effecting the decline is the climate change sub-indicator (internal factor) of the economy as explained above in oil security. Meanwhile, the climate change sub-indicator for the gas exporters, as an external factor, earned an average of 49%.

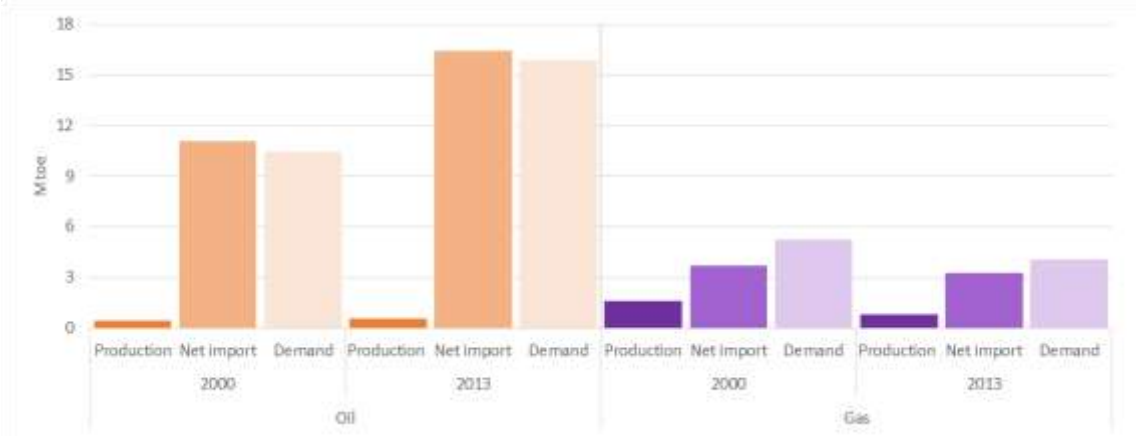
The social indicator is the lowest (lowest risk) among the other indicators, and demonstrated a downward trend (10% in 2013 from 15% in 2000). This could be attributed to the decline in gas consumption per capita, which decreased by 33% from 0.34 toe/person in 2000 to 0.23 toe/person in 2013, well below the APEC average (0.46 toe/person in 2000; 0.58 toe/person in 2013).

Import and Sources

With limited oil resources, Chile is considered to be a minor crude oil producer, thus highly dependent on imports. Crude oil imports provided around 98% of the economy's refinery demand. However, crude oil imports had slowly decreased, 0.3% annually from 2000 to 2013, which was compensated by an increase in oil product imports. Net imports for oil products rose 11% annually, which stood at 7.7 Mtoe in 2013. The economy has three refinery facilities with total capacity of 227 thousand barrels per day (kbbl/d), and was further increased to 333 kbbl/d in 2014 (OGJ, 2000-15). The economy's existing refinery capacity only produced around 55% of oil product demand in 2013 (APERC, 2015). Overall, total net oil imports (crude and oil products) went up by almost 50%, which stood at 16.4 Mtoe in 2013 from 11.1 Mtoe in 2000 (Figure 7.4).

Having modest gas reserves, the economy is able to produce only a small amount of gas. However, gas production declined by 50% in 2013, which was recorded at 0.81 Mtoe (0.9 Bcm), from the 2000 level. But with the falling gas supply requirement as a result of displacement from coal for power generation, gas imports slightly declined annually at a rate of 0.9% (Figure 7.4). Total gas imports of 3.3 Mtoe in 2013 provided about 80% of the economy's gas requirement (IEA, 2015). The economy is looking at importing LNG from the United States by 2016 with the foreseen operation of the Sabine Pass LNG export terminal (EIA, 2015).

Figure 7.4: Production, Net Imports and Demand, 2000-13



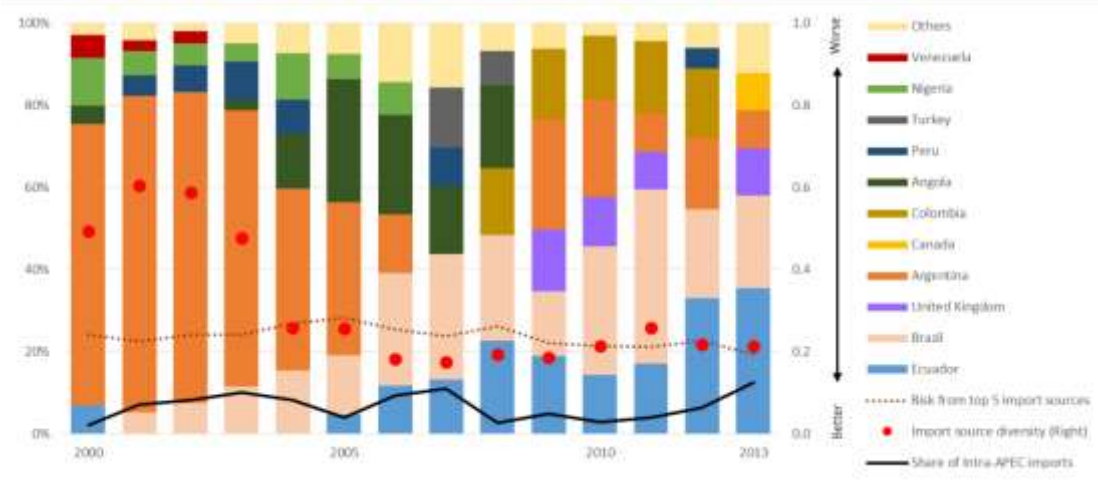
Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Crude Import Sources

Chile's diversity index for crude oil displayed significant improvement, from mid-concentration (0.49 HHI) to moderate-low concentration (0.21 HHI) (Figure 7.5). From nearly 70% import dependency on Argentinian crude oil, the economy was able to diversify its sources to others such as the United Kingdom

and Canada, and previously from Colombia, Peru and Turkey. In 2013, Ecuador was the largest supplier of crude providing 34% of the total imports. Other major suppliers were Brazil (23%), the United Kingdom (11%), Argentina (9.0%) and Canada (9.0%).

Figure 7.5: Crude Oil Import Sources, 2000-13



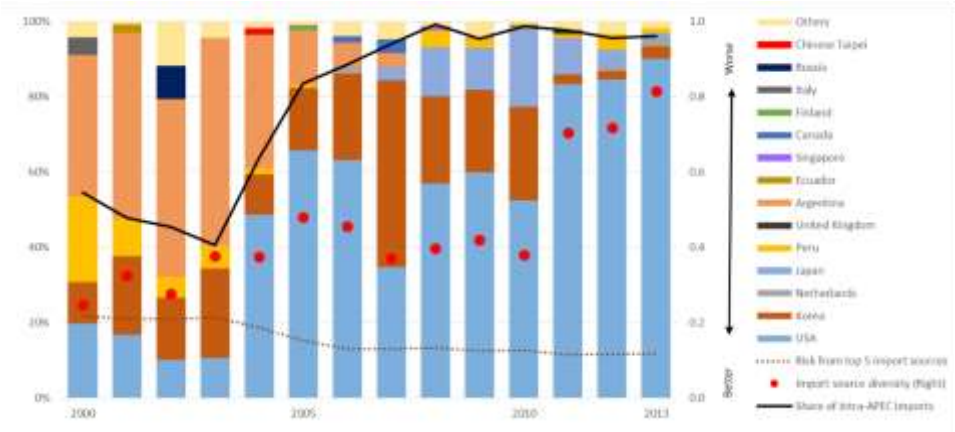
Sources: APERC analysis and UN Comtrade, 2016.

In terms of risk associated with the major exporters of crude, the economy was able to reduce the risk to 19% in 2013 (24% in 2000) due to the entry of imports from the United Kingdom and Canada, and the reduction of imports from Argentina. Considering that the economy is dependent on its neighbouring economies, intra-APEC imports remained low, although it expanded to 13% in 2013 (2.0% in 2000) largely contributed to by Canada imports.

Oil Product Import Sources

The United States has become the major source of oil product imports for the economy, beginning in 2004 with about half of total oil product imports. The share of the United States to total imports aggressively increased to 90% in 2013, from 20% in 2000, displacing imports coming from Argentina and later on from Korea and Japan. Given this, the diversity index worsened to about 0.81 HHI in 2013 from only 0.25 HHI in 2000 (Figure 7.6). However, the risk from major sources dropped by half following the increase in imports from the United States. The risk level in 2013 stood at 12% from 25% in 2000 when the bulk, about 38% of total imports, came from Argentina. Intra-APEC imports expanded to 96% in 2013 (54% in 2000), which was also contributed to by imports from Japan; Korea; and, Peru.

Figure 7.6: Oil Product Import Sources, 2000-13

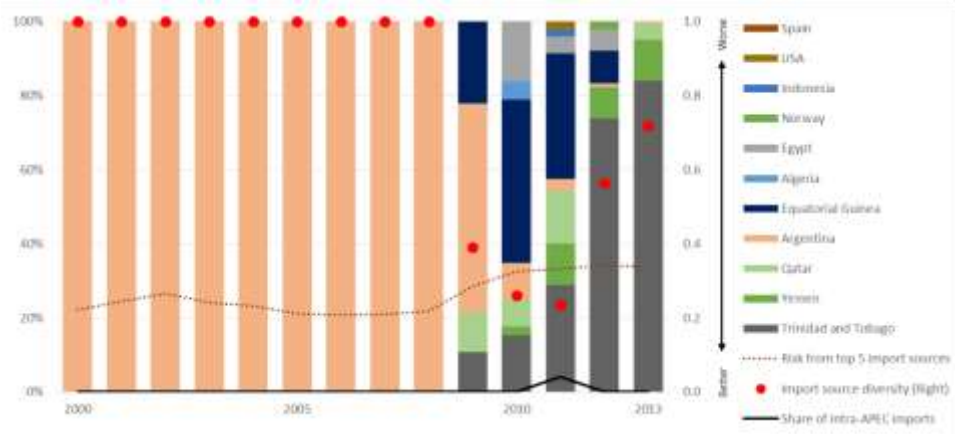


Sources: APERC analysis and UN Comtrade, 2016.

Gas Import Sources

Initially in the historical period, the economy sourced its gas imports mainly from Argentina via trans-border pipelines. But with the development of a RGT in 2009, the economy started receiving gas imports in the form of LNG. Eventually, the share of Argentinian gas fell to about 1.0% of total imports in 2013 (which was also due to declining gas production of Argentina). It was replaced by LNG imports from Trinidad and Tobago with more than 80% share in total gas imports in 2013, Yemen with 11% and Qatar with 4.0%. Equatorial Guinea was also a major source of LNG imports until 2012. With the changes in import sources, the diversity index improved from 1.0 HHI in 2000 to 0.24 HHI in 2011, but climbed to 0.72 HHI in 2013 as the economy's LNG imports were concentrated more on Trinidad and Tobago (Figure 7.7). Risk from gas exporters worsened to 34% in 2013 (24% in 2000) caused by gas imports from Yemen. Intra-APEC imports were only noted in 2010 (4.0%) as a portion of the LNG imports came from the United States (2.0%) and Indonesia (2.0%) during this year.

Figure 7.7: Natural Gas Import Sources, 2000-2013



Sources: APERC analysis and Cedigaz 2016.

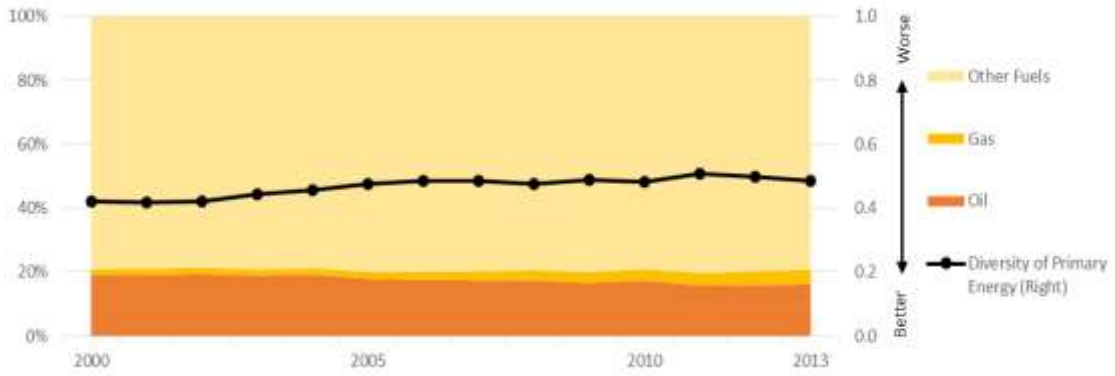
CHINA

Economy-Energy Overview

China is one of the world's largest economies occupying a total land area of 9.6 million square kilometres (km2) with a total population of 1.4 billion in 2013 (NBS, 2015). The economy's gross domestic product (GDP) in 2013 was recorded at USD 15 700 billion (USD 2010 Price and Purchasing power parity [PPP]), which grew by more than three times from the 2000 level (WB, 2015; EDMC, 2015).

The economy is also rich in energy resources both in fossil fuels and renewable energy. The economy has total coal recoverable reserves of 114.5 billion tonnes (Bt), proven oil reserves of 18.5 billion barrels (Bbbl), and natural gas proven reserves of 3.5 trillion cubic metres (Tcm) (BP, 2015). The economy has also great potential for unconventional fossil fuels, specifically shale gas, which could boost its energy resources. However, the economy has relatively low reserves per capita compared with the global average – coal at 84 tonnes (only 68% of the global average), oil at 13 barrels (5.6%) and natural gas at 2,569 cubic metres (cm) (9.9%).

Figure 8.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

With expanding economic activity, the economy's primary energy supply surged significantly, with almost a threefold increase from 1,161 million tonnes of oil equivalent (Mtoe) in 2013 to 3,009 Mtoe in 2013. The economy's energy supply mix has been dominated by coal, about two-thirds of the total in 2013. Oil contributed 16% to the total supply mix, gas 5.0%, and renewables 11%, of which 25% was hydro (IEA, 2015). With this, the economy's supply mix has a mid-concentration diversity index based on HHI of 0.50 in 2013 (Figure 8.1).

The oil supply requirement of the economy displayed an upward trend, which doubled in 2013 (486 Mtoe) from the 2000 level of 221 Mtoe, equivalent to an annual growth rate of 7.6%. The economy is the world's second largest oil consumer, and second largest oil net importer (EIA, 2015). It is projected that the oil supply requirement will peak post 2030, and starts to gradually decline due to continuous structural optimization of traditional industry sectors and the implementation of energy efficiency improvements that help reduce oil demand in other sectors, as well as the expanding share of less-energy intensive manufacturing compared with the declining shares of most intensive sectors (APERC, 2016).

Like oil, the gas supply requirement went up significantly at 16% per year from 21 Mtoe (23 billion cubic metres [Bcm]) in 2000 to 140 Mtoe (156 Bcm) in 2013 as a result of growing gas utilisation in the industry, transport and building sectors, thus increasing the gas share to 5.0% of the primary energy supply mix from only 2.0% in 2000. Although domestic gas production had increased at 12% annually, the economy started to import gas in 2006, and it increased enormously at an 76% annual growth rate reaching 42 Mtoe (47 Bcm) in 2013 from merely 0.8 Mtoe (0.9 Bcm) in 2000. The future gas supply requirement is projected to expand further, increasing annually at 5.5% until 2040 and increasing its share to 13% of the energy supply requirement. This could be attributed to the replacement of coal by gas in the industry and building sectors, and the capacity expansion of gas-fired power plants (APERC, 2016).

Energy intensity fell by 25%, which stood at 191.7 tonnes of oil equivalent energy (toe) per USD million GDP (toe/USD million) in 2013 compared with the 2000 level of 255.1 toe/USD million based on the primary energy supply requirement. In the same year, energy consumption per capita more than doubled, which registered at 2.2 toe/person from 0.9 toe/person in 2000 (EGEDA, 2015).

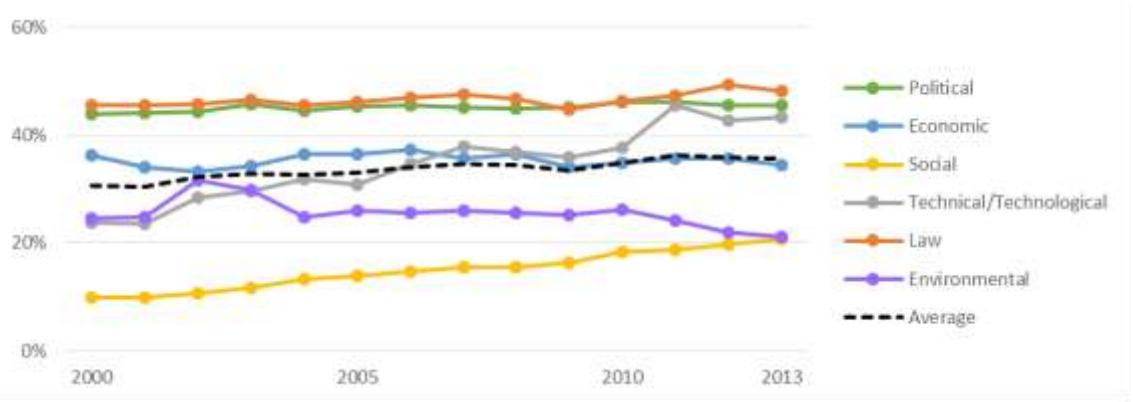
Oil Security

Overall, China's oil security index is still at moderate-low exposure with an index value of 36% in 2013 (Figure 8.2). Earning a low index means lower exposure to supply disruption risk. However, it may be noted that the security index had been deteriorating (increasing index and thus the risk) over the historical period, from 31% in 2000.

The law indicator had the highest risk among the six indicators at 48% (mid-exposure to risk), which was relatively stable (during the historical period). This indicator covered four sub-indicators with one as an external factor in determining the risk level. The oil stockpiling sub-indicator obtained the highest index under the law indicator at 82% as the reported oil stocks were about 30 days of domestic demand, considered low compared with other APEC economies (APERC, 2015). This sub-indicator will be improved in the near term as the economy intends to build more oil storage capacity for strategic reserves that could hold at least 500 million barrels of crude oil by 2020. The plan covers three phases with the first phase completed in 2009

with 103 million barrels of storage capacity; the second phase with 170 million barrels in 2017; and, the third phase with 232 million barrels in 2020 (EIA, 2015). As a goal, the economy would like to have strategic reserves equivalent to 90 days of net imports (APERC, 2015). Currently, the economy holds about 350 million barrels of commercial crude oil storage capacity (EIA, 2015). In 2015, the economy had an estimated 191 million barrels of strategic crude oil reserves located in seven above-ground facilities and one underground facility, which were built up at a time of low oil prices (FT, 2015; Reuters, 2015). Also being considered is to have a minimum stockholding obligation on industry under the National Petroleum Reserve. As proposed, the National Petroleum Reserves should be composed of government stocks and obligatory industry stocks for both crude oil and petroleum products (IEA, 2014).

Figure 8.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The other sub-indicator that contributed to the high index value for the law indicator is the resource extraction regulations. The resource extraction regulations sub-indicator was 57% in 2013 from 52% in 2000, based on the Regulatory Climate Index of the Global Petroleum Survey (GPS) that evaluates the quality of regulations such as regulatory compliance and enforcement. A higher Regulatory Climate Index means that some investors perceived the existing regulations could discourage investment. Likewise, the "rule of law" sub-indicator as an external factor (for import sources) also had a high index, 48% in 2000 to 52% in 2013. Using the Worldwide Governance Index (WGI) of the World Bank (WB), specifically on the quality of contract enforcement and property rights of the different economies, revealed that oil exporters to the economy for both crude and oil products had gained higher results in "rule of law." In particular, Angola and Iran had higher index for crude oil, and Venezuela for oil products.

The political indicator received an index of 45% historical average (46% in 2013). Contributing factors for this indicator are the local stability, exporter's stability (import sources), the absence of international/multilateral agreements on oil security and piracy (both as internal and external factors). The local stability sub-indicator, based on WGI regarding perceptions on the likelihood of political instability, rose

to 61% (moderate-high risk) in 2013 from 55% in 2000. A high index means that the economy has a high perception on the likelihood of having an unstable political climate. As for the exporter's stability sub-indicator (external factor), the index was more than 50%, as some exporters to the economy were also perceived as not having a better political environment. The chokepoint sub-indicator (external factor) also posed a risk, although was still low at 11%, on average, based on the share to total imports, specifically from Middle East import sources and Angola. As the economy has no known international/multilateral agreements, this sub-indicator is high as well.

The technical/technology sub-indicator showed an increasing trend (increasing risk), from 24% in 2000 to 43% in 2013 (from moderate-low exposure to mid-exposure to risk). The indictor included six sub-indicators (one is an external factor). The oil reserves-production (R/P) ratio sub-indicator was among the factors that contributed to this upward trend. Over the historical period, this sub-indicator went up from 0% in 2000 to 43% in 2008 and started to gradually go down to 21% in 2013. This could be attributed to continuous growth in oil production to meet domestic demand, but no additional reserves came in as oil fields were maturing, thus the reserves-production ratio was rising. Only in 2009 where additional oil reserves were accounted, and every year thereafter, there were modest additions to reserves until 2013. The economy's oil fields are matured and now likely to experience declining production. However, the use of enhanced oil recovery (EOR), new production from offshore and small discoveries in existing basins contributed to a modest increase in reserves and production. The economy has been investing on EOR techniques (i.e., water injection and polymer and steam flooding) for the matured fields to make up for declining production. If the economy wants to enhance its oil reserves and production, huge investment would be required for developing new oil fields in deep-water and tight oil extraction (EIA, 2015). At current oil reserves, production could be sustained for up to 16 years.

As domestic oil production could not catch up with the increase in demand, the economy's oil self-sufficiency had been steadily declining with import dependency increasing over the historical period. As such, this sub-indicator under technical/technology went up to 57% in 2013 from 24% in 2000. The crude import dependency level rose to 58% in 2013 from 28% in 2000, although import dependency on oil products remained at a low level, only 5.0% in 2013. The low dependency on oil product imports was credited to having large refinery capacity, more than enough to meet domestic requirements. In 2013, the refinery utilisation rate stood at 71%. The refinery utilisation rate sub-indicator is seen to further improve with the addition of 680 thousand barrels per day (kbbl/d) refinery capacity in 2015 (EIA, 2015).

On the other hand, the trans-border oil pipeline utilisation sub-indicator showed an increasing trend, which significantly surged from 0% in 2005 to 100% in 2013, which could be translated to full capacity pipeline operation. The economy operated its first trans-border oil pipeline in 2006 to receive imports from Kazakhstan and Russia. Initially, the pipeline capacity was 200 kbbl/d and expanded to 400 kbbl/d in 2013. Another trans-border pipeline was built in 2011 to transport oil imports from Russia (from east Siberian new

oil fields). The pipeline is a 597-mile spur line, which can deliver 300 kbbl/d of Russian oil. This sub-indicator could be improved as a new oil import pipeline was constructed in 2015 with a capacity of 400 kbbl/d connected to Myanmar oil fields. This pipeline is also planned to serve as an alternate transport route for Middle East crude to avoid the Strait of Malacca as a potential chokepoint. Around 80% of the economy's crude oil imports passes through this route (EIA, 2015).

The economic indicator (with 10 sub-indicators) remained steady at 35%. One of the main contributors to this indicator is the total oil net imports over demand sub-indicator, which the index had been constantly rising, reaching 62% in 2013 from 34% in 2000. This was a result of growing reliance on imports, specifically for crude oil as explained above. The oil intensity sub-indicator also obtained a high result at 51% in 2013, but had dropped significantly from a high of 83% in 2000. The economy's oil intensity decreased by 36%, from 48.6 toe/million 2010 USD in 2000 to 30.9 toe/million 2010 USD in 2013. A reduced oil share was recorded in power generation, industry and even transport, which affected the oil intensity. The oil intensity sub-indicator is determined relative to the intensity level of other APEC economies (highest and lowest), and the changes (highest recorded) in the economy's intensity level over the historical period. The "Ease of Doing Business" sub-indicator (from World Bank) deteriorated (improved) by 11 percentage points, 40% in 2013 from the 2000 level of 51%, while the oil pricing sub-indicator, which considered the presence of subsidies as a potential risk, was likewise high.

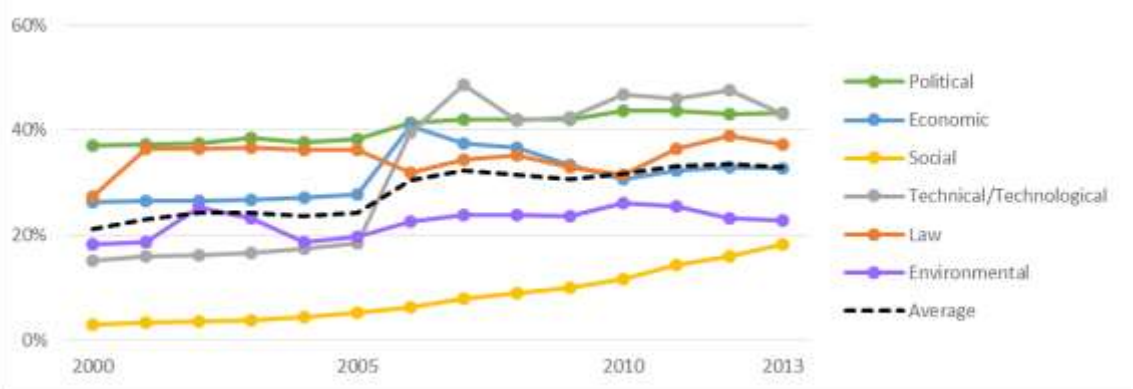
As the economy's oil consumption per capita had been rising over the historical period, it caused the social indicator (only the oil consumption per capita as a sub-indicator) to increase, registering 21% in 2013 from only 10% in 2000. Oil consumption per capita was recorded at 0.18 toe/person in 2000 and went up to 0.36 toe/person in 2013, which were below the APEC average (0.78 toe/person in 2000; 0.80 toe/person in 2013). The same as in the oil intensity, the oil consumption per capita index is measured based on the oil consumption per capita of other APEC economies (highest and lowest level), and the historical variation in per capita level of the economy.

With regard to the environmental indicator, the climate change sub-indicator (internal factor) of the economy earned 41% in 2013, lower by nine percentage point from the 2000 level as reported by the Notre Dame Global Adaptation Index (ND GAIN). The decrease could be seen as an improvement in the economy's, exposure, adaptive capacity and readiness for climate change that could have impact on oil supply security. There was also improvement in the climate change sub-indicator (external factor) of oil exporters to the economy, from 44% in 2000 to 40% in 2013.

Gas Security

The average gas supply security index is also within the moderate-low exposure, and a bit lower, at 33% in 2013, than the oil security index (Figure 8.3). However, a significant jump in the security index was observed in 2006 at 30%, from 24% the previous year. The increase in 2006 was triggered mainly by the technical/technology indicator, which was 44% in 2013, up from only 16% in 2000. The index for this indicator also sharply went up to 39% in 2006 from the previous year's level of 19%. This indicator covered eight sub-indicators with two under the external factors. The factors that pushed up the indicator's index are the regasification terminal (RGT) utilisation rate and the liquefied natural gas (LNG) export terminals' utilisation rate of gas exporters (external factor) sub-indicators. The economy constructed and operated its first RGT in 2006, and since then gas imports in the form of LNG surged dramatically. The economy became the third largest LNG importer in the world, after Japan and Korea, representing around 8.0% of global LNG consumption (IEA, 2015). As LNG imports grew, the RGT utilisation rate increased from 23% in 2006 to 50% in 2013; the highest utilisation rate was recorded in 2010 at 70%. RGT capacity in 2013 stood at 48 billion cubic metres per year (Bcm/y), and expanded to 54 Bcm/y the following year. Additional capacity of 45 Bcm/y is expected to be in operation in 2017, which could improve the index for this sub-indicator in the future (EIA. 2015). Meanwhile, the LNG exporter terminal utilisation rate sub-indicator likewise earned a high index as LNG terminals of gas exporters showed higher utilisation rates, such as Qatar and Australia. Further, the economy's underground gas storage capacity (sub-indicator) was nearly at full capacity, hence received a 97% index in 2013.

Figure 8.3: Gas Supply Security Index, 2000-13



Source: APERC analysis.
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economy had ramped up its gas imports via pipeline, exceeding LNG imports. As a result, the utilisation rate of existing gas pipelines had been increasing during the historical period, recorded at 42% in 2013 (24% in 2010), which also contributed to the increase of the technical/technology indicator. The first trans-border gas pipeline of the economy was the Central Asian Gas Pipeline (CAGP) connecting to Turkmenistan, Uzbekistan and Kazakhstan through three parallel lines and began transporting gas in 2010, specifically from Turkmenistan. The current capacity of CAGP is 54 Bcm/y, initially only 31 Bcm/y in 2010. Gas imports from Uzbekistan started in 2012. The economy is also importing gas from Myanmar that began in mid-2013 through 11.9 Bcm/y pipeline capacity. And as the economy signed gas supply agreements with Russia in 2014, imports of gas through pipelines are expected to rise with the construction and operation of additional pipelines in 2018 under these agreements, specifically coming from west and east Siberia gas fields (EIA, 2015).

It was observed that the gas reserves-production ratio (R/P) sub-indicator (under the technical/technology indicator) had been growing on a year-on-year basis, as production increased much faster than reserves. The gas R/P sub-indicator grew to 58% in 2013 from 0% at the beginning of the historical period. Historically, production grew at a faster rate of 12% annually, while reserves only rose annually at around 7.0%. It is estimated that the lifespan of gas proven reserves would be as much as 25 years (APERC, 2016). To boost its gas reserves, the economy has been exploring and developing complex and technically challenging frontier areas – deep-water, gas from coal seams (coalbed methane/CBM), and shale gas (EIA, 2015). The first deep-water field came online in 2014 and CBM production is still at the early stages of development. The economy is seen to have huge potential for unconventional gas resources, specifically shale gas. In 2011, the economy declared that shale gas is an independent mineral resource so as not to be covered by administrative procedures for conventional gas to encourage greater private investment in shale projects. The Guidance Catalogue of Foreign Investment and Industry has been modified to categorize foreign investment participation in shale gas projects as an "encouraged investment," thereby these projects will be granted preferential and fiscal measures (APERC, 2016).

Another factor that contributed to the abrupt spike in the gas security is the economic indicator composed of six sub-indicators. The indicator rose (increased risk) to 34% from 27% in 2000, but the large jump was observed in 2006 at 42% from the previous year's level of 28%. This could be attributed to the gas import diversity sub-indicator earning 100% in 2006 as Australia was the only source of gas imports during that time. Thereafter, declining gradually as other gas imports came in from Turkmenistan, Qatar, Malaysia, Indonesia, etc.

The political indicator (same sub-indicators in oil security) was high at 44% in 2013 (from 38% in 2000), particularly influenced by local stability and exporter's stability sub-indicators. Similarly to oil, the local stability greatly affected the economy's political indicator as explained above. On the other hand, the exporter's stability received an index of 46% in 2013 (32% in 2006) due to increasing gas imports from

Turkmenistan, replacing a portion of Australian imports. Turkmenistan had a higher local stability index under the WGI than Australia.

The law indicator demonstrated an escalating trend reaching 37% in 2013 from 28% in 2000. This indicator has three sub-indicators (one as an external factor) in assessing the risk level. As in the oil security, the Regulatory Climate Index of the GPS for the economy was high, therefore affecting the law indicator. The "rule of law" sub-indicator (external factor) had an increasing index for the exporters of gas to the economy. Among the gas exporters, Turkmenistan and Indonesia had higher index in "rule of law" under the WGI. In the gas emergency preparedness sub-indicator, the economy improved from 25% in 2000, and down to 0% beginning in 2010 with the construction and operation of pipelines as another way of receiving gas imports, coupled with the capacity expansion of RGT.

The environmental indicator (same sub-indicators in oil security) earned a relatively lower result (second to the lowest), compared with the other indicators with 23% in 2013, although displayed an increasing trend. Mainly, the increase was caused by the rising index value of the climate change sub-indicator for the gas exporters, 51% in 2013 from 24% in 2006. From the gas exporters, risk on climate change was high for Turkmenistan and Indonesia. On the other hand, the internal risk on climate change for the economy, as discussed in oil security, had improved over the historical period.

The social indicator had the lowest risk at 18% in 2013, a significant increase 2000 level of 3.0%. The primary contributing factor for the social indicator is the gas consumption per capita, which grew considerably because of the increasing share of gas in the primary mix. Gas consumption per capita of the economy was still at a low level compared with oil, only 0.02 toe/person in 2000 to 0.10 toe/person, way below the APEC average (0.46 toe/person in 2000; 0.58 toe/person in 2013). However, gas consumption per capita might expand in the near future as the economy plans to boost the share of gas to total energy supply to at least 10% by 2020 (EIA, 2015). This would also displace some amount of pollution as gas displaces coal use. In 2013, gas share to total primary energy supply was registered at 5.0% (IEA, 2015).

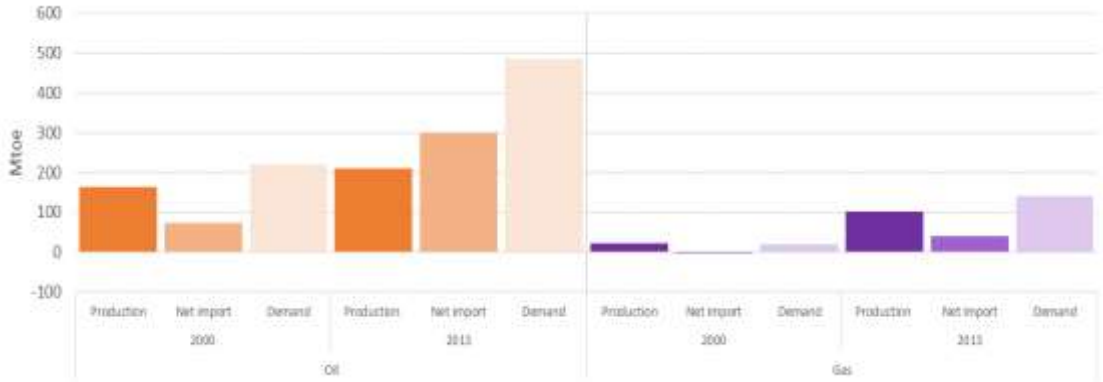
Import and Sources

China's production of crude oil is not enough to meet its domestic refinery demand, which only grew at 2.0% annually from 2000 to 2013. To compensate for the shortfall of domestic crude production, the economy has relied on imports with a fourfold increase in 2013 (282 Mtoe) from the 2000 level, demonstrating a growth rate of 11% annually. Consequently, net imports sharply climbed by almost five times resulting in import dependency to progressively rise to 58% in 2013, from only 28% in 2000 (IEA, 2015) (Figure 8.4). As for oil products, refinery output registered an annual increase of 6.8%, which brought down the economy's import dependency to 5% in 2013 (from 8.0% in 2000). The economy's refinery capacity of 13.5 million barrels per day (mmbbl) could meet more than 100% of its domestic oil product

demand in 2013 (APERC, 2015). Overall oil net imports (both crude and oil products) intensified with a 300% increase in 2013 from the 2000 level.

Despite an increase in domestic gas production (12%/year), the economy started to import gas in 2006, and it increased enormously at 76% annual growth rate reaching 42 Mtoe (47 Bcm) in 2013 from merely 0.8 Mtoe (0.9 Bcm) in 2000. From having a negative import dependency in 2000, it escalated to 2.0% in 2007 and further expanded to 28% in 2013. Net imports rose by about two-thirds, which stood at 39 Mtoe (44 Bcm) in 2013 from 1.2 Mtoe (1.3 Bcm) in 2000 (Figure 8.4). As discussed above, the economy is receiving gas imports from transitional gas pipelines and in the form of LNG.

Figure 8.4: Production, Net Imports and Demand, 2000-13



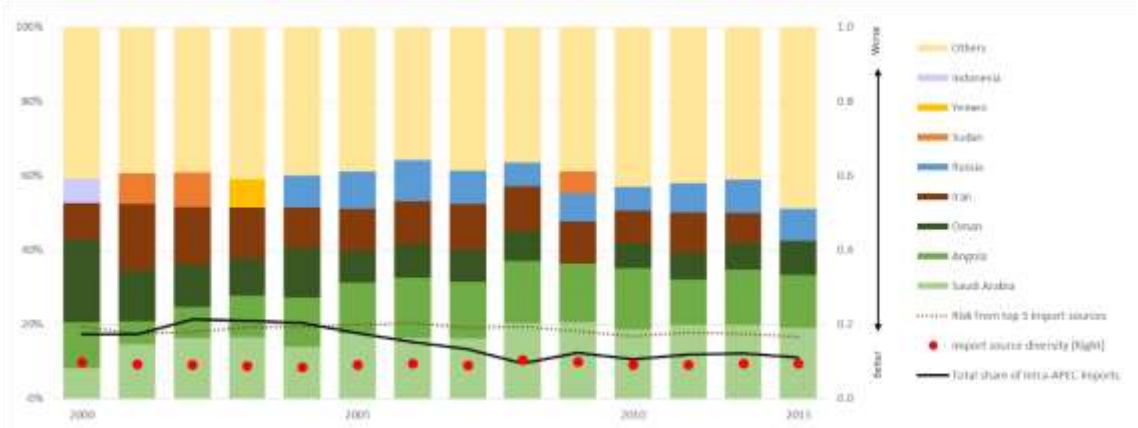
Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Crude Import Sources

China's import sources for crude oil are extremely diversified with an index of 0.09 (very low concentration) in 2013, which remained stable over the historical period (Figure 8.5). Major crude oil exporters to the economy in 2013 were Middle East producing economies such as Saudi Arabia (19%) and Oman (9.0%). Previously, Iran provided 8.0% of total crude imports (2012) of the economy. Initially, Oman was the primary source of Middle East crude, a 20% share to total imports in 2000, but slowly the share dwindled as the amount of crude from Saudi Arabia increased. In the same year (2013), Angola contributed 14% of the total imports, while Russia sent about 9.0%. The economy started getting crude from Russia in 2004 to further diversify its import sources.

Looking at the risk associated with the top five import sources, the risk was still low at 17% in 2013, down from 19% in 2000. Such low risk could be credited to well-diversified sources that somehow offset the imports coming from high-risk crude oil import sources, such as those from the Middle East. Meanwhile, the intra-APEC import share remained at a low level, only 11%, and mostly contributed to by imports from Russia.

Figure 8.5: Crude Oil Import Sources, 2000-13

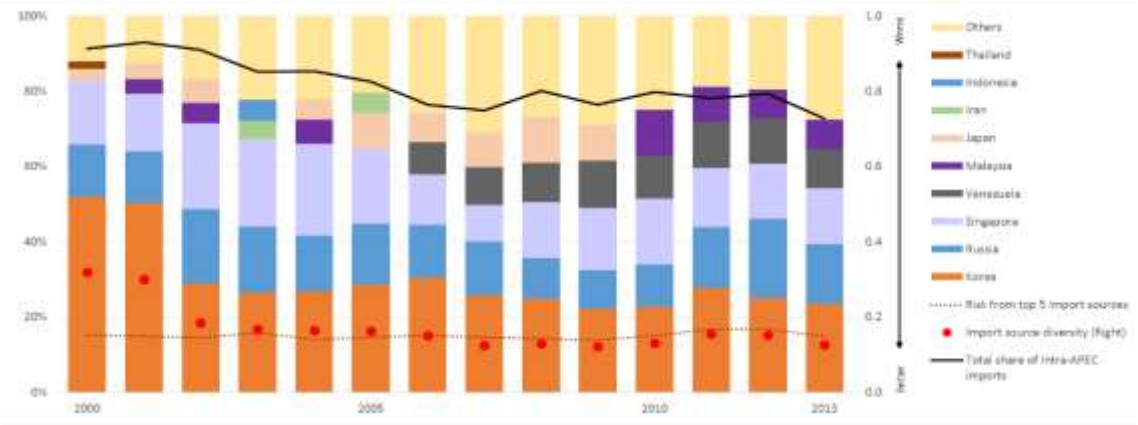


Sources: APERC analysis and UN Comtrade, 2016.

Oil Product Import Sources

Korea has been a major exporter of oil products to China. However, the share of imports from Korea diminished to 24% in 2013 from more than half in 2000 with increased imports from other existing sources, like Singapore; Russia; Malaysia; and, Japan. This was coupled with the entry of imports from Venezuela in 2006. With reduced imports from Korea, the diversity index improved by about 50%, from 0.32 HHI in 2000 to 0.13 HHI in 2013 (Figure 8.6). The top five exporters of oil products in 2013 were Korea (24%); Russia (16%); Singapore (15%); Venezuela (10%); and, Malaysia (8.0%). Over the historical period, the risk related to the top five import sources could be considered low at 15%, on average, as it balanced the risks among high- and low-risk import sources. In 2000, the intra-APEC share was more than 90% of total imports with Korea contributing significantly, but gradually declined to 73% in 2013. Venezuela imports contributed to the decline.

Figure 8.6: Oil Product Import Sources, 2000-13



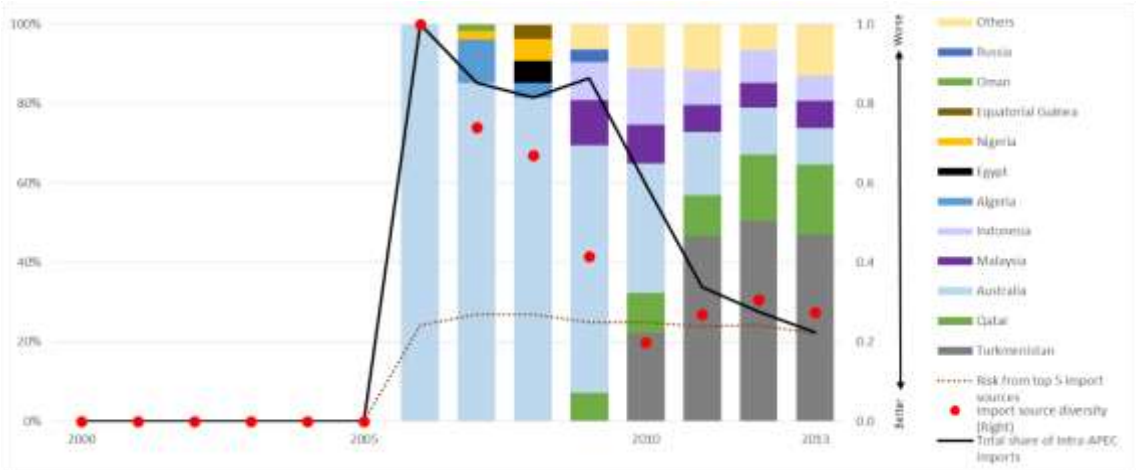
Sources: APERC analysis and UN Comtrade, 2016.

Gas Import Sources

As discussed above, the economy began to import gas in 2006, all coming from Australia. In the succeeding years, imports from Australia were reduced to around 80% with the coming of other sources like Algeria, Egypt, Oman, Nigeria, Equatorial Guinea and even Russia. The imports from these sources were later replaced by Malaysia, Indonesia and Qatar in 2009, and Turkmenistan through pipeline imports in 2010 that also further decreased imports from Australia. As the economy diversified its gas import sources, the diversity index greatly improved to 0.27 HHI (moderate-low concentration) from highly concentrated import sources in 2006 (1.0 HHI) (Figure 8.7). In 2013, Turkmenistan became the major exporter of gas, almost half of total gas imports. Australia's share to total gas imports was registered at 8.0% of the total; Qatar at 18%; Malaysia at 7.0%; and, Indonesia at 6.0%. The risk associated from gas exporters was at moderate-low concentration, 22% in 2013 from 24% in 2000.

As the shares of Turkmenistan and Qatar gas imports expanded, the intra-APEC import share dropped to 22% in 2013 from a high of 100% in 2000 when Australia was the sole exporter of gas. Malaysia and Indonesian gas imports likewise declined from initial shares of 12% and 9.0% in 2009, respectively.

Figure 8.7: Natural Gas Import Sources, 2000-2013



Sources: APERC analysis and Cedigaz 2016.

HONG KONG, CHINA

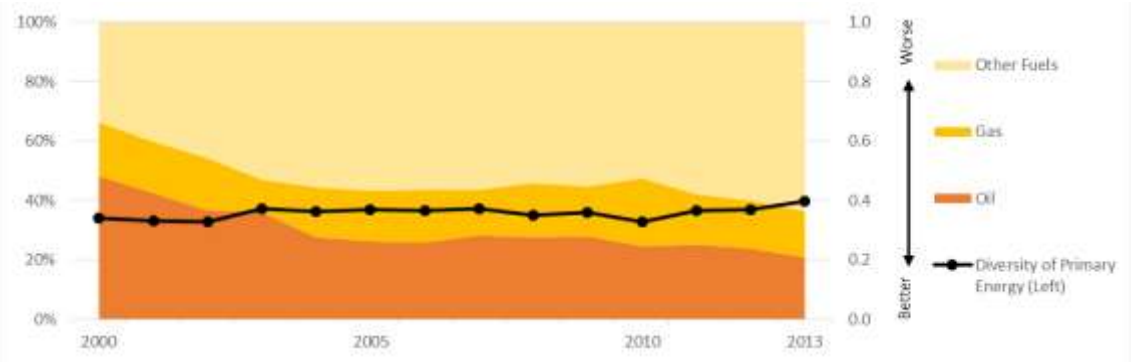
Economy-Energy Overview

Hong Kong, China is a special administrative region of the People's Republic of China with 7.2 million population in 2013, exhibiting an annual growth rate of only 0.6% during the last 13 years (2000-13). In the same year, gross domestic product was at USD 363.8 billion (2010 Price and Purchasing Power Parity [PPP]), considered among the highest in the Asia-Pacific Economic Cooperation (APEC).

The economy lacks energy resources, specifically fossil fuels, and with no oil refineries, thus relies on imports to meet domestic energy needs. The total primary energy supply was recorded at 13.9 million tonnes of oil equivalent (Mtoe) in 2013, only 3.0% higher than 2000. Coal maintained the highest share to total primary energy supply (57%), followed by oil (21%), gas (16%) and other sources (6%) (EGEDA, 2015). From this energy mix, the diversity index in 2013 was at 0.40 HHI (at the boundary of moderate-low concentration), from 0.34 in 2000 (Figure 9.1). Increasing coal share triggered the increase in the diversity index.

The oil supply requirement had been on a downward swing, which stood at 2.9 Mtoe in 2013 from 6.5 Mtoe in 2000, a decrease of 56%. This reduction was contributed to largely by decreasing oil demand from the industry sector, which fell by almost 60% over the historical period, and the transport sector with oil demand lower by around 40%. The oil supply requirement is foreseen to remain almost stagnant, increasing only by 0.05% annually until 2040 (APERC, 2016).

Figure 9.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

On the other hand, the natural gas supply requirement also dropped by 12% reaching 2.2 Mtoe (2.4 billion cubic metres [Bcm]) in 2013 from 2.4 Mtoe (2.7 Bcm) in 2000. However, gas demand is projected to accelerate significantly at a rate of 4.4% annually with its share to primary energy increasing to 50% in 2040 from only 16% in 2000 due to gas replacing coal (APERC, 2016).

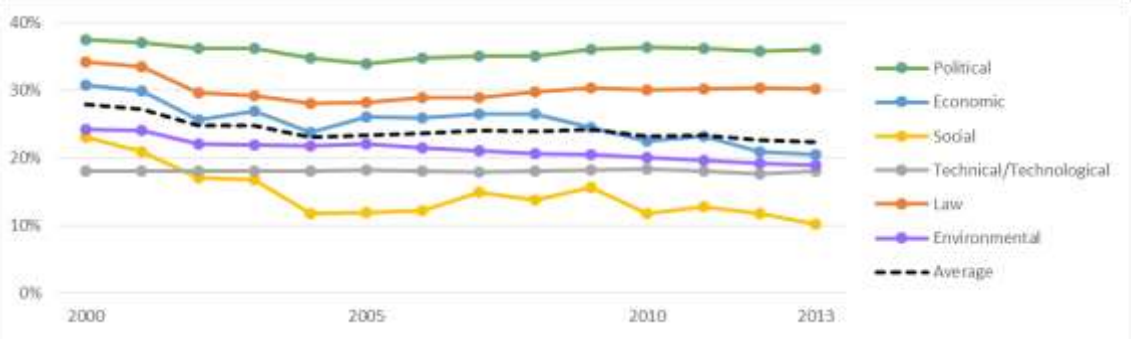
Energy intensity improved by 37% in 2013, which stood at 38.3 toe/USD million in 2013 from 61.0 Mtoe in 2000. The economy has set a target of reducing energy intensity by 40% below the 2005 level by 2025 (EB, 2015). Similarly, primary energy per capita declined by 5.0% in 2013, 1.9 toe per person (toe/person) from 2.0 toe/person in 2000 (EGEDA, 2015).

Oil Security

Hong Kong, China's oil security index improved by six percentage points at 22% in 2013 from 28% in 2000 (Figure 9.2). A low index means lower exposure to supply disruption risk. The political indicator earned the highest risk at 36%, a slight decrease from the 2000 level of 38%, among the other indicators used in this study. The indicator considered six sub-indicators, three sub-indicators assigned each to internal and external factors. In the absence of international/multilateral agreements on oil security, the economy received a higher index in this sub-indicator. The local stability was stable at 31%, on average, over the historical period, while the exporter's stability sub-indicator as an external factor for oil exporters realised a decreasing trend (36% in 2013; 50% in 2000). This could be attributed to the entry and increasing shares of oil exporters with better local stability situation, such as Japan and Chinese Taipei. The local stability is based on the ranking of the World Governance Index (WGI) by the World Bank (WB) on the perception regarding the likelihood of political instability.

The law indicator (with three internal sub-indicators and one as an external factor) also displayed a downward trend (declining risk) (30% in 2013; 34% in 2000), mainly contributed to by external factor, the "rule of law" sub-indicator." The index of this sub-indicator fell to 29% in 2013 (45% in 2000) which could be influenced by entry and increased shares to total imports of those oil exporters with better standing in "rule of law" of the WGI. In the WGI "rule of law," economies are evaluated on the quality of contract enforcement, property rights, etc., that could pose a risk to supply security. The oil stockpiling sub-indicator was high, more than 90%, for having lower oil stocks compared with other APEC economies. Right after the oil crisis in 1970s, the economy decided to have legislative and administrative arrangements to address any supply disruption. These arrangements include a voluntary code of practice in 1982 between oil companies and town gas that sets maintaining strategic reserves for gas oil and naphtha equivalent to 30 days of retained imports from the previous year (ENB). Town gas is another fuel product being used in the economy which is manufactured locally using naphtha and natural gas as feedstock (Town gas, 2013).

Figure 9.2: Oil Supply Security Index, 2000-13



Source: APERC analysis.
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economic indicator, consisting of 10 sub-indicators, improved (decreasing risk) by 11 percentage points, from 31% in 2000 to 29% in 2013. The oil intensity sub-indicator contributed significantly as demonstrated by a sharp drop, 17% in 2013 from a high of 64% in 2000. The economy's oil intensity fell by 73%, 8.0 toe/USD million in 2013 from 29.4 toe/USD million in 2000. This also resulted in a declining trend for oil share to primary energy as a sub-indicator (21% in 2013; 48% in 2000). The decline (both oil intensity and oil share) was a result of decreasing demand from the industry and transport sectors (as explained above). The oil intensity took into account the historical changes in the economy's intensity level (highest recorded), and its level relative to other APEC economies (based on highest and lowest levels). The diversity index for oil product import sources (as a sub-indicator) likewise greatly improved, 21% in 2013 from 91% in 2000. The sub-indicator on "Ease of Doing Business" of WB earned 11% in 2013 (13% in 2000), thus having a favourable business climate that could contribute to reducing risk.

The environmental indicator, which covered the climate change and natural disaster sub-indicators (both applied as internal and external factors), was 19% in 2013 (24% in 2000) following an improvement in the climate change sub-indicator of the economy, which dropped to 41% in 2013 (from 49% in 2000). A very large decrease had been observed for climate change sub-indicator for oil exporters (27% in 2013; 47% in 2000) due to better index (on climate change) of some of the oil exporters, such as Singapore and Japan. This sub-indicator used the Notre Dame Global Adaption Index (ND-GAIN), which evaluates different economies on exposure, readiness and adaptive capacity to climate change impact.

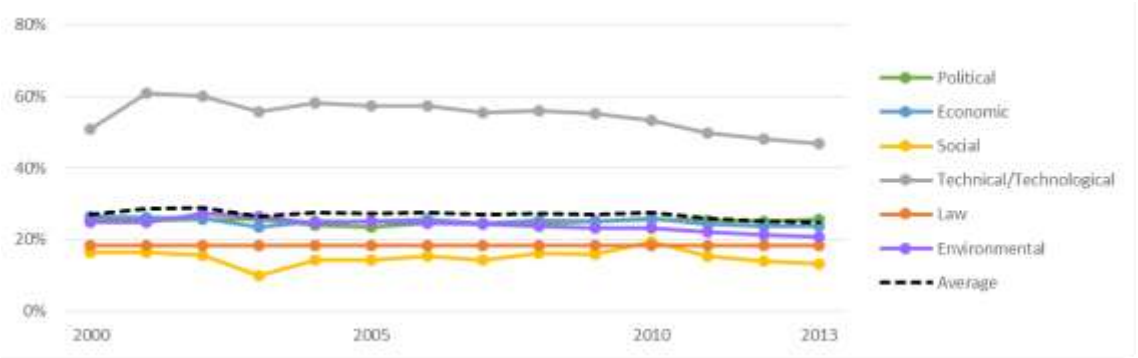
The technical/technology indicator had been stable at 18%, on average, over the historical period. This indicator is made up of six sub-indicators, one of which is under external factor. The logistics efficiency sub-indicator was steady at 21%, which is anchored on the Logistics Performance Index (LPI) of WB that assesses trade infrastructure, logistics quality, competence, among others. Since the economy has no oil resources, the reserves/production ratio sub-indicator was also high.

On the other hand, the social indicator (with only one sub-indicator – the oil consumption per capita) earned the lowest at 10% in 2013, a decrease of 13 percentage points from the 2000 level (23%). Oil consumption per capita notably fell by nearly 60% in 2013, 0.47 toe/person from 0.98 toe/person in 2000. The 2013 oil consumption per capita level was below the APEC average of 0.80 toe/person. The methodology used in determining the index for oil intensity was also applied in oil consumption per capita.

Gas Security

Hong Kong, China obtained a higher index in gas security at 25% in 2013 (moderate-law exposure category), and had been on a downward trend from a high of 27% in 2000 (Figure 9.3). The technical/technology indicator reaped the highest risk at 47% in 2013 (51% in 2000). For the gas security, this indicator covered eight sub-indicators (two under external factor). This indicator went up as high as 61% in 2001 before it started to decline. The gas production rate sub-indicator (as an external factor) was the main reason for such a trend. This sub-indicator rose to 74% in 2001 (from 0% in 2000) as the gas production rate of China, the only exporter of gas, only expanded less than the increase in import quantity requirement of the economy. However, this gradually dropped (reaching 0% in 2013) following an increase in China's gas production, and at some point decreasing import requirements of the economy during the historical period. The trans-border gas pipeline utilisation rate sub-indicator demonstrated a decreasing trend, fell to 63% in 2013 from 95% in 2000. The utilisation rate even reached 100% in 2008, but began to decrease with the additional capacity in 2010. As the economy does not maintain underground gas storage, this sub-indicator earned a high index value. Similarly, with no gas resources, the reserves-production ratio sub-indicator is also high.

Figure 9.3: Gas Supply Security Index, 2000-13



Source: APERC analysis.
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The political indicator (similar sub-indicators as in oil security) recorded the second highest index at 25%, historical average. Although the economy has no international/multilateral agreements on gas

security, this sub-indicator was given 50% due to its political nature as being part of China, and thus the risk is shared (with China) during any supply disruption. The exporter's stability likewise contributed at 61% in 2013 (55% in 2000). The economy's local stability also added to political indicator as explained in the oil security index.

The economic indicator (with only six sub-indicators) realised a small improvement, 24% in 2013 from 26% in 2000. One of the contributing factors is the gas intensity sub-indicator, which fell to 28% in 2013 (51% in 2000), following a decline of 46% in the economy's intensity level. The gas intensity decreased to 5.9 toe/USD million in 2013 from 11 toe/USD million in 2000. This also caused a reduction in gas share to primary energy (sub-indicator) to 16% in 2013 (18% in 2000). As the economy only relied on one source of gas imports, the import diversity (sub-indicator) was 100%.

The environmental indicator decreased from 25% in 2000 to 21% in 2013, mainly due to climate change sub-indicator as an external factor. China, as the only gas exporter, improved its climate change index in ND-GAIN over the historical period.

Meanwhile, the law indicator, which is composed of three sub-indicators (one as an external factor) had been stable at 18%, on average. The gas emergency preparedness sub-indicator is the main contributor to the law indicator. This sub-indicator was 50% with the existence of gas pipelines with China.

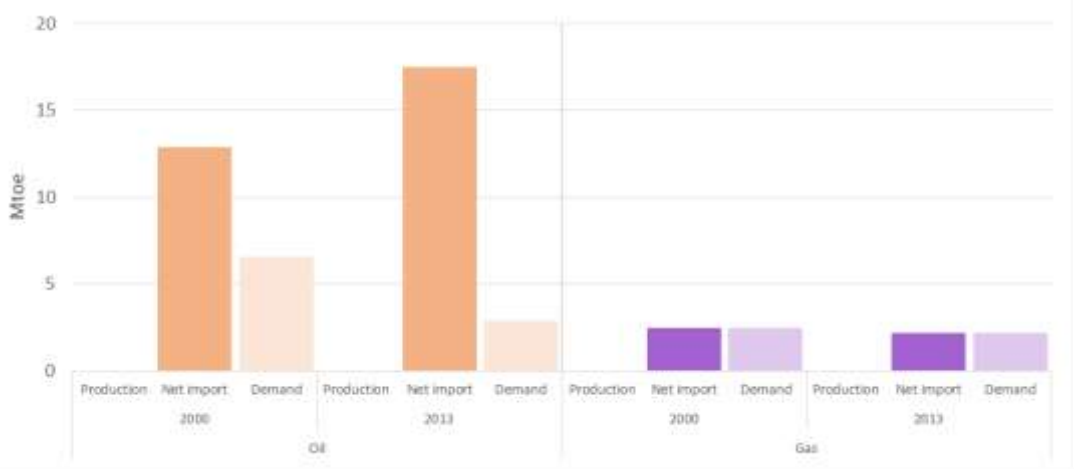
As the gas supply requirement saw a decline over the historical period, the social indicator had a lowest index (13% in 2013 from 16% in 2000). The gas consumption per capita decreased by 18%, 0.30 toe/person in 2013 from 0.37 toe/person in 2000, lower than APEC average (0.58 toe/person).

Imports and Sources

With no oil resources and refinery facilities, Hong Kong, China has been dependent on oil product imports. Although the oil supply requirement had been decreasing, imports still increased annually at 1.8% reaching 18.2 Mtoe in 2013 (14.5 Mtoe in 2000). The economy imported more than its domestic requirement (which had been declining over the historical period), thus some imports were re-exported. However, export volume decelerated by more than half, which stood at 0.73 Mtoe in 2013. Overall net imports of oil products escalated by 36%, 17.5 Mtoe in 2013 from 12.9 Mtoe in 2000. The net import level in 2013 was six times that of domestic demand (Figure 9.4).

Relatedly, the economy relies on gas imports for its domestic demand. China exports gas to the economy via pipeline. Gas imports demonstrated a downward trend, falling at a rate of 1.0% annually during the historical period. Total gas imports in 2013 were recorded at 2.2 Mtoe (2.4 Bcm), lower by 12% from 2.4 Mtoe (2.7 Bcm) in 2000 (Figure 9.4).

Figure 9.4: Production, Net Imports and Demand, 2000-13

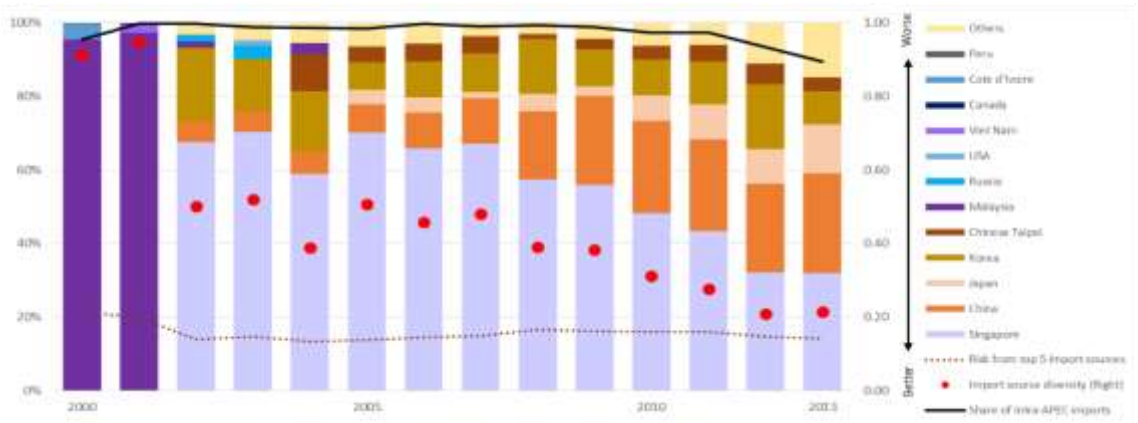


Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Oil Product Import Sources

Initially, the economy was heavily dependent on oil product imports from Malaysia, which contributed more than 90% of total imports in 2000 and 2001 (Figure 9.5). However, imports from Malaysia were eventually displaced with the entry of imports from Singapore; Korea; and, China in 2002, and later from Chinese Taipei in 2004 and Japan in 2005. In 2013, Singapore accounted for 32% of total imports, while China provided 27%; Japan 13%; Korea 9.0%; and, Chinese Taipei 4.0%. It was also observed that Singapore's share to total imports fell from 68% in 2002 resulting from expanding shares of other exporters such as China and Japan. Following this trend in import sources, the economy's diversity index improved to 0.21 HHI in 2013 from a high of 0.91 HHI in 2000.

Figure 9.5: Oil Product Import Sources, 2000-13



Sources: APERC analysis and UN Comtrade, 2016.

The risk level from import sources fell to 14% in 2013 (21% in 2000) resulting in substantial shares of those exporters with a better local stability situation, such as Singapore and Japan. Intra-APEC imports declined to 85% in 2013 (95% in 2000) with remaining import requirements were sourced outside APEC region.

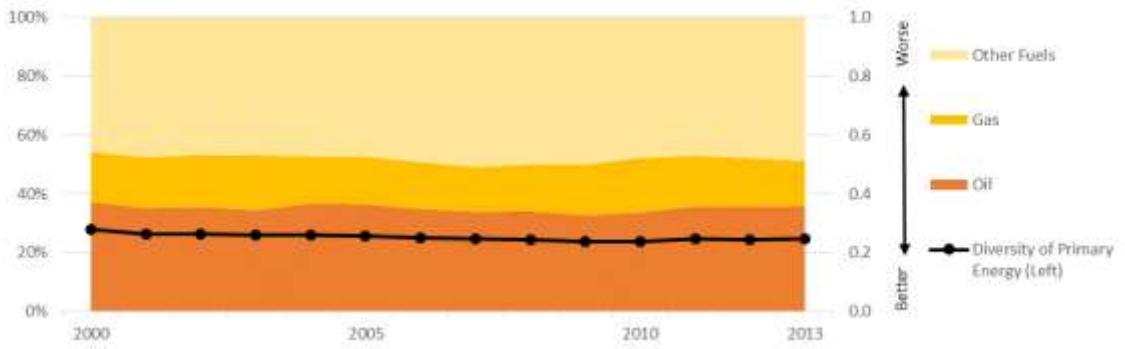
INDONESIA

Economy-Energy Overview

Indonesia is a large archipelago located in Southeast Asia covering a total land area of 7.9 million square kilometres and with a total population of around 251 million in 2013. The economy's gross domestic product (GDP) grew annually at 5.4%, on average, which stood at USD 2,381.7 billion (USD 2010 Price and Purchasing Power Parity [PPP]) in 2013 from USD 1,203.3 (USD 2010 Price and PPP) in 2000 (WB, 2015; EDMC, 2015). The economy is also a member of the Group of Twenty (G20).

Indonesia is rich in fossil fuel resources making the economy the world's largest coal exporter and fourth-largest coal producer, and fifth-largest liquefied natural gas (LNG) exporter and tenth-largest gas producer. For crude oil, the economy's production has been declining due to maturing fields and a slower reserve replacement rate caused by declining investment. The replacement rate of oil reserves significantly decreased to 47% in 2013 (EIA, 2015). The two largest oil fields have undergone enhanced oil recovery (EOR) application to boost production (Jakarta Post, 2012). The decreasing production resulted in the decision to exit from being a member of the Organization of Petroleum Exporting Countries (OPEC) in 2009. In December 2015, the economy re-joined OPEC.

Figure 10.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

The economy's primary energy supply requirement grew at 2.5% annually, reaching 214 Mtoe in 2013 from 156 Mtoe in 2000. Oil contributed about 37% to total primary energy supply in 2013, gas 15%, coal 15%, and renewables 34%, the bulk of which was biomass. From this energy supply mix, the economy's diversity index is at moderate-low concentration based on HHI of 0.25 in 2013 (Figure 10.1).

The oil supply requirement of the economy demonstrated an upward trend, 2.2% annually, translating to 77 Mtoe in 2013 from 58 Mtoe in 2000. Meanwhile, the economy's crude oil production had progressively decelerated to 42 Mtoe in 2013, 40% lower than 2000. The proven oil reserves of the economy were 3.7 billion barrels of oil (Bbbl) in 2013 (BP, 2015). It is projected that the economy's oil requirement will keep on increasing at a higher growth rate of 3.2% until 2040 (APERC, 2016).

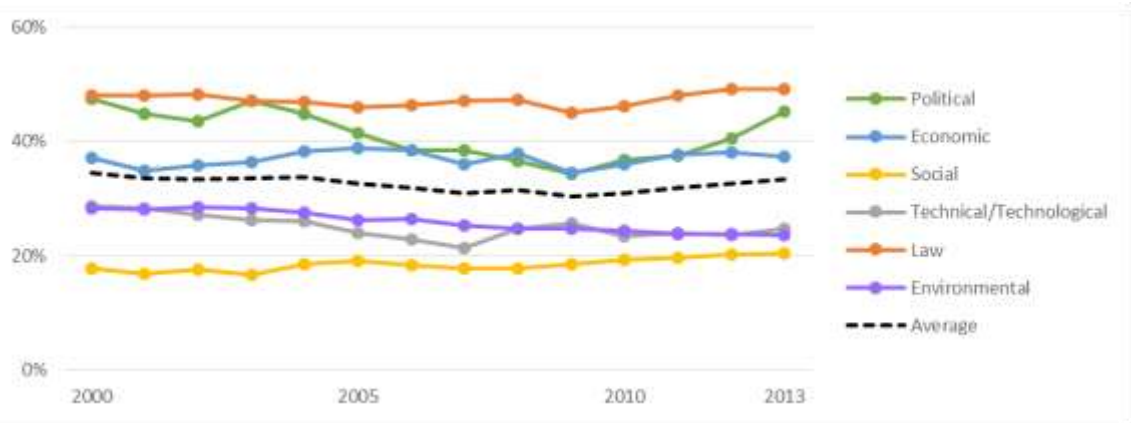
The gas supply requirement, on the other hand, exhibited a slower growth rate, rising at 1.6% annually – 33 Mtoe (37 billion cubic metres [Bcm]) in 2013 from 27 Mtoe (30 Bcm) in 2000. Although the economy's gas production expanded slightly at 0.2% annually, the output could still cover more than twice that of domestic gas demand. Gas reserves estimates were placed at 2.9 trillion cubic metres (Tcm) (BP, 2015). The economy's future gas requirement is seen to grow much faster at 5.0%, expanding its share to 21% of the energy supply requirement in 2040 (APERC, 2016).

The economy's energy intensity improved by 31% from the 2000 level of 129.3 tonnes of oil equivalent (primary energy) per USD million GDP (toe/USD million) to 89.7 toe/USD million in 2013. The primary energy per capita was 0.85 toe/person in 2013 from 0.74 toe/person in 2000 (EGEDA, 2015).

Oil Security

Indonesia's oil security index was 33% in 2013, a moderate-low exposure, a bit lower than the 2000 level of 35% (Figure 10.2). Obtaining a low index is translated to lower supply disruption risk. From the six indicators used for this study, the law indicator earned the highest risk at 49%, on average. This indicator made used of four sub-indicators with one as an external factor. The resource extraction sub-indicator gained a high and increasing trend at 74% in 2013 (66% in 2000). This sub-indicator assessed the perception on the quality of policy regulations that deter investment on upstream activity (exploration and development of resources) based on the Regulatory Climate Index of the Global Petroleum Survey (GPS). Having a high index means that the existing policies have strong restraining effects on investment. Existing policies could be one of the several factors for the insufficient investment in unexplored areas such as licensing approvals at the regional level of government, the issuance of permits and land acquisition (EIA, 2015). However, the economy is now taking steps to further promote exploration in offshore and frontier regions by providing incentives to reduce risks such as a higher equity split between the government and contractors, 35% for oil and up to 40% for gas as production shares to the contractor, and other financial incentives. The economy is also intending to simplify the process of obtaining permits and licenses through the creation of a "one-stop-shop" (APERC, 2016).

Figure 10.2: Oil Supply Security Index, 2000-13



Source: APERC analysis.
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

In the strategic oil stockpiling sub-indicator (under the law indicator), the economy 88% as the level of stock is relatively low compared with other APEC economies. Through its state-owned oil company, the PERTAMINA, the economy requires that oil companies should maintain 22 days of operational oil stock based on domestic oil demand (IEA, 2014). This sub-indicator may improve once the plan to strengthen the stockpiling system through the creation of economy-wide energy reserve system is realised. There are three classifications under the proposed reserve system:

- Energy Strategic Reserves composed of energy resources to be held and regulated;
- Energy Buffer Reserves for public emergency stocks to be held by the government, equivalent to 30 days of net imports; and,
- Operational Reserves to be provided by the industry, around 21-23 days of stocks, and private companies, 21 days of operational stocks (IEA, 2014a).

The "rule of law" sub-indicator as an external factor (law indicator) exhibited a decrease reaching 40% in 2013 from 44% in 2000. Based on the World Governance Indicator (WGI) on "rule of law" aspect, specifically on the quality of contract enforcement from the exporter's side, the economy modestly improved its situation by sourcing more imports from low-risk exporters for both crude oil and oil products.

The political indicator obtained 45% index in 2013 (47% in 2000), although initially decreasing reaching 35% in 2009, and after which began to rise again. This indicator utilised six sub-indicators, three sub-indicators assigned each as internal and external factors. The piracy sub-indicator (as an internal factor) contributed to the trend in the political indicator, which took into account the number of incidences of piracy attacks. At the beginning of the historical period, the economy only had an index of 32% and slowly went down to 4.0% in 2009 as the incidence of piracy improved, but started to increase up to 53% in 2013. The local stability sub-indicator received 90% in 2000 and went down to 60% in 2013 (high index means lower

stability) as the political environment improved. This sub-indicator also made use of WGI on the likelihood of having an unstable political climate. Meanwhile, the exporter's stability sub-indicator (as an external factor) rose to 49% in 2013 (45% in 2000) with increasing imports from Azerbaijan, Nigeria and even from Turkey for crude oil imports. As the economy being part of the ASEAN Petroleum Security Agreement (APSA), the international/multilateral agreements on oil security sub-indicator is low, although at 50% as the said agreement has not been put to test during actual oil supply disruptions. But having this security agreement, which the economy and the other ASEAN member states can request for assistance during oil supply emergencies, contributes to lowering the risks.

The economic indicator (with 10 sub-indicators) displayed a steady trend at 37%, on average. The presence of fuel subsidies in oil pricing (as a sub-indicator) contributed significantly to the index value for the economic indicator. Its implementation could be a risk to the economy as lower oil prices might encourage more consumption without considering any conservation efforts or judicious use, which could push demand beyond supply. The fuel subsidy represents at least 7.0% of the economy's annual budget since 2005 (EIA, 2015). This sub-indicator may decline with the new policy that took effect in 2015 that removes subsidies for gasoline with an octane rating of 89 RON, and applying a fixed subsidy for diesel oil with an octane rating of 48. Said policy intends to reduce fuel consumption, and consequently imports (APERC, 2016).

The oil intensity sub-indicator (under economic indicator) showed a declining trend (improvement in risk level) (60% in 2013, 92% in 2000) following an improvement of 33% in the economy's intensity level, from 48.1 toe/USD million in 2000 to 32.2 toe/USD million in 2013. This sub-indicator is assessed based on the intensity level (highest and lowest level) of other APEC economies including historical variations in the economy's intensity level (highest recorded). Meanwhile, as the economy became a net oil importer (total oil) in 2004, the total oil net imports over demand sub-indicator increased drastically to 46% in 2013 from 0% in 2000. On the "Ease of Doing Business" of the World Bank (WB) as a sub-indicator, the economy was able to improve its business climate exhibiting a decreasing index, from 70% in 2000 to 41% in 2013. On the other hand, the diversity index sub-indicator had a stable result for crude oil import sources, while for oil products, it escalated to 32% in 2013 (29% in 2000) with expanding imports from Singapore.

The technical/technology indicator received 25% in 2013, lower by four percentage points from the 2000 level. This indicator considered six sub-indicators (one assigned as an external factor). The oil reserves-production (R/P) ratio sub-indicator dropped to 5.0% in 2013 (23% in 2000) not because of increasing reserves, but due to the declining production, which registered a much faster decreasing rate than reserves. At the current level of reserves, production could still be covered for about 12 years. With lower production, the economy's oil self-sufficiency sub-indicator went up to 15% from 0% in 2000. Also decreasing was the refinery utilisation rate sub-indicator with 85% in 2013 (91% in 2000) as a result of declining refinery output, which was being offset by expanding oil product imports. In 2013, refinery only provided around 59% of domestic oil product consumption.

The environmental indicator, which covered climate change and natural disaster sub-indicators, dropped to 24% in 2013 (28% in 2000) as the climate change sub-indicator (as an internal factor) of the economy in terms of its adaptive capacity and readiness for climate change impact improved based on the Notre Dame Global Adaption Index (ND-GAIN). The sub-indicator index fell to 50% in 2013 from 60% in 2000. Improvement in the climate change sub-indicator index (external factor) for exporters of oil was likewise observed with increasing imports and the entry of exporters that are less vulnerable in terms of climate change impact.

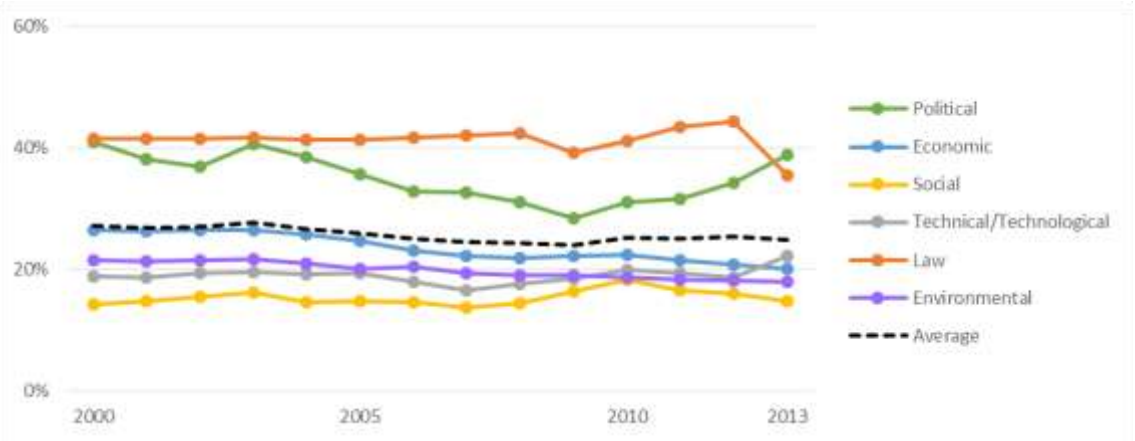
The social indicator (with only one sub-indicator) climbed to 20% in 2013 from 18% in 2000 as a result of growing oil consumption per capita. The economy's oil consumption per capita was up by 11%, 0.30 toe/person in 2013 from 0.27 toe/person in 2000. The per capita level was below the APEC average of 0.78 toe/person in 2000 and 0.80 toe/person in 2013. Similar to the oil intensity, it is computed relative to other APEC economies' oil consumption per capita level, as well as changes in the economy's per capita level over the historical period.

Gas Security

The economy achieved a much lower risk in gas security at 25% in 2013 from 27% in 2000 (Figure 10.3). The political indicator (same sub-indicators used in oil security) obtained the highest risk, among the indicators, at 39% in 2013 (from 41% in 2000), and follows the same trend in oil security (political indicator). The local stability of the economy and incidence of piracy contributed to the political indicator, which are already explained above. As APSA may also include gas supply security, the same index is given in the international/multilateral agreement on gas security sub-indicator, equivalent to the oil security.

The law indicator (with three sub-indicator with one assigned as an external factor) earned the second highest risk at 35% in 2013, a decline from 42% in 2000. The primary reason for the decrease could be attributed to the improvement in the gas emergency preparedness sub-indicator. The operation of the economy's first LNG regasification terminal (RGT) in 2013 with a capacity of 5.0 billion cubic metres per year (Bcm/y) improved the gas emergency preparedness sub-indicator. In the following year, another RGT was built with a capacity of 7.0 Bcm/y. The economy plans to import LNG starting 2018 to meet its rising gas demand. The economy has entered into a contract with Cheniere Corpus Christi (United States) to receive a total of 2.0 Bcm/y of LNG for a period of 20 years beginning 2018 (Platts, 2014). At the moment, the current RGT facilities serve the domestic power plants and industrial customers in Java and Sumatra (EIA, 2015). Another sub-indicator that also influenced the law indicator is the resource extraction regulations as already discussed in the oil security portion.

Figure 10.3: Gas Supply Security Index, 2000-13



Source: APERC analysis.
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The technical/technology indicator had been going up, from 19% in 2000 to 22% in 2013, but initially gradually decreased to 17% in 2007. For gas, the indicator included eight sub-indicator with two are under external factors. Mainly, the gas R/P ratio sub-indicator influenced the trend in the technical/technology indicator. This sub-indicator showed a downward and upward trend as a result of erratic gas production output during the historical period. The economy has been intensifying its efforts to boost gas reserves and to have a better reserve replacement ratio for gas (than for oil). The ratio has been declining in recent years. The current gas reserves could sustain production for around 40 years. The economy is also promoting the development of unconventional gas resources such as coalbed methane (CBM) and shale gas. It is estimated that the economy has CBM resource potential of around 12.8 Tcm based on preliminary studies. The shale gas potential is expected to be explored from the results of studies conducted, and that commercial production could begin in 2020 (EIA, 2015). The absence of underground gas storage facilities resulted in a high index (for this sub-indicator). On the other hand, the operation of the RGT in 2013 already had an utilisation rate of 36%, which contributed to the technical/technology indicator. Although the economy has trans-border gas pipelines, these are being used to export gas to Singapore and Malaysia. Exports through pipelines are about 30% of total gas exports of the economy (EIA, 2015).

The economic indicator (with six sub-indicators) demonstrated a steady decline (decreasing risk) at 20% in 2013 from 26% in 2000. The gas intensity sub-indicator significantly affected the economic indicator as the intensity level dropped by 38% from the 2000 level of 22.1 toe/USD million to 13.7 toe/USD million in 2013. However, there might be future changes in gas intensity with growing gas consumption from industry and power sectors, both accounting for the largest chunk at around 54% and 24% of total domestic consumption, respectively, in 2013. A policy on Domestic Market Obligation (DMO) has been introduced for the priority allocation of gas use in (a) oil and gas production, (b) the fertilizer industry, (c) the power

generation sector, and (d) other industrial sectors (IEA, 2014a). Gas consumption would likely expand further amidst lower spot prices of Asian gas, while the power sector is seen to demand more gas with the proposed addition of 13 gigawatts (GW) of gas-fired capacity in 2020 (EIA, 2015). In the same manner, gas share to total primary energy supply sub-indicator slightly slid down to 15% in 2013 (17% in 2000). As the economy likewise provided fuel subsidies for gas consumption (gas pricing), this sub-indicator gained a high index for the economy compared with other APEC economies not enforcing price subsidies.

The environmental indicator, using the same sub-indicators in oil security, decreased over the historical period (18% in 2013, 21% in 2000). The improvement in the economy's climate change adaptive capacity and readiness contributed to the decline as explained above (oil security).

The social indicator had been steady at 15%, on average, as gas consumption per capita remained stable at 0.13 toe/person over the historical period. The economy's per capita level was below the APEC average of 0.58 toe/person in 2013.

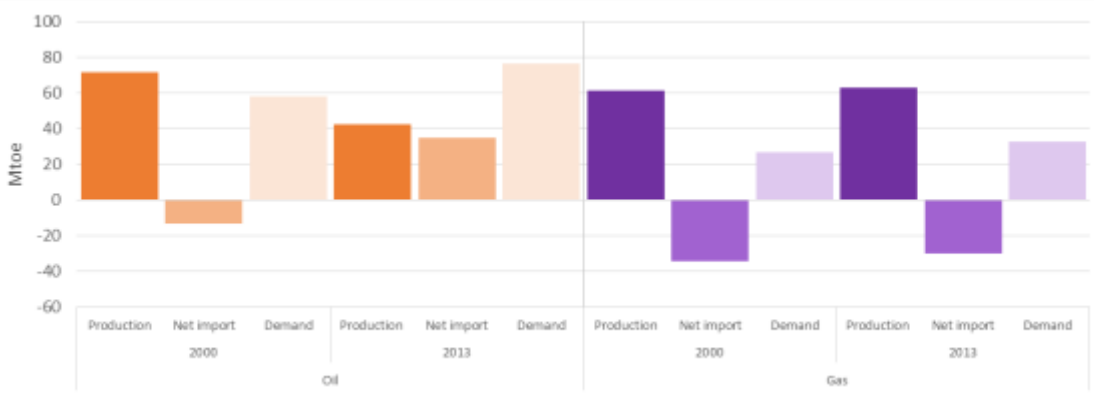
Import and Sources

Over the historical period, Indonesia's crude oil production exhibited a continuous decline that resulted in almost doubling the import requirement, and a cut of about half in export volume. Crude oil imports grew at a rate of 4.7% annually, reaching 23.4 Mtoe in 2013 (12.8 Mtoe in 2000). On the other hand, crude exports dropped to 15.9 Mtoe in 2013 (30.2 in 2000), translating to annual declining rate of 4.8%. With this, the economy became a net crude importer in 2009.[28] A similar trend is observed in oil products, increasing imports and decreasing exports. Oil product imports accelerated at a rate of 6.1% annually, translating to more than a twofold increase from the 2000 level of 12.8 Mtoe to 31.8 Mtoe in 2013, while exports of oil products dwindled annually at 5.2%. In 2013, the economy had a total refinery capacity of 1.01 million barrels per day (Mmbbl/d) with an utilisation rate of 85% in the same year (OGJ, 2000-15). With growing domestic demand, the economy is planning to expand its refinery capacity to about 1.7 Mmbbl/d. Overall, the economy became an oil net importer (combined crude and oil products) beginning in 2004, and since then net imports had been expanding significantly at 9.3% annually (until 2013) (Figure 10.4).

For natural gas, the economy's production experienced just a slight increase of 0.2%, between 2000 and 2013, with a recorded reduction in output beginning in 2010, a 16% decrease in the 2013 output level. With domestic gas consumption increasing at a faster rate (1.6% annually) than production, export volume showed a declining rate of 1.0% annually (Figure 10.4). As explained above, the economy will be building additional RGT capacity to receive LNG imports in the near future to supplement domestic supply in meeting growing gas consumption. Currently, the economy is self-sufficient in domestic gas supply as production level could still provide for its gas demand requirement.

[28] Initially, Indonesia registered higher imports than exports in 2006, but in the next two years (2007-2008) exports exceeded imports.

Figure 10.4: Production, Net Imports and Demand, 2000-13

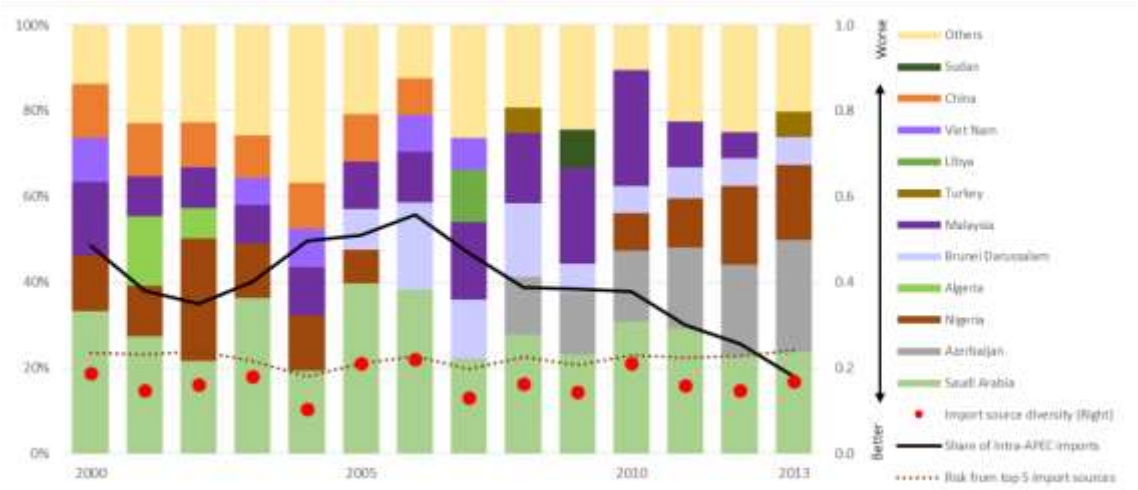


Note: Excluding international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Crude Import Sources

Indonesia's diversity index for crude import sources had improved at 0.17 HHI (low concentration) in 2013, from a high of 0.21-0.22 HHI in 2005 and 2006 (Figure 10.5). During those years with a high diversity index, the share of Saudi Arabian crude was about 40% of total imports. Saudi Arabia has been a major source of crude for the economy. However, Saudi Arabia's share to total imports slowly dwindled as the economy sourced from Brunei Darussalam in 2005 and Azerbaijan in 2008, and with the re-entry of Nigerian crude in 2010. Turkey also sent its crude to the economy in 2013. Azerbaijan over took Saudi Arabia in 2013 with a share of 26% of total imports, with only 24% for Saudi Arabia. Nigeria provided 17% of total imports, Brunei Darussalam 6.0% and Turkey 6.0%.

Figure 10.5: Crude Oil Import Sources, 2000-13



Sources: APERC analysis and UN Comtrade, 2016.

Looking at the risk from the major import sources, the level of risk was 24% in 2013, from a low of 18% recorded in 2004. In 2004, the share of Nigeria was reduced to 8.0%, which contributed to lowering the overall risk. The high-risk exporters, such as Nigeria, Azerbaijan and even Turkey were balanced out by imports from Brunei and Malaysia. Malaysian crude was part of the economy's crude import mix until 2012.

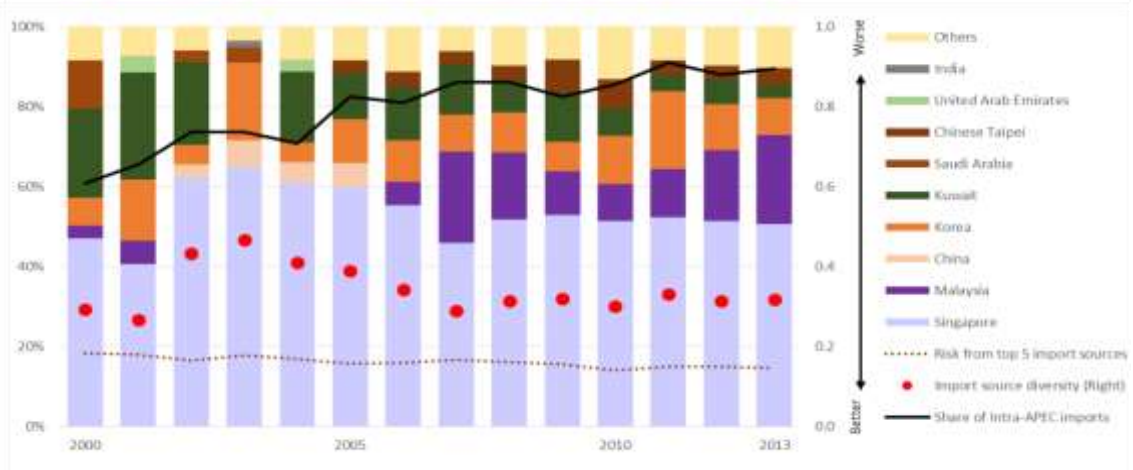
At the beginning of the historical period, the intra-APEC import share was high, with nearly half of total crude imports largely contributed to by China; Malaysia; and, Viet Nam. High intra-APEC imports occurred in 2006 with the entry and huge share of Brunei Darussalam's crude. Eventually, as the economy sourced more from outside the APEC region, the share fell to only 18% in 2013.

Oil Product Import Sources

Singapore had been the major source of oil product imports providing about half of the total during the historical period (Figure 10.6). Other major suppliers of imports in 2013 were Malaysia (22%); Korea (9.0%); Chinese Taipei (4.0%); and, Kuwait (3.0%). At some point, the economy also imported oil products from China; India; Saudi Arabia; and, the United Arab Emirates. Over the historical period, the economy's diversity index slightly increased, from 0.29 HHI in 2000 to 0.32 HHI in 2013.

The risk associated with top oil product exporters was still low at 15% in 2013 (from 19% in 2000). The reduction in risk could be attributed to expanding imports from low-risk economies such as Singapore and Chinese Taipei as compared with imports coming from other exporters. As the economy is highly dependent on oil product imports from its neighbouring economies, the intra-APEC share was high even at the beginning of the historical period at 61%, and progressively went up to about 90% in 2013, more than half of which was contributed to by Singapore.

Figure 10.6: Oil Product Import Sources, 2000-13



Sources: APERC analysis and UN Comtrade, 2016.

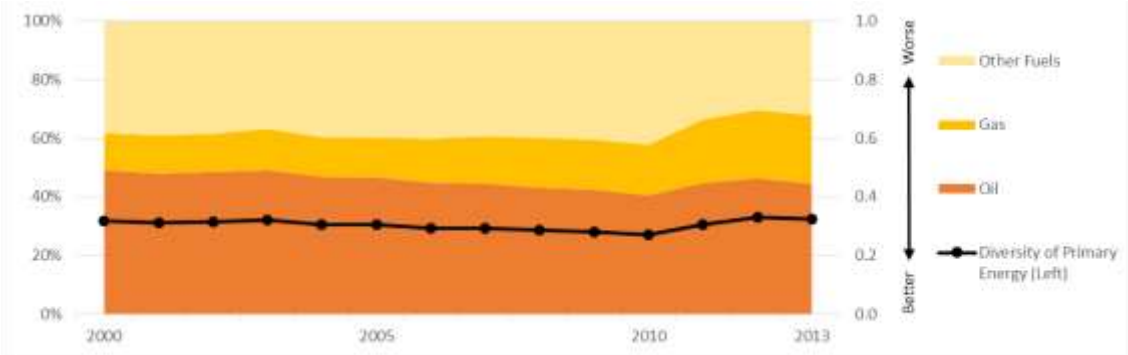
JAPAN

Economy-Energy Overview

Japan is located in Northeast Asia occupying a total land area of 377,972 square kilometres with a total population of 127 million in 2013. The economy is the third-largest economy in the world after the United States and China. The economy's gross domestic product in 2013 was recorded at USD 4,448 billion (2010 USD and Purchasing Power Parity [PPP]), which only grew annually at less than 1.0% over the 13-year period (2000-13).

Japan is a resource-scarce economy that heavily depends on imports for most of its energy resources. The economy's energy self-sufficiency level was 6.0% in 2013. In the same year, total primary energy supply stood at 455 million tonnes of oil equivalent (Mtoe), a decrease of 12% from the 2000 level of 519 Mtoe (IEA, 2015). There were two significant declines in primary energy supply, in 2008 during the economic recession and in 2011 due to the great earthquake that hit the economy. The economy gradually reduced its dependency on oil until 2010, but its share to primary energy supply increased again after the earthquake (nuclear accident) that led to the shutdown of all nuclear power plants. In order to make up for the loss of nuclear power plants, natural gas also increased its share. Oil contributed the largest share to primary energy supply at around 46%, followed by coal with 27%, and natural gas with a 23% share (IEA, 2015). From this energy mix, the economy had a 0.32 HHI (moderate-low concentration) diversity index for its primary energy supply in 2013 (Figure 11.1).

Figure 11.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

The economy's oil supply requirement displayed a downward trend before the great earthquake, decreasing at a rate of 2.3%, and picked up in the succeeding two years (2011-2012), and then declined the following year to the same level in 2010. The economy was the third-largest oil consumer in the world, next to the United States and China, consuming about 4.3 million barrels per day (Mmbbl/d) in 2013, around 5.0% of global oil consumption (BP, 2015). It is projected that the economy's supply requirement will continue to decrease at a rate of 1.4% annually until 2040 which could be attributed to fuel economy improvements in transport, fuel switching (from oil to electricity in the buildings sector) and the decreasing power generation from oil-fired plants (APERC, 2016).

The economy's gas supply requirement had been growing at 3.8% over the historical period with a significant increase of 16% noted in 2011 due to the expanded use of natural-gas fired power plants to cover the loss of nuclear power generation. The economy is endowed with a small amount of gas resources of about 21 billion cubic metres (Bcm), equivalent to only one-fifth of 2013 annual consumption (BP, 2015; OGJ, 2014). Such reserves allow the economy to produce a small volume of gas which stood at 3.0 Bcm in 2013 (IEA, 2015), about 2.6% of the total gas requirement. The increasing gas consumption is expected to decline with the restart of other nuclear power plants, displacing power generation from gas being utilised as base load power plants, but with the scheduled retirements of some nuclear power plant facilities after 2025, the need for gas will increase again (APERC, 2016).

Being an energy-efficient economy, energy intensity fell by 21%, reaching 102.2 tonnes of oil equivalent energy per USD million GDP (toe/USD million) in 2013 compared with the 2000 level of 129.6 toe/USD million based on the primary energy supply requirement. Likewise, primary energy per capita decreased by 13% in 2013, which registered at 3.6 toe/person from 4.1 toe/person in 2000 (EGEDA, 2015).

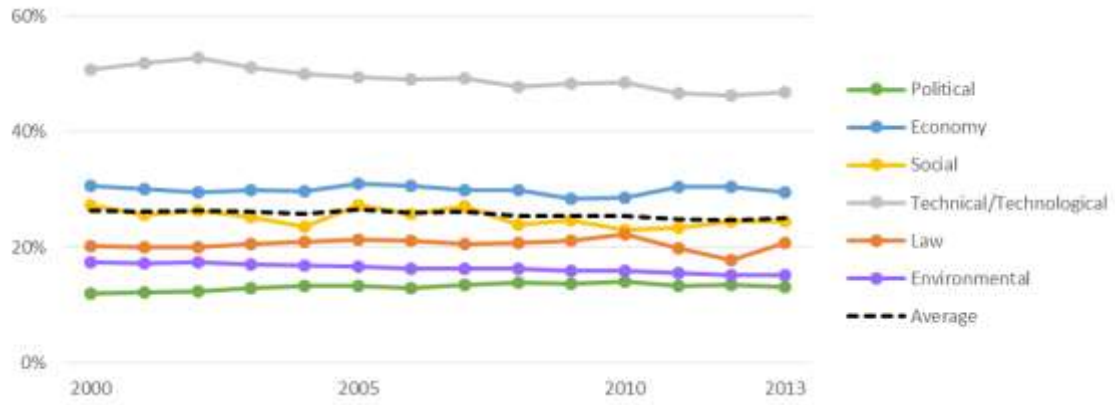
Oil Security

Japan's oil security index had been steady during the historical period with a slight decrease from 26% in 2000 to 25% in 2013 (Figure 11.2). A low index means lower risk on supply disruption. The economy earned high risk in the technical/technology indicator, 47% in 2013 from 51% in 2000, the highest among the indicators used in this study. This indicator utilised five sub-indicators as part of internal factors, and one sub-indicator as external factor. Given its limited oil resources, the economy had high index in the reserves-production ratio and oil self-sufficient sub-indicators. As of 2013, the economy had oil reserves of around 44 million barrels (Mmbbl), which allowed a very small amount of oil production of about 131 thousand barrels per day (kbbl/d) (OGJ, 2014). Over the historical period, production decelerated by nearly 30%, from 2000 to 2013, and only provided 0.4% of refinery demand. To augment the limited oil resources, the government allows oil companies to participate in the exploration and production projects overseas to secure a stable supply of oil (as well as gas). The Japan Bank for International Cooperation (JBIC) offers

loans for upstream companies at favourable rates to encourage them to bid for projects in hydrocarbon-producing economies (EIA, 2015). On the other hand, the economy's 28 refinery facilities with total capacity of 4.4 million barrels per day (Mmbbl/d) were already operating at 87% utilisation rate in 2013, from a high of 94% in 2005, which resulted in a high index for the refinery utilisation rate sub-indicator (OGJ, 2000-15).

The economy earned better standing in the logistics efficiency under the Logistics Performance Index (LPI) of the World Bank (WB), which looks at logistics quality and competence relating to trade, among other factors. The economy was among the top three in the APEC region in the LPI in 2013 with high performance in trade logistics. With highly diversified crude oil import sources, the economy had realised a lower and decreasing trend in the oil production rate sub-indicator (external factor) from 21% in 2000 to 4.0% in 2013. This sub-indicator assessed the production rate of crude oil exporters, as to whether the production levels were on an increasing or decreasing trend.

Figure 11.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economic indicator (with 10 sub-indicators) received an index of 31%, on average. Both the oil share to primary energy supply and oil intensity sub-indicators displayed decreasing indices. As the economy's oil supply requirement had been decreasing (except in 2011 and 2012 due to the great earthquake), the oil share to primary sub-indicator declined from 49% in 2000 to 45% in 2013. Similarly, the oil intensity sub-indicator went down to 47% in 2013 (66% in 2000). Oil intensity was improved by nearly 30%, 45.5 toe/USD million in 2013 from 63.7 toe/USD million in 2000. The Top-Runner Program contributed significantly to such improvement. Said Program was expanded in 2013 with the partial amendment of the Energy Conservation Law of 1979 now covering energy consuming items that contribute to high efficiency or energy conservation, such as building insulation materials.

When it comes to diversity of import sources (under the economic indicator), the crude oil import diversity sub-indicator slightly increased (18% in 2013; 16% in 2000), while for oil product import diversity

sub-indicator decelerated (16% in 2013; 24% in 2000). *Please see discussion below on imports and sources.* The economy has a better business environment receiving a 22%, on average, in the "Ease of Doing Business" of the WB (as sub-indicator).

The social indicator declined (decreased risk) to 25% in 2013 from 28% in 2000 due to a reduction in the oil consumption per capita sub-indicator. In 2013, the economy's oil consumption per capita stood at 1.6 toe/person, a decrease of 21% from the 2000 level of 2.0 toe/person. However, the economy's per capita level was still high compared with APEC average of 0.80 toe/person in 2013.

Meanwhile, the law indicator, composed of four sub-indicators (one as an external factor) received a 20% historical average. One of the contributing factors is the oil strategic stockpiling sub-indicator. As of December 2013, the economy held oil stocks equivalent to 157 days of net imports, which was over the stockholding of 90 days required by the International Energy Agency (IEA) (IEA, 2014). The economy holds public strategic petroleum reserves (SPR) and enforces a minimum stockholding requirement to industry. Initially, the Oil Stockpiling Act only covered crude oil but was expanded to include even oil products, such as gasoline, diesel oil, kerosene, and fuel oil. Refineries, distributors and importers are obliged to hold 70-90 days of average daily imports, sales or petroleum production from the previous 12 months, and 70 days of oil stocks for industry (IEA, 2014a). The 70-day oil stock of industry was relaxed to 67 days after the earthquake (EIA, 2015). The economy also obtained low index in oil emergency preparedness sub-indicator with the creation of the National Emergency Strategy Organization (NESO), which sets the institutional structure and arrangements in dealing with oil supply disruptions/emergencies (APERC, 2015). One of the response measures in the event of a supply emergency is embodied in the Oil Stockpiling Act Amendments in 2012, which require the mobilization and releasing of oil stocks and liquefied petroleum products not only to address a shortage of oil supply from overseas, but also in the event of a supply shortfall in the economy resulting from any disaster (METI, 2012). The economy also signed lease agreements with oil producing economies (like Saudi Arabia and the United Arab Emirates) for crude oil storage to store 6.3 million barrels for each of these producers. The agreement is for three years with a priority to purchase oil during supply disruption (EIA, 2015).

The "rule of law" sub-indicator, an external factor under the law indicator, had 44% (from a high of 46%), resulting from the dominance of Middle East crude oil imports, as well as from oil product exporters (with a high index in "rule of law"), such as India, etc. Russia also exports crude to the economy via the 2,900-mile Eastern Siberia-Pacific Ocean (ESPO) pipeline (EIA, 2015). This sub-indicator was based on the World Governance Indicator (WGI) by the WB, which evaluates the quality of contract enforcement by the different economies.

The environmental indicator, which considered climate change and natural disaster as sub-indicators (both assigned as internal and external factors), declined from 18% in 2000 to 15% in 2013 resulting from an improved index in the climate change sub-indicator (27% in 2013; 31% in 2000). This

sub-indicator is anchored on the Notre Dame Global Adaption Index (ND-GAIN) that measures different economy's exposure, adaptive capacity and readiness in terms of climate change impact. The same trend was observed for the climate change sub-indicator (as an external factor), as some oil exporters (crude and oil products) had also made improvements in this sub-indicator in the ND-GAIN.

The political indicator demonstrated the lowest risk with a historical average of 13% (low index means higher stability). This indicator considered six indicators, three each under internal and external factors. Mainly, the international/multilateral agreement sub-indicator contributed to the political indicator. The economy is a founding member of the IEA and thus covered by the International Energy Program (IEP), which implements collective and coordinated actions among members in the event of any supply disruptions. The agreement can reduce the risk during emergencies as assistance through collective/coordinated actions from IEA members is available (IEA, 2014a). The local stability sub-indicator had 30% in 2013, an increase from 27% in 2000. The index was based on WGI's local stability that assesses the quality of governance and the possibility of having an unstable political climate. The exporter's stability sub-indicator also increased as well to 56% in 2013 from 46% in 2000 with high dependency on Middle East imports for crude, and for those oil product exporters with a high WGI index on local stability. Similarly, the chokepoint sub-indicator rose from 14% in 2000 to 15% in 2013 based on the share of exporters to total oil imports.

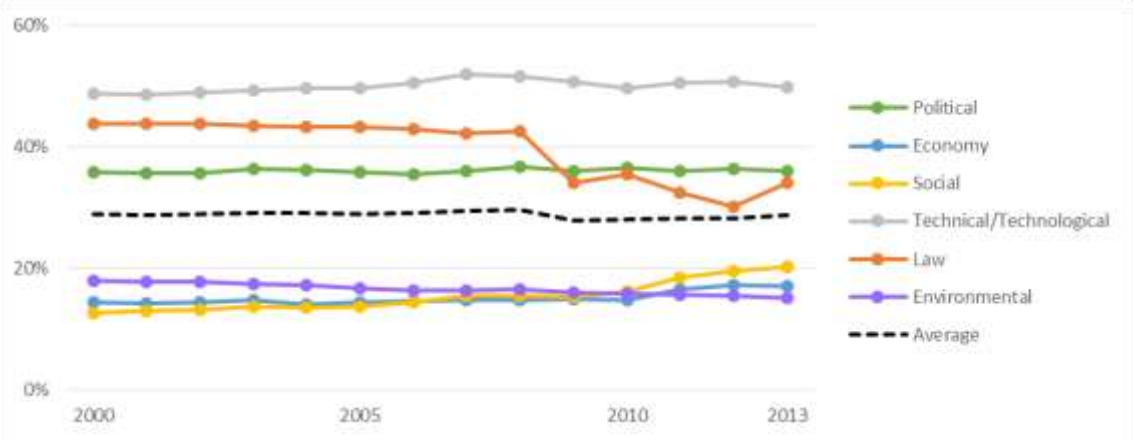
Gas Security

Japan's gas security risk is higher than oil at around a 29%, on average, with the technical/technology indicator receiving the highest risk (Figure 11.3). This indicator covered eight sub-indicators with two under external factors. This indicator picked up marginally to 50% in 2013 (48% in 2000). The reserves-production (R/P) ratio sub-indicator contributed significantly as it progressively went up to 31% in 2013 from only 1.0% in 2000. In 2013, it was reported that the economy had 21 Bcm of proven gas reserves (OGJ, 2014). The gas reserves had been declining over the historical period, a decrease of around 18% in 2013 from the 2000 level, while gas production escalated by 20% in the same period resulting in having a lower R/P ratio. As the economy had been producing a small amount of gas, only 3.0% of the total domestic gas requirement, the gas self-sufficiency sub-indicator was 97%.

The regasification terminal (RGT) utilisation rate sub-indicator was also a factor in the technical/technology, which gradually climbed to 47% in 2013 (33% in 2000). The economy has been dependent on liquefied natural gas (LNG) imports to meet its domestic gas requirement, making the economy the world's largest LNG importer. The first LNG import was received from Alaska in 1969, thus making the economy the pioneer in LNG trade (EIA, 2015). The economy operates a total of 28 RGTs with an aggregate capacity of around 250 billion cubic metres per year (Bcm/y). The RGT capacity grew by 22% in 2013 from the 2000 level, while imports increased much faster at 63% for the same period. The economy

likewise maintains the largest regasification storage capacity in the world, which could hold 15.6 million cubic metres (Mcm) (551 million cubic feet [Mcf]) of gas (EIA, 2015).

Figure 11.3: Gas Supply Security Index, 2000-13



Source: APERC analysis.
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

Among the external factors in the technical/technology indicator, the gas production rate sub-indicator for gas exporters declined to 2.0% in 2013 (33% in 2000) due to the increasing share of those exporters with an increasing gas production rate over the historical period, specifically those with huge gas reserves compared with others. However, the LNG exports terminals (as an external sub-indicator) of some gas exporters to the economy had been operating at almost full capacity, which contributed to the high risk in technical/technological indicator.

The political indicator (using the same sub-indicators in oil security) had been 37%, the historical average. The economy received a high index in the international/multilateral agreement on gas security sub-indicator as the current IEP-IEA does not yet include an agreement on gas security. However, with the growing importance of gas in the global energy mix, gas supply security might be covered soon by IEA to ensure the stable gas supply for its members. The exporter's stability (external factor) sub-indicator improved by 10 percentage points, 43% in 2013 from 53% in 2000. The decline could be credited to the expanding shares of Australia and Qatar to total gas imports with better local stability index in WGI as compared with other exporters.

The law indicator, composed of three sub-indicators (one as an external factor) showed improvement from 44% in 2000 to 34% in 2013 resulting from decreasing indices in gas emergency preparedness sub-indicator and the "rule of law" sub-indicator (as an external factor). The gas emergency preparedness sub-indicator decreased to 25% in 2009 with the operation of a regasification storage facility, which lowers the risk as it serves as a buffer during seasons with higher demand, and perhaps in the event of supply emergencies. Meanwhile, the "rule of law" sub-indicator displayed a downward trend increasing

import shares from Australia and Qatar.

Following an increase in gas consumption per capita, the social indicator's index increased (increased risk) to 21% in 2013 (13% in 2000). Gas consumption per capita was registered at 0.52 toe/person in 2000 to 0.83 toe/person in 2013, with a larger increase in 2011 after the earthquake. Similar to oil, this per capita level was above the APEC average in 2013 (0.58 toe/person).

In the same manner, the earthquake also affected the economic indicator (consisting of six sub-indicators), which had a steady index of 15% until 2010, but went up after the earthquake to 18% in 2013. The increase was primarily driven by a rise in gas share to primary energy and gas intensity sub-indicators. Gas utilisation was expanded after the earthquake to compensate for the loss of power generation from nuclear power plants, which led to the abrupt increase in gas share to 22% in 2011 (23% in 2013) from 17% in 2010. The increased gas share also affected the economy's gas intensity, which went up to 23.3 toe/USD million from only 20.0 toe/USD million, translating to a growth rate of 17% in the same period. Prior to the earthquake, the gas supply requirement only grew by 21% from 2000 to 2010. On the other hand, the gas import diversity index (sub-indicator) decelerated (13% in 2013; 20% in 2000) as the economy's dependency on Indonesian imports reduced from about one-third of total gas imports in 2000, down to 7.0% in 2013.

The environmental indicator (same sub-indicators used in oil security) gradually improved from 18% in 2000 to 15% in 2013 as the climate change sub-indicator (external factor) for the gas exporters steadily decreased to 39% in 2013 (from 48% in 2000). This was caused by the expansion of import shares from Australia and Qatar displacing some amount of imports from Indonesia. Australia and Qatar had better ND-GAIN index in climate change than Indonesia. The climate change sub-indicator for the economy also contributed as already explained above in the oil security.

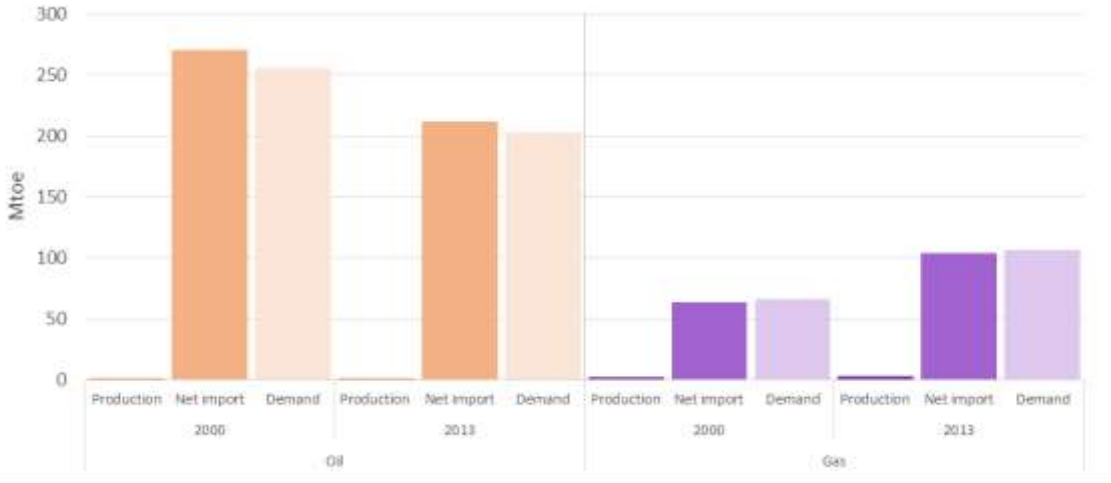
Import and Sources

With limited oil and gas resources, Japan has been heavily dependent on imports to meet its energy requirements. The economy is a net oil importer, but its imports were declining over the 2000-2013 period. Crude oil imports reduced by 18% in 2013 from the 2000 level, while oil product imports decreased by 17% during the same period. As discussed above, the economy's oil supply requirement dropped by 17% (from 2000 to 2013), although an increase was observed in 2011 and 2013. After the earthquake, the economy used crude oil for direct burn in power plants (EIA, 2015). With huge refinery capacity (4.4 Mmbbl/d), the economy has also been exporting petroleum products. Export volume in 2013 (17 Mtoe) almost tripled from the 2000 level (4.5 Mtoe). Overall oil net imports were down by 22% in 2013 (from the 2000 level), and covered more than 100% of the economy's domestic requirement, 105% in 2013 (Figure 11.4).

Similarly, the economy has no significant gas reserves and with only a small amount of gas production (about 3.0% of demand). As gas supply requirement grew by 62% in 2013 (from the 2000 level),

gas imports likewise went up. The economy's LNG imports increased by 3.8% annually, which stood at 104 Mtoe in 2013 (115 Bcm). Following a 16% increase in gas supply requirement in 2011 (from the previous year's level), gas imports went up by 18% as well. Having a small amount of domestic gas production, net imports were about 98% (historical average) of total demand (Figure 11.4).

Figure 11.4: Production, Net Imports and Demand, 2000-13



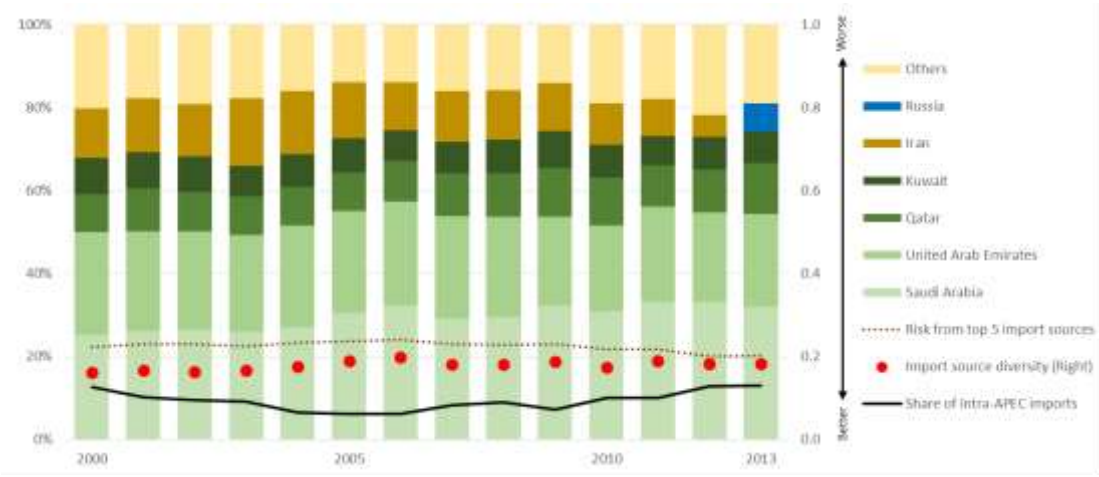
Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Crude Import Sources

The economy experienced oil crises in the 1970s that led to increased imports from outside the Middle East, such as from China and Indonesia, to diversify import sources since then. The dependency from the Middle East decreased from 91% in 1967 to 68% in 1987, but it escalated again and peaked at 90% in 2009. The efforts of expanding imports from Russia in recent years successfully reduced its dependency from the Middle East to around 83% in 2013 and 81% in 2014 (APERC, 2015; METI, 2016).

In 2013, Saudi Arabia provided 32% of total crude imports, the United Arab Emirates (UAE) with 22%, Qatar with 12%, Kuwait with 8.0%, and Russia with 7.0%. The import diversity level was low at 0.16 HHI in 2000, but slightly increased to 0.18 HHI in 2013 as the share of Saudi crude expanded (from 25% in 2000) (Figure 11.5). Risk from the major import sources gradually declined to 20% in 2013 (22% in 2000) with decreasing imports from Iran, which received a higher local stability index in the WGI. With high dependency on Middle East crude, the intra-APEC import share was only at 13% (both in 2013 and 2000), and the lowest share was recorded at 6.0% in 2005 and 2006. The intra-APEC imports could be further improved as the United States has begun exporting its ultra-light crude oil (condensate) in 2014. The economy was one of the first to import U.S. crudes (EIA, 2015).

Figure 11.5: Crude Oil Import Sources, 2000-13

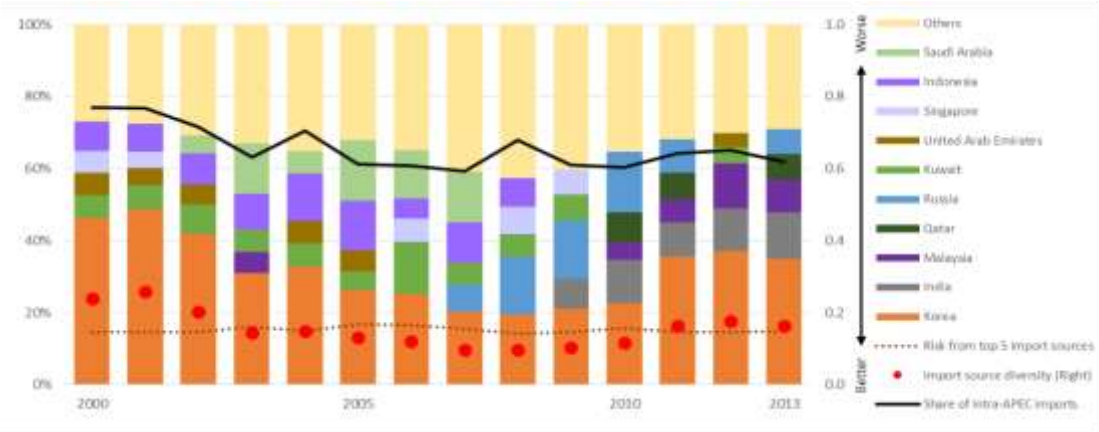


Sources: APERC analysis and UN Comtrade, 2016.

Oil Product Import Sources

Over the historical period, the economy was able to further diversify its oil product import sources, from 0.24 HHI in 2000 to 0.16 HHI in 2013 (Figure 11.6). Korea has been the major and consistent source of imports, although its share dwindled from a high of 46% in 2000 down to 35% in 2013. Other major sources of imports in 2013 were India (13%); Malaysia (9.0%); Qatar (7.0%); and, Russia (7.0%). Historically, risk from major sources of imports was stable at 15%, on average, despite the entry of imports from high-risk exporting economies, which was offset by larger shares of low-risk exporters. Intra-APEC import share was high at 64% in 2013, but decelerated from 77% in 2000, with a large contribution from Korea.

Figure 11.6: Oil Product Import Sources, 2000-13

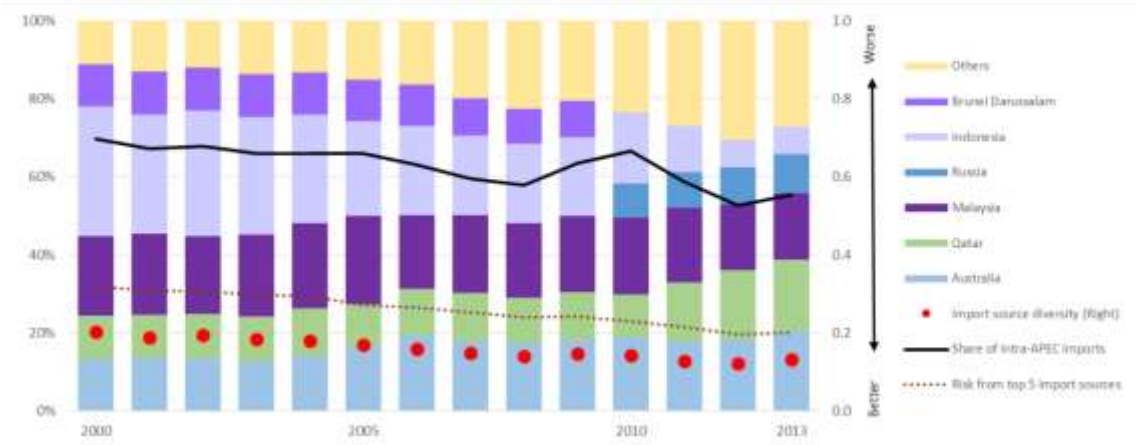


Sources: APERC analysis and UN Comtrade, 2016.

Gas Import Sources

Initially, the economy was dependent on Indonesia for gas imports, about 30% of total imports in 2000, but slowly declined over the historical period with the expanding shares of other major and regular sources of imports such as Australia; Brunei Darussalam; Malaysia; and, Qatar, and later on from Russia. Brunei Darussalam exported gas to the economy until 2009, which was replaced by Russian exports the following year. In 2013, Australia contributed the largest share to total imports, around 20% (11% in 2000); Qatar with 18% (11% in 2000); Malaysia with 17%; Russia with 10%; and, Indonesia with 7.0%. Based on the shares of gas exporters to total imports and the entry of new sources, the economy's diversity index displayed an improvement, 0.13 HHI in 2013 from 0.20 HHI in 2000 (Figure 11.7). The economy has begun importing LNG from Papua New Guinea in 2014 which would improve further the diversity of import origins. Similarly, risk from major exporters declined as a result of expanding shares from low-risk exporters. In terms of intra-APEC imports, the share gradually decreased to 55% in 2013 (70% in 2000) with the increasing share of Qatar imports to total.

Figure 11.7: Natural Gas Import Sources, 2000-2013



Sources: APERC analysis and Cedigaz 2016.

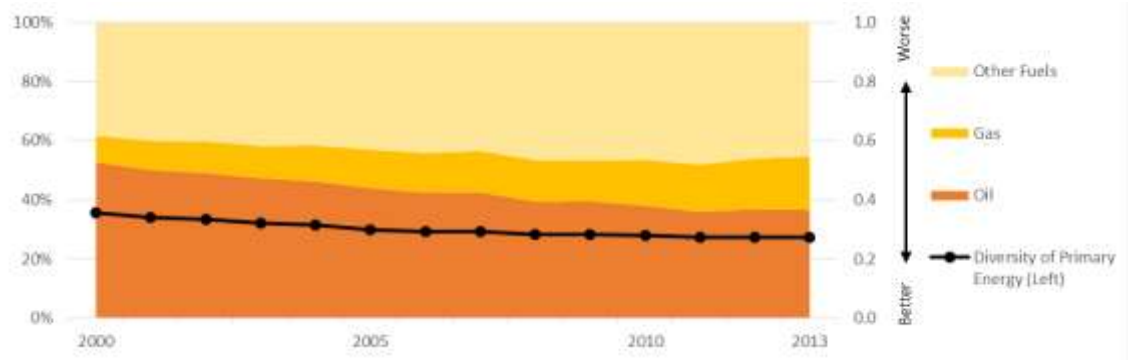
KOREA

Economy-Energy Overview

Korea is situated in Northeast Asia and occupies a total land area of 99,538 square kilometres (km2). In the last 13 years (2000-13), Korea has been one of the fastest-growing economies in Asia with its gross domestic product (GDP) growing at a rate of 6.5%, reaching USD 1,643 billion (2010 USD and Purchasing Power Parity [PPP]) in 2013. In the same year, total population stood at around 50 million with a density of more than 500 people per kilometre, on average (WB, 2015; EDMC, 2015).

Korea has insufficient fossil fuel resources with a small amount of oil resources (condensate), 6.0 billion cubic metres (Bcm) of natural gas reserves, and 320 million tonnes (Mt) of recoverable coal reserves (KESIS, 2015; EIA, 2014). As such, the economy relies heavily on energy imports to meet its domestic energy requirements and sustain economic growth, about 97% of primary energy consumption, which is the ninth-largest in the world (EIA, 2015; BP, 2015). With its huge energy requirement, the economy is the fifth-largest oil importer, and second-largest importer of coal and liquefied natural gas (LNG) (APERC, 2016).

Figure 12.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

In 2013, Korea's primary energy supply requirement was 264 Mtoe, which grew annually at 2.6% during the 13-year period. More than half of the energy requirement was sourced from oil (38%) and gas (18%), while coal provided one-third, nuclear added 14%, and renewables around 2.0%. From this energy mix, the economy received a diversity index of 0.27 in 2013, having a moderate-low concentration of energy sources. It may be observed that the diversity index declined over the historical period, from 0.36 in 2000, due to a decreasing share of oil to total primary energy (Figure 12.1).

The economy's oil supply requirement had been on a decreasing trend, slightly declining at 0.2% annually, 97 Mtoe in 2013 from 99 Mtoe in 2000, due to reduced requirements from power, industry and residential sectors resulting from the expanded use of natural gas, coal and nuclear energy. Oil share to total primary energy decelerated from more than half in 2000 down to 37% in 2013. The economy's oil supply requirement is projected to continue its trend, decreasing at 0.6% annually until 2040 (APERC, 2016). To offset the limited oil resources, the economy has been engaging in several oil exploration and development projects overseas to secure more crude oil for its domestic requirement (EIA, 2015).

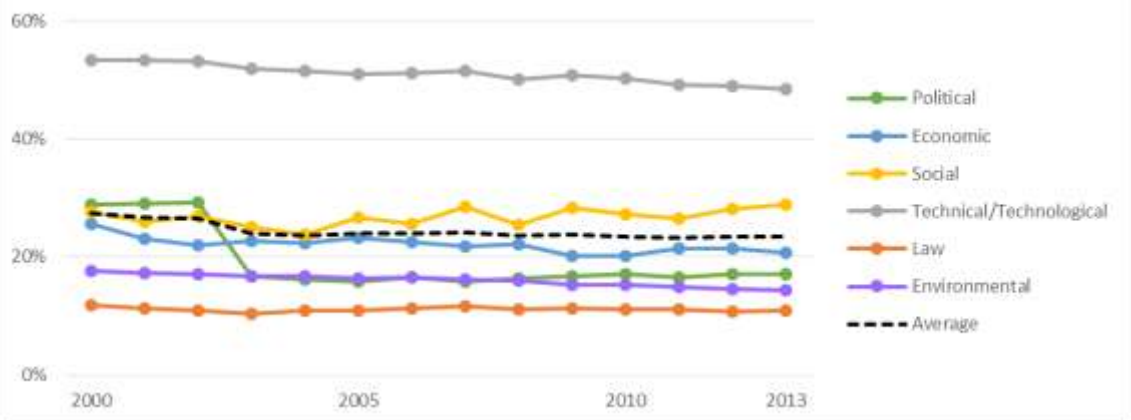
Natural gas has become an important fuel for the economy with almost a threefold increase in gas supply requirement, 48 Mtoe in 2013 from 17 Mtoe in 2000. Gas share to primary energy supply doubled in 2013, 18% of the total (from 9.0% in 2000). Nearly all of the gas supply requirement is being satisfied by imports. The economy's modest gas reserves only account for about 1.0% of total gas consumption. Although the economy is not among the top major gas consuming economies in the world, it is the second-largest importer of LNG next to Japan (EIA, 2015). Gas consumption is seen to grow annually at 1.0% (until 2040) (APERC, 2016).

In 2013, energy intensity was 160.6 tonnes of oil equivalent per USD million GDP (toe/USD million), an improvement of 17% from the 2000 level. On the other hand, primary energy per capita had increased by 17% in 2013 at 5.3 toe/person from 4.0 toe/person in 2000 (EGEDA, 2015).

Oil Security

Overall, Korea's oil security index showed improvement during the historical period, down to 23% in 2013 from 27% in 2000 (Figure 12.2). Receiving a low index means lower risk level on supply disruption. Among the indicators used, the technical/technology indicator received the highest risk in 2013 at 48% (53% in 2000). This indicator covered six sub-indicators in determining the risk level with one assigned as an external factor. Factors that contributed to a high index value in the technical/technology indicator are the oil reserves-production (R/P) ratio and the oil self-sufficiency sub-indicators. The economy has very limited oil resources, for which the small amount of production of ultra-light crude-oil (condensates) only represents 0.5% of total refinery demand. Given this, almost all of the crude oil requirement was imported, and thus the import dependency level is at 100%. The high refinery utilisation rate sub-indicator was also a contributing factor as the refiners' operating capacity was already at 90% level. In 2013, the economy had six refinery facilities with an aggregate capacity of 3.0 million barrels per day (Mmbbl/d), which could meet about 123% (at 85% operating capacity) of its domestic oil products demand (OGJ, 2000-15; IEA, 2015). The economy has the sixth-largest refinery capacity in the world, three of which are among the 10 largest in the world, making the economy as one of the leading refiners in Asia. With this much refinery capacity, the economy is a net exporter of oil products with significant exports to China; Japan; Indonesia; and, Singapore (EIA, 2015).

Figure 12.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The logistics efficiency sub-indicator, based on the Logistics Performance Index (LPI) of the World Bank (WB), is one of the reasons for the improvement in the technical/technology indicator. The LPI assesses the infrastructure and logistics efficiency and quality of the different economies. This sub-indicator demonstrated a decrease from 29% in 2000 to 26% in 2013. The oil production rate (sub-indicator) of crude oil exporters as an external factor of security risk also slid down significantly to 5.0% in 2013 (20% in 2000) with the increasing import share of oil-rich exporting economies from the Middle East. The share of crude oil imports from the Middle East increased from around 70% in 2000 to 80% in 2013.

The social indicator index (with only one sub-indicator) had been steady as the economy's oil consumption per capita exhibited a minimal reduction, 0.7% annually, registered at 1.9 toe/person in 2013 (from 2.1 toe/person in 2000). The economy's oil consumption per capita level was above the APEC average of 0.80 toe/person in 2013. It should be noted that this sub-indicator is computed relative to the oil consumption per capita level (highest and lowest level) of other APEC economies, and the historical variations in the economy's per capita level (highest recorded).

The economic indicator displayed an improvement (declining risk) over the historical period at 21% in 2013 from 26% in 2000. As the oil supply requirement slowly fell, oil intensity considerably improved by 40%, higher than the energy intensity reduction. The economy registered an oil intensity level of 58.8 toe/USD million in 2013, from the 2000 level of 101.4 toe/USD million. The same approach (methodology) in oil consumption per capita was used for oil intensity sub-indicator. The economy likewise received a better standing in the "Ease of Doing Business" sub-indicator from WB, translating to having a favourable business environment that could reduce the risk. The "Ease of Doing Business" sub-indicator dropped by 10 percentage points, from 26% in 2000 to 16% in 2013. However, there was an increase in the crude oil diversity sub-indicator as Saudi Arabia crude expanded its share to total imports, while the oil product diversity sub-indicator decreased with the entry of other exporters making the sources more diversified.

The political indicator showed the largest improvement, a decrease of 12 percentage points in 2013 at 17% from 29% in 2000 (low index means lower risk). It (political indicator) composed of six sub-indicators, three each assigned as internal and external factors. The key reason for the decline is the economy's accession as a member of the International Energy Agency (IEA) in 2002, which implements an International Energy Program (IEP) covering collective and coordinated actions on emergency responses during oil supply disruption among member economies (IEA, 2012). Said agreement reduces the risk of the economy in the event of oil supply emergencies. The local stability sub-indicator was 45% in 2013 (43% historical average), which is under the category of mid-exposure. The local stability sub-indicator used the World Governance Indicator (WGI) of WB, which evaluates the quality of governance and the perceptions on the likelihood of political instability. Similarly, the exporter's stability sub-indicator (as an external factor) likewise received a high index with a historical average of around 50% as the economy is highly dependent on Middle East imports, specifically for crude oil. With this, the chokepoint sub-indicator had been rising as the share of Middle East imports increased over the historical period.

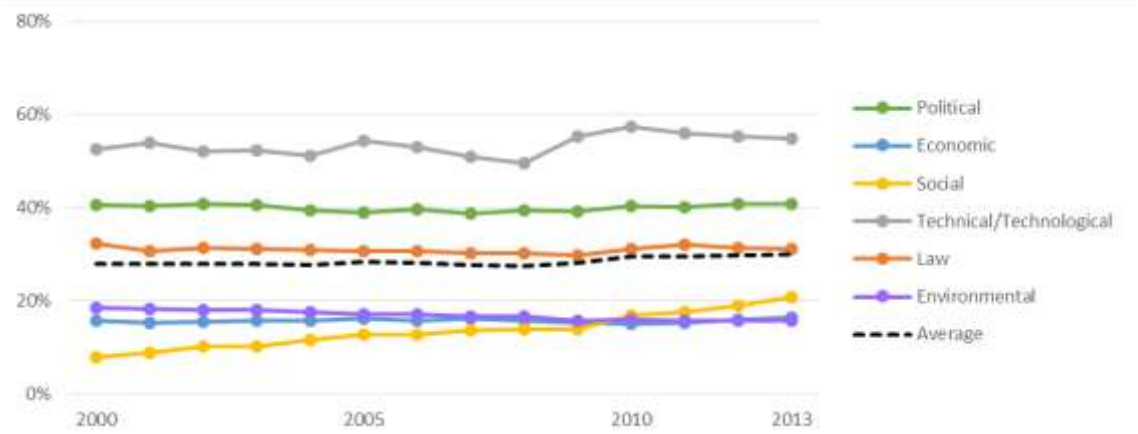
The environmental indicator, covering climate change and natural disaster sub-indicators (both considered under internal and external factors) dropped to 14% in 2013 (from 18% in 2000). This resulted in an improvement in the climate change sub-indicator (internal factor) to 25% in 2013 (from 31% in 2000). The climate change sub-indicator is based on the Notre Dame Global Adaption Index (ND-GAIN), which evaluates the different economy's exposure, adaptive capacity and readiness to the impact of climate change. The climate change sub-indicator (external factor) for oil exporters also demonstrated a decreasing index, which could be attributed to the increasing share of oil exporters and new entrants with a lower ND-GAIN index.

The law indicator earned the lowest risk at 11% (historical average). This indicator included four sub-indicators (one as an external factor). The economy obtained the lowest index in the oil strategic stockpiling sub-indicator for having the largest oil stock level compared with other APEC economies. The economy exceeded the required 90 days of oil net imports stockholding obligation as required by IEA by holding government stocks and requiring a minimum stockholding obligation on industry. Crude refiners are obliged to hold at least 40 days of stocks, in either crude or products (excluding naphtha), based on a 12-month average of their previous year's sales. Product importers, LPG importers and petrochemical companies are also required to hold at least 30 days of stocks based on their domestic sales (APERC, 2015). As of December 2013, the economy's oil stock level was 233 days of net imports (IEA, 2014). The economy has established an emergency policy and measures with the creation of the National Emergency Strategy Organization (NESO), which contributes to lowering the risks during supply emergencies (APERC, 2015). From the WGI, the "rule of law" sub-indicator (external indicator) for the oil exporters, although relatively high, dropped to 42% in 2013 (46% in 2000). The "rule of law" evaluates the quality of contract enforcement, among others.

Gas Security

Korea obtained a higher supply security risk for gas at 30% in 2013 (still under the moderate-low exposure category), a modest increase from 28% in 2000 (Figure 12.3). The same as in oil, the technical/technology indicator received the highest risk, among the indicators. This indicator covered eight sub-indicators (two as part of the external factors). Despite having proven gas reserves, production is small and negligible to meet the growing gas demand of the economy. Almost all of the economy's gas requirement is met through LNG imports since the economy has no trans-border gas pipeline. Given this, the gas self-sufficiency sub-indicator was 100%. In 2013, the economy imported around 54 billion cubic metres (Bcm) of LNG, representing about 15% of global LNG trade (EIA, 2015). As the economy started to produce a minimal amount of gas in 2005 and with no additional gas reserves finds, the R/P ratio sub-indicator progressively went up to more than 70% in 2013 from only 34% in 2005, which caused the technical/technology indicator to have an increasing trend.

Figure 12.3: Gas Supply Security Index, 2000-13



Source: APERC analysis.
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economy has built huge regasification terminals (RGT) relative to its gas demand with a total capacity of 146 billion cubic metres per year (Bcm/y) in 2013. This total capacity had a 40% RGT utilisation rate (as a sub-indictor) in 2013, thus still having more spare capacity that could be utilised to receive LNG imports from other sources and consequently contributing to lowering the security risk (under the technical/technology indicator). Meanwhile, the LNG export terminals (liquefaction capacity) of gas exporters were already operating at almost full capacity, thereby the LNG utilisation rate sub-indicator as an external factor had a high index.

The political indicator (with same sub-indicators used in oil security) demonstrated a stable historical index of 41%, on average. The exporter's stability sub-indicator (as an external factor) had been

going down, 50% in 2013 from 58% in 2000, as a result of increasing imports from Qatar, replacing a large portion of Indonesian gas imports. Qatar received a better local stability index compared with Indonesia based on WGI, which led to the decrease in exporter's stability sub-indicator. However, as the share of Middle East imports increased (54% in 2013; 33% in 2000), the chokepoint sub-indicator likewise escalated. As the IEP-IEA agreement currently does not yet cover gas security, the international/multilateral agreement on gas security sub-indicator received a high result. This sub-indicator may improve once IEA decided to include gas in its supply security portfolio considering the growing importance of gas in the energy mix of many economies.

The law indicator also displayed a steady index at 31%, which consisted of three sub-indicators (one as an external factor). The economy received a 50% index in the gas emergency preparedness sub-indicator for the reason that all gas imports were received via LNG tanker. The presence of a pipeline as another means of receiving gas imports could enhance the gas emergency preparedness of the economy in the event that the shipment of LNG is disrupted due to various possible reasons. On the other hand, the "rule of law" sub-indicator (as an external factor) declined to 42% in 2013 (46% in 2000) with increasing Qatar imports.

The social indicator index significantly rose to 21% in 2013 from only 8.0% in 2000 as triggered by the gas consumption per capita sub-indicator. The economy's gas consumption per capita more than doubled in 2013 at 0.95 toe/person from 0.46 toe/person in 2000. The gas consumption per capita level was above the APEC average of 0.58 toe toe/person in 2013.

The economic indicator, composed of six sub-indicators, remained stable at 16% over the historical period. Although the gas share to primary energy and gas intensity sub-indicators went up, the increases were offset by the improvement in gas import diversity sub-indicator and the "Ease of Doing Business" sub-indicator as explained in the oil security. Gas share to primary energy expanded from 9.0% in 2000 to 18% in 2013, while gas intensity rose to 29.0 toe/USD million in 2013 from only 17.4 toe/USD million in 2000. Meanwhile, the diversity index declined by 10 percentages points, from 27% in 2000 to 17% in 2013, as the economy diversified its imports sources (please see discussion on Imports and Sources section).

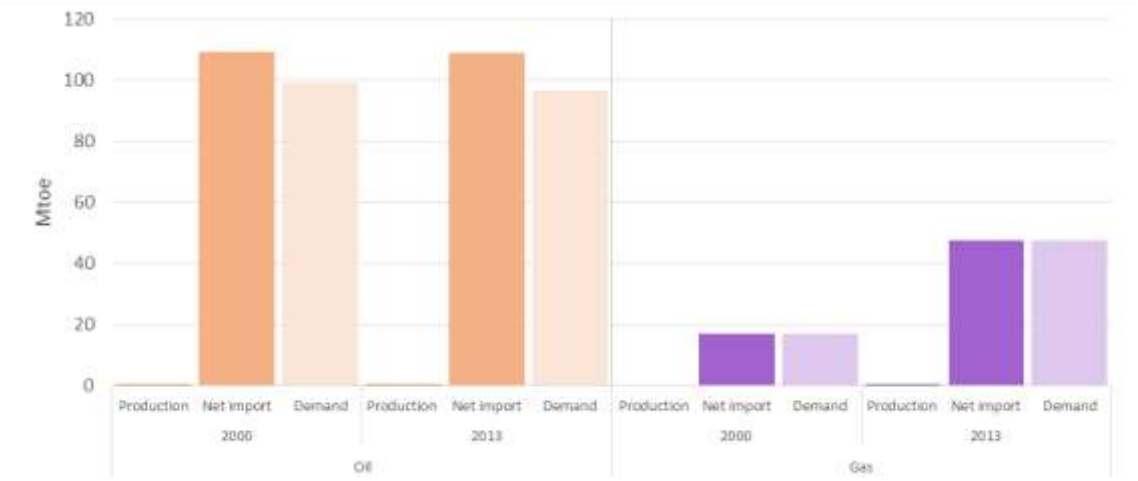
The environmental indicator decreased (15% in 2013; 18% in 2000) with the improvement in the climate change sub-indicator (as an internal factor) as already discussed above (oil security). Similarly, the climate change sub-indicator for exporters as an external factor decelerated as Qatar also received a lower ND-GAIN index on climate change.

Import and Sources

Without much oil resources allowing negligible crude production, Korea is heavily dependent on imports for its refinery demand. However, following a decline in the oil supply requirement, crude imports were going down from the 2000 level until 2009 and then went up again as demand increased. Almost similar trend was observed for the economy's oil product exports, although exports still exhibited an annual growth rate of 2.5%. On the other hand, despite the decreasing oil supply requirement, oil product imports had demonstrated a steady increase over the historical period, which grew at 3.9% annually. Overall, total oil imports just slightly rose at 0.8% annually during the same period, while oil net imports were almost unchanged in 2013 (from the 2000 level), which stood at 109 Mtoe (Figure 12.4).

Just like in oil, the economy has no significant amount of gas reserves with local production covering only less than 1.0% of demand. As domestic gas supply requirement nearly tripled in 2013 (from the 2000 level), so as the economy's gas imports. Gas imports, in the form of LNG, grew annually at 8.2% reaching 48 Mtoe in 2013 (53 Bcm) (Figure 12.4).

Figure 12.4: Production, Net Imports and Demand, 2000-13

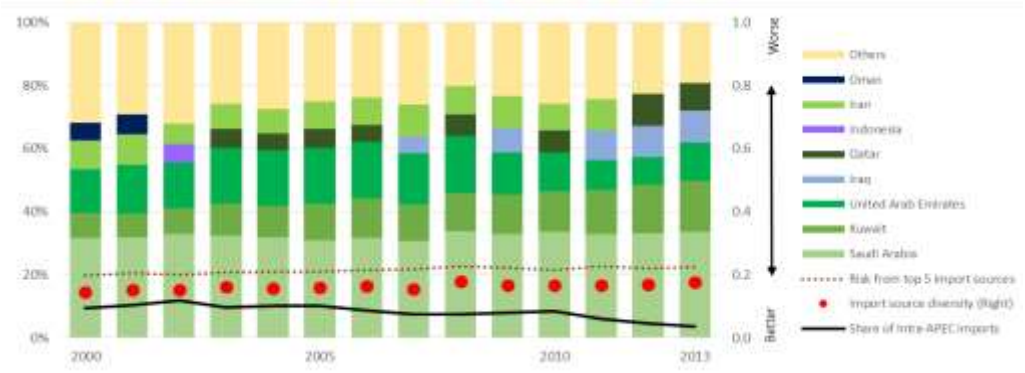


Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Crude Import Sources

Korea's diversity index for crude oil imports was at 0.18 HHI (low concentration) in 2013, higher than the 2000 level of 0.15HHI (Figure 12.5). The increase in the diversity index was due to the expanding share of Saudi Arabia's and Kuwait's crude oil to total imports. The share of Saudi crude went up to 34% in 2013 from 32% in 2000, and Kuwait to 16% from 8.0%. The economy relied significantly on Middle East imports, about 80% of total imports (from 68% in 2000).

Figure 12.5: Crude Oil Import Sources, 2000-13



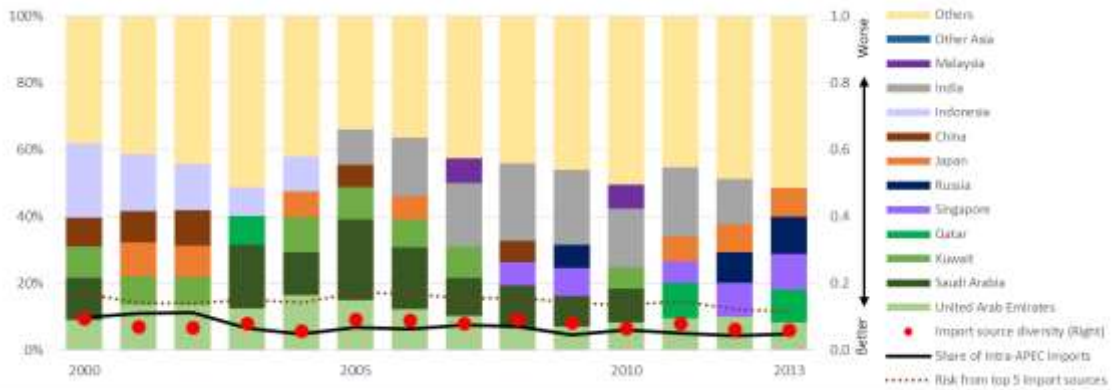
Sources: APERC analysis and UN Comtrade, 2016.

The risk associated with the major import sources was still considered moderate-low at 22% in 2013 (20% in 2000), from a high of 23%. The increase was caused by a higher share of Saudi imports, but those years with the highest index (23%) was a result of imports from Iran and Iraq, which both had higher local stability index. Given the economy's dependency on Middle East crude, intra-APEC imports were at a low level, only 4.0% in 2013 (from 9.0% in 2000) largely contributed to by Indonesia's and Australia's imports.

Oil Product Import Sources

Over the historical period, the economy's oil product import sources were highly diversified with an index of 0.06 HHI in 2013 (0.10 HHI in 2010) (Figure 12.6). Only the United Arab Emirates (UAE) had been the consistent and major source of imports. The UAE share to total imports even reached as high as 16% in some years. In 2013, import sources were Singapore (11%); Russia (11%); Qatar (10%); Japan (9.0%); and, UAE (8.0%). Before, the economy received imports from China; Indonesia; Malaysia; India; Saudi Arabia; and, Kuwait as the major import sources in certain years during the historical period.

Figure 12.6: Oil Product Import Sources, 2000-13



Sources: APERC analysis and UN Comtrade, 2016.

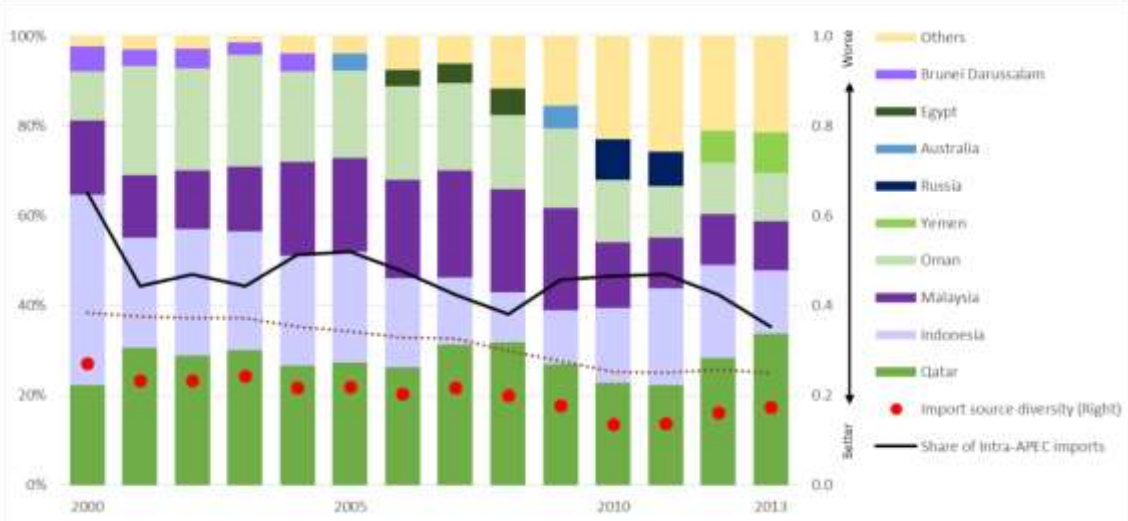
The risk from oil product major exporters was still low at 12% with the entry of Singapore and Japan exports, from 17% in 2000 when among the major import sources, such as India and Saudi Arabia, had higher index in local stability. Meanwhile, the share of intra-APEC imports went down to 5.0% in 2013 (largely from Singapore and Japan) from 10% in 2000.

Gas Import Sources

Mainly, the economy sourced much of its gas imports from four sources – Qatar, Indonesia, Malaysia and Oman. Initially, Indonesia provided more than 40% of import requirements of the economy, but gradually lost its market share from other major import sources. In 2013, Qatar secured a 34% share to total imports, while Indonesia's share was cut to 14%. In the same year, Malaysia had 11%, Oman with 11% and Yemen, which started to export gas in 2012, cornered 9.0% of total imports. With this trend on import sources, the economy's diversity index improved to 0.17 HHI (low concentration) in 2013 from 0.27 HHI (moderate-low concentration) in 2000 (Figure 12.7).

Associated risk from major gas exporters was relatively high at 38% in 2000, but went down to 25% with expanding import shares from Qatar and even Malaysia (with better local stability index compared with Indonesia). With declining share of Indonesia, intra-APEC imports decreased from a high of 65% in 2000 to 35% in 2013 (with a contribution from Malaysia).

Figure 12.7: Natural Gas Import Sources, 2000-2013



Sources: APERC analysis and Cedigaz 2016.

MALAYSIA

Economy-Energy Overview

Malaysia, located in Southeast Asia, has a total territory of about 330,803 square kilometres (km2). The economy is separated by the South China Sea into two main geographical areas comprising Peninsular Malaysia in the west, and Sabah and Sarawak on the island of Borneo. The capital city of Malaysia is Kuala Lumpur, while Putrajaya hosts the seat of the federal government (EPU, 2013). In 2013, the population was 29.5 million, an increase of 1.7% from 29 million in 2012 (EGEDA, 2015).

Malaysia's gross domestic product (GDP) reached USD 514 billion (2010 USD purchasing power parity [PPP]) in 2013, with GDP per capita around USD 17,446. The largest contributions to GDP were from services (55%) and manufacturing (25%) (MOF, 2014). In 2014, the main export products were electrical and electronic (E&E) products at about 33% of total exports, petroleum products at 9.2% and liquefied natural gas (LNG) at 8.4% (MATRADE, 2015).

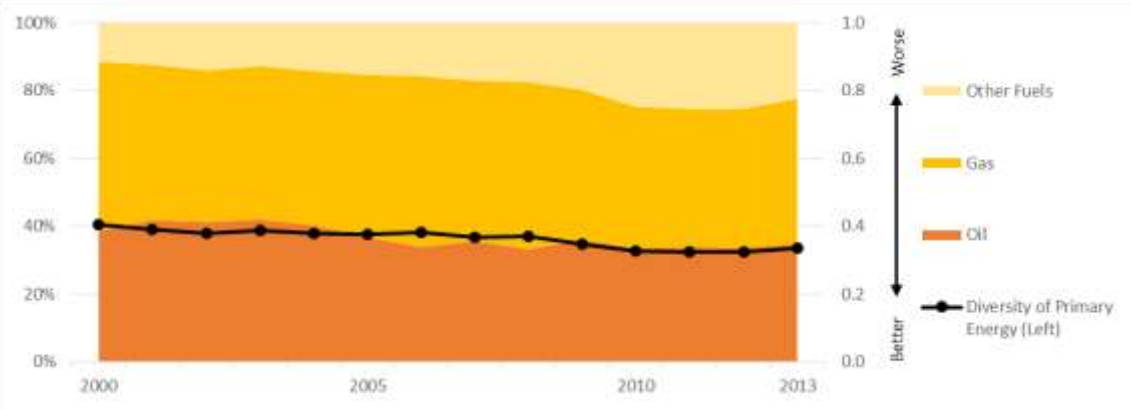
When compared with other large economies in the Asia-Pacific Economic Cooperation (APEC), Malaysia's energy resources can be considered moderate in absolute terms. A 2013 survey shows that the East Malaysian states hold nearly two-thirds of Malaysia's energy reserves; the rest are located in Peninsular Malaysia. The economy's oil reserves (including condensate) were 5.9 billion barrels (Bbbl), 40% of which is found in Peninsular Malaysia (the Malay basin). The abundant natural gas reserves of the economy are estimated at approximately 98 trillion cubic feet (Tcf), with nearly half found in the Sarawak basin. The coal reserves, assessed at 1.9 billion tonnes (Bt), are located mostly in Sarawak and Sabah (EC, 2014).

In May 2015, the government launched the Eleventh Malaysia Plan 2016–20 as the final stage in the journey toward realizing Vision 2020, a long-term development plan launched in 1991 that envisions Malaysia as a fully developed economy, by 2020. Under the Eleventh Malaysia Plan, energy security and RE will continue to be considered, while demand-side management (DSM), a major paradigm shift, which incorporates energy efficiency and conservation measures, will be implemented in order to ensure the sustainable management of energy resources. Several notable strategies, initiatives and targets to improve energy security in Malaysia under the Eleventh Malaysia Plan are strengthening the gas supply security and connectivity with total supply to Peninsular Malaysia of 2,500 million standard cubic feet per day (mmscf/d), operationalize regasification terminal-2 (RGT-2) in 2017 and provide an additional buffer from swing field and supply storage in RGT-1 (EPU, 2015).

Malaysia's total primary energy supply was 89 million tonnes of oil equivalent (Mtoe) in 2013, an increase of 80% from the 2000 level of 49 Mtoe. Natural gas contributed the largest share at approximately 43% (38 Mtoe), followed by oil with a 35% share (31 Mtoe) and coal with a 17% share (15 Mtoe). Other

resources include hydro, which in 2013 provided a minimal share of approximately 5% (4.6 Mtoe) to the primary energy supply (IEA, 2015). In 2000, the combination of both the oil and gas shares as primary energy equals 89%, and recognizing that Malaysia has been overly reliant to gas, more coal was introduced in the fuel mix, which caused the share of both oil and gas to drop to 78% in 2013 (Figure 13.1). Due to the introduction of more coal, Malaysia's primary energy diversity improved from 0.40 in 2000 to 0.34 in 2013.

Figure 13.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

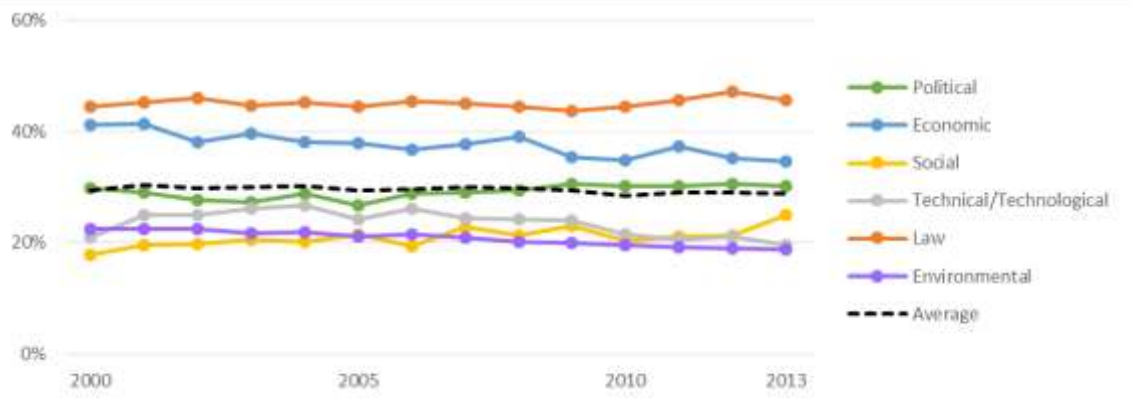
In 2013, energy intensity stood at 135.2 toe/million 2010 USD based on the primary energy supply requirement, a drop from 137.4 toe/million 21010 USD in 2000. The same trend is seen for the primary energy per capita that increased from 2.1 toe/person in 2000 to 3.0 toe/person in 2013 (IEA, 2015 and EGEDA, 2015).

Oil Security

Malaysia's overall average oil supply security index decreased from 30% in 2000 to 29% in 2013. Out of the six indicators that were evaluated, three indicators – political, social and law – showed a slight increase in risk while the other three indicators decreased (Figure 13.2).

The political indicator reduced by 0.3%, from 35.5% in 2000 to 35.2% in 2013. This indicator reached its lowest risk point in 2005 at 30.6% due to better local stability as reported by the World Governance Index (WGI), as well as a reduction in piracy attacks from 21 incidents in 2000 to three incidents in 2005. However, in 2013, both indicators showed an upward trend, of which the local stability risk reached slightly lower than the 2000 level, while the piracy incidents reached the highest point of 24 attacks. However, the chokepoint risk (external risk) reduced by 0.1%, which helped to stall the overall political indicator from increasing further.

Figure 13.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economic indicator realised a big improvement, peaking in 2001 at 42% before dropping to 35% in 2013. There are four sub-indicators under the economic indicator that contributed hugely to the reduction of risk – improvement in "Ease of Doing Business" from 38% in 2001 to 21% 2013, oil intensity reduction from 84% risk in 2000 (53 toe/million 2010 USD) to 73% risk in 2013 (47 toe/million 2010 USD), improvements in the crude oil import source diversity from 0.22 HHI in 2000 to 0.11 HHI in 2013, and improvements in the oil product import source diversity from 0.97 HHI in 2000 to 0.37 HHI in 2013.

There is only one indicator used to determine the social indicator, which is oil consumption per capita. As a developing economy, Malaysia's oil consumption per capita continued to increase over the years due to rapid economic expansion and a rising middle class, from 0.81 toe/person in 2000 to 1.05 toe/person in 2013 (nearly a 30% increase). With the huge development of mass public transportation in the economy, oil consumption per capita is expected to increase at a lower rate compared with historical growth.

The technical/technology indicator shows a slight decrease, from 21% in 2000 to 20% in 2013, mainly because of the improvement in oil reserves-production (R/P) ratio from 10.6 years in 2004 to 18.6 years in 2013 due to aggressive exploration by the state-owned oil company, PETRONAS. Malaysia also improved its logistics efficiency marginally by 1.5 percentage points from 2000 to 2013, which further lowered the risk. However, a slight increase was seen in refinery utilisation rate (in case of emergency, a higher utilisation rate is assumed to give higher constraints to oil product supply) from 75% in 2000 to 88% in 2013.

The law indicator showed almost a stable number for the first half of the historical period. It peaked in 2012 to 52% as the resource extraction regulation sub-indicator showed an upward trend before coming down to 44% in 2013. As oil stockpiling is considered to be one of the sub-indicators under the law indicator, the economy notched the highest risk in this sub-indicator due to the lack of stockpiling facilities. However, the economy should be able to improve the law risk once the government decides to introduce an

oil stockpiling policy in the future.

The final indicator was established in order to gauge supply disruption risk due to environmental factors. Only two sub-indicators are used under this indicator, which are readiness and vulnerability in facing climate change and natural disaster risk. This indicator showed an improvement from 22% in 2000 to 19% in 2013, partly due to the economy's improved in readiness and reduced vulnerability towards climate change as reported by the Notre Dame-Global Adaptation Index (ND-GAIN). The ND-GAIN indexes showed that Malaysia's vulnerability was 0.38 in 2000 and 0.34 in 2013, while the readiness improved from 0.46 in 2000 and to 0.61 in 2013 (ND GAIN, 2016).

Gas Security

On average, the gas security risk is slightly higher than oil by 2.0 percentage points. Malaysia is a net gas exporter and in 2013, Malaysia became the second-largest LNG exporter in the world, outsized only by Qatar (IGU, 2015). With seven projects now under construction (with a total capacity of 58 million tonnes per year), Australia is expected to overtake both Qatar and Malaysia to have the largest liquefaction capacity by 2018.

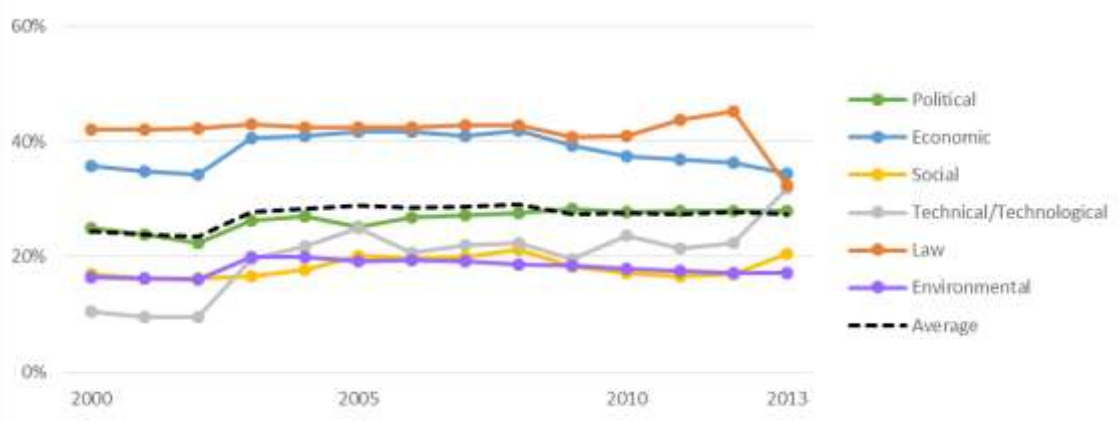
In the year 2000, Malaysia's average gas security risk was lower than oil at 24% and by 2013, the risk increased to 27%. Two indicators showed improvement – law and economic indicators – while the rest of the indicators displayed an upward trend (Figure 13.3).

Malaysia started to import gas (through pipelines) in 2003, which subsequently resulted in a big jump in the technical/technology indicators, as well as in the sub-indicators.[29] There are many factors that contributed to the decision to import gas, such as a mismatch between resource locations and load centres, which is a major challenge for the economy (while Peninsular Malaysia accounts for more than 85% of electricity demand, nearly two-thirds (64%) of fossil fuel production takes place in Sabah and Sarawak (EC, 2015)), the proximity of the import source production location to demand centres and the cost of transporting the fuel.

The economy's political indicator increased slightly by around 2.0 percentage points from 26% in 2000 to 28% in 2013. Apart from local stability and piracy incident indicators that have been discussed earlier in the oil security index (gas supply security indexation utilised the same data), the increase of risk in the import source stability sub-indicator greatly influenced the upward trend in the political indicator (from 0% in 2000 due to no imports to 8.0% in 2003 – the highest, and 5.0% in 2013).

[29] The study recognized that there are many rational reasons considered in the decision to import fuel, such as cost, proximity and regional integration objective. However, as energy self-sufficiency is always at the top of most government agendas, once the economy sought to import fuel, it means the supply risk will subject to external factors that may be beyond the economy's control.

Figure 13.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economic indicator improved from 36% in 2000 to 34% in 2013. There are many sub-indicators that showed improvement, such as the share of gas to primary energy from 50% in 2000 to 43% in 2013 and gas intensity reduction from 68.6 toe/million 2010 USD in 2000 to 58 toe/million 2010 USD in 2013. If we look at the 2003 (the year Malaysia started to import gas) to 2013 period, the risk under the economic indicator fell tremendously, at nearly 15 percentage points. One of the primary factors that contributed to risk reduction occurred is the operationalization of a regasification terminal (RGT) in 2013 (which also improved the law indicator). In 2003, Malaysia's gas import source diversity stood at 1.0 HHI, which means there was only one import source and a severe lack of diversity. By introducing RGT in 2013, the import source diversity improved to 0.23 HHI.

The social indicator has only one indicator which is gas consumption per capita. In 2000, Malaysia's gas consumption per capita was 1.06 toe/person and reached its highest point in 2008 at 1.4 toe/person before going down to 1.3 toe/person in 2013. The overall increase contributed to the upward trend in the social indicator, from 17% in 2000 to 21% in 2013. However, the economy's gas consumption per capita could be considered low compared with other major gas consumers such as Russia with 2.8 toe/person and the United States with 1.9 toe/person, both recorded in 2013.

The technical/technology indicator increased, with high volatility, from 11% in 2000 to 32% in 2013. Malaysia started to import gas in 2003, which resulted in the first risk increase and in 2004. In 2010, the indicator increased again due to the high utilisation of trans-border gas pipelines that reached 100% (from 2003 – 2009, the trans-border gas pipeline utilisation rate was only around 60% - 75%). The reason for the sudden spike was because of supply disruptions from local production due to fire incident that occurred on one of the major gas platforms. This incident forced the gas supplier to buy more gas from neighbouring economies. Another increase was seen again in 2013 as the economy introduced a new RGT. Although RGT will definitely improve import source diversity, it will added constraints on technical/technology capacities

such as the utilisation rate of the RGT. In 2013, the utilisation rate of RGT was at 40%, while the LNG exporter's liquefaction capacity rate stood at 62%.

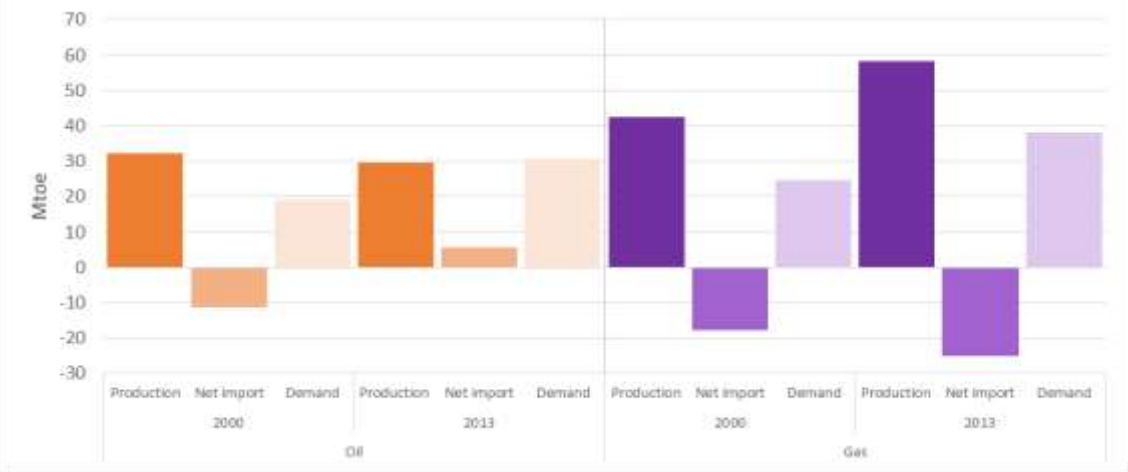
Under the law indicator, three sub-indicators were used – resource extraction regulations (which was briefly discussed under the oil supply security index), gas emergency preparedness and the "rule of law" (only applied to exporters in order to gauge the risk of contract flaunting). In the gas emergency preparedness, there are four elements considered – the existence of a gas emergency preparedness policy, underground storage, availability of transitional pipelines and availability of RGT. The introduction of RGT helped the economy to reduce the risk in this sub-indicator by 17%. The "rule of law" sub-indicator for gas exporters decreased from 34% in 2003 (where there was one import source) to 28% in 2013 (there were eight import sources due to the completion of RGT).

As for the environmental indicator, the study utilised the same data as in the oil supply security index. Since the economy's environmental factors have been discussed earlier in the oil chapter, this section only focused on environmental risk from import sources. Import source vulnerability and readiness in facing climate change decreased from 30% in 2003 to 25% in 2013 as the economy started to diversify its import sources, from one economy to eight economies in 2013. Thus, it helped to maintain the environmental indicator for gas at 17% for the 2000-2013 period.

Imports and Sources

Malaysia produced 29.7 Mtoe of oil in 2013 (a slight decrease from 32.2 Mtoe in 2000), while oil demand increased from 19.1 Mtoe in 2000 to 30.9 Mtoe. The economy's total oil exports in 2000 was 11 Mtoe. In 2013, the economy became a net oil importer (5.7 Mtoe), mostly oil products such as diesel (IEA, 2015).

Figure 13.4: Production, Net Imports and Demand, 2000-13



*Note: *Excludes international bunkers.*
Source: APERC analysis and IEA World Energy Statistics 2015.

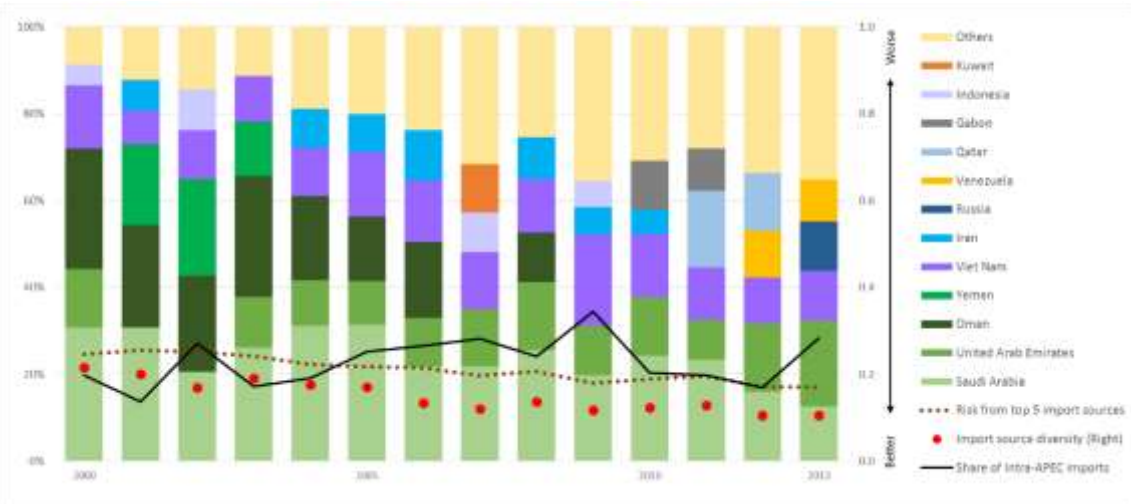
As for gas, although the production increased by almost double, the demand rose by more than double, which prompted the economy to build RGT in order to meet the increasing demand. Gas imports went up by nearly five times, from 2.0 Mtoe in 2000 to nearly 10 Mtoe in 2013 (Figure 13.4).

Malaysia produces top-quality crude oil that is highly sought after by economies around the world. Thus, the economy's crude oil production is able to fetch a higher price in the global market. From the economy's perspective, it makes sense to sell the crude oil for higher revenue and import other types of crude oil to be refined locally.

Crude Import Sources

Malaysia imported most of the crude oil from Middle East economies, mainly Saudi Arabia, the United Arab Emirates and Oman (Figure 13.5). However, by 2013, the shares of these economies as exporters reduced significantly from 72% in 2000 to 32% in 2013. This showed that the economy diversified its import sources, which eventually lowered the import supply disruption risk from 23% in 2000 to 17% in 2013. Most of the risk reduction was due to better exporter's "rule of law" risk (from 42% in 2000 to 26% in 2013) as well as lower chokepoint risk (from 20% in 2000 to 13% in 2013). Intra-APEC crude oil imports to Malaysia accounted for about 20%-30% for most of the time, the bulk of which sourced from Viet Nam.

Figure 13.5: Crude Oil Import Sources, 2000-13



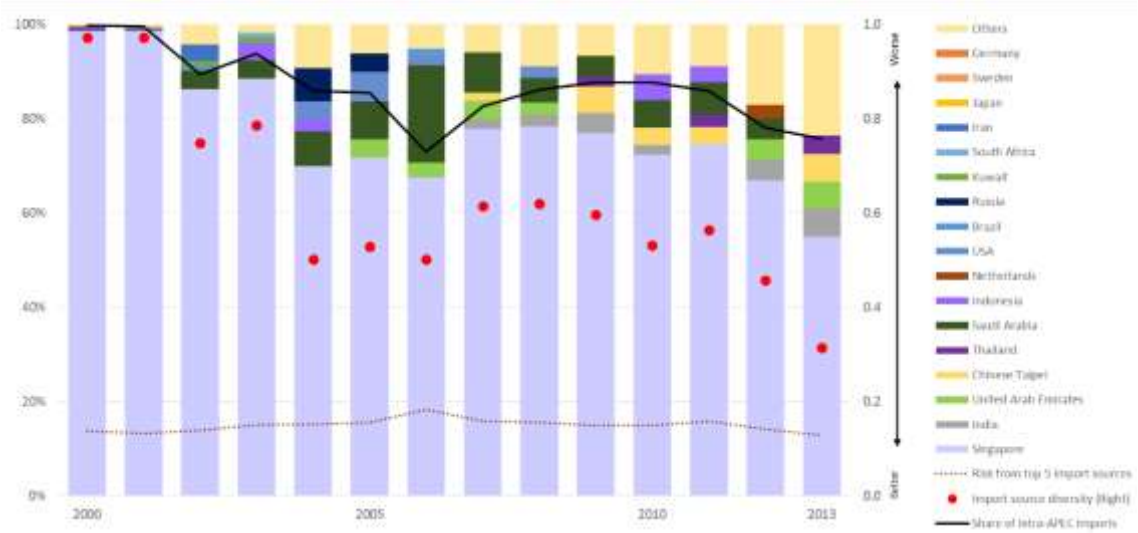
Sources: APERC analysis and UN Comtrade, 2016.

Oil Product Import Sources

The same case could be seen for oil products where the economy started to diversify the import sources. Singapore used to be the major source of oil product imports for the economy. However, Singapore's share to total imports fell from nearly 100% in 2000 to around 55% in 2013 (Figure 13.6).

Although the economy diversified its import sources, the risk of import supply disruption remained almost the same as in 2000. This was due to the proximity of Singapore (which eliminates the chokepoint risk) as well as the high political risk and higher degree of "rule of law." The highest risk was recorded in 2006 when imports from Saudi Arabia increased by three-fold. This does not indicate that Saudi Arabia per se is a high-risk supplier, but there are other factors that contributed to the risk such as chokepoint risk, piracy and regional stability.

Figure 13.6: Oil Product Import Sources, 2000-13

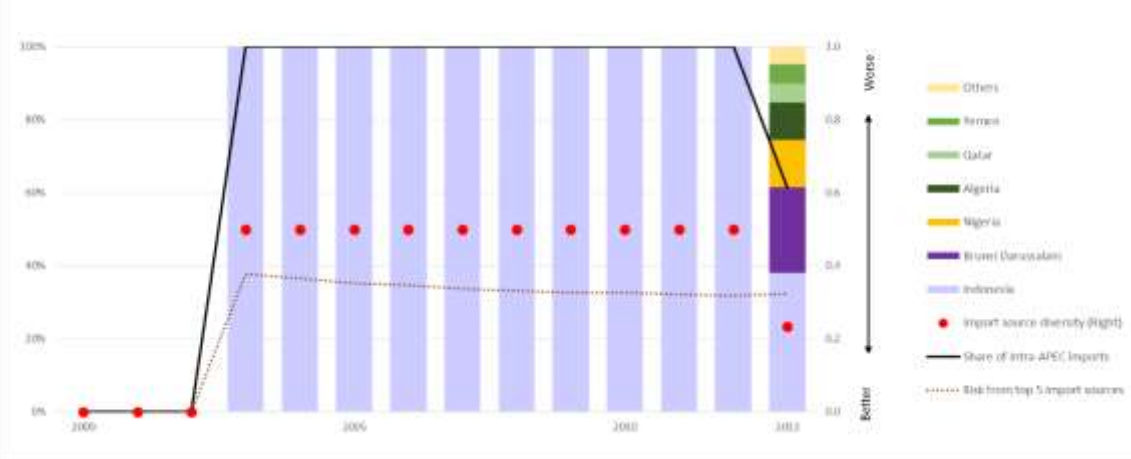


Sources: APERC analysis and UN Comtrade, 2016.

Gas Import Sources

As mentioned earlier, Malaysia started to import gas in 2003 from a single source. In 2013, when the RGT started its operation, the economy imported gas from more than seven economies. The risk of import supply disruption decreased slightly as the economy diversified its import sources. In 2003, the exporter risk was 38%, and the risk decreased to 32% in 2013. Despite an increase in chokepoint risk as more gas was coming from the Middle East region and Africa, the diversification of import sources managed to improve the exporter "rule of law" risk, as well as exporter's gas production risk (as higher gas production from exporters indicates a steadier flow of gas).

Figure 13.7: Natural Gas Import Sources, 2000-2013



Sources: APERC analysis and Cedigaz 2016.

MEXICO

Economy-Energy Overview

Mexico, officially known as the United Mexican States (Estados Unidos Mexicanos in Spanish), is a North American federal republic bordered by the United States to the north, Belize and Guatemala to the south, and the Atlantic and Pacific Oceans on the east and west, respectively. For cultural and historic reasons, Mexico has been commonly regarded as a Latin American economy, although its geographical location and economic integration are in North America (APERC, 2016). Several major reforms and free trade agreements introduced since the 1990s have resulted in macroeconomic stability and increased the flow of foreign direct investment into Mexico, making it one of the largest developing economies with a robust manufacturing industry. In 2013, the economy's gross domestic product (GDP) reached USD 1,900 billion (USD 2010 Price and Purchasing Power Parity [PPP]), exhibiting an annual growth rate of 2.0% in the last 13 years (2000-2013) (WB, 2015; EDMC, 2015). In the same year, total population stood at 123.7 million.

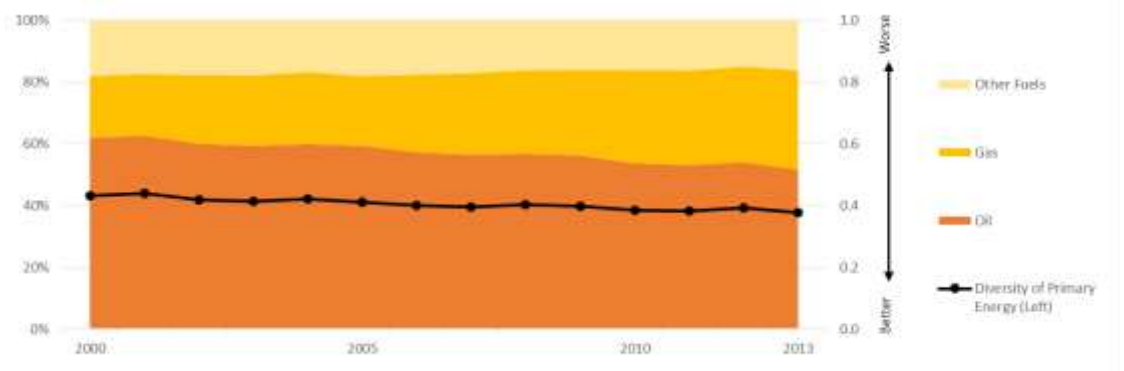
By the end of 2013, the net primary energy supply of Mexico amounted to more than 191 million tonnes of oil equivalent (Mtoe), an increase of 32% over the 2000 level. Oil, the major source of energy in Mexico, held a 52% share of primary source, followed by gas with 32% (both fuels providing an aggregate share of 84% of the primary energy supply) (IEA, 2015). Other fuel sources, such as coal, nuclear and renewable energy, accounted for the remaining 16%, a decrease of 2.0 percentage points compared with 2000 (Figure 14.1). Over the 2000-2013 period, oil share gradually declined (from more than 60% in 2000), while gas contribution expanded significantly from only 20% in 2000, which resulted in the improvement in the primary energy diversity level from 0.43 HHI in 2000 to 0.38 HHI in 2013.

In 2014, Mexico produced 2.4 million barrels per day (Mmbbl/d) of crude oil, mostly the heavy type. This volume was 3.7% lower than the previous year level, mostly due to the decline in several major fields. In particular, the economy faces the challenge of replacing the output from its once largest oil asset Cantarell, a supergiant field, which was already at its peak in 2004 producing around 2.1 Mmbbl/d, more than 60% of the total crude oil production in Mexico. However, its productivity has been decreasing rapidly since then. By the end of 2014, Cantarell produced less than 0.4 Mmbbl/d, representing only 15% of the economy-wide production (PEMEX, 2014).

In the last few years, the biggest oil company in Mexico, the Petróleos Mexicanos (PEMEX), has focused its strategy on the discovery and development of new oil fields that can offset the natural decline of its major assets. The economy is a net crude oil exporter with around half of its total crude oil production being exported, especially to the United States, making it the third-largest oil supplier to the U.S. in 2014, after Canada and Saudi Arabia (EIA, 2016). Despite its robust production of crude oil and a domestic distillation

capacity of 1.7 Mmbbl/d from the six refineries, the economy is a net importer of oil products, especially gasoline.

Figure 14.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

On the other hand, although the economy is one of the largest gas producers in the APEC region, its production level shows a declining trend. In 2000, the economy produced 36 billion cubic metres (Bcm) of gas, and it peaked in 2009 with 48 Bcm before declining to 42 Bcm in 2013. In spite of huge gas production, the economy imported around 23 Bcm of gas, mainly from the U.S., equivalent to 34% of total domestic demand (Cedigaz, 2016).

In 2013, energy intensity stood at 100.7 toe/million 2010 USD based on the primary energy supply requirement, an increase of 1.0% from the 2000 level. The same increasing trend can be seen in primary energy per capita, which stood at 1.6 toe/person, an increase of 10% from the 2000 level (IEA, 2015 and EGEDA, 2015).

Oil Security

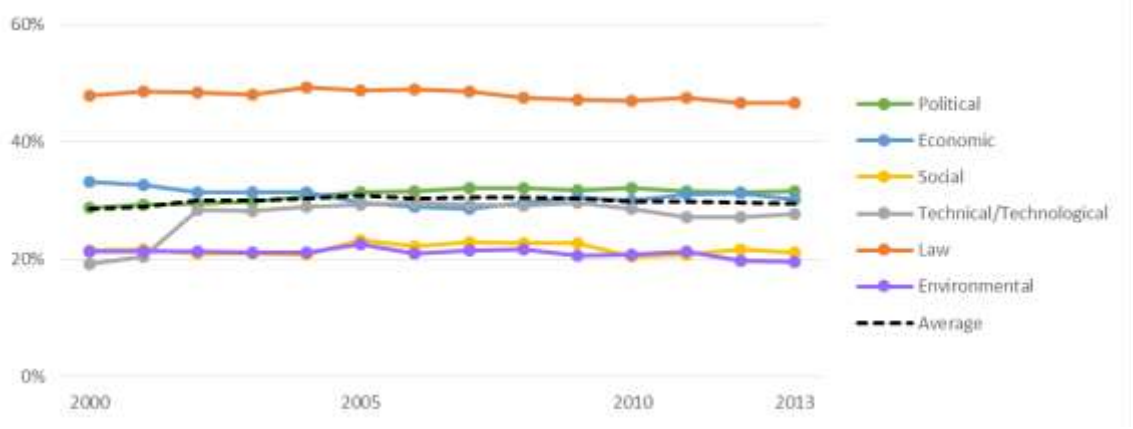
On average, Mexico's oil supply security index[30] was 29% for most of the years (Figure 14.2). Out of the six indicators established, two indicators – political and technical/technology – exhibited an increase in security index, while the other four indicators displayed a decreasing increase or remained unchanged.

The political indicator, which is based on the average of six sub-indicators, increased by 3.0% (from 29% in 2000 to 32% in 2013) due to an increase in risk in the local stability sub-indicator. Mexico is expected to improve the political risk once the economy becomes a full-fledged IEA member with support under the IEA-International Energy Program (IEP). From the results, by becoming an IEA member, the

[30] Although the study made an analysis on both crude oil and oil products, the study excludes Mexico's external risk for crude oil since the total crude oil import is too small – less than 2.0% of total crude oil demand.

economy's political risk could be improved by 10 percentage points. Meanwhile, there is a very low risk of chokepoints as the economy imported most of its oil products from the United States.

Figure 14.2: Oil Supply Security Index, 2000-13



Source: APERC analysis.
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The technical/technology indicator, which is determined by six technical/technology sub-indicators, recorded the highest risk increase from 19% in 2000 to 28% in 2013. The increase was caused mainly by the sudden drop in proven oil reserves (the data was taken from EIA's database), from 27 billion barrels in 2001 to 13 billion barrels in 2002 (IEA, 2015). However, excluding the abrupt drop in the oil reserves sub-indicator, the economy's index in technical/technology indicator showed an improvement of 1.0% (28% in 2013 compared with 29% in 2002), mainly due to the lower refinery utilisation rate. In 2013, the refinery utilisation rate was89% compared with 94% in 2002.

Under the economic indicator, which is made up of 11 sub-indicators, a major improvement is seen under the oil share to primary energy and oil intensity, with risk reduction in these sub-indicators reduced by more than 10% each. However, the increase of oil product imports, from 34% in 2000 to 40% in 2013, offset some of the risk reduction. Although oil product imports increased, the diversity of import sources improved from 0.77 HHI in 2000 to 0.68 HHI in 2013.

As for the social indicator, the economy's oil consumption per capita reached its peak in 2005 at 0.91 toe/person before going down to 0.80 toe/person in 2013. This improved the index of this indicator from a high of 31% in 2005 to 29% in 2013.

The law indicator exhibited a slight decrease, from 48% in 2000 to 47% in 2013. There are four sub-indicators that contributed to the law index – three sub-indicators for internal factors (resource extraction regulations, emergency preparedness and strategic stockpiling), and a sub-indicator for exporter's rule of law. Most of the internal sub-indicators have the same risk except for resource extraction regulations

(which is derived from the Global Petroleum Survey (GPS), which saw a slight uptick in 2011 (70% index value) before coming down to the same level recorded in 2000-2010 (69% index value). On top of that, the exporter's "rule of law" (for both crude and oil products) reduced from 23% in 2000 to 19% in 2013, which subsequently improved the external risk. The economy does not maintain an oil stockpile (APERC, 2015). Thus, building an oil stockpile may improve the index, although the necessity of having an oil stockpile needs to be discussed further.

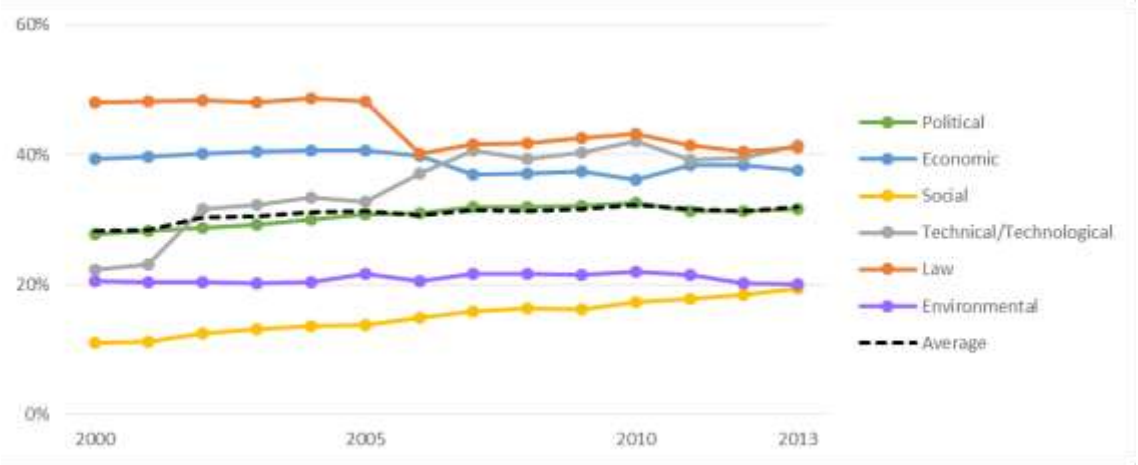
Finally, the environmental indicator risk reduced slightly from 21% in 2000 to 20% in 2013, partly because of the economy's improved index in readiness and reduced vulnerability towards climate change impact as reported by the Notre Dame Global Adaptation Index (ND GAIN). Based on this index, the economy's vulnerability improved by nearly 10% (ND GAIN showed that Mexico's vulnerability was 0.38 in 2000 and 0.35 in 2013, where a lower index means the economy is better prepared) (ND-GAIN, 2016).

Gas Security

In the year 2000, Mexico's average gas security index was the same as oil at 29%. By 2013, the risk increased to 32%, making it higher than oil (at 30%). Out of the six indicators evaluated, four of them demonstrated an increase in risk, while the other two indicators showed a reduction trend (Figure 14.3).

The political indicator index increased from 28% in 2000 to 32% in 2013. At least two sub-indicators demonstrated an upward trend – local stability and source of gas imports' stability. Local stability, which has been discussed earlier in the oil supply security index section, displayed an increase in risk from 55% in 2000 to 65% in 2013.

Figure 14.3: Gas Supply Security Index, 2000-13



Source: APERC analysis.
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

Although three-quarters of the gas was imported from the United States through pipelines, the risk of supply disruption due to political stability and the absence of violence/terrorism is very low, since the U.S. is considered to be a highly stable economy. However, the same thing cannot be said for other import sources such as Nigeria, which contributed about 5.0% of the total gas imports in 2013.[31] Due to the high political risk as indicated through WGI, the economy's gas import source stability sub-indicator increased by 1.2 percentage points, from 2.7% in 2000 to 3.9% in 2013. Theoretically, if the economy replaces Nigeria (with the same import share) with a more stable import source such as Qatar or Malaysia, the risk under this indicator could be lower by 0.2% - 0.3%.

The economic indicator showed a slight decrease from 40% in 2000 to 39% in 2013. Out of the six sub-indicators (under this indicator), two of them marked huge increases – the gas intensity sub-indicator, from 20 toe/million 2010 USD in 2000 to 32 toe/million USD 2010 in 2013, and gas share to primary energy, from 20% in 2000 to 32% in 2013. In 2000, the diversity of import sources was 1.0 HHI (meaning there is a single import source) as the United States was the only import source. By 2013, the diversity level dropped to 0.55 HHI as the economy imported its gas from multiple sources, which subsequently reduced the risk in the gas import source diversity sub-indicator and offset some of the increases in other sub-indicators' index.

On the social indicator, the economy's gas consumption per capita steadily increased from 0.28 toe/person in 2000 to 0.50 toe/person in 2013. However, this could be considered to be low compared with other major gas producers such as Russia with 2.8 toe/person and the United States with 1.9 toe/person. With the projected economic expansion in the future, the economy's gas demand is expected to increase by 3.5% annually until 2040 from the 2010 level, which could subsequently increase the gas consumption per capita level (APERC, 2016).

Technical/technology indicator demonstrated the highest increase among the indicators, almost doubling, from 23% in 2000 to 42% in 2013. Out of the eight sub-indicators that made up this indicator, four of them contributed to the rapid increase in this indicator, as follows:

- A sudden drop in gas reserves from 717 Mtoe in 2002 to 382 Mtoe in 2003 (EIA, 2016);
- The introduction of regasification terminal (RGT) in 2006 (that subsequently introduced new constraints in the technical/technology indicator) pushed the RGT utilisation rate from 0% in 2005 (when there was no RGT) to 30% in 2013;
- A decrease in gas self-sufficiency level from 92% in 2000 to 66% in 2013; and,
- Higher trans-border gas pipeline utilisation rate (gas imports from the U.S.) from 13% in 2000 to 41% in 2013.

There are three sub-indicators under the law indicator – resource extraction regulations, gas

[31] In the WGI - Political Stability and Absence of Violence/Terrorism indicator, the World Bank indicates that the governance performance can be constituted as -2.5 (weak) to 2.5 (strong). Nigeria scored -2.08 in 2013 for this indicator (WB, 2016)

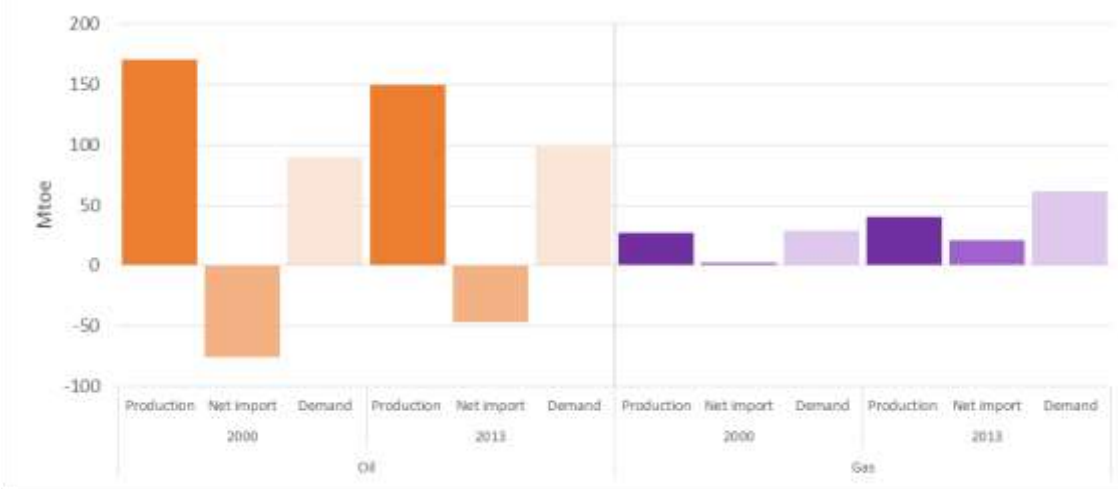
emergency preparedness and exporter's rule of law. The law indicator decreased from 49% in 2000 to 42% in 2013, resulting from improvements in the gas emergency preparedness sub-indicator. The study considered that having a RGT will improve the emergency preparedness sub-indicator. As the economy introduced an RGT in 2006, the gas emergency preparedness sub-indicator decreased by 25% in the same year (from 50% in 2000), which subsequently affected the law indicator. Other factors also considered in this sub-indicator are the availability of a policy to tackle gas supply disruption, and availability of underground gas storage and trans-border gas pipelines.

The environmental indicator showed a slight decrease from 21% in 2000 to 20% in 2013, the same as in the oil supply security index. As discussed in the oil security index, the economy improved its readiness and reduced vulnerability towards climate change impact. Since most of the gas imports came from the United States, the external risk for the environmental indicator is more or less the same as oil.

Imports and Sources

Although Mexico is one of the biggest net energy producers in the APEC region, the production recorded a declining output trend since 2000. In 2000, the economy produced about 170 Mtoe of oil, but decreased to 150 Mtoe in 2013 (IEA, 2015). Most of the oil products are consumed locally, while the rest is for exports, mainly to the United States. As production level declined and local consumption increased, the net oil imports (crude and oil products) shrank almost 40%, from 76 Mtoe in 2000 to 47 Mtoe in 2013 (Figure 14.4).

Figure 14.4: Production, Net Imports and Demand, 2000-13



Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Mexico's gas production increased from 36 Mtoe in 2000 to 42 Mtoe in 2013 (a 17% increase). At the same time, the economy's gas demand increased by more than double from 28 Mtoe in 2000 to 62 Mtoe

in 2013. It clearly showed that the economy's gas production is insufficient to meet local demand, which subsequently pushed Mexico to import gas – through pipelines from the United States, as well as in liquefied natural gas (LNG) form.

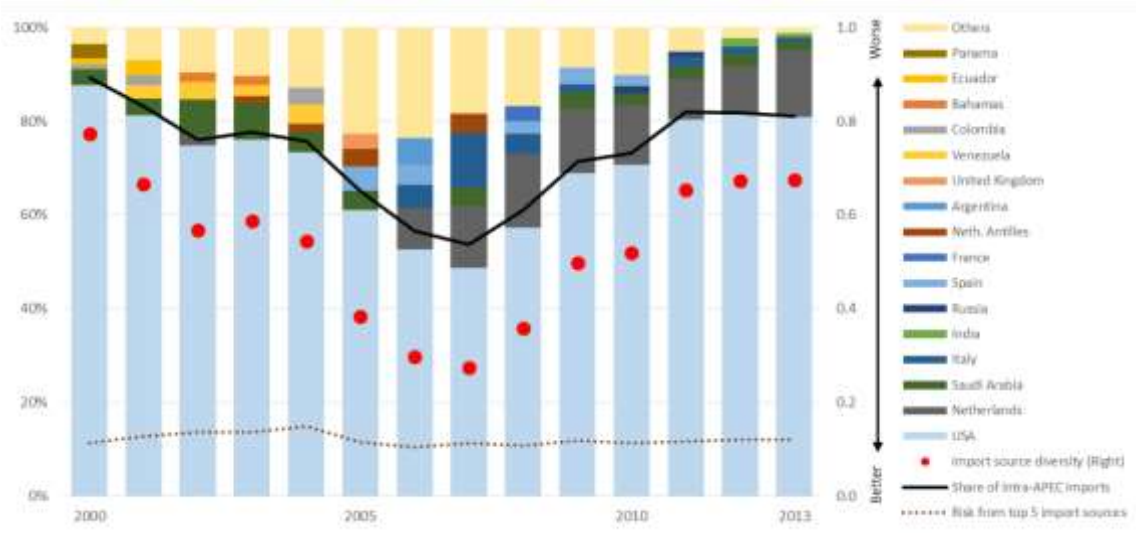
Even though Mexico is considered to be a net oil exporter due to its huge crude oil production, in reality, the economy is a net oil product importer. With oil product demand at around 72 Mtoe in 2013, nearly a quarter of this demand was met by imports. The economy's net oil product imports in 2013 stood at 20 Mtoe) (IEA, 2015).

Oil Product Import Sources

As Mexico sourced about 88% of its oil product imports from the United States in 2000, diversity index level was high at 0.77 HHI. However, as the U.S. import share decreased to 53% in 2007 following an increase of oil imports from the Netherlands (13% share) and Italy (12% share), the diversity level improved to 0.27 HHI. However, by 2013, diversity of oil imports sources deteriorated to 0.68 HHI due to the increase in the United States imports again (81% share). Although import share from the Netherlands increased slightly by 1.0%, share of Italy was down to 1.0% (Figure 14.5).

The top five exporters provided around 80% to 90% of the economy's oil product imports. Major exporters (top five) of oil products kept on changing every year with the exception of two economies – the United States and Saudi Arabia. Both economies had been consistently appeared in the economy's top import sources over the historical period.

Figure 14.5: Oil Product Import Sources, 2000-13



Source: APERC analysis and UN Comtrade, 2016.

The risk covered by the top five import sources was relatively low – at 11% in 2000, peaking in 2004 at 15%, and down to 12% in 2013. Since most of the oil product imports came from the United States, any risk changes in the U.S. will affect the economy's risk of supply disruption (albeit at a very low rate). As one of these indicators is local stability, the U.S. recorded the highest risk on political stability in 2004, which subsequently affected the economy's import source risk. However, the U.S. political stability risk improved over the years.

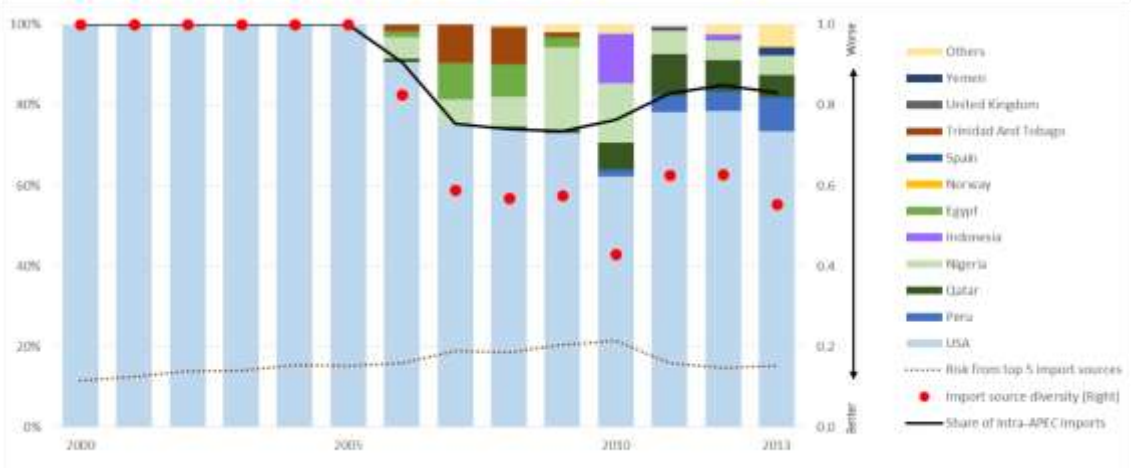
Since the United States is the major oil product exporter to the economy, the intra-APEC imports had been high over the historical period. In 2000, intra-APEC imports was at 89% of total oil product imports and went down 81% in 2013. However, if we exclude the US from the intra-APEC share, the economy only imports about 1.0%-4.0% of its oil products from APEC members. Russia is the only APEC economy that appeared in the top five oil product import sources twice in 2010 and 2011 with 2.0% and 1.0% share, respectively.

Gas Import Sources

In 2000, the United States was the only gas exporter to the economy and continued to be until 2005 when RGT was (Figure 14.6) (Cedigaz, 2016). Although the U.S. still dominates as the major source of gas imports, the economy has been trying to diversify its import sources. In 2013, there were 10 economies that exported gas to the economy.

Similar to oil, the intra-APEC imports was high during the historical period, contributed mainly by the United States. In addition to the U.S., Indonesia (in 2010 and 2012) and Peru (from 2010 onward) were the other APEC economies that exported gas in LNG form.

Figure 14.6: Natural Gas Import Sources, 2000-2013



Source: APERC analysis and Cedigaz, 2016.

From the major exporters (top five exporters), the supply disruption risks slightly higher than oil at 12% in 2000, and it peaked in 2010 at 21% before going down to 15% in 2013. In 2010, the economy recorded the best import source diversity at 0.43 HHI, but with the highest risk from the top five exporters. In the earlier discussion, it was mentioned that gas imports from Nigeria increased the overall gas supply disruption risk for the economy due to unstable political condition (Nigeria).

Other risks, such as the "rule of law" and LNG terminal utilisation also saw increases. In 2010, 20% of total gas imports came from Nigeria resulted in a 15% "rule of law" risk. Meanwhile, the United States with a 62% import share only resulted in 13% risk. If imports from Nigeria could be replaced (theoretically) by Australia or Russia (both APEC members) with same import share, the "rule of law" risk could be reduced to 10 and 2.0 percentage points, respectively. A deeper analysis on the risk may help avoid or minimize any supply disruption in the future.

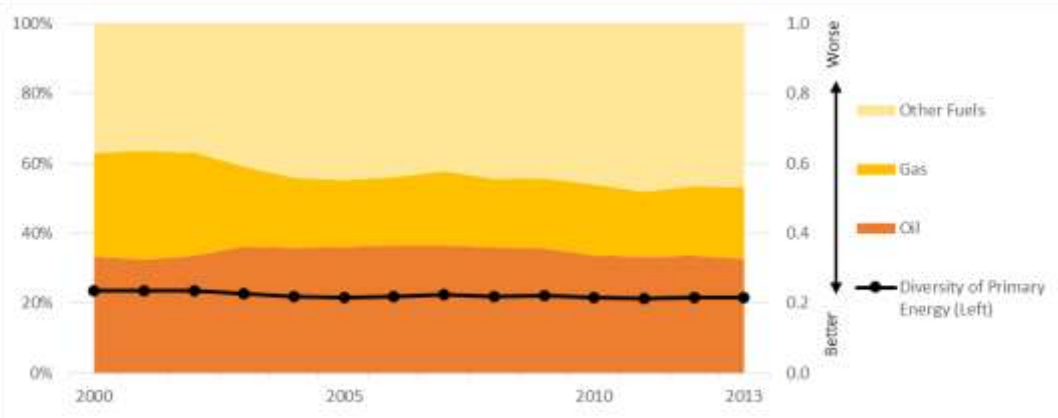
NEW ZEALAND

Economy-Energy Overview

New Zealand is an island economy in the South Pacific, comprised of the North Island, South Island and numerous outer islands. While its land area is between that of Japan and the United Kingdom, its low population of about 4.4 million is comparable to a medium-sized Asian city. Due to its remote location, New Zealand has no electricity or pipeline connections to other economies. New Zealand has a mature economy with a per capita gross domestic product (GDP) of about USD 32,526 (2010 USD and Purchasing Power Parity [PPP]) in 2013 (EGEDA, 2015).

New Zealand is self-sufficient in all energy forms except oil. It has a vast renewable energy potential, which in 2013 accounted for 74% of electricity generation, largely from hydro, geothermal and wind. In 2013, the economy's total primary energy supply was 20 million tonnes of oil equivalent (Mtoe). Oil and gas were the major contributors with a combined share of 53%, while the rest was made up of renewables, such as geothermal, wind, solar and others (21%), hydro (10%), coal (8%) and biomass, biogas, waste heat, and others providing the remainder 7.0% (IEA, 2015) (Figure 15.1).

Figure 15.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

The economy has a high primary energy diversity level. In 2013, diversity index improved to 0.22 HHI from the 2000 level of 0.24 HHI. During the 2000-2013 period, oil share remained stable (33%), while and gas share decreased 10%. The decrease in gas share coupled with increases in renewable energy shares, contributed to the improvement of primary energy diversity.

The economy held modest energy reserves– 128 million barrels (Mmbbl) of oil and liquefied petroleum gas (LPG), 56 billion cubic metre (Bcm) of natural gas and 571 million tonnes (Mt) of coal at the end of 2014 (MBIE, 2015). Oil is sourced from 19 fields in the Taranaki region on the North Island. The production of crude oil, natural gas liquids and condensate was down by 13% on an energy-equivalent basis in 2013 compared with 2012. Oil production peaked in 2008 underpinned by the coming on-line of the newest fields Pohokura, Kupe, Tui and Maari, and from onshore fields such as Cheal and Sidewinder (MBIE, 2015). New Zealand is a net importer of oil with indigenous production accounting for around 30% of the domestic oil demand in 2013 (IEA, 2015).

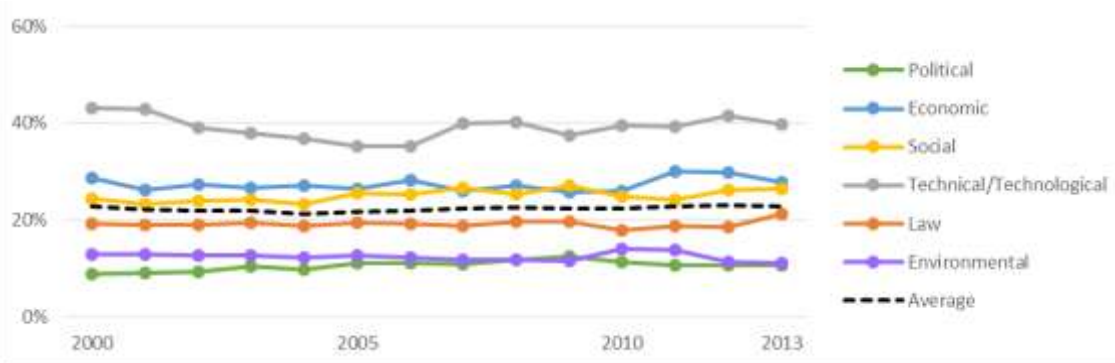
The economy's gas consumption shrank by one-fifth, from 5.1 Mtoe in 2000 to 4.0 Mtoe in 2013. All the gas supplied was locally produced from 18 fields. The economy does not have liquefied natural gas (LNG) terminals or trans-border gas pipelines (MBIE, 2013). Gas is largely used for industrial heat, electricity generation and in methanol and urea production.

In 2013, energy intensity stood at 125.5 toe/USD million based on the primary energy supply requirement, a drop by 17% from the 2000 level. On the other hand, primary energy per capita was stable at about 4.4 toe/person during the historical period (IEA, 2015 and EGEDA, 2015).

Oil Security

New Zealand's average oil supply security index showed a stable risk, around 22%-23% (for 2000-2013) (Figure 15.2). Out of the six indicators that were evaluated, three indicators – political, social and law demonstrated a slight increase in risk, while the other three indicators decreased.

Figure 15.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

Among APEC members, New Zealand has one of the lowest risks in the political indicator. The political indicator index, which is based on the average of risks of six sub-indicators (three sub-indicators are

assigned as internal risk and the other three as external risk), showed an upward trend from 9.0% in 2000 to 11% in 2013. The local political stability improved from 25% in 2000 to 21% in 2013 (a lower percentage means higher stability) and no piracy incidents recorded in the economy. On top of that, the economy, being a member of the International Energy Agency (IEA), is covered by the IEA-International Energy Program (IEA-IEP), which contributed to reducing the political risk significantly. As for external sub-indicators, the import source stability (both crude oil and oil products) had been the main factor that caused the increase in the political indicator (from 20% in 2000 to 55% in 2013) over the historical period. However, the diversity of import sources improved (which will be discussed under the economic indicator) that helped to lower the chokepoint risk from 11% in 2000 to 8.0% in 2013.

Under the economic indicator, which is made up of 11 sub-indicators, a slight improvement of 1.0 percentage point was recorded from 29% in 2000 to 28% in 2013. This improvement was mainly contributed to by import source diversity – especially for oil products and to some extent crude oil. The economy imported its oil products from 32 economies in 2000, the number increased to 54 economies in 2013. Other than diversity, a decrease in oil intensity, from 50 toe/million 2010 USD in 2000 to 31 toe/million 2010 USD in 2013, contributed to the improvement in the economic indicator.

As for the social indicator, the economy's oil consumption per capita reached its peak in 2003 at 1.5 toe/person before going down to 1.4 toe/person in 2013. Since the risk in oil consumption per capita was made against the highest and lowest oil consumption per capita level among APEC members, as well as the changes (highest recorded) in the economy's oil consumption per capita during the historical period, the economy's social indicator displayed a slight increase from 25% in 2000 to 27% in 2013.

The technical/technology indicator, an average index of six technical/technology sub-indicators, reduced from 43% in 2000 to 40% in 2013. Among the sub-indicators that contributed largely to the increase were the oil self-sufficiency level, which deteriorated from 36% in 2000 to 32% in 2013 and the reserves-production (R/P) ratio for oil (derived from EIA database), which peaked in 2006 with 25.7 years before going down to 7.4 years in 2013. The refinery utilisation rate improved from a 100% rate in 2000 to 83% in 2013, while the ability for exporters to produce crude oil improved, 16% in 2000 to 10% in 2013.

The law indicator showed a slight increase in risk, from 19% in 2000 to 21% in 2013. There are four sub-indicators under this indicator – three sub-indicators for internal, which are resource extraction regulations, emergency preparedness and strategic stockpiling, and exporter's "rule of law". Among these sub-indicators, only resource extraction regulations, which is derived from the Global Petroleum Survey (GPS), displayed an upward risk, from 21% in 2000 to 30% in 2013, although the economy received the lowest resource extraction regulation risk among APEC members. As for emergency preparedness, the economy manage to get the lowest risk due to the availability of regulations in order to address emergencies and high stockpiling requirements (96 days of net imports), which made the index for law indicator relatively low (APERC, 2015).

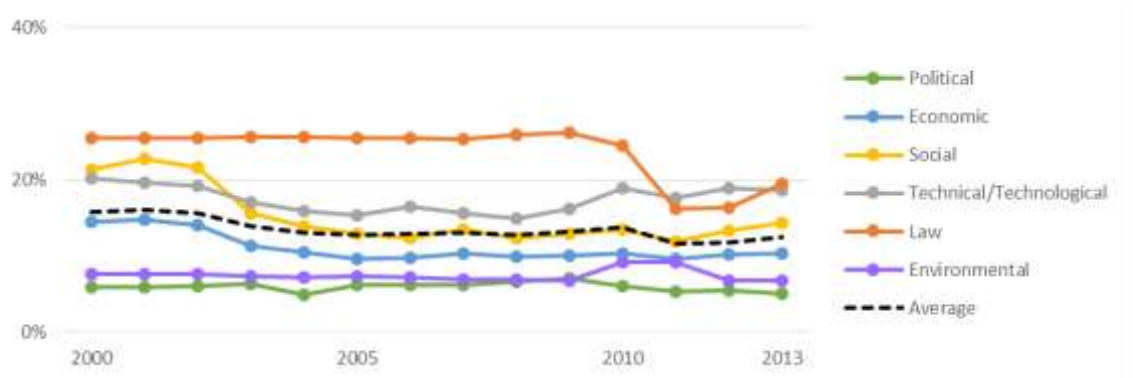
On the environmental indicator with two sub-indicators - readiness and vulnerability in facing climate change impact, and natural disaster risk – gained an improvement from 13% in 2000 to 11% in 2013, partly due to improve in readiness and reduced vulnerability in facing climate change impact as reported by the Notre Dame Global Adaptation Index (ND-GAIN). In fact, ND-GAIN considered the economy with the best overall index in the world with low vulnerability towards climate change and a high readiness index. The ND-GAIN showed the economy's vulnerability was 0.28 in 2000 and 0.26 in 2013, while the readiness improved from 0.85 in 2000 to 0.89 in 2013.

Gas Security

Generally, New Zealand's average gas security index is lower than oil at 16% in 2000 and 12% in 2013. All indicators demonstrated improvements, led by the social and law indicators (Figure 15.3). Since the economy does not import gas, the discussion will focus on internal factors that can influence gas supply security.

The political indicator, which is made up of six sub-indicators showed a slight decrease from 6.0% in 2000 to 5.0% in 2013, attributed to low risk in the local stability sub-indicator with 21% in 2013from 25% in 2000. Other internal sub-indicators that were used to determine the political indicator are the piracy threat and the existence of a multilateral agreement on gas emergency supply. Since there are no piracy incidents reported in the economy and no gas import infrastructure such as RGT or pipelines (which makes a multilateral agreement not so relevant) available, both sub-indicators got 0% risk.

Figure 15.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economic indicator exhibited a decrease from 15% in 2000 to 11% in 2013. Out of the seven sub-indicators (two of the sub-indicators are related to imports), four of them marked a decrease. The gas intensity decrease from 48.1 toe/million 2010 USD in 2000 to 27.5 toe/million 2010 USD in 2013 (which can

be translated as 56% in 2000 to 34% in 2013 in index form), while gas share to primary energy went down to 20% in 2013 from 30% in 2000. The "Ease of Doing Business" sub-indicator derived from the Doing Business Report improved, and higher diversity of primary energy also, from 0.24 HHI in 2000 to 0.22 HHI in 2013.

The social indicator has one sub-indicator – the gas consumption per capita. The economy's gas consumption per capita had steadily decreased from 1.3 toe/person in 2000 to 0.90 toe/person in 2013, which contributed to the decrease in the social indicator from 22% in 2000 to 15% in 2013. Although, the economy's gas consumption per capita can be considered to be low compared with other major gas producers, such as Russia with 2.75 toe/person and the US with 1.93 toe/person (both recorded in 2013), it is still higher than the APEC average of 0.58 toe/person.

The technical/technology indicator also realised a decrease, from 21% in 2000 to 19% in 2013. There are two sub-indicators that contribute to the decrease, the gas R/P ratio sub-indicator and the underground natural gas storage sub-indicator. Based on data derived from EIA, the economy's 2013 gas production level could last for about 11.6 years, far lower than its peak in 2008 with 17.5 years (EIA, 2016). The economy's underground gas storage was first introduced in 2011 with a capacity of holding 0.27 Bcm of gas (or equivalent to 6.0% of local demand in 2013). The introduction of underground gas storage helped reduced the risk of the technical/technology indicator.

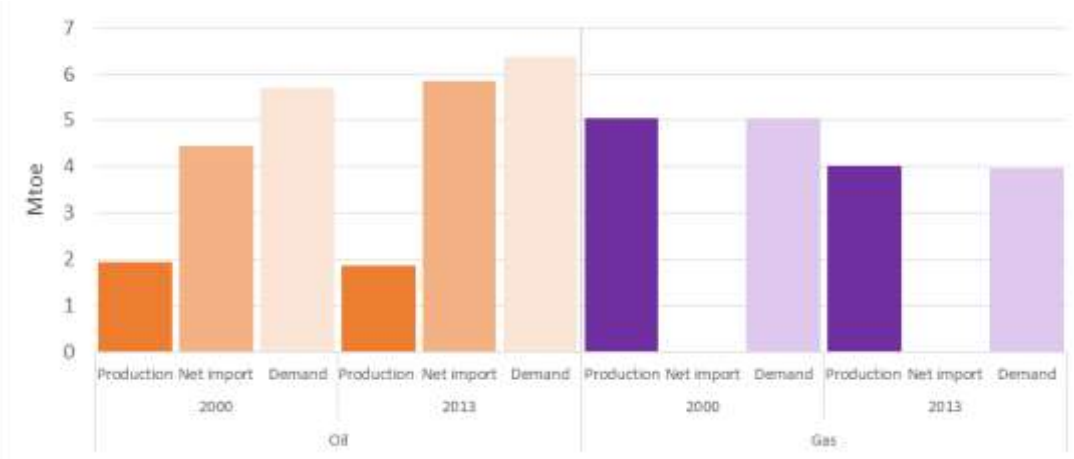
There are three sub-indicators under the law indicator for gas – resource extraction regulations, gas emergency preparedness and exporter's rule of law. As discussed earlier in the oil security, the resource extraction regulation sub-indicator increased from 21% in 2000 to 30% in 2013. The gas emergency preparedness sub-indicator has four components that are related to law (or policy) – availability of RGT, trans-border pipelines, and underground storage, and gas emergency preparedness. The availability of trans-border pipelines was not included since the economy is located far from other producing economies. However, the study retained the RGT availability component since this infrastructure could be one of the options for the economy to import gas (given that the gas reserves will last for less than 12 years) in order to meet future demand. As the underground storage was introduced in 2011, it contributed to lowering the law risk by 8.0%, from 25% in 2010 to 17% in 2011.

As for the environmental indicator, risks included in this indicator are limited to internal risks since the economy does not import gas. Given that the economy received fairly high (low index) in readiness and is among the lowest in terms of climate change vulnerability (as discussed in the oil chapter), the gas supply disruption risk due to climate change impact is low. However, the natural disasters (earthquakes) that occurred in Canterbury (2010) and Christchurch (2011) increased the environmental indicator index by 2.0 percentage points for both 2010 and 2011 (CRED, 2016).

Imports and Sources

New Zealand is a net crude and oil product importer. Although the economy produce oil, it is not enough to cover the demand in New Zealand. On the other hand, New Zealand rely solely with domestic gas production in order to meet the local demand.

Figure 15.4: Production, Net Imports and Demand, 2000-13



Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Crude Oil Import Sources

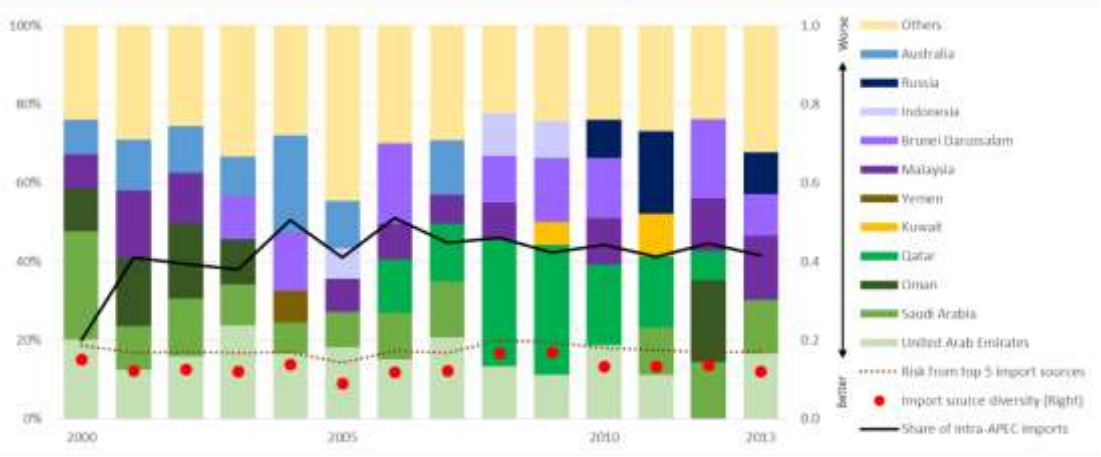
Economies from the Middle East and North Africa (MENA) region, such as the United Arab Emirates (UAE) and Saudi Arabia, had been consistently appeared as the top crude oil exporters to the economy over the historical period. However, there had been a shift in import sources for New Zealand. In 2000, nearly 70% of crude oil imports came from MENA – Saudi Arabia and UAE both accounted for 48% of total imports, while nearly 10% of crude imports came from Southeast Asia economies. By 2013, MENA contributed 57% of total imports, while Southeast Asia (SEA) economies' share increased to 30% - mainly from Brunei Darussalam (11%) and Malaysia (16%). Even though the import sources are mainly from MENA and SEA, the economy still realised a very high diversity (by share). The economy's import source diversity stood at 0.12 HHI in 2013 from 0.15 HHI in 2000 (a lower HHI means a higher diversity level) (Figure 15.5).

The top five crude oil exporters to the economy roughly supplied around 60% to 70% of total imports. The risk posed by the top five exporters was still relatively low – at 19% in 2000, peaking in 2008 at 20% and down to 17% in 2013. A deeper analysis showed that the risk in 2008 peaked due to the sudden increase in share of Qatar crude oil imports – from 15% in 2007 to 32% in 2008 – which increased the risk of exporter's stability, as well as chokepoint risk.

In terms of intra-APEC trade, the economy imports from APEC members increased from 20% in

2000 to 42% in 2013. Australia; Brunei Darussalam; Malaysia; and Russia occasionally appeared as the top five exporters of crude oil to the economy.

Figure 15.5: Crude Oil Import Sources, 2000-13

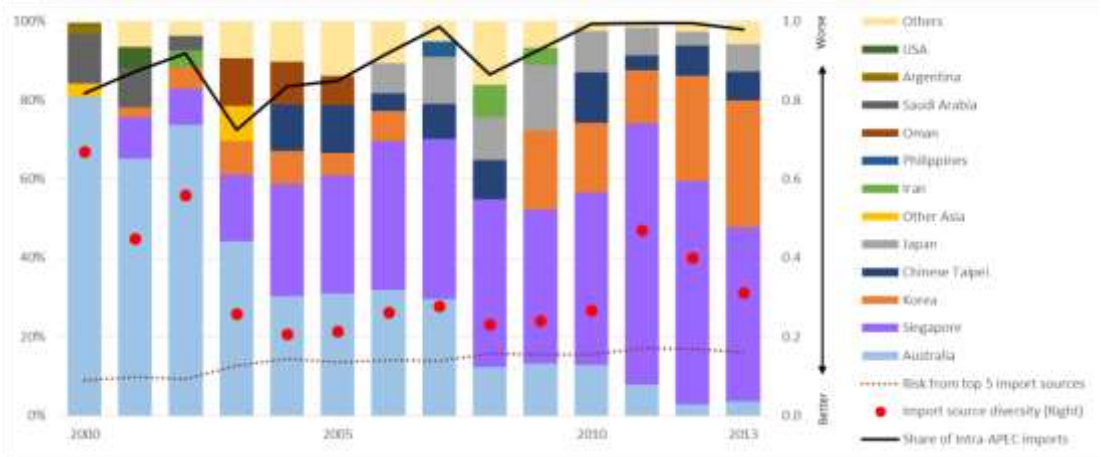


Source: APERC analysis and UN Comtrade, 2016.

Oil Product Import Sources

The same analysis on oil products revealed that in 2000, 80% of oil product imports came from Australia, and its share dropped to 4.0% in. Despite that, Australia consistently appeared as a top five oil product import source for the economy. Korea and Singapore became the main oil product import sources, with a combined share of 76% in 2013 (Figure 15.6). APEC members had been the major source of oil product imports for New Zealand over the historical period. During the historical period, nearly all oil product imports came from Australia; Japan; Korea; Singapore; and, Chinese Taipei, all of which are APEC members.

Figure 15.6: Oil Product Import Sources, 2000-13



Source: APERC analysis and UN Comtrade, 2016.

The supply disruption risk of the top five oil product exporters was lower than crude oil, at 9.0% in 2000, peaking at 17% in 2011, before coming down to 16% in 2013. The economy recorded the best import source diversity at 0.21 HHI in 2004. The primary contributing factor for a lower risk compared with crude oil is the highly stable import sources. All APEC members that exported oil products to the economy received a better political stability index based on WGI, as well as lower chokepoint risk as most of the exporters are located in East Asia.

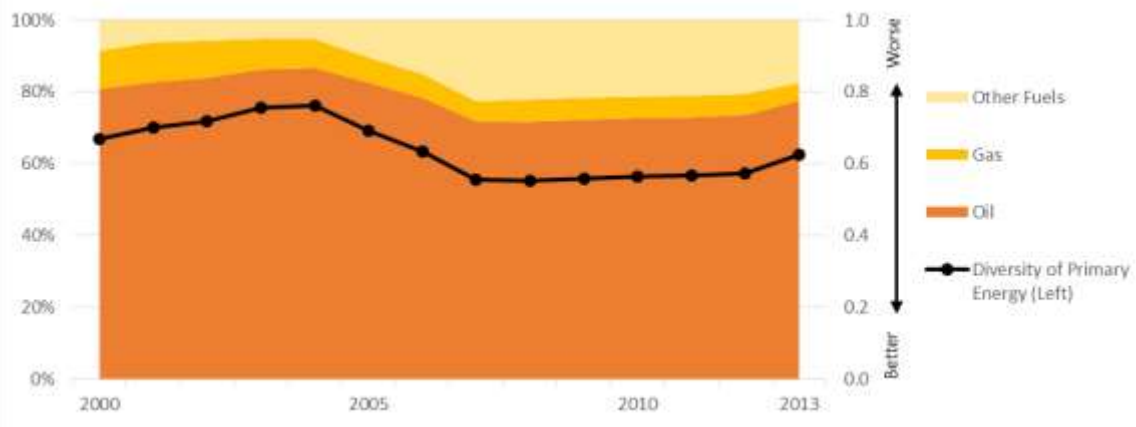
PAPUA NEW GUINEA

Economy-Energy Overview

Papua New Guinea (PNG) is located in the south-west part of the Pacific Ocean, just south of the equator. It is comprised of more than 600 islands, including the eastern half of New Guinea – the world's second-largest island – as well as the Bismarck Archipelago, the D'Entrecasteaux island group and the three islands of the Louisiade Archipelago. The mainland and the larger islands are mountainous and rugged, with a string of active volcanoes dotting the northern part of the mainland and continuing to the island of New Britain. PNG had a population of more than 7.0 million in 2013, spread across a total area of 462,840 square kilometres (km2). The natural resource extraction industry, which includes minerals, oil and gas, contributes to approximately 80% of PNG's export income (MRA, 2012).

In 2013, PNG's net primary energy supply was 2,561 kilotonnes oil equivalent (ktoe), an increase of 130% over the 2000 level. Of the total supply in 2013, light crude oil and petroleum products accounted for the largest share (78%), followed by gas (5%) and hydro and other renewables contributed the remainder (16%) (EGEDA, 2015) (Figure 16.1).

Figure 16.1: Primary Energy Supply, 2000-13



Source: APERC analysis and EGEDA, 2015
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

High dependency on oil makes PNG one of the least diverse in terms of primary energy in the APEC region. In 2004, PNG's primary energy supply diversity recorded the lowest diversity level (high index) at 0.76 HHI and improved to 0.62 HHI in 2013 as more geothermal and hydro were introduced in the primary energy mix.

Production of crude oil in PNG started in 1992 and peaked at over 125, 000 barrels per day (bbl/d) the following year. Despite exploration activities that resulted in the development of additional oilfields, production has gradually declined reaching 36, 000bbl/d in 2014 (EIA, 2016).At this rate, crude oil reserves are expected to be depleted by 2026. Crude oil has been refined locally since the first refinery plant was commissioned in 2004 with a refining capacity of 33 thousand barrels per day (kbbl/d) (OGJ, 2015).

PNG's natural gas resource potential remains underexplored and undeveloped, except for the Hides gas field, which provides 145–155 million cubic metres per year (Mcm/y) primarily used for power generation to supply the Porgera Gold Mine in the central highlands of the economy. However, the economy's liquefied natural gas (LNG) project development was initiated in 2009 to develop these resources.

The PNG LNG Project is operated by Esso Highlands Limited (Company), a subsidiary of ExxonMobil. The Project is a joint venture between Esso Highlands Limited and Oil Search Limited, Santos, AGL, JX Nippon Oil & Gas Exploration, Minerals Resources Development Company, and Petromin PNG Holdings Limited, as well as local landowners. It is a 6.9 million tonnes per year (Mt/y) integrated LNG project sourced from the Hides, Angore and Juha fields, and from associated gas in the Kutubu, Agogo, Moran and Gobe Main oil fields. Said Project commenced production in April 2014 and the first LNG deliveries began in May 2014 to Asian customers (PNG LNG, 2014).

In 2013, energy intensity stood at 139.5 toe/million 2010 USD based on the primary energy supply requirement, an increase of 22% from the 2000 level. The same increasing trend can be seen in primary energy per capita which stood at 0.35 toe/person, an increase of 68% from the 2000 level (EGEDA, 2015).

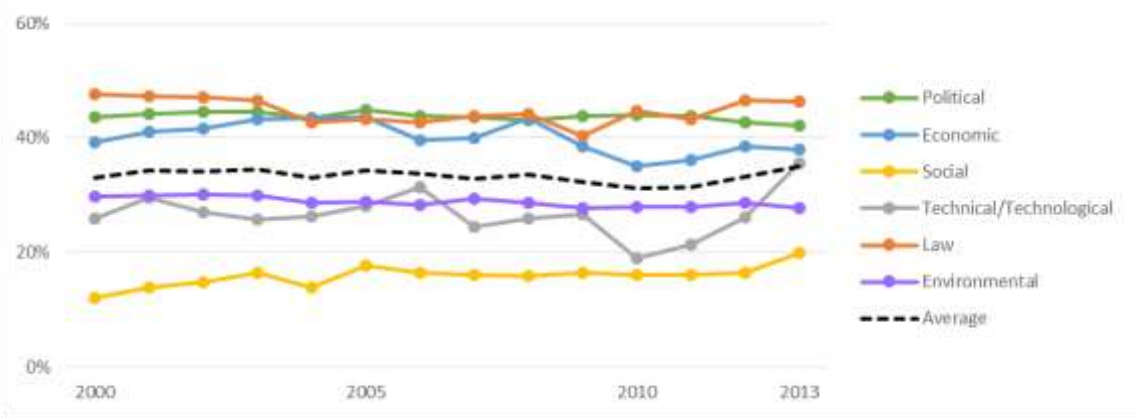
Oil Security

Based on the six oil security indicators – political, economy, social, technical, legal and environmental – PNG's oil supply security index showed an upward trend (increasing risk), from an average of 33% in 2000 to 35% in 2013. The technical/technology and social indicators contributed to this trend. Although the other four indicators showed some reductions (improvements) in their respective security indices, these were not sufficient enough to offset the increase recorded by the technical/technology and social indicators (Figure 16.2).

The economy's political indicator displayed a slight decrease (decline in risk) from 44% in 2000 to 43% in 2013. This indicator is based on the average of the six sub-indicators, three sub-indicators are assigned as internal risks and the other three as external risks. On the other hand, the local political stability risk showed an increase from 57% in 2000 to 61% in 2013 (higher percentage means lower stability). Although there were no piracy incidents recorded in PNG in 2013, the lack of an international agreement on oil supply emergencies pushed the political indicator to have a higher index. An agreement, similar to the International Energy Agency-Internal Energy Program (IEA-IEP) or the ASEAN Petroleum Security

Agreement (APSA), will help to reduce the political risk index. Theoretically, if PNG entered into some sort of international agreement (like the IEA-IEP or APSA type), the economy's political-risk could be lowered by 25 percentage points (43% political risk without an agreement and 18% risk with an agreement in 2013).

Figure16.2: Oil Supply Security Index, 2000-13



Source: APERC analysis.
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

Under the economic indicator, which is made up of 11 sub-indicators, a slight improvement of 1.0% was recorded from 40% in 2000 and down to 39% in 2013. This improvement was mainly contributed to by several sub-indicators – improvement in primary energy diversity, better "Ease of Doing Business" index (the data was derived from the Doing Business Report published by the World Bank Group), reduction of oil share to primary energy, and the diversity of import sources for oil products. However, there are two sub-indicators that recorded an increase in risk, which eventually offset most of the risk reductions gained from other sub-indicators. Sub-indicators that demonstrated an upward risk trend were the oil intensity (oil intensity increased from 93 toe/million 2010 USD in 2000 to 108 toe/million 2010 USD in 2013), and the share of net oil imports to demand (prior to 2011, the economy was a net exporter for total oil [crude and oil products).

For the social indicator, only one sub-indicator used to determine the risk, which is oil consumption per capita. As the economy is a developing economy, the oil consumption per capita (as well as oil intensity) is expected to increase in the future. The oil consumption per capita reached its peak in 2013 at 0.27 toe/person. Based on the projection (from the APEC Energy Demand and Supply Outlook 6th Edition), the economy's oil consumption per capita will reach 0.48 toe/person in 2040 (APERC, 2016). Although the oil consumption per capita is expected to almost double by 2040, it is still considered to be low compared with other APEC economies. In 2013, the highest oil consumption per capita recorded among APEC economies was 3.01 toe/person)

The technical/technology indicator, which is determined by six sub-indicators, is the biggest factor that contributed to the increase of the overall risk. Among sub-indicators that contributed to the risk increase

are oil self-sufficiency level and exporter's crude oil production level. In 2000, the economy's oil production was considered sufficient to meet local demand. As mentioned earlier, the economy became a net importer for total oil (crude and oil products) in 2012. However, the analysis showed that the economy became a net crude oil importer even earlier than the said year (2012), which was 2008, and this heavily influenced the upward trend for the technical/technology indicator.

The law indicator shows a slight decrease in risk, from 48% in 2000 to 47% in 2013. There are four sub-indicators under this indicator – three sub-indicators for internal which are resource extraction regulations, emergency preparedness and strategic stockpiling, and one sub-indicator for external which is exporter's rule of law. Among these sub-indicators, only resource extraction regulations, derived from the Global Petroleum Survey (GPS), showed an upward risk from 59% in 2000 to 71% in 2013. Despite the increase, the economy managed to improve its index to 48% in 2009 before it went up to 65% in 2010 (before ending up at the 2013 level). Theoretically, if PNG managed to maintain the 2009 index value in resource extraction regulations up to 2013, the risk under the law indicator should be able to improve further by another 3.0 percentage points.

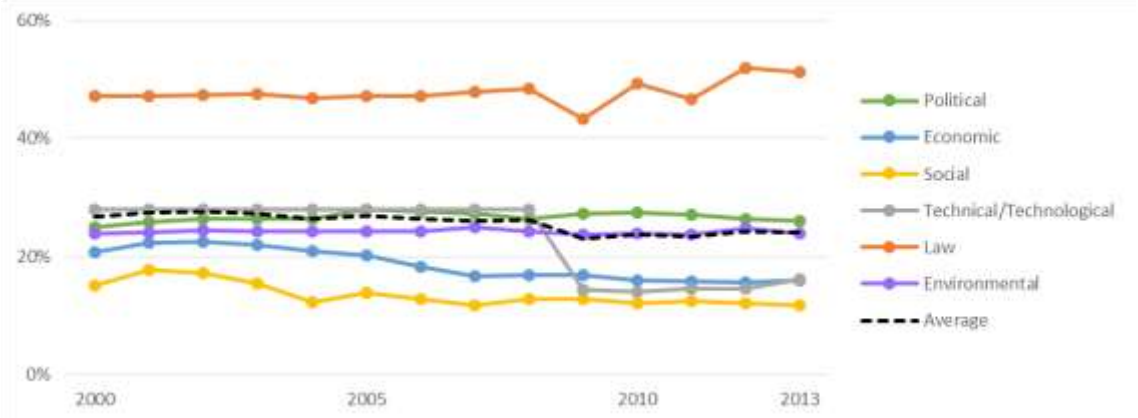
The environmental indicator has two sub-indicators – the climate change threat and natural disaster risk (both applied as internal and external factors). This indicator gained an improvement from 30% in 2000 to 28% in 2013, not so much because of a higher index on readiness level to face climate change threat or because of a lower vulnerability level towards climate change. In fact, according to the Notre Dame Global Adaptation Index (ND GAIN), the economy is one of the highly vulnerable economies, but somehow offset by the reduction in environmental risk of oil import sources (a deeper discussion on import sources can be found later in this chapter).

Gas Security

PNG's average gas security risk was lower than oil from 28% in 2000 down to 25% in 2013, a contrast compared with the oil supply security index that showed an upward risk trend. From six indicators evaluated, three of them realised improvement, led by the technical/technology indicator followed by economic and social indicators (Figure 16.3). Since the economy does not import gas, the discussion will focus on internal factors that can influence gas supply security.

The political indicator increased slightly from 26% in 2000 to 27% in 2013, attributed mainly to higher risk in the local political stability sub-indicator (57% in 2000 to 61% in 2013). The economy can lower the risk if the economy has an international gas emergency supply agreement (an agreement like APSA) that can help to address gas supply disruption. By having some sort of international or multilateral agreement, the economy can lower the political risk by another 12 percentage points. However, the agreement will be meaningful if there are sufficient enablers, such as import infrastructure available.

Figure 16.3: Gas Supply Security Index, 2000-13



Source: APERC analysis.
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economy indicator index declined to 17% in 2013 from 22% in 2000 because of the decrease in risks from four internal sub-indicators. The gas intensity sub-indicator reduced from 44% in 2000 to 26% in 2013 (same in oil, gas intensity index was calculated against the highest and lowest intensity among APERC members, as well as the changes in the economy's intensity level [highest recorded] within the historical period). The gas share to primary energy sub-indicator also went down to 5.0% from 11% in 2000, while index for "Ease of Doing Business" and diversity of primary energy sub-indicators also improved.

The social indicator has only one sub-indicator, which is gas consumption per capita. The gas consumption per capita steadily decreased from 0.022 toe/person in 2000 to 0.017 toe/person in 2013, which contributed to the decrease in social risk indicator. The economy's gas consumption per capita can be considered to be the lowest in APEC in 2013. However, projection revealed that gas consumption per capita will increase by more than 20 times in 2040 to 0.37 toe/person due to higher gas demand (APERC, 2016).

The economy's gas reserves increased tremendously from around 2.0 Bcm in 2008 to 264 Bcm in 2009, the same year when LNG project development was initiated in order to export this resource. The sudden increase in reserves resulted in a huge boost to the technical/technology indicator for PNG (although in reality gas produced was exported as LNG). This indicator showed a drop from 29% in 2000 to 15% in 2009 before it went up to 17% in 2013. Since the economy does not import gas, other sub-indicators such as the trans-border pipeline utilisation rate and RGT utilisation rate were kept at 0%.

There are three indicators under the law indicator for gas – resource extraction regulations, gas emergency preparedness and exporter's rule of law. As discussed earlier in the oil chapter, the resource extraction regulation sub-indicator increased from 59% in 2000 to 71% in 2013. The gas emergency preparedness sub-indicator has four components that are related to law (or policy) – availability of RGT, availability of trans-border pipelines, gas emergency preparedness, and availability of underground gas storage. Although PNG now is a net gas producer, gas demand in PNG is expected to see rapid growth for

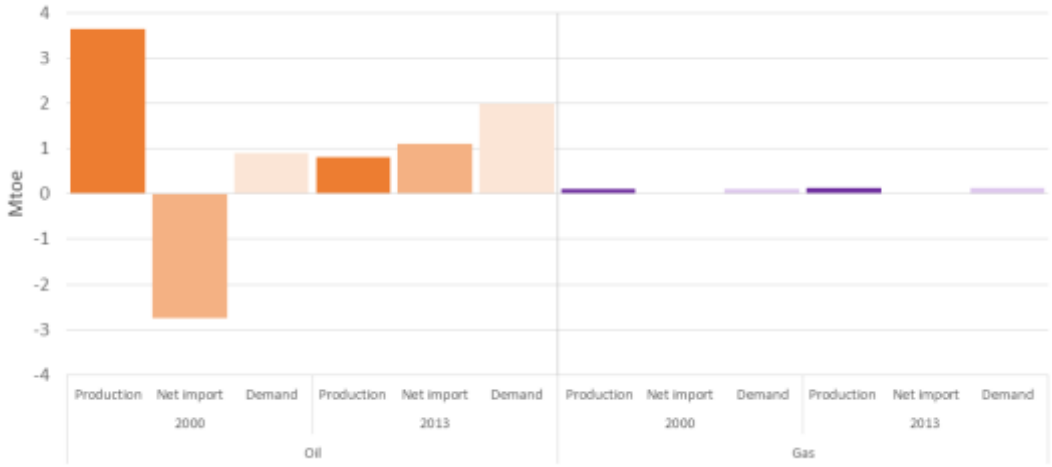
the next few decades. From projection, gas demand will increase from 0.14 Bcm/year in 2013 to 5.0 Bcm/year in 2040 (slightly lower than the combination of Brunei Darussalam and the Philippine's gas demands in 2013) (APERC, 2016). With this rapid demand increase, the economy may need to start to prepare for long-term emergency preparation such as building a trans-border pipeline, which can reduce the risk of the law indicator from 53% to 44% in 2013.

As for the environmental indicator, the same sub-indicators were used as in the oil supply security. Since the economy does not import any gas, the risk shown here is only limited to indigenous risk. As such, no change on risk for the economy under this indicator at 25% index.

Import Share and Sources

As PNG does not import any gas, this section will only discuss crude oil and oil product import risk, focusing on the top five exporters. Among APEC members, the economy can be considered to be a small oil producer and on declining trend. The economy produced 3.7 Mtoe of crude oil in 2000, and was significantly reduced to 0.8 Mtoe by 2013 (Figure 16.4), which subsequently turned the economy as net oil importer in 2011 (EGEDA, 2015).

Figure 16.4: Production, Net Imports and Demand, 2000-13



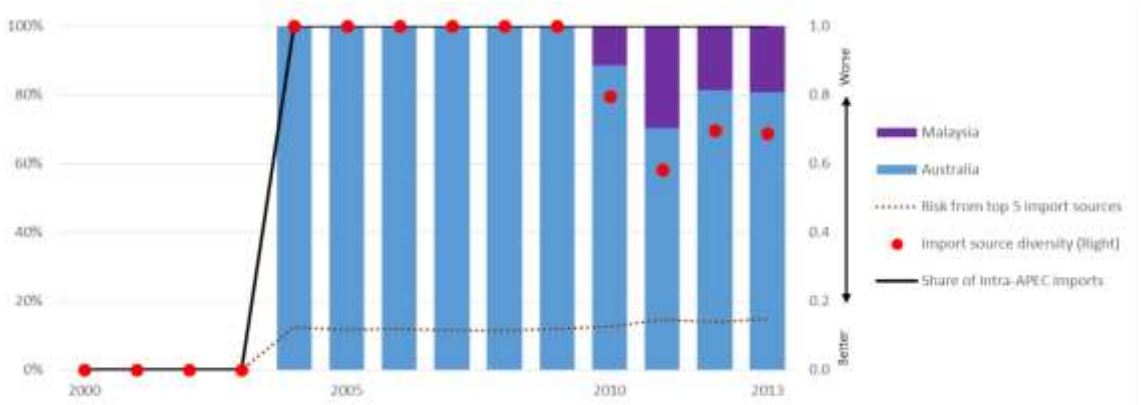
Note: Excludes international bunkers.
Source: APERC analysis and EGEDA 2015.

Crude Oil Import Sources

The economy's first and only refinery started its operation in 2004, and prior to that, no crude oil imports were recorded. Due to the completion of the refinery, the economy started to import crude oil only from Australia (2004-2009) and in 2010 from Malaysia as other source crude imports for the economy (Figure 16.5). Despite there were only two import sources, the supply interruption risk was reasonably low for the

economy as both could be considered to have stable political climate and with no risk on chokepoints. In addition, as both economies are APEC members, intra-APEC trade with stood at 100%.

Figure 16.5: Crude Oil Import Sources, 2000-13

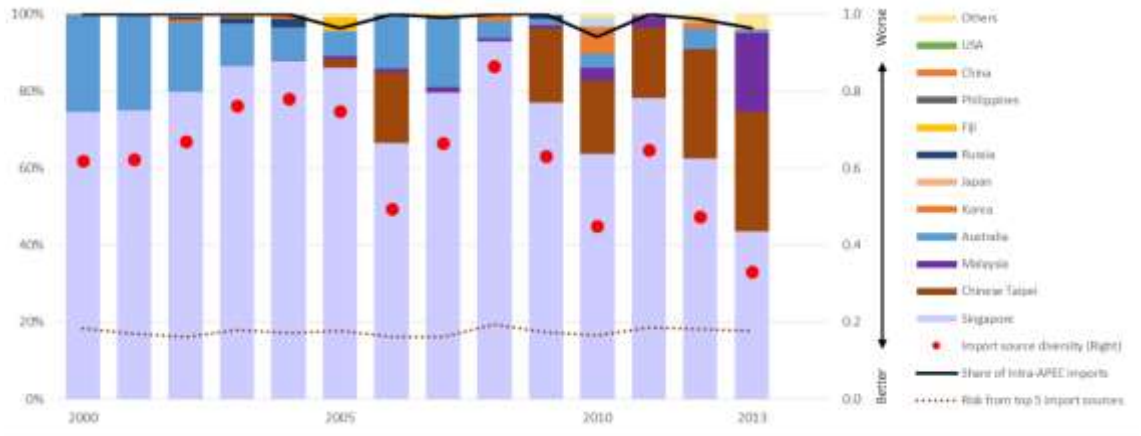


Source: APERC analysis and UN Comtrade, 2016.

Oil Product Import Sources

In 2000, 75% of oil product imports came from Singapore, while the rest from Australia. Given Singapore's and Australia's proximity to the economy, it makes sense to import most of its oil products from these economies. The economy managed to diversify the import sources for oil products by 2013, with Singapore's share dropped to 44%, following the increase in imports from Chinese Taipei providing 31% to total imports and Malaysia contributed 21%. Australia's share to total imports decreased to 1.0%.

Figure 16.6: Oil Product Import Sources, 2000-13



Source: APERC analysis and UN Comtrade, 2016

The economy recorded the best import source diversity at 0.33 HHI in 2013, far better than in 2000, which recorded 0.62 HHI. The supply disruption risk from major exporters slightly higher than crude

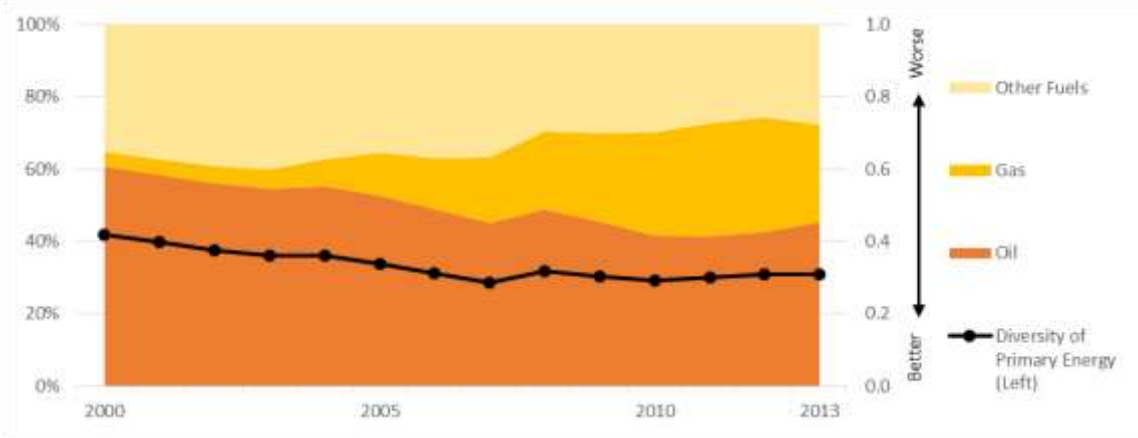
oil at 18% in 2013 (compared with 15% for crude). Highly stable import sources contributed to having low risk in both crude oil and oil products as all APEC economies exporting to the economy received relatively high political stability (lower index) (based on WGI – Political Stability and Absence of Violence/Terrorism indicator) and lower chokepoint risk as most of the import sources are located in East Asia. Therefore, it is highly recommended for the economy to maintain the current (2013) oil product import sources due to low risk and higher intra-APEC trade.

PERU

Economy-Energy Overview

Peru is a constitutional republic located on the west central coast of South America, bordered by the Pacific Ocean, with Chile to the south, Ecuador and Colombia to the north, and Brazil and Bolivia to the east. With a land area of 1.3 million square kilometres (km2), the economy is divided into three main geographical regions: the Costa to the west, the mountain region (Andes Mountains) and the Amazon region (Selva), covered by the Amazon rainforest. In 2013, the economy had a total population of about 30 million, an increase of 1.3% from the previous year (EGEDA, 2015). The GDP of the economy reached USD 339 billion (2010 USD and Purchasing Power Parity [PPP]), with its GDP per capita growing at 4.4% to reach USD 11,095 (EGEDA, 2015), and its key economy segments were services (49%), manufacturing and construction (21%), and mining (12%) (BCRP, 2014).

Figure 17.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-.080 is moderate-high concentration, and 0.81 and above is high concentration.

Peru's total primary energy supply (TPES) in 2013 was 21.5 Mtoe, an increase of 80% from the 2000 level. By energy source, in 2013, almost half (10.4 Mtoe) of the TPES was from oil, 26% from natural gas (5.7 Mtoe) and 4.0% from coal (1 Mtoe). Non-fossil energy sources, such as hydro, wood, biomass, wind and others constituted the remainder at 21% (4.5 Mtoe) (IEA, 2015) (Figure 17.1). In terms of primary energy diversity, which is derived by using Herfindahl-Hirschman Index (HHI) methodology, the economy showed an improvement from 0.42 HHI in 2000 to 0.31 HHI in 2013 because of the increase in gas share in the fuel mix.

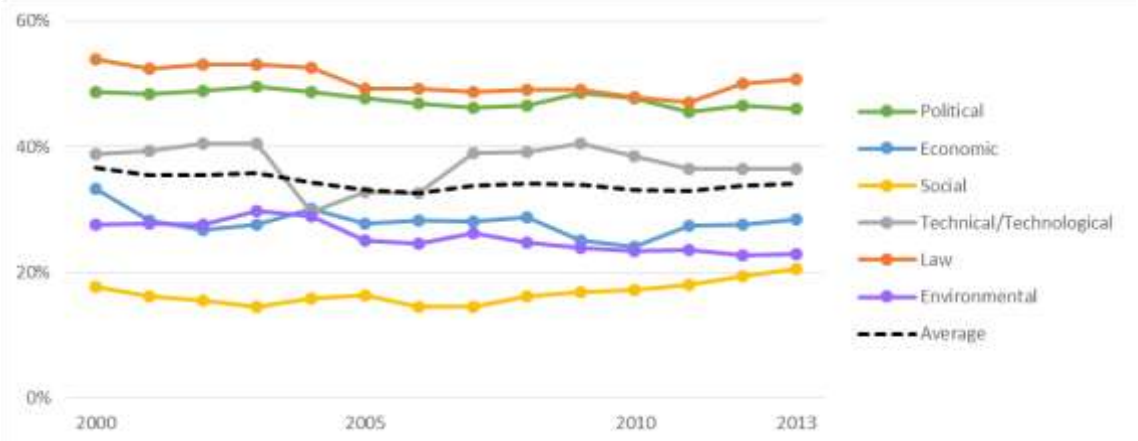
Owing to its scarce oil resources, Peru is a net importer of oil. Domestic production is not only insufficient to meet the economy's demand, but since most crude oil produced is of extra-heavy quality and domestic refineries are unable to process it, a substantial share of the domestic production is exported. In contrast, the proven gas reserves of the economy stood at 0.4 trillion cubic metres (tcm) in 2013. The Camisea Gas Project is the largest energy project in the economy, which commenced operation in 2004 by supplying gas to the local market. By 2010, the economy started to export through the liquefied natural gas (LNG) port located in Pisco (south of Lima) (MEM, 2014).

In 2013, energy intensity stood at 63.8 toe/million 2010 USD based on the primary energy supply requirement, a drop of 14% from the 2000 level. On the other hand, primary energy per capita was stable at about 4.4 toe/person from 2000-13 (IEA, 2015 and EGEDA, 2015).

Oil Security

The study used a scale of 1.0% to 100% for the six indicators, where 1.0% means the lowest risk while 100% means the highest risk. Peru's average oil supply security index showed a decrease in risk, from 37% in 2000 to 34% in 2013 (Figure 17.2). Out of the six indicators that were evaluated, all indicators displayed improvements in risk level (decreasing index) except social indicator.

Figure 17.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economy's political indicator index declined from 49% in 2000 to 46% in 2013, largely due to two factors – improving local stability as well as more stable import sources. The economy's local stability sub-indicator, which is derived from WGI–Political Stability and Absence of Violence/Terrorism, improved from 72% in 2000 to 65% in 2013. Similarly, the stability of oil import sources improved from 66% in 2000 to 53% in 2013 due to higher imports from the US (further discussion on import source risk can be found

later in this chapter). One of the reasons for the high index in political indicator is because of lack of regional or international agreement on oil supply security (APERC, 2015). Based on the analysis, having such agreement could lower the index by at least 15 percentage points from the 2013 level.

Under the economic indicator, composed of 11 sub-indicators, an improvement of 4.0% was recorded from 33% in 2000 to 29% in 2013. This improvement was mainly contributed to by four sub-indicators – primary energy diversity (from 0.42 HHI in 2000 to 0.31 HHI in 2013 due to an increased share of gas), a huge improvement in the "Ease of Doing Business" indicator, and a decrease of oil share in primary energy, which subsequently reduced the oil intensity from 45 toe/million 2010 USD in 2000 to 29 toe/million 2010 USD in 2013. However, two sub-indicators – crude oil import source diversity and oil product import source diversity, increased as the imports were concentrated in very few sources. The trend in both sub-indicators is discussed in the Import Share and Sources Section of this Chapter.

As for the social indicator, the oil consumption per capita is the only sub-indicator used to determine the risk. The economy's oil consumption per capita reached its highest level in 2013 at 0.32 toe/person, slightly higher than the 2000 level of 0.29 toe/person. This resulted in an increase from 18% in 2000 to 21% in 2013. However, when compared with other APEC members, the economy's oil consumption per capita could still be considered low.

Under the technical/technology indicator, the reduction of risk in three sub-indicators – the economy's logistics efficiency, higher oil reserves-production (R/P) ratio, and increased exporter's oil production, helped to reduce the indicator's index from 39% in 2000 to 37% in 2013. The economy's R/P ratio increased from 7.9 years of oil in 2000 to 17.1 years in 2013 (the highest R/P ratio was in 2004 at 28.8 years), mainly due to an increase in reserves (EIA, 2016). On the other hand, the index of the two sub-indicators increased – the refinery utilisation rate from 76% in 2000 to 100% in 2013, and the oil self-sufficiency (due to a decrease in oil self-sufficiency level from 68% in 2000 to 43% in 2013).

The law indicator demonstrated a slight decrease in risk, from 54% in 2000 to 51% in 2013. There are four sub-indicators under this indicator – three sub-indicators under internal factors, which are resource extraction regulations, emergency preparedness and strategic stockpiling, and exporter's rule of law as an external factor. The resource extraction regulation sub-indicator, which is derived from the Global Petroleum Survey (GPS), showed an upward risk, from 51% in 2000 to 59% in 2013. However, the economy received the highest risk on the oil stockpiling sub-indicator as the economy does not possess an oil stockpile (APERC, 2015).

Only two sub-indicators are used for the environmental indicator, which are readiness and vulnerability to climate change impacts, and natural disaster risk. This indicator showed an improvement from 28% in 2000 to 23% in 2013, partly due to the economy's improvement in readiness and reduced vulnerability towards climate change, as reported by the Notre Dame Global Adaptation Index (ND GAIN). The ND GAIN for the economy's vulnerability to climate change was 0.46 in 2000 and reduced to 0.42 in 2013, while

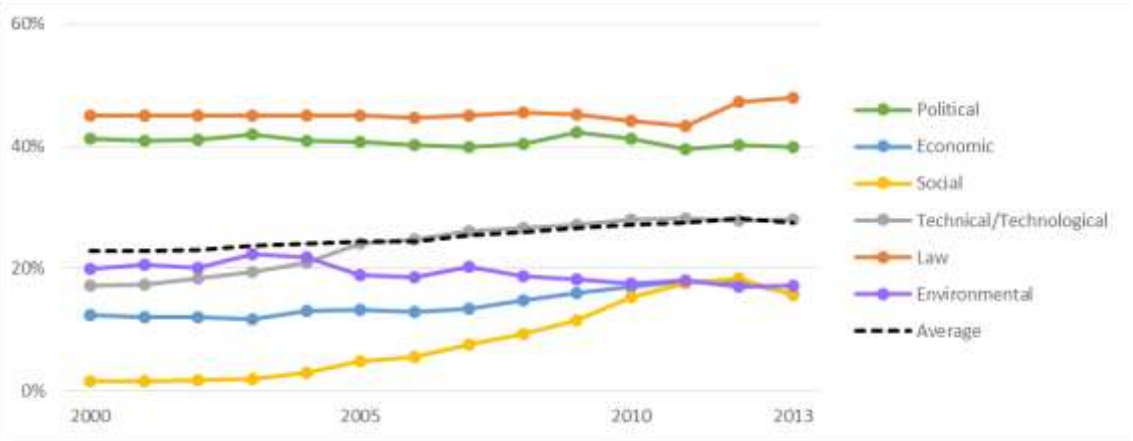
the readiness in 2000 was 0.35 and improved to 0.47 in 2013) (ND-GAIN, 2016). At the same time, the economy's oil import sources' environmental risk also showed a decreasing index as more oil product imports coming from the United States, which received a better ND-GAIN index (ND-GAIN, 2016).

Gas Security

Peru's average gas security index is generally lower than oil but displayed an increasing trend. In 2000, Peru's gas security index was 23%, but it goes up to 27% by 2013. The increase was mainly contributed to by the social, economic, law and technical/technology indicators. Two indicators – political and environmental– gained a slight decrease but insufficient to offset increases recorded in other indicators (Figure 17.3). Since the economy does not import gas, the discussion will focus on internal factors that can influence gas supply security.

The political indicator realised a slight decrease in index, from 42% in 2000 to 41% in 2013, attributed to low risk in the local stability sub-indicator (as discussed in the oil security chapter). As the economy does not have any agreements related to gas supply during emergencies, the study assigned the highest index, which is 100%. By having this kind of agreement, the economy's index in the political indicator theoretically can be lowered to 29% (based on 2013 index value).

Figure 17.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economic indicator showed an increase from 13% in 2000 to 16% in 2013. Out of the five sub-indicators (two of the sub-indicators are related to imports which will not be discussed as the economy does not import gas) that the study considered, two of them marked an increase – gas share to primary energy, from 4.0% in 2000 to 27% in 2013, and gas intensity from 3.0 toe/USD million in 2000 to 17 toe/USD million in 2013 (similar to oil, gas intensity risk was calculated against the highest and lowest

intensity level among APERC economies, as well as the changes [highest recorded] in the economy's intensity level within the historical period). However, with the increase in gas share, it resulted in improving the overall primary energy diversity index.

On the social indicator with gas consumption per capita as a sub-indicator, the economy's gas consumption per capita increased steadily, from 0.02 toe/person in 2000 to 0.19 toe/person in 2013. This translated to an index of 2.0% in 2000 to 16% in 2013. When compared with other APEC members, the economy's gas consumption per capita could be considered to be one of the lowest in the region. However, based on the projection, the gas consumption per capita of the economy will increase tremendously for next few decades because of higher gas demand, particularly in the power sector (APERC 2016).

The technical/technology indicator also exhibited an increase, from 18% in 2000 to 29% in 2013. The gas R/P ratio sub-indicator index escalated as a result of rapid growth in gas production. As the economy's gas production expanded by more than 20 times over the last 15 years, the R/P ratio decreased rapidly from more than 100 years in 2000 to 32 years of gas reserves in 2013 (EIA, 2016). However, compared with most gas producer economies, the economy's R/P ratio for gas could be considered to be high.

There are three sub-indicators under the law indicator for gas – resource extraction regulations, gas emergency preparedness and exporter's rule of law. As discussed earlier in the oil chapter, the resource extraction regulation sub-indicator increased from 51% in 2000 to 59% in 2013. The gas emergency preparedness sub-indicator is made up of four components that are related to law (or policy) – availability of RGT, availability of trans-border pipelines, gas emergency preparedness and availability of underground gas storage. Since Peru does not have RGT, trans-border pipelines or underground gas storage, it resulted in a quite high index for the law indicator.

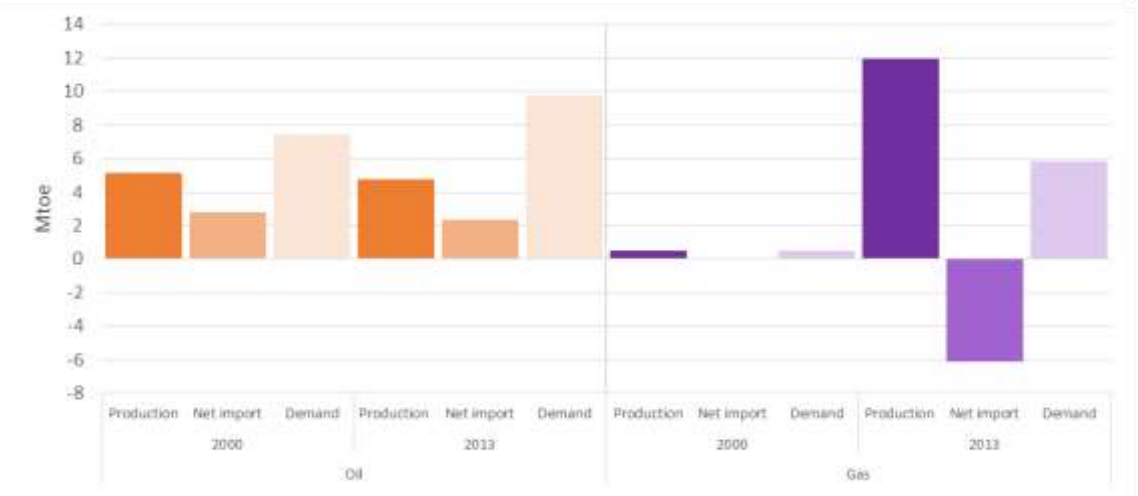
As for the environmental indicator, the risk is only domestic as the economy does not import gas. Given that Peru showed a lot of improvement in readiness and vulnerability in facing climate change, as discussed in the oil chapter, it managed to improve the environmental index from 20% in 2000 to 18% in 2013.

Import Share and Sources

As Peru does not import any gas, this section will only discuss crude oil and oil product import risk, focusing on the major exporters. Among the APEC economies, Peru can be considered to be a small oil producer. The economy produced 5.2 Mtoe of crude oil in 2000, and the production level reduced to 4.8 Mtoe in 2013. Peak in oil production occurred in 2010 with 6.9 Mtoe (Figure 17.4) (IEA, 2015). With an increase in total oil demand, from 7.4 Mtoe in 2000 to 9.8 Mtoe in 2013, the economy's net oil imports increased from 2.0 Mtoe in 2000 to 5.6 Mtoe in 2013. As for gas, the economy is a net exporter of LNG

since 2010 due to the completion of the LNG port located in Pisco (MEM, 2014).

Figure 17.4: Production, Net Imports and Demand, 2000-13

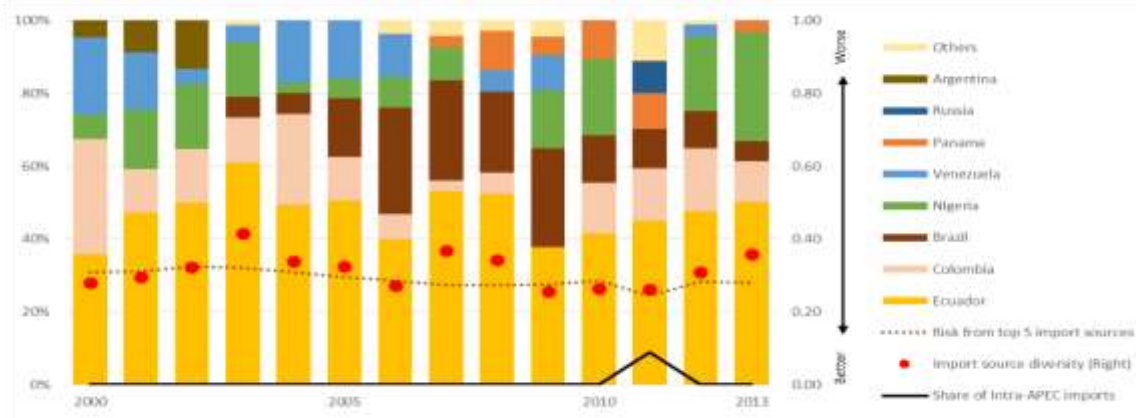


Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Crude Oil Import Sources

The economy imported about 3.1 Mtoe of crude oil in 2000 and it increased to 4.3 Mtoe in 2013 following an increase in oil demand increased while the production remained at the same level. Economies from South America, such as Ecuador (which had been supplying more than 40% of total crude oil imports) and Brazil, had consistently appeared as the top crude oil exporters to the economy over the historical period. However, there had been a shift in import sources for the economy (UN Comtrade, 2016). In 2000, more than 90% of crude oil imports came from South America, and reduced to 70% in 2013 as a result of increasing imports from other sources, such as Nigeria with about 30% share to total imports. Given the economy relied on very few economies for crude oil imports, import source diversity index stood at 0.36 HHI in 2013 as compared with 0.28 HHI in 2000 (Figure 17.5).

Figure 17.5: Crude Oil Import Sources, 2000-13



Source: APERC analysis and UN Comtrade, 2016.

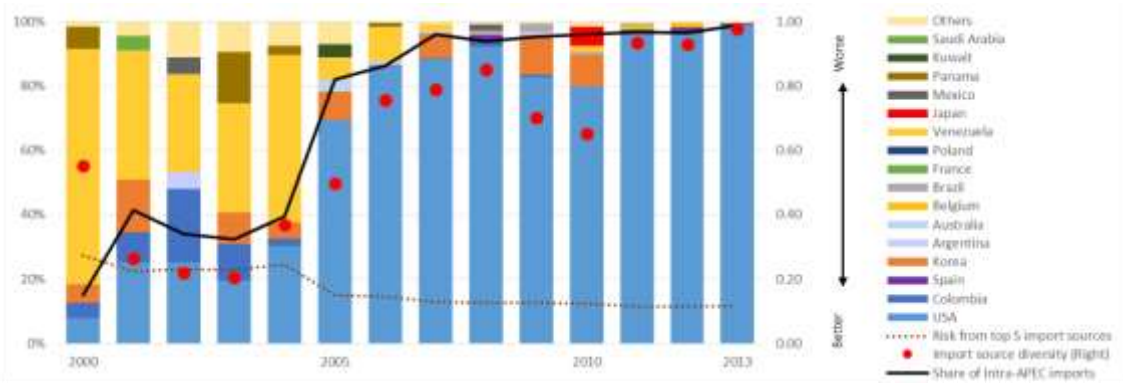
The risk associated with the major exporters (covering almost 100% of total crude imports) could be considered to be slightly high, but improving, from 31% in 2000 to 28% in 2013. The reduction in risk was triggered by reduced imports from Colombia (32% in 2000 to 11% in 2013). Colombia gained a high index on political stability (based on WGI- Political Stability and Absence of Violence/Terrorism sub-index). However, recent political developments in Colombia, where the Government and the Revolutionary Armed Forces of Colombia (FARC) signed a peace agreement in September 2016, may improve the situation as well as the risk (New York Times 2016). Although the economy managed to diversify crude oil import sources by importing more from Nigeria (from 7.0% in 2000 to 30% in 2013), the imports eventually increased the chokepoint risk slightly from 2.0% in 2000 to 3.0% in 2013.

In terms of intra-APEC trade, the economy does not import crude oil from APEC economies with the exception of Russia, which occurred in 2011.

Oil Product Import Sources

The major exporters to the economy provided almost 100% of total oil product imports. However, there was a huge shift in the economy's oil product import sources over the historical period (UN Comtrade, 2016). In 2000, 73% of imports came from Venezuela, but in 2013, 99% of imports was sourced from the United States (Figure 17.6).

Figure 17.6: Oil Product Import Sources, 2000-13



Source: APERC analysis and UN Comtrade, 2016.

Although the economy's import source diversity index got worse (from 0.55 HHI in 2000 to 0.98 HHI in 2013), the overall risk from the major exporters improved tremendously from 27% to 12%. This was attributed to the improvement seen in three sub-indicators (under external factor) – import source stability, import source exposure to climate change, and better "rule of law," largely contributed by imports from the U.S. As for intra-APEC imports, the increase of U.S. imports subsequently improved the rate from a low of 15% in 2000 to 99% in 2013. Apart from the United States, other sources from the APEC region were Australia; Japan; and Korea which occasionally appeared as top five oil product exporters to the economy.

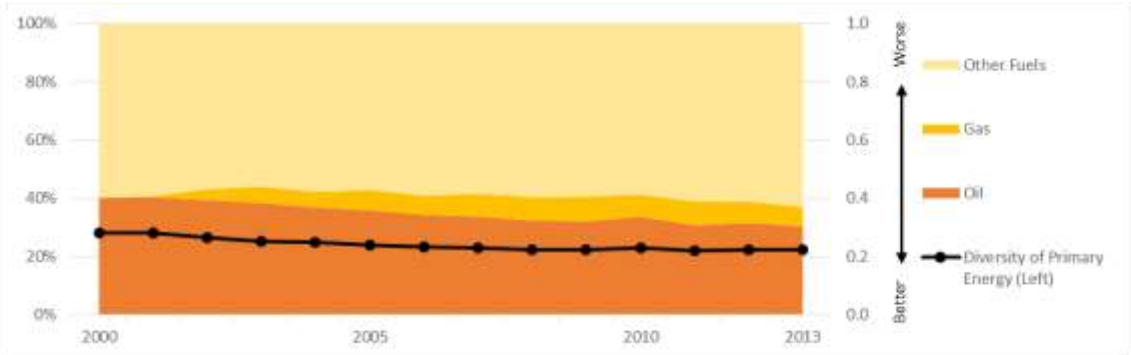
PHILIPPINES

Economy-Energy Overview

The Philippines is an archipelago with 7,107 islands covering a total land area of 300, 000 square kilometres (km2) with a total population of 97.6 million in 2013, growing at annual rate of 1.7% over the last 13 years (2000-13). In the World Population Ranking, the economy is the twelfth most populated in the world and the seventh in Asia (WB, 2014). In the same year, gross domestic product (GDP) reached USD 609.9 billion (USD 2010 Price and Purchasing Power Parity [PPP]), which grew at a rate of 4.3% annually from the 2000 level (WB, 2015; EDMC, 2015).

The Philippines has modest energy resources with proven oil reserves of around 76 million barrels (Mmbbl) (including condensate), 24 billion cubic metres (Bcm) (847 billion cubic feet [Bcf]) of natural gas, and 440 million tonnes (Mt) of coal (DOE-ERDB, 2015b). It has been a longstanding policy of the economy to harness its domestic energy resources to improve and maintain its energy self-sufficiency and reduce dependence on imported energy.

Figure 18.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

In 2013, total primary energy supply stood at 44.6 million tonnes of oil equivalent (Mtoe), an increase of 12% from the 2000 level (40.0 Mtoe). Around 56% of the primary energy was produced locally, mainly from coal and renewable energy (DOE, 2014; IEA, 2015). Oil provided the largest share of about one-third of the total primary energy, while coal contributed 24%, gas 7.0% and renewable energy 39%, largely from hydro, geothermal and biomass. From the primary energy supply mix, the diversity index of the economy in 2013 was at 0.22 (moderate-low concentration) from a high of 0.28 in 2000. The decline was driven by the decreasing share of oil in the primary energy supply.

The economy's oil supply requirement exhibited a downward trend, which stood at 13.5 Mtoe in 2013 from 16.0 Mtoe in 2000, a decrease of 1.3% annually in the last 13 years due to a reduced contribution of oil-based thermal plants in the power generation mix. With this, oil share decreased from 40% in 2000 to 30% in 2013. And with a small amount of oil reserves, the economy was able to produce 747,000tonnes of oil equivalent (ktoe) (6.0 Mmbbl) of oil in 2013, ten times higher than in 2000 at 54 ktoe (0.42 Mmbbl). Given this modest production, the economy has been heavily dependent on crude imports (almost 100%) for its refinery demand. Based on the 6th APEC Energy Outlook, the economy's oil supply requirement is projected to increase at 3.1% annually until 2040 (APERC, 2016).

The natural gas supply requirement had been growing at an annual rate of 56% over the historical period, from only 0.01 Mtoe (0.01 Bcm) in 2000 to 2.9 Mtoe (3.2 Bcm) in 2013. Currently, the economy is self-sufficient in gas largely coming from its Malampaya gas field providing nearly 100% of the gas supply requirement, and fuelling three natural gas-fired power plants. However, production from Malampaya, being a mature gas field, is seen to be depleted between 2022 to 2025 (APERC, 2016). In 2013, production from Malampaya stood at 3.5 Bcm, lower by 8.0% from the previous year's level (DOE, 2014). Future gas demand is expected to increase at 2.8% annually (APERC, 2016).

The economy realised an improvement of 41% in its energy intensity from 123.9 tonnes of energy per USD million GDP (toe/USD million) in 2000 to 73.1 toe/USD million in 2013. Similarly, primary energy per capita fell by 11% in 2013, 0.45 toe per person (toe/person) from 0.51 toe/person in 2000 (EGEDA, 2015).

Oil Security

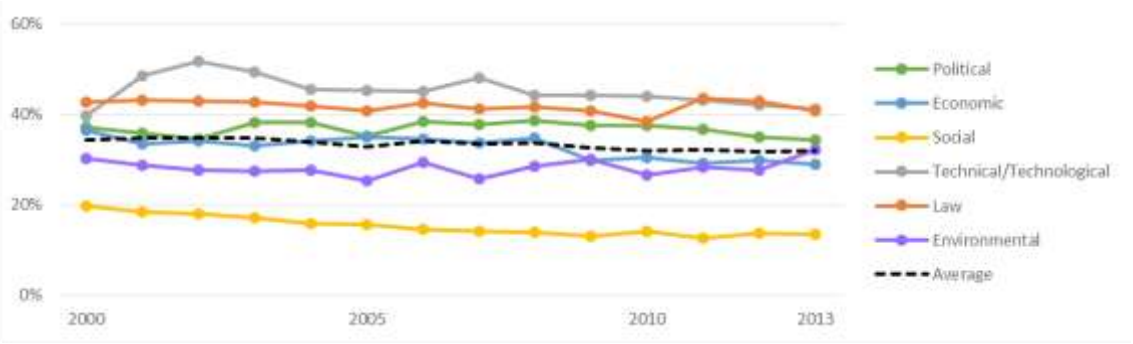
The Philippines's oil security demonstrated a declining index, 32% in 2013 from 34% in 2000, under the category of moderate-low exposure. A low index means lower risk to supply disruption. From the six indicators used to determine the risk, the law and technical/technology indicators earned the highest risk at 41% each in 2013.

The law indicator exhibited a slight decreased, from 43% in 2000 to 41% in 2013. This indicator considered four sub-indicators, one as an external factor. The main contributor for a high result in law is the oil stockpiling sub-indicator, which received 87% in 2013 as the level of oil stocks was relatively low as compared with other APEC economies. The economy has not established strategic oil stockholding, but enforces a minimum inventory requirement (MIR) for oil companies. Under the MIR, the refiners are required to have total in-economy stocks of crude and finished products equivalent to 30 days, while bulk marketers should have 15 days in-economy stock, and LPG players seven days of stocks (APERC, 2015). In 2013, the economy was able to maintain more than the required MIR, which was equivalent to 38 days of supply, consisting of 31 days for crude oil and products in-economy stocks and seven days in-transit (DOE,

2014a). In the resource extraction regulation sub-indicator, the economy received a quite high result at 47%, on average, with highest recorded at 56% in 2012. This sub-indicator used the Regulatory Climate Index of the Global Petroleum Survey (GPS) that evaluates perceptions as to whether the existing policies deter investment in upstream sectors. As the economy has established an oil contingency plan that could be used during supply disruptions or emergencies, the sub-indicator for oil emergency preparedness received the lowest at 0%.

For external factors, the "rule of law" sub-indicator (under the law indicator) for the oil exporters improved by 9.0 percentage points, 29% in 2013 from 38% in 2000. This could be attributed to the increased share of those oil exporters for both crude and oil products, which gained a better result in the "rule of law" of the World Governance Index (WGI) of WB that evaluates the quality of contract enforcement, among other factors.

Figure 18.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The technical/technology indicator rose to a high of 59% in 2002 (from 40% in 2000), and began to decline afterward reaching 41% in 2013. This indicator is made up of six sub-indicators with one assigned as an external factor. The primary cause for this trend is the external factor in the oil production rate sub-indicator for crude oil exporters. There was a decline in the production level of some Middle East exporters, such as Saudi Arabia, Oman and Iran, during 2001, 2002, 2007 and 2009. It may be noted that the economy is highly dependent on Middle East imports for crude. And having limited oil resources, the economy also received a high index in oil self-sufficiency sub-indicator, but declined to 90% in 2013 from 100% in 2000 as domestic crude oil production increased and oil supply requirement declined. However, with a higher production level, the oil reserves-production (R/P) ratio sub-indicator climbed to 97% in 2013 (from 0% in 2000). To boost the exploration and development of the economy's 16 sedimentary basins with combined oil and gas resource potential of 4,777 million barrels of oil equivalent (Mboe), the government has launched and conducted the Philippine Energy Contracting Round (PECR) to offer, through a competitive bidding system, onshore and offshore oil and gas blocks to prospective investors. In 2014, the

economy offered 11 potential areas to both local and foreign investors (DOE, 2015a).

With the decline in refinery output, decreasing annually at a rate of 5.3% over the historical period, the refinery utilisation rate sub-indicator (under the technical/technology indicator) fell significantly to 44% in 2013 (90% in 2000). As a result, the share of refinery output to total demand declined from a high of more than 90% in 2000 to about 50% in 2013. The economy resorted to more oil product importation to fill the gap in refinery production.

The political indicator decreased to 34% in 3013 from 37% in 2000. This indicator covered six sub-indicators, three each assigned as internal and external factors. The local stability sub-indicator received a high index of more than 70% (moderate-high), although an improvement was observed during the historical period (71% in 2013 from 78% in 2000). This sub-indicator is also based on WGI on the likelihood of having an unstable political environment, and having an upper bound index means that perception on the possibility of instability is high. As the economy is a party to the ASEAN Petroleum Security Agreement (APSA), the index for the international/multilateral agreement on oil security sub-indicator was set at 50% for the reason that said agreement has not been tested yet in the event of actual oil supply disruptions. This agreement contributes to lowering the risk as the economy could request assistance during supply emergencies. Meanwhile, the exporter's stability (external factor) sub-indicator had a decreasing index (34% in 2013; 41% in 2000) resulting from expanding shares of those oil exporters (both crude and oil products) with a better local stability index, like Saudi Arabia for crude oil as compared with other Middle East exporters. Relying heavily on Middle East crude also led to risk in the chokepoint sub-indicator, although still low at 11%, on average.

The environmental indicator considered two sub-indicators – risks on climate change and natural disaster – and both applied as internal and external factors. This indicator received 32% in 2013, but saw a modest reduction (below 30%) within the historical period. The climate change sub-indicator was 51% in 2013 (from a high of 59% in 2000) using the Notre Dame Global Adaption Index (ND-GAIN), which assesses the exposure, adaptive capacity and readiness to climate change impact of different economies. The economy also earned a risk in the natural disaster sub-indicator based on the Centre for Research on the Epidemiology of Disasters (CRED). The economy is often visited by typhoons with an annual average of 20 typhoons. To address the impact of climate change, the Philippine Climate Change Commission was created in 2009 to monitor and evaluate programs and action plans on climate change (APERC, 2016). On the other hand, the climate change sub-indicator for external factors (import sources) also gained a declining index (26% in 2013; 41% in 2000).

The economic indicator, composed of 10 sub-indicators, improved by 8.0 percentage points, from 37% in 2000 to 29% in 2013. Several sub-indicators contributed to the decrease. The oil intensity sub-indicator realised a large drop by more than half, falling to 40% from a high of 92% in 2000. The economy's oil intensity significantly decreased by 55% in 2013, down to 22.2 toe/USD million from 49.7

toe/USD million in 2000. This likewise led to the reduction in the oil share to primary energy sub-indicator (30% in 2013; 40% in 2000). The main driver for the decrease in these sub-indicators was the cut in the power generation from oil-based power plants by half, coupled with a decrease in oil consumption by the industry sector. It should be noted that the oil intensity is based on the highest and lowest intensity level among the APEC economies, and the historical changes (highest recorded) in the economy's intensity level.

The "Ease of Doing Business" sub-indicator from WB under the economic indicator realised a drop in the index by 16 percentage points from 60% in 2000 to 44% in 2013, thus the economy made remarkable improvement in its business climate which could contribute to lowering the risk. In terms of import diversity, the crude oil import diversity sub-indicator increased until 2008 at 45%, and afterward began to fall (26% in 2013) with the entry of Russian crude, while the oil product import diversity index displayed a steady reduction over the historical period. (Please see discussion on Imports and Sources Section).

The social indicator (with oil consumption per capita as the only sub-indicator) received the lowest risk and demonstrated decreasing trend (13% in 2013 from 20% in 2000) triggered by dwindling oil consumption per capita. In 2013, the economy's oil consumption per capita was at 0.14 toe/person, lower by 33% from the 2000 level of 0.21 toe/person. The economy's per capita level was way below the APEC average of 0.80 toe/person in 2013. Similar methodology used for oil intensity sub-indicator was applied to oil consumption per capita sub-indicator.

Gas Security

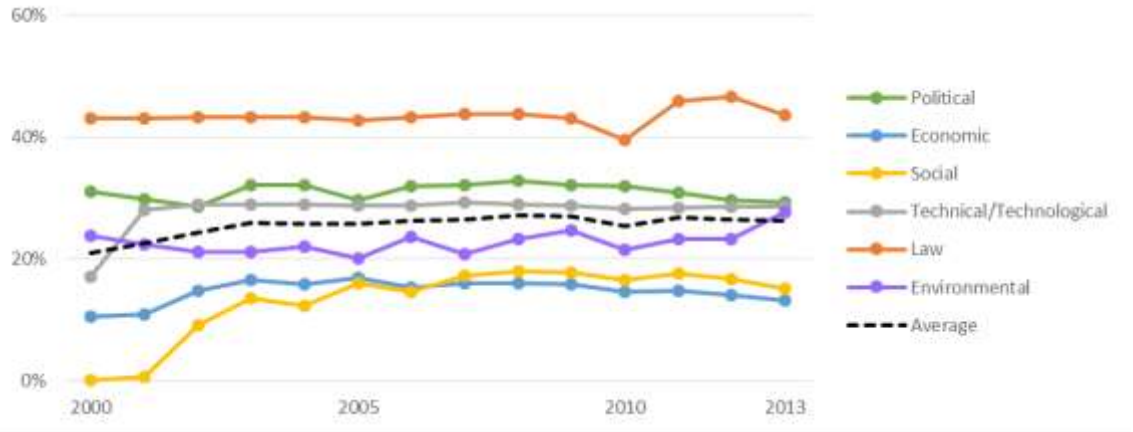
The Philippines obtained a lower gas security index than oil at 26% in 2013 (moderate-law exposure category), but displayed an increasing trend (21% in 2000) over the historical period. The law indicator reaped the highest risk, which had been steady at 45%, on average. This indicator is consisted of only three sub-indicators (one as an external factor). The gas emergency preparedness sub-indicator received a high result at 75% in the absence of a regasification terminal (RGT) and storage facilities to receive imports, despite gradually depleting gas resources. However, this sub-indicator will be improved in the near term as the economy started developing its first RGT facility. The Energy World Corporation (EWC) is developing the first liquefied natural gas (LNG) hub in the economy comprised of a LNG receiving terminal, regasification plant and two storage tanks, with each having a capacity of 130,000 cubic metres (cm) (DOE, 2015a). The resource extraction regulation sub-indicator contributed to the high index of the law indicator as already explained above (oil security).

The political indicator (same sub-indicators as in oil security) registered the second highest at 30% in 2013, a slight decrease from the 2000 level of 32%. The local stability sub-indicator, as explained in the oil security, caused the high index in political indicator. Another contributing factor is the international/multilateral agreement on gas security sub-indicator, for which the economy gained the same

index equivalent in the oil security. APSA may also cover gas supply security, thereby reducing the risk of the economy.

The environmental indicator (same sub-indicator as in oil security) demonstrated an increasing index at 28% in 2013 from 25% in 2000. This was mainly due to the climate change and natural disaster sub-indicators of the economy (as explained in the oil security).

Figure 18.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The technical/technology indicator rose by 12 percentage points, reaching 29% in 2013 from 17% in 2000 (from low to moderate-low exposure). This indicator covered eight sub-indicators with two assigned as external factors. The gas R/P ratio sub-indicator significantly affected the technical/technology indicator. With declining gas reserves and production remained at the same level, the gas R/P ratio gradually went up. Since large gas production came online from Malampaya in 2001, production increased on a year-on-year basis, which grew annually at a rate of 12% until 2009 and started to gradually decrease. A decline of 8.0% in production level in 2013 from the previous year's level was noted as caused by a 30-day shutdown of the Malampaya gas production facility (DOE, 2014). Until now, the economy is still self-sufficient in gas resources.

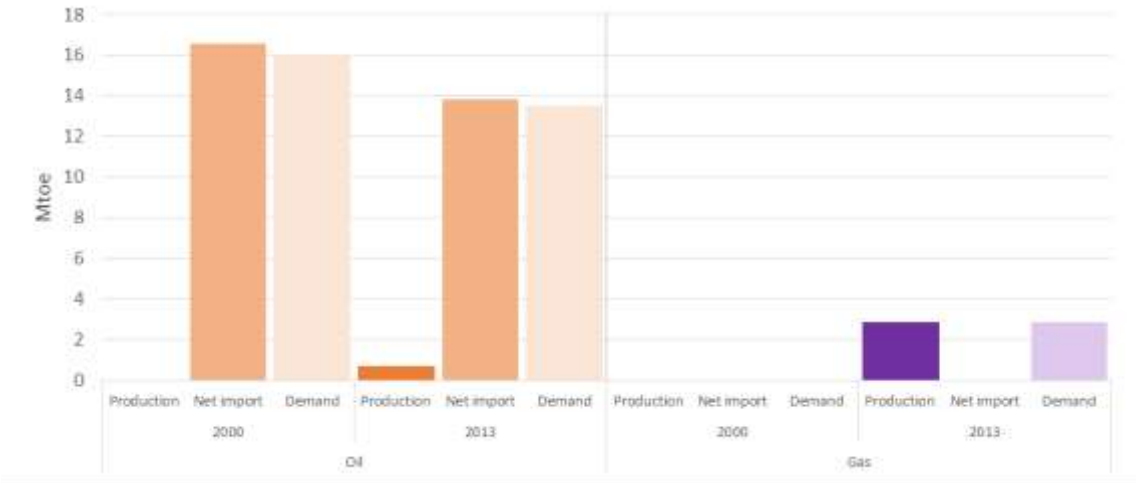
As the gas supply requirement of the economy showed an upward trend over the historical period, the social indicator received an increasing index (16% in 2013 from 0% in 2000). The gas consumption per capita sub-indicator led to the rise in the social indicator. The economy's gas consumption per capita went up to 0.03 toe/person in 2013 from merely 0.001 toe/person in 2000. The gas consumption per capita level was significantly below the APEC average (0.58 toe/person in 2013). The same approach (methodology) in oil security was used in computing the index for gas consumption per capita sub-indicator (as well as in gas intensity sub-indicator).

The economic indicator (with six sub-indicators) had the lowest risk at 14% in 2013, from 11% in 2000. The gas intensity sub-indicator influenced the increase in the economic indicator. The economy's gas intensity grew annually at 25%, which stood at 4.8 toe/USD million in 2013 from merely 0.03 toe/USD million in 2000. This also resulted in an increased share of gas to primary energy to 7.0% in 2013 (from 0.02% in 2000).

Imports and Sources

The Philippines is a net importer of crude oil with a very small amount of domestic production accounting for only 3.0% of total crude oil supply (DOE, 2014). Domestic production of crude oil is exported to Korea; Singapore and Thailand, or being refined at the Shell refinery facility (DOE, 2015). Given this, the economy's dependency on crude oil imports is high, almost 100%. However, with decreasing refinery demand, crude oil imports fell by more than half (52%) in 2013, from 15.4 Mtoe in 2000 to 7.4 Mtoe in 2013. The economy maintains two refinery facilities, Petron and Shell, with a total distillation capacity of 285 thousand barrels per day (Kbbl/d), from 420 Kbbl/d capacity in 2000 when the Caltex (now Chevron) refinery was still in operation (OGJ, 2000-15). Refinery output had been decreasing at 5.5% annually, thus reducing its share to total oil demand by 50% in 2013 (from more than 90% in 2000). To compensate for reduced refinery output, oil product imports more than doubled, from 3.0 Mtoe in 2000 to 7.8 Mtoe in 2013, despite a decrease in the economy's oil supply requirement. The economy also exports a modest amount of oil products. Overall, total oil imports (crude and oil products) dropped by 16%, which stood at 16.6 Mtoe in 2013 from 13.9 Mtoe in 2000.

Figure 18.4: Production, Net import and Demand, 2000-13



Note: Excluding international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

The economy produces its own gas to meet domestic supply requirements. Over the historical period, gas production had been rising, but started to diminish with depleting reserves. As the economy

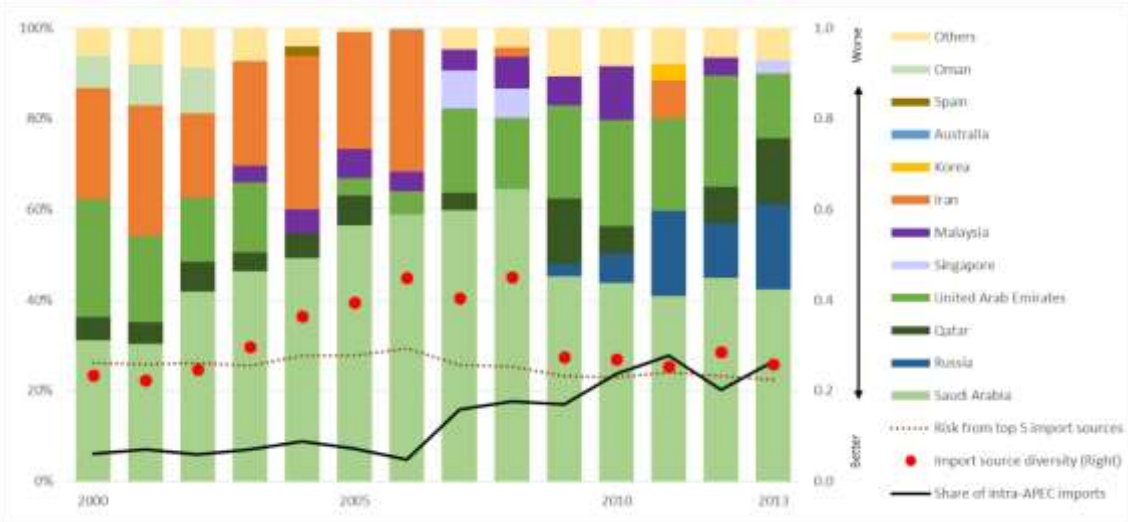
started to build RGT, LNG imports could be expected in the near future. LNG imports would be critical for the economy in anticipation of gas reserves depletion and future growth in gas demand.

Crude Import Sources

The bulk of crude oil imports were sourced from the Middle East, about 71% in 2013 from a high of 94% in 2000. Even with reduced dependence on Middle East crude, the economy's diversity index still went up to 0.26 HHI in 2013 (0.23 HHI in 2000) with a high import share from Saudi Arabia. The diversity index reached as high as 0.45 HHI during the historical period. Saudi Arabia had been a major exporter of crude oil to the economy with an increasing share to total imports, which was recorded at 42% in 2013 (from 31% in 2000). Other major exporters in 2013 were Russia with a 19% share, Qatar with 15%, and the United Arab Emirates with 14%. In the same year, Singapore also exported crude oil (re-export) to the economy with a 3.0% share. The entry of Russian crude in 2009 and the expanded share of Qatar and UAE, reducing the share of Saudi crude (65% in 2008 to 45% in 2009), which helped to decrease the diversity index to 0.27 in 2009 from 0.45 the previous year.

The level of risk associated with the major exporters of crude oil had been on a decreasing trend, 22% in 2013 from 26% in 2000. The declining risk could be attributed to expanding shares from Qatar and UAE to total imports (displacing some amount of imports from Saudi Arabia), which both have better results in local stability compared with Saudi Arabia. Intra-APEC import share improved to 26% in 2013, largely contributed to by Russia, from only 6.0% in 2000.

Figure 18.5: Crude Oil Import Sources, 2000-13

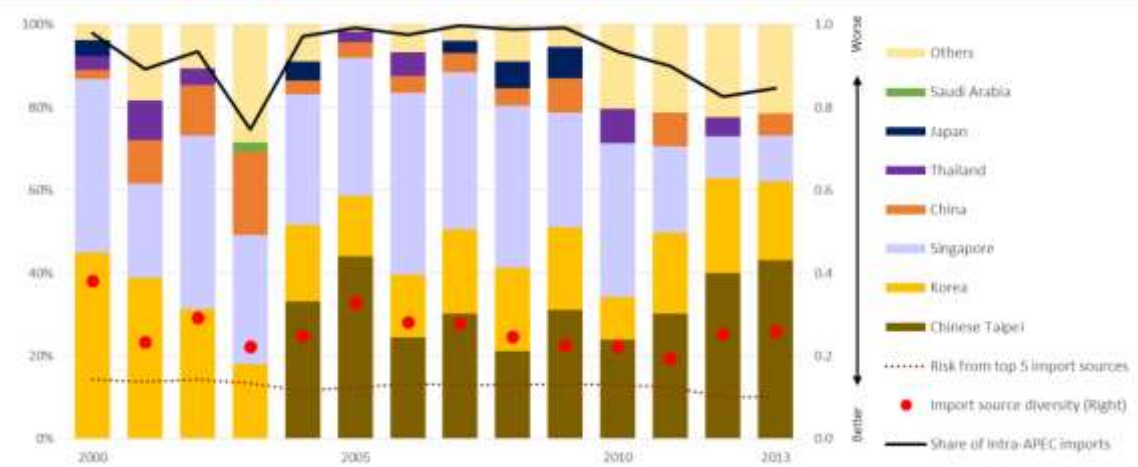


Sources: APERC analysis and UN Comtrade, 2016.

Oil Product Import Sources

The economy relies on its neighbouring APEC economies for oil product imports. Over the historical period, China; Korea; Singapore; and Chinese Taipei were the major exporters of oil products. Initially, the economy was highly dependent on Korea's and Singapore's oil product imports with shares of 45% and 43%, respectively, in 2000. However, their shares gradually slid down with a contribution from China and the entry of oil product imports from Chinese Taipei starting in 2004. In 2013, Chinese Taipei provided 43% of total imports, while Korea accounted for about 19%, Singapore 11% and China 5.0%. From these changes, the economy's diversity index improved to 0.26 HHI in 2013 from 0.38 HHI in 2000. Likewise, the risk level from import sources fell to 10% in 2013 (14% in 2000) following increased shares of those exporters with a better index in local stability than the others. Intra-APEC imports decelerated to 85% in 2013 (98% in 2000) as the economy previously also received imports from Thailand and Japan during the historical period.

Figure 18.6: Oil Product Import Sources, 2000-13



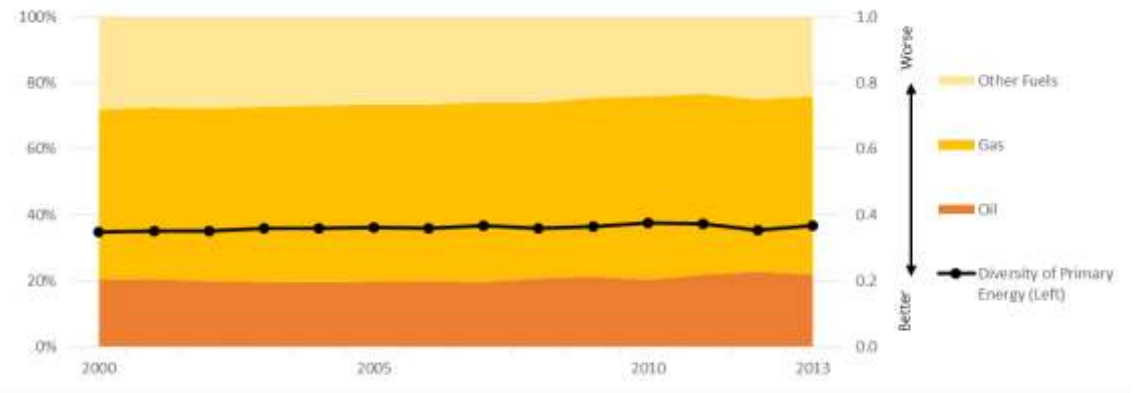
Sources: APERC analysis and UN Comtrade, 2016.

RUSSIA

Economy-Energy Overview

Russia is the world's largest region, spanning over 17 million square kilometres (km2). It is the only APEC economy located in both Europe and Asia. Russia's vast natural resources include major deposits of coal, natural gas, oil and other minerals. Despite its land area advantage, two-thirds of the economy is a zone of high-risk agriculture due to the mostly continental climate, which is either too cold or too dry. Centralised district heating is provided for 6–8 months per year, while cooling during the summer is not widely used. Russia's economic growth had slowed from the 2012 level of 3.4% to 1.3% in 2013 with an average growth rate of 4.4% for the period of 2000–13 (WB, 2015; EDMC, 2015). Russia's major industries include oil and gas production, petroleum refining, mining, iron and steel, chemicals, machinery and motor vehicles. The energy sector's output accounts for about 30% of the economy's GDP, which is more than 50% of the tax and custom duty payments, 70% of total exports and 30% of the total investment. During the same period, the economy's population declined from 147 million to 144 million (EDMC, 2015).

Figure 19.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-.080 is moderate-high concentration, and 0.81 and above is high concentration.

Russia's total primary energy supply in 2013 was 731 million tonnes of oil equivalent (Mtoe), comprising of natural gas (54%), crude oil and petroleum products (22%), and other fuels such as coal, hydro and nuclear (24%) (IEA, 2015). In terms of primary energy diversity, which is derived by using the Herfindahl-Hirschman Index (HHI) methodology, the economy's primary energy mix became slightly concentrated on gas where the diversity was 0.35 HHI in 2000 and inched up a bit to 0.37 HHI in 2013 following an increase in gas share (from 51% in 2000 to 54% in 2013) (Figure 19.1).

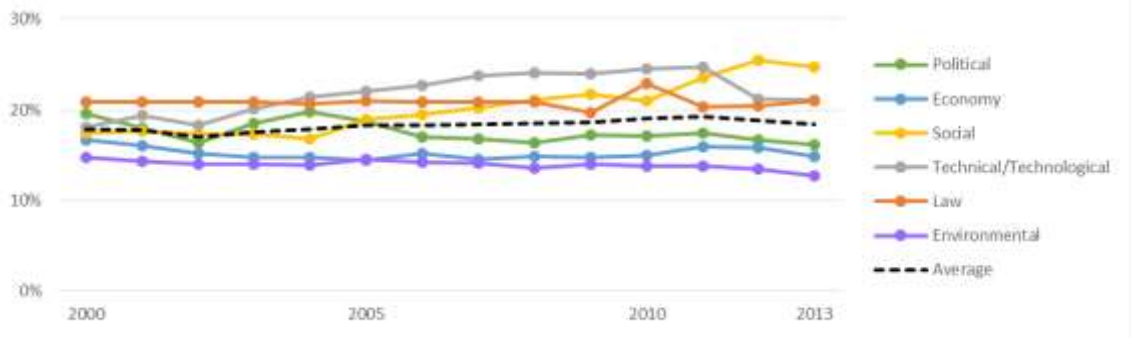
In terms of proven reserves recorded in 2013, Russia held 17% of the world's gas, 6.2% oil, 18%

coal (BP, 2015), and about 18% of its reasonably assured resources of uranium (NEA, 2014). Several other resources remain undiscovered, but the formidable obstacles of climate, terrain and distance hinder their exploitation. In 2013, the economy's energy intensity stood at 32 toe/million 2010 USD based on the primary energy supply requirement, a drop of 34% from the 2000 level. On the other hand, primary energy per capita increased from 4.2 toe/person in 2000 to 5.1 toe/person in 2013 (IEA, 2015 and EGEDA, 2015).

Oil Security

Based on the scale of 1.0% to 100% for each of the six security indicators used (1.0% means the lowest risk, while 100% means the highest risk), Russia's average oil supply security index showed a stable level, at around 18% (2000-2013) (Figure 19.2). From the six indicators that were evaluated (for the period 2000 to 2013), two indicators – social and technical/technology – displayed an increase in risk, while the others exhibited a decrease. As the economy is a huge oil producer and exporter, the study focuses on internal risk for oil security indexation.

Figure 19.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economy's political indicator earned an improvement from 32% in 2000 to 26% in 2013 largely because of better local stability. The local stability sub-indicator is derived from the World the Governance Index (WGI), which the economy received a declining index (78% in 2000 to 65% in 2013) (higher index means lower stability). For the other sub-indicators, the economy did not register any piracy incidents, and not a party to any international/multilateral agreement on oil supply security. Having no piracy incidents, the economy obtained a 0% index for this sub-indicator. Considering that the economy is one of the largest oil producers in the world, the study assigned 0% risk in the international agreement on oil emergency supply sub-indicator as well.

Under the economic indicator, composed of 11 sub-indicators, an improvement of 2.0 percentage points was recorded, from 17% in 2000 to 15% in 2013. This improvement was mainly contributed to by the

oil intensity sub-indicator, which saw the index going down to 63% in 2013 from 93% in 2000. The economy's oil intensity decreased from 69 toe/million 2010 USD in 2000 to 50 toe/million 2010 USD). The oil intensity index was calculated based on a combination of highest and lowest intensity levels within the APEC economies, as well as the changes (highest recorded) in the economy's intensity level over the historical period. However, other economic sub-indicators, such as the "Ease of Doing Business," primary energy diversity, and oil share to primary energy demonstrated a slight upward trend in index, which offset some of the risk reductions (like in oil intensity).

As for the social indicator, with the oil consumption per capita as the only sub-indicator, the index increased to 66% in 2013 from 46% in 2000. Similar methodology used in oil intensity was applied in determining the index for oil consumption per capita. The economy's oil consumption per capita steadily grew over the years, from 0.86 toe/person in 2000 to 1.1 toe/person in 2013, a slightly higher than the APEC average of 0.80 toe/person.

The technical/technology indicator also displayed an upward trend, from 18% in 2000 to 21% in 2013. The trend was caused by high refinery utilisation and changes in the oil reserves-production (R/P) ratio. Although some sub-indicators, such as logistics efficiency showed some improvements, these were insufficient to offset the increases from other sub-indicators. There had been a steady rise in risk from 2003 to 2011 contributed to by high refinery utilisation and a lower R/P ratio. Despite the lower R/P ratio, the economy's oil reserves could still last for at least 20 years having huge exploration and production potential (EIA, 2016). An increase of proven reserves of oil in 2011 improved the R/P ratio sub-indicator index from 26% in 2010 to 3.0% in 2011.

The law indicator exhibited a stable outcome throughout the historical period at an average of 21%. Four sub-indicators were considered under this indicator – three sub-indicators for internal which are resource extraction regulations, emergency preparedness, and strategic stockpiling, and exporter's rule of law (external factor). The resource extraction regulation sub-indicator, which is derived from the Global Petroleum Survey (GPS), earned a steady but high index, around 83%-84% (lowest was recorded in 2009 with 79%) (FI, 2016). Although no information on the oil stockpiling level, the study assigned 0% risk for this indicator due to the economy's huge amount of oil production (APERC, 2015).

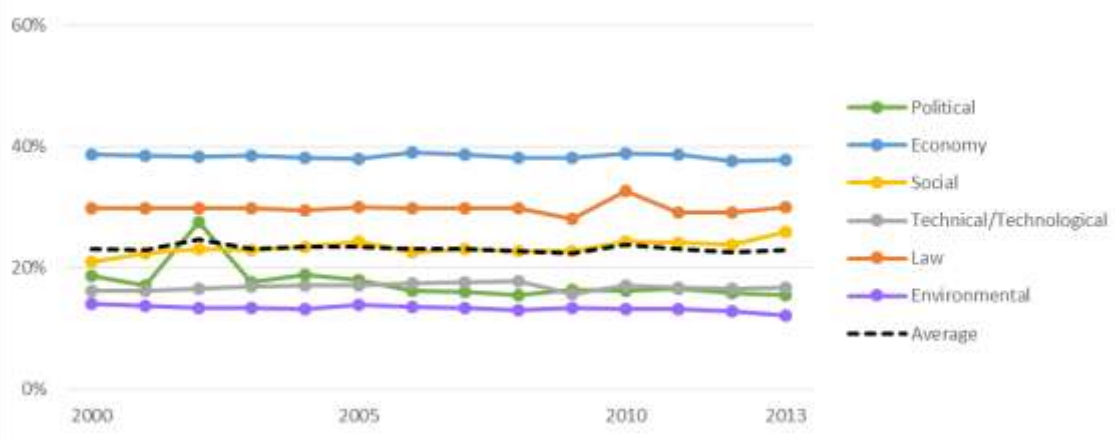
The environmental indicator included two sub-indicators used both under internal and external factors – the readiness and vulnerability in facing climate change impact, and natural disaster risk. This indicator obtained a declining index, from 15% in 2000 to 13% in 2013, because of an improvement in readiness and reduced vulnerability towards climate change impact. As reported by the Notre Dame Global Adaptation Index (ND GAIN), the economy's index dropped to 0.24 in 2013 (from 0.26 in 2000 in vulnerability to climate change, while the readiness improved from 0.47 in 2000 to 0.56 in 2013 (ND-GAIN, 2016).

Gas Security

Generally, Russia's gas security exhibited a higher index than oil but at a stable trend, an average of 23% (Figure 19.3). A higher index in gas security was attributed to the high gas share in primary energy as compared with oil. Since the economy does not import gas (although Cedigaz data showed that the economy imported gas from neighbouring economies, presumably as a transit point), the discussions focus only on internal factors affecting gas supply security.

The political indicator showed a slight decrease from 19% in 2000 to 16% in 2013 caused by low risk in the local stability sub-indicator (as discussed above in the oil security). Similar to oil, being a large gas producer, the study excluded the economy from the calculation of risk for the international/multilateral agreement on gas security. The economy has not entered into any agreements related to gas supply security (such as the International Energy Agency-International Energy Program)

Figure 19.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economic indicator received a steady index, albeit the highest (with a highest risk), averaging at 40%. Out of the six sub-indicators, three of them – gas share to primary energy, gas intensity and gas pricing (domestic consumption) [32]– contributed to the economic indicator's high index (IEA, 2015 and 2016). Gas contributed more than 50% of the total primary energy, which subsequently affected the economy's gas intensity, one of the highest in APEC (174.5 toe/million USD 2010 in 2000). However, gas intensity showed a declining trend, down to 123.5 toe/million USD 2010 in 2013, thus, reduced the risk in economic indicator.

The Technical/technology indicator also demonstrated a stable risk outcome. The economy's gas reserves continued to increase over the years, from 43,800 Bcm in 2000 to 49,900 Bcm in 2013. The gas

[32] According to the IEA Fossil Fuel Subsidy Database, Russia provided USD17.5 billion (2013 price) of gas subsidies in 2014 (IEA, 2016).

reserves level is seen to last for at least 80 years (Cedigaz, 2016). In terms of underground gas storage capacity, the economy is capable of storing about 20% of total gas demand (one of the highest in APEC), which could help reduce the gas supply disruption risk.

The social indicator (with only one sub-indicator – the gas consumption per capita) increased to 27% in 2013 from 22% in 2000. The economy's gas consumption per capita had continuously surged, from 2.2 toe/person in 2000 to 2.8 toe/person in 2013, which was significantly higher than the APEC average of 0.54 toe/person in 2013.

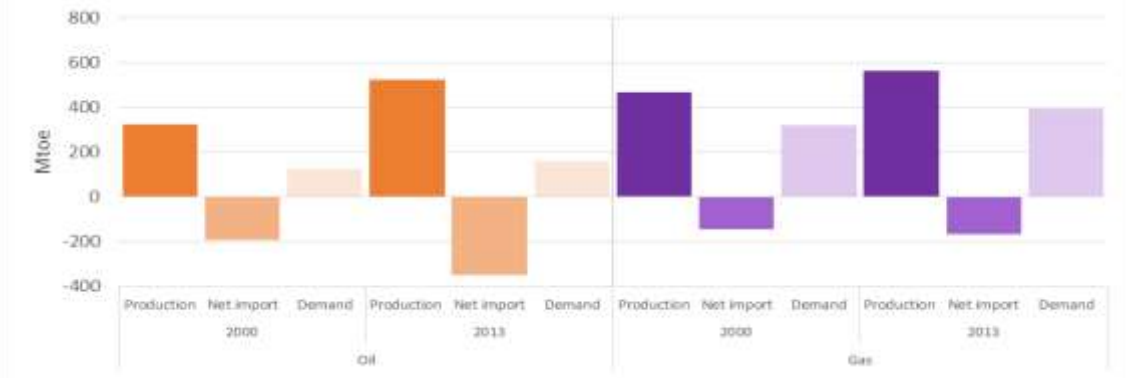
The law indicator considered two internal sub-indicators – resource extraction regulations and gas emergency preparedness. The resource extraction regulation sub-indicator, as discussed earlier in the oil security, maintained an index of 83%-84%. The gas emergency preparedness sub-indicator included four components – emergency plan, availability of trans-border pipelines, availability of regasification terminal (RGT) and availability of underground storage. For this sub-indicator, the economy managed to get 0% risk even without an RGT. This is for the reason that the economy has one of the most extensive pipeline systems. Likewise, the economy, being a large gas producer, could meet its increasing gas demand.

As for the environmental indicator, the same sub-indicators were utilised (as in oil security index) Since the economy does not import gas, the risk only covers domestic risk, the same as in oil security – an improvement from 14% in 2000 to 12% in 2013.

Import Share and Sources

Russia only imports gas and oil equivalent to less than 1.0% of total demand, which could be described as being self-sufficient in both fuels. The economy produced 524 Mtoe of oil in 2013 against its total oil demand of 160 Mtoe, translated to having net oil exports of 364 Mtoe. In the same year, the economy's gas production was recorded at 563 Mtoe of gas with domestic demand only at 395 Mtoe. The rest of the production was sent as exports mostly to European economies (IEA, 2015) (Figure 19.4).

Figure 19.4: Production, Net Imports and Demand, 2000-13



Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

SINGAPORE

Economy-Energy Overview

Singapore is located south of the Malaysian Peninsula between the Strait of Malacca and the South China Sea. This Southeast Asian economy occupied a total land area of 714 square kilometres (km2) in 2013 with a population of 5.4 million (EGEDA, 2015). Singapore is completely urbanized and highly industrialized, with a robust and growing diversified economy despite its lack of domestic energy and mineral resources and small land size, of which a significant part is reclaimed land. The economy's impressive economic success is due to certain factors including turning itself into a regional hub for tourism, financial activities, shipbuilding, petroleum and related equipment, biotechnology, high tech and solar energy, and its expanding role in international cargo and fuel shipping.

Singapore's gross domestic product (GDP) of USD 414 billion and per capita of USD 76,149 (2010 USD and Purchasing Power Parity [PPP]) in 2013 reflected growth of 5.5% and 3.2%, respectively, from the 2000 levels. Service-producing industries accounted for the largest GDP share (66%), with the biggest sub-sector represented by wholesale and retail trade (18%), followed by goods-producing industries (23%), with manufacturing and housing representing 17% and 4.3%, respectively (SingStat, 2015a).

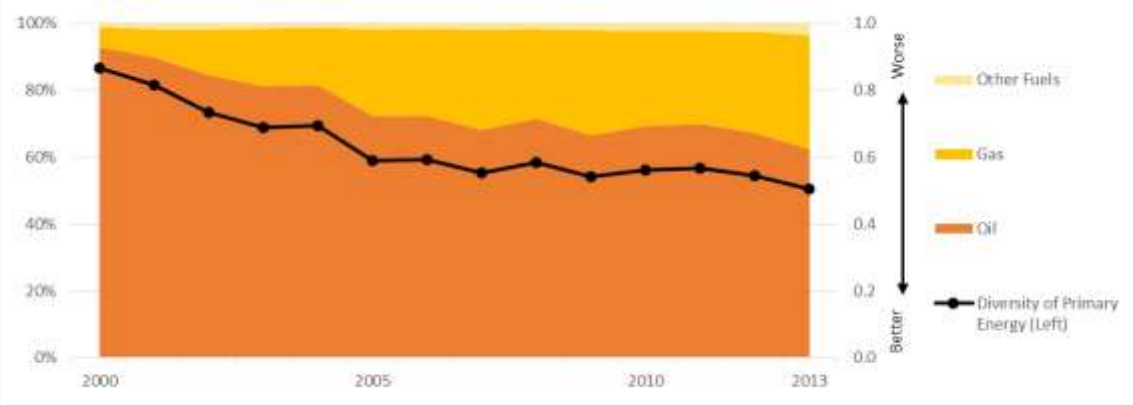
In 2013, the economy's exports amounted to USD 513 billion, of which the respective shares of domestic exports (USD 274 billion) and re-exports (USD 239 billion) were 53% and 47%, respectively. Non-oil products accounted for the bulk of the exports (76%), with machinery and equipment representing the largest share (46%), followed by chemicals and chemical products (12%), miscellaneous manufactured articles (8.7%), manufactured goods (3.2%) and food, beverages and tobacco (2.2%), leaving the rest for miscellaneous transaction articles (1.2%), crude materials (0.7%) and animal and vegetable oils (0.1%). Oil exports (refined oil products and lubricants) accounted for 24% of the economy's exports (SingStat, 2015b).

In 2013, total primary energy supply reached 26 Mtoe (IEA, 2015). Oil had the largest share with over 60% (16.3 Mtoe), followed by natural gas with a 34% share (8.9 Mtoe. Other fuels, such as coal and renewables, accounted for a 4.0% share of the total primary energy supply. Based on this primary energy mix, the diversity index stood at 0.51 HHI (under the category of mid-concentration) in 2013 with a high share of oil. However, the diversity index improved from a high of 0.87 (high concentration) as the oil share gradually declined (from 92% in 2000), while gas share increased (from 6.0% in 2000 to 34% in 2013) (Figure 20.1).

In the same year, the economy's total imports of crude oil, petroleum products and gas stood at 158 Mtoe to meet its energy requirements and the needs of the local oil refineries, which a significant amount of their refined products are exported. The economy imports all its crude oil and gas requirements. Of the total oil product imports and locally produced refined products, about 55% (84 Mtoe) was exported (IEA,

2015). The remaining oil imports were used domestically for marine and aviation bunkering, signifying the role of the economy in international shipping and aviation.

Figure 20.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-.080 is moderate-high concentration, and 0.81 and above is high concentration.

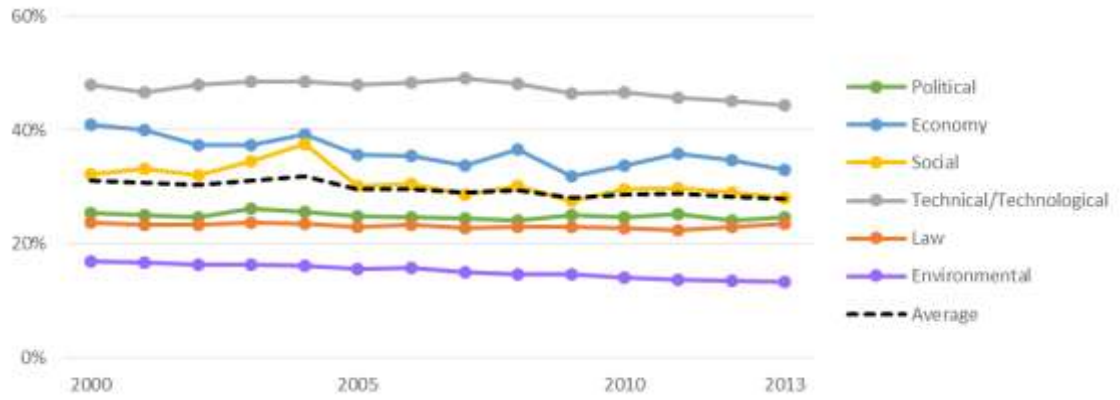
In ensuring the continuity of energy supply and as a part of energy security initiatives, the economy completed and commenced commercial operation of its first liquefied natural gas (LNG) regasification terminal (RGT) in May 2013, with an initial capacity of 3.5 million tonnes per annum (Mtpa), located on a 40-hectare site on the south-west part of Jurong Island. This capacity increased to 6.0 Mtpa in January 2014 when the third LNG tank, the fourth Open Rack Vaporizer and two High Pressure Booster Pumps were completed and brought into service. Additionally, the Secondary Berth and the Gas Engine Generator achieved mechanical completion at that time (SLNG, 2014).

The economy's energy intensity showed a downward trend, from 91.5 toe/million 2010 USD in 2000 to 63.5 toe/million 2010 USD in 2013, a drop of 31%. On the other hand, primary energy per capita increased modestly from 4.6 toe/person in 2000 to 4.8 toe/person in 2013 (IEA, 2015 and EGEDA, 2015).

Oil Security

From the six oil security indicators (political, economic, social, technical/technology, legal and environmental) used to determine the level of risk, Singapore earned a decreasing risk on oil security, from 31% in 2000 to 28% in 2013 (Figure 20.2). Using a scale of 1.0% to 100% for each indicator, where 1.0% means the lowest risk, while 100% means the highest risk, the economy's oil security index falls under the category of moderate-low exposure to risk. All six indicators evaluated displayed decreases in risks (declining index) led by the economic indicator.

Figure 20.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economy recorded a huge improvement under the economic indicator (composed of 11 sub-indicators) from 41% in 2000 to 33% in 2013. This improvement was mainly contributed to by five sub-indicators:

- Primary energy diversity improved from 87% in 2000 to 51% in 2013 due to the increased share of gas);
- Slight improvement in the "Ease of Doing Business" sub-indicator. Singapore consistently appeared as the top economy in the world in the Ease of Doing Business Report published by the World Bank) (WB, 2016b);
- Decrease of oil share in primary energy from a high of 93% in 2000 to 62% in 2013;
- Oil intensity reduction from 85 toe/million 2010 USD in 2000 to 40 toe/million 2010 USD in 2013 (the index for oil intensity was determined based on the highest and lowest intensity levels within the APEC economies, as well as the changes (highest recorded) in the economy's intensity level over the historical period); and,
- Higher diversity level for oil product imports, from 0.11 HHI in 2000 to 0.07 HHI in 2013.

However, the crude oil import diversity sub-indicator increased from 0.16 HHI in 2000 to 0.18 HHI in 2013, as a result expanding oil imports from Middle East economies. Although the economy does not produce crude oil, it produces a lot of oil products for export. This means that a crude oil supply disruption can create a devastating effect to the economy.

The political indicator showed a low and stable index at around 25%. The economy's local stability risk, which is derived from World Governance Index (WGI), improved from 29% in 2000 to 23% in 2013 (one of the lowest in APEC), while the crude oil exporter's stability (external factor) increased slightly from 44% in 2000 to 48% in 2013. The economy imported more than 85% of its crude oil from the Middle East and North Africa (MENA) region. Aside from deteriorated stability of oil exporters, the economy likewise

experienced an increased risk in piracy sub-indicator, from 1.0% in 2000 to 5.0% in 2013. Eliminating the piracy threat, which requires a regional effort, can improve the oil supply security by 1.0%. As the economy is part of the ASEAN Petroleum Security Agreement (APSA), it contributed to reducing the risk (political indicator) by nearly 12 percentage points. Under the chokepoint sub-indicator, which is calculated based on the route taken by most of the oil tankers to the economy, the risk improved from 19% in 2000 to 16% in 2013. Theoretically, if 10% of import sources from MENA shifted to Russia (presumably Russia will export its oil from the eastern part), it will reduce the chokepoint risk further by 2.0 percentage points.

As for the social indicator using oil consumption per capita as the only indicator, the index fell to 28% in 2013 from 32% in 2000. The economy's oil consumption per capita reached its highest point in 2004 at 6.0 toe/person, before going down by half to 3.0 toe/person in 2013. Similar methodology in getting the index for oil intensity was applied to determine the index for oil consumption per capita sub-indicator. Although the economy's oil consumption per capita decreased tremendously, it can still be considered to be high compared with the APEC average of 0.80 toe/person.

The technical/technology indicator, a combination of six sub-indicators (five internal and one external) that are related to reserves and technical capabilities, showed the highest risk. Despite the limitation on oil reserves, the economy managed to reduce the risk from 48% in 2000 to 44% in 2013, attributed to the increase in oil production of import sources (as a sub-indicator). A decline in oil production from import sources, which can occur due to war, declining reserves or other reasons, can disrupt oil supply in the long run. Being known as one of the biggest oil product producers and exporters in the world, the economy's refinery utilisation rate was already at 74% in 2013, which could be considered as moderate-high. However, there is still enough extra capacity to meet the local demand.

The law indicator exhibited a slight decrease in risk from 24% in 2000 to 23% in 2013. Four sub-indicators made up this indicator – resource extraction regulations, emergency preparedness, strategic oil stockpiling, and "rule of law" for oil exporters to the economy. With no crude oil resources (and gas resources), the study assigned a 0% index for the resource extraction regulation sub-indicator based on the Global Petroleum Survey (GPS). Meanwhile, the economy's oil stockpile, which is 50 days for refiners and 60 days for power generation was 51% in 2013 (the study used the comparison with the highest and lowest number of days of stockpiling in APEC economies to establish the index) (APERC, 2015). As the economy already put in place an emergency policy (and plan) in case of any oil supply disruption, a 0% risk was assigned on oil emergency preparedness sub-indicator. Lastly, the "rule of law" sub-indicator (an external factor) for import source displayed a slight improvement, from 45% in 2000 to 43% in 2013.

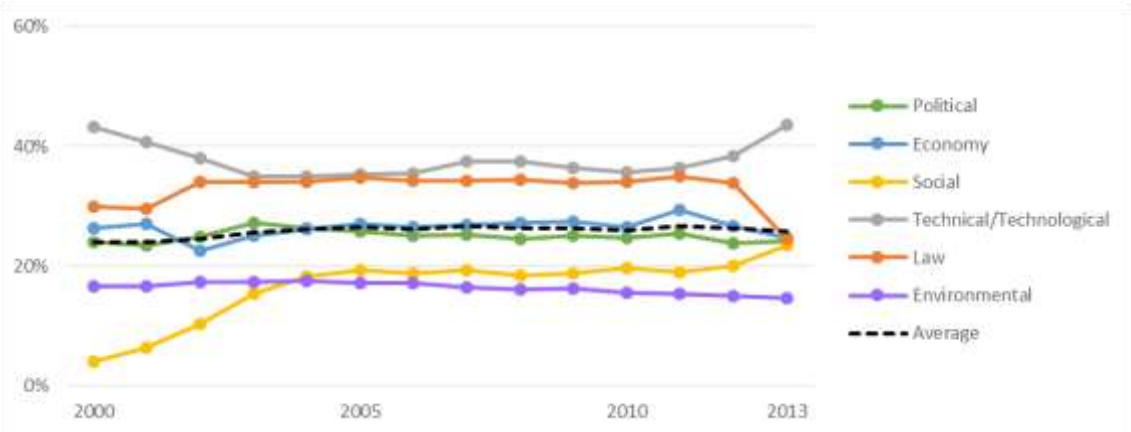
The environmental indicator covered two sub-indicators – the readiness and vulnerability to climate change impact, and natural disaster risk – both applied as internal and external factors. This indicator realised an improvement from 49% in 2000 to 40% in 2013. The economy improved its index in readiness and reduced vulnerability towards climate change as reported by the Notre Dame Global Adaptation Index

(ND GAIN). The ND GAIN revealed that the economy's vulnerability slightly fell (improved) to 0.33 in 2013 from 0.34 in 2000, while the readiness index in 2000 was 0.76 and went up to 0.89 in 2013 (ND GAIN, 2016). At the same time, the environmental risk from oil import sources also showed an improvement, a decrease from 49% in 2000 to 40% in 2013, largely due to the increase of readiness level in most of import sources.

Gas Security

Singapore received a lower average gas security risk than oil, but on an increasing trend. The economy's gas security index went up to 26% in 2013 from 24% in 2000. The increase was mainly contributed to by the social indicator. Although other indicators, such as the law and economic indicators, also showed improvements, these were not enough to offset the increase recorded in the social indicator that eventually led the average index to go up (Figure 20.3). The economy does not produce gas, and thus imports its entire gas supply requirement through pipelines and in LNG form.

Figure 20.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The political indicator displayed an increase, from 24% in 2000 to 27% in 2003 before gradually decreasing to 24% in 2013. Even though the economy's political stability showed improvement (as discussed in the oil security indexation chapter), the import sources' political stability prevented the risk from going down further. Prior to 2013, the economy imported all of its gas supply from Malaysia and Indonesia through pipelines. When the first RGT was introduced in 2013, the economy started to receive LNG imports from Qatar and Equatorial Guinea (Cedigaz, 2016), which eventually led the import source stability sub-indicator to increase from 49% in 2000 to 56% in 2013. However, the risk recorded for this sub-indicator in 2013 was actually better than the 77% risk registered in 2003 (the highest). In addition, the completion of RGT helped improved the import source diversity sub-indicator.

The economic indicator exhibited a slight decrease, from 26% in 2000 to 25% in 2013. Out of the seven sub-indicators (two of the sub-indicators under external factor), two of them exhibited an increase – the gas share to primary energy, from 6.0% in 2000 to 34% in 2013, and gas intensity, from 5.5 toe/USD million in 2000 to 21.6 toe/USD million in 2013. The increases in these two sub-indicators held the economic indicator's improvement by 9.0 percentage points (assuming that the economy maintain its gas share and gas intensity at the 2000 level). Despite of the increase (from these two sub-indicators), improvement in other sub-indicators, such as the primary energy diversity sub-indicator, contributed to the decrease in the economic indicator index. As discussed earlier, although the exporter's stability sub-indicator showed an upward risk trend due to additional imports from Equatorial Guinea and Qatar, it improved the import source diversity (based on share) from a high of 100% in 2000 (when Malaysia was the only exporter in 2000) to 58% in 2003 (when the economy began to import gas from Indonesia) and down to 54% in 2013 (RGT started to receive LNG shipments).

The social indicator (with only one sub-indicator, the gas consumption per capita) demonstrated the largest increase in risk, from 4.0% in 2000 to 23% in 2013. The economy's gas consumption per capita steadily increased to 1.65 toe/person in 2013 from only 0.28 toe/person in 2000.

The technical/technology indicator also demonstrated an increase in risk. Of the eight sub-indicators under this indicator, two of them are related to gas production and self-sufficiency (based on local production), which are not directly applicable to the economy's situation. The technical/technology indicator exhibited an improvement, from 43% in 2000 to 35% in 2003 caused by lower trans-border gas pipeline utilisation rate. As discussed earlier, the economy only sourced gas from Malaysia (through pipelines) prior to 2003. The economy started to import gas from Indonesia in 2003 (also through pipelines), which subsequently reduced the trans-border (import) pipeline utilisation rate from a high of 98% in 2000 to 54% in 2003. However, in 2013, the utilisation rate increase to 93%, and coupled with RGT introduction (the RGT utilisation rate is one of the factors that also influenced the risk), the technical/technology risk increased to 44%.

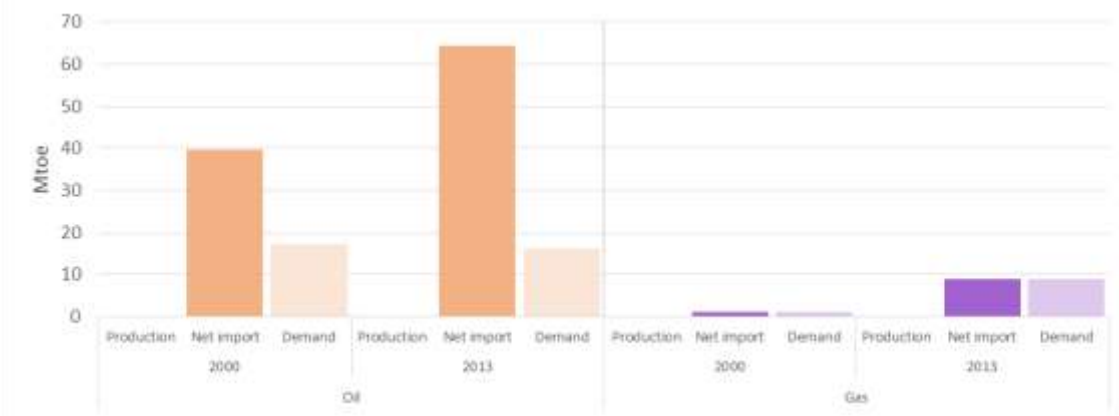
The law indicator for gas is composed of three sub-indicators – resource extraction regulations (already discussed in the oil chapter), gas emergency preparedness, and the "rule of law" for gas exporters to the economy import sources. The gas emergency preparedness sub-indicator is consisted of four components that are related to law (or policy) – availability of trans-border pipelines and RGT, gas emergency preparedness, and availability of underground gas storage. Since the only missing component is the underground gas storage, the economy received a fairly low result for this sub-indicator. This sub-indicator caused the law indicator to drop, from 34% in 2000 to 25% in 2013, with the establishment of RGT. On the "rule of law" sub-indicator for the import sources, the risk showed an upward trend, from 44% in 2000 to 58% in 2013. However, the introduction of RGT improved the sub-indicator risk from 62% in 2011.

As for the environmental indicator, same sub-indicators were used as in the oil supply security. The economy's environmental risks have been discussed earlier in the oil security section, chapter. As for the import sources, exposure to climate change increased, from 46% in 2000 to 48% in 2013, higher than the exposure shown in the oil security. This could be attributed to a lower number of gas import sources as compared with oil.

Import Share and Sources

As Singapore is a major oil and gas importer, this analysis might help to better understand risks associated with the import sources, focusing on the top five exporters. The economy's net imports in 2013 stood at 64 Mtoe, about four times higher than its domestic demand of 16 Mtoe. High oil import levels signify the role of the economy in international shipping and aviation. As for gas, all imported gas was used to meet local demand at 9.0 Mtoe in 2013 (IEA, 2015) (Figure 20.4).

Figure 20.4: Production, Net Imports and Demand, 2000-13

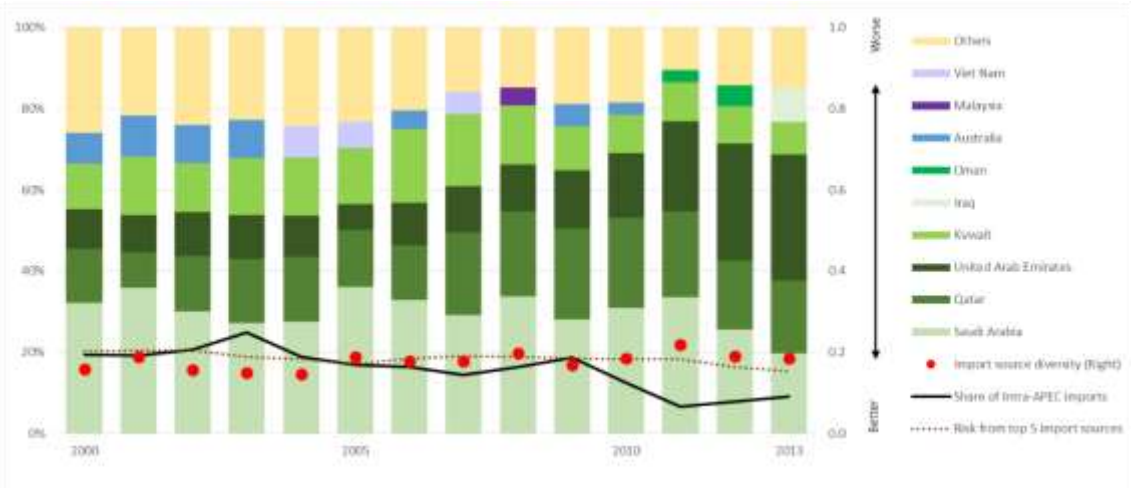


Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Crude Import Sources

Singapore imported about 46 Mtoe of crude oil in 2013, a decrease of 24% from its peak in 2005 at 60 Mtoe. From the 2000-2005period, the economy had consistently imported 70% of its crude oil supply from the MENA region, with the share continuing to go upward reaching its peak at 89% in 2011 before going down slightly to 85% in 2013 (Figure 20.5). Four economies have been the major sources for crude oil imports – Saudi Arabia, Qatar, the United Arab Emirates and Kuwait. Even though the economy relied on MENA for its crude oil supply, the imports sources could still be considered well-diversified, and recorded only a minor increase from 0.16 HHI in 2000 to 0.18 HHI in 2013.

Figure 20.5: Crude Oil Import Sources, 2000-13



Source: APERC analysis and UN Comtrade, 2016.

Looking at the risks associated with the major exporters (top five) of crude oil derived from their shares to total imports revealed decreasing risk level with an improved in index, 20% in 2000 to 15% in 2013. The reduction in risk was realised from the increase in exporter's oil production rate. However, some of the gains (from the oil production sub-indicator) were offset by a higher risk in chokepoints considering the higher import share from MENA.

In terms of intra-APEC trade, APEC economies, such as Australia; Indonesia and Viet Nam, used to supply about 20% of the economy's total crude oil imports. However, by 2013, intra-APEC imports only accounted for 9.0% of the total crude imports (UN Comtrade, 2016).

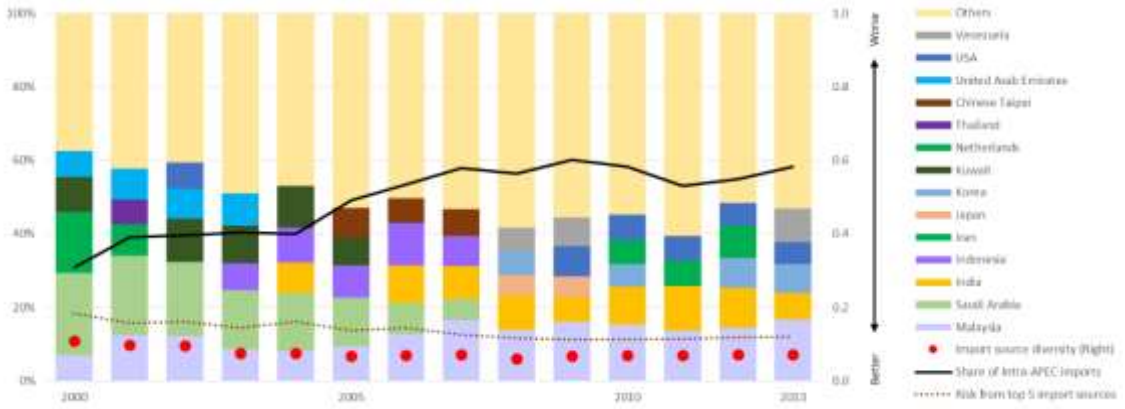
Oil Product Import Sources

The economy imported 104 Mtoe of oil products in 2013, almost three times higher than the 2000 level. Only Malaysia had been consistently appeared as among the top five exporters of oil products to the economy, with share ranging from 7.0% in 2000 to 17% in 2013 (Figure 20.6). Saudi Arabia used to be one of the major oil product sources for the economy (from 2000-2007), while India started to be one of the major import sources post 2006. In terms of the diversity of import sources, the economy had one of the most diverse import sources with 0.11 HHI in 2000 and improved to 0.07 HHI in 2013. The share of intra-APEC imports also improved, from only 31% in 2000 to nearly 60% in 2013, as the share of oil product imports from Korea (6.0%); Russia (6.0%); and, the US (8.0%) increased.

Risks from the top five major import sources also improved, from 18% in 2000 to 12% in 2013. The main factors contributed to the improvement were lower chokepoints, better local stability and higher degree of "rule of law" of import sources. Lower chokepoint risk, from 15% in 2000 to 6.0% in 2013, was

triggered by the economy's shift in importing oil products from MENA to East and South Asia. Decreasing share of MENA also resulted in declining risk in local stability for exporters (31% in 2000 to 27% in 2013), and on the "rule of law" (30% in 2000 to 23% in 2013).

Figure 20.6: Oil Product Import Sources, 2000-13

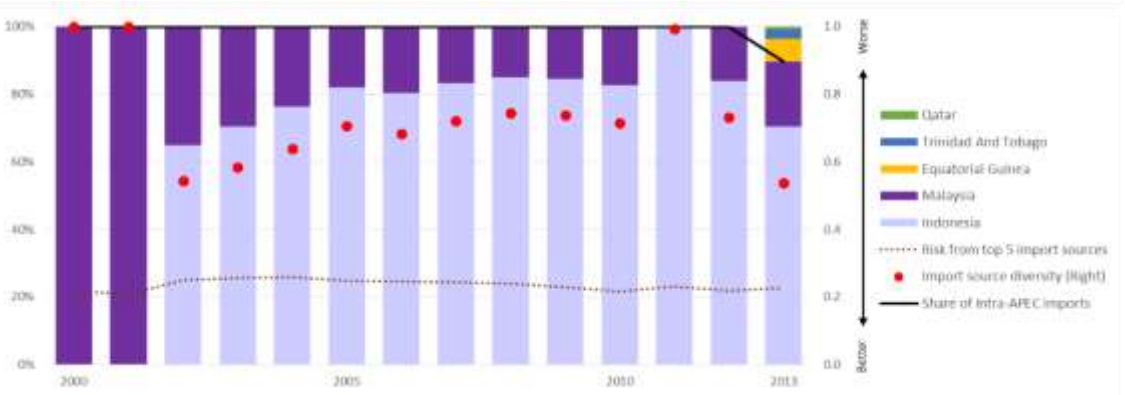


Source: APERC analysis and UN Comtrade, 2016.

Gas Import Sources

The economy imported all of its gas requirements from Malaysia and Indonesia before the completion of RGT in 2013. Both economies exported their gas via pipelines. With this, intra-APEC imports remained at 100% for most of the time over the historical period until 2013. The establishment of RGT subsequently improved the import source diversity, but not necessarily the risks from major import sources (top five). Risks associated with the import sources stayed at almost the same level (22% in 2000 to 23% in 2013) as LNG shipments came from Qatar and Equatorial Guinea passed through chokepoints, which constituted additional risk for the economy (Figure 20.7).

Figure 20.7: Natural Gas Import Sources, 2000-2013



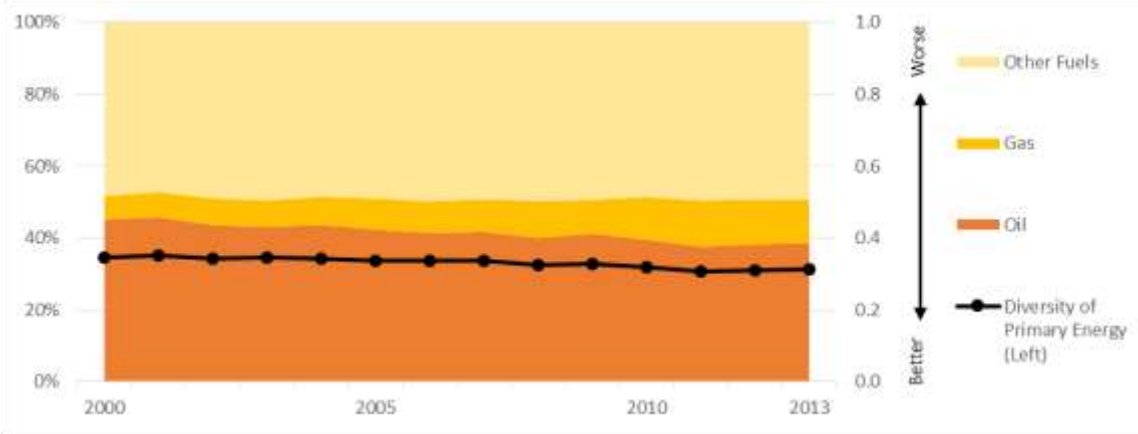
Source: APERC analysis and Cedigaz, 2016.

CHINESE TAIPEI

Economy-Energy Overview

Chinese Taipei is an archipelago consisting of Taiwan, Penghu, Kinmen and Matsu, located off the south-east coast of China and south-west of Japan, with an area of 36,193 square kilometres (km2). In 2013, Chinese Taipei's gross domestic product (GDP) was USD 942 billion, and its per capita income was USD 40,368 (2010 USD and Purchasing Power Parity [PPP]). The economy's GDP grew on average rate of 4.7% from 2000-2013. Within the past few decades, Chinese Taipei's economic structure changed substantially, shifting from industrial production to the services sector, wherein the latter constituted 65% of the GDP, followed by industry (33%) and agriculture (1.7%) in 2013 (BOE, 2016). The economy is one of the most densely populated areas in the world, but its population growth rate has been relatively flat; the economy's population of 23 million grew at a rate of 0.4% in 2013 compared with the 2000 level (EGEDA, 2015).

Figure 21.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-.080 is moderate-high concentration, and 0.81 and above is high concentration.

The growth of the total primary energy supply (TPES) had been stable over the historical period, rising from 85 Mtoe in 2000 to 109 Mtoe in 2013, an increase of 23%. Fossil fuels continue to be the dominant fuel with oil contributing the largest share (39%), followed by coal (34%), natural gas (15%) and other fuels (13%) (IEA, 2015). In terms of primary energy diversity, the economy recorded a stable but improving diversity index, from 0.35 HHI in 2000 to 0.31 HHI in 2013. The slight improvement was caused increasing gas share (7.0% in 2000 to 12% in 2013), while oil share decline from 45% in 2000 (Figure 21.1).

Lacking natural resources, Chinese Taipei is highly dependent on energy imports to meet domestic energy demand. The economy has estimated oil reserves of only 2.3 million barrels (Mmbbl) and gas reserves of about 6.2 billion cubic metres (Bcm) (EIA, 2015). In 2013, the economy imported 45 Mmbbl of crude oil, 15% lower than the 53 Mmbbl in 2012. In 2013, Saudi Arabia, Oman, Kuwait, United Arab Emirates and Iran were the major suppliers, accounting for 75% of total oil imports, while the other regions made up the rest of the imports (BOE, 2016). To prevent supply disruption, the Petroleum Administration Act 2001 requires local refiners to maintain stocks of more than 60 days of sales volumes (APERC, 2015).

As the economy relies heavily on energy imports, the government has been striving to enhance overseas supply security by establishing the Petroleum Administration Act, which requires refiners and importers to maintain 60 days of sales volumes (calculated from the average domestic sales and private consumption over the preceding 12 months). The government uses the Petroleum Fund to finance the storage of oil and also stockpiles 30 days of oil demand. The Act mandates that a liquid petroleum gas stockpile of more than 25 days of supply be maintained (BOE, 2014).

The economy's energy intensity showed a continuous downward trend, from 164.9 toe/million 2010 USD in 2000 to 129.7 toe/million 2010 USD in 2013, a drop of 21%. On the other hand, primary energy per capita increased modestly from 3.8 toe/person in 2000 to 4.6 toe/person in 2013 (IEA, 2015 and EGEDA, 2015).

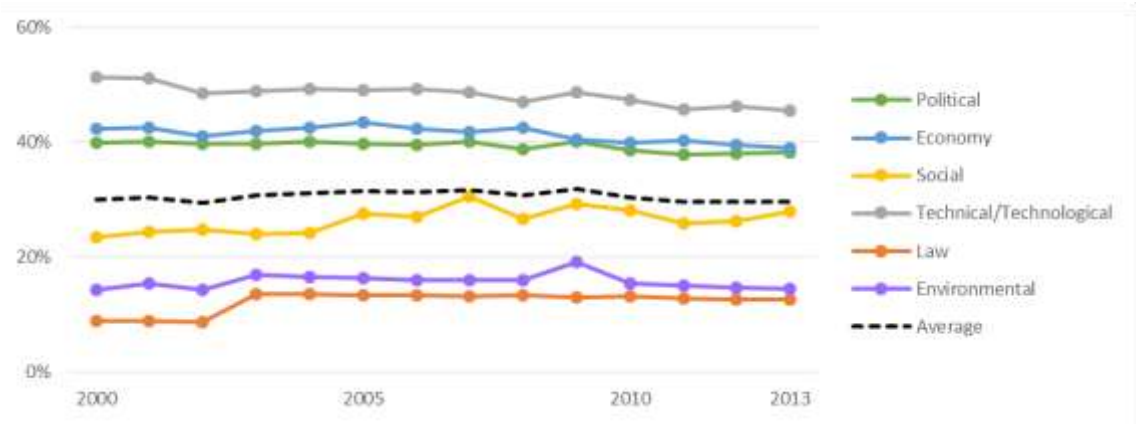
Oil Security

Using the six oil security indicators – political, economic, social, technical/technology, legal and environmental – Chinese Taipei's oil supply security index received a relatively stable outcome at around 30% index (Figure 21.2). From a scale of 1.0% to 100% index for each indicator, where 1.0% means the lowest risk, while 100% means the highest risk, the economy's oil security index is within the category of moderate-low exposure to risk. Out of six indicators that were evaluated, two indicators – political, economic and technical/technology indicators – exhibited improvement, while the others showed a slight increase in index.

The political indicator earned a decrease in risk, from 40% in 2000 to 38% in 2013. The economy's local stability (sub-indicator) risk, which is derived from World Governance Index, contributed to the improvement in political indictor with index decreasing to 33% in 2013 from 41% in 2000. Meanwhile, the local stability sub-indicator for oil exporters to the economy increased from 41% in 2000 to 43% in 2013. The increase could be attributed to increasing reliance on Middle East and North Africa (MENA) region for crude oil, from a 40% share of total imports in 2000 to 75% in 2013 (BOE, 2016). With this, the chokepoint sub-indicator also demonstrated an increase in risk (16% in 2000 to 17% in 2013), as more oil tankers from MENA need to go through chokepoints, such as the Strait of Hormuz and the Strait of Malacca. As the

economy does not have any agreements on emergency oil supply, the study assigned 100% risk for this sub-indicator. Theoretically, having such agreement could push the risk down by 12 percentage points.

Figure 21.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economy likewise recorded a decrease in risk for the economic indicator (composed of 11 sub-indicators), from 42% in 2000 to 39% in 2013. The decrease was mainly contributed to by four sub-indicators:

- Higher diversity for primary energy diversity (0.35 HHI in 2000 to 0.31 HHI in 2013);
- Improved "Ease of Doing Business" index (31% in 2000 to 21% in 2013 (derived from Doing Business Report published by the World Bank Group)) (WB, 2016b);
- Lower oil share in primary energy (45% in 2000 to 39% in 2013);
- Oil intensity reduction from 74 toe/million 2010 USD in 2000 to 50 toe/million 2010 USD in 2013. (The index for oil intensity capita was computed based on highest and lowest per capita level of the APEC economies, and the historical changes in the economy's intensity level (highest recorded); and,
- Higher oil product import source diversity level (0.17 HHI in 2003[33] to 0.07 HHI in 2013).

However, some of the improvements under the economic indicator were offset due to a lower level of diversity in crude oil import sources, which used to be 0.12 HHI in 2000 but went up to 0.25 HHI in 2013.

As for the social indicator with oil consumption per capita as the only sub-indicator, the index went up 28% in 2013 from 24% in 2000. The oil consumption per capita reached its highest point in 2007 at 2.0 toe/person, before going down to 1.8 toe/person in 2013, slightly higher than the 2000 level (1.7 toe/person). The economy's oil consumption per capita was higher than APEC average of 0.80 toe/person

[33] UN Comtrade does not have specific records on Chinese Taipei trade data due to political reasons. Chinese Taipei trade data is classified as "Other Asia, not specified elsewhere" (UNStats, 2010). Therefore, the study utilised crude oil import data from the Ministry of Economic Affairs, Bureau of Energy and oil product imports from the Customs Administration, Ministry of Finance (BOE, 2016 and CA, 2016).

in 2013. The index for oil consumption per capita was determined using the same methodology applied in oil intensity.

Technical/technology indicator contributed the highest index to the overall oil supply security, which consisted of six sub-indicators. Despite the limitation on oil reserves, the economy managed to reduce the risk from 51% in 2000 to 46% in 2013, largely due to the increase in oil production rate (as a sub-indicator) from import sources (a decline in oil production from import sources could occur due to war, declining reserves or other reasons that could disrupt oil supply in the long run). The economy's low refinery utilisation rate also added to the decline in risk for the technical/technology indicator. Although the economy is known as one of the largest oil product producers and exporters in this region, the refinery utilisation rate was still not in full capacity at a 76% in 2013 (down from nearly a 100% utilisation rate in 2000).

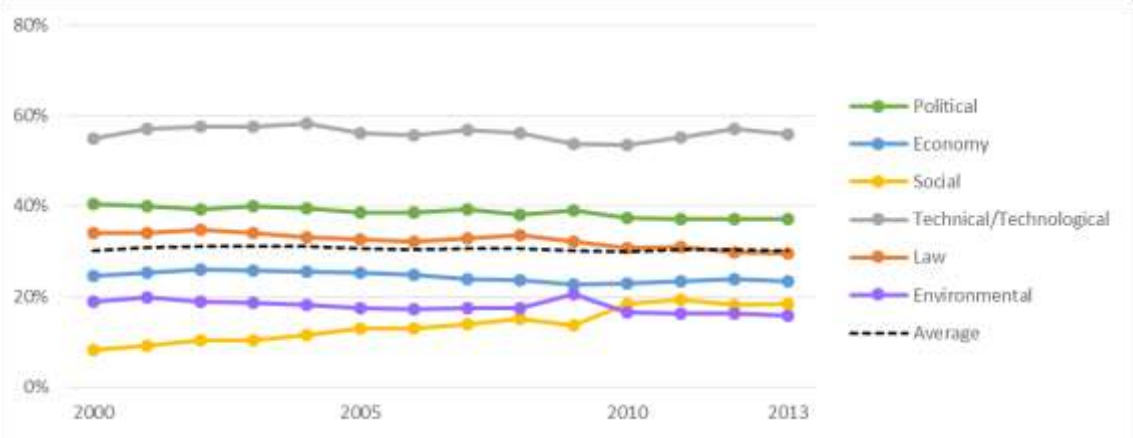
The law indicator exhibited an increase in risk, from 9.0% in 2000 to 13% in 2013. This indicator included four sub-indicators – the resource extraction regulations, emergency preparedness, strategic oil stockpiling and "rule of law" for exporters. Since there is no data available in the Global Petroleum Survey (GPS) for the economy, which determines the resource extraction regulation sub-indicator index, the study assigned 0% risk for this sub-indicator. The economy's oil stockpile of about 90 days of net imports could be considered to be one of the highest among APEC economies. Thus, the economy gained a low index for this sub-indicator (oil stockpiling) at 14% in 2013. The study used as benchmark the highest and lowest number of days of stockpiling among the APEC economies to establish the index (APERC, 2015). In terms of emergency preparedness (sub-indicator), the economy received a 0% index due to availability of emergency policy and plan. Lastly, the exporter's "rule of law" sub-indicator showed an increase, from 21% in 2000 to 36% in 2013.

The environmental indicator covered two sub-indicators – the vulnerability and readiness to climate change impact, and natural disaster risk – both applied as internal and external factors. The study utilised the Notre Dame Global Adaptation Index (ND-GAIN) in order to gauge the readiness and vulnerability of economies in facing climate change impact (ND-GAIN, 2016). Unfortunately, the ND-GAIN index does not provide data for Chinese Taipei. In order to establish the environmental indicator index for Chinese Taipei, the study utilised Japan's data as proxy. Chinese Taipei and Japan are both high income economies located in the same geographical area (East Asia) with island type economies. However, the study recognized that the index may not be as accurate as using original data. As such, the economy may want to give attention to the risk of oil exporter's exposure towards climate change impact, which the index significantly went up by 13 percentage points (22% in 2000 to 35% in 2013).

Gas Security

Chinese Taipei's earned a slightly higher gas security risk than oil but at a stable trend. The economy's gas security average index was at 30% in most of the years over the historical period. Despite having a steady average index, two indicators – technical/technology and social – exhibited an increasing trend, while other indicators managed to offset the increases to make the average index stable (Figure 21.3).

Figure 21.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The technical/technology indicator received the highest risk, among the indicators, which also displayed a slight increase in risk from 55% in 2000 to 56% in 2013. With limited gas resources, the reserves-gas production ratio and gas self-sufficiency greatly contributed to the higher risk for this indicator. Likewise, the index for utilisation rates of the economy's regasification terminal (RGT), and the exporters' liquefied natural gas (LNG) terminal (export terminal) were operating at their maximum capacities, which also added to the high risk.

The social indicator (only the gas consumption per capita as sub-indicator) significantly increased by 11 percentage points (8.0% in 2000 to 19% in 2013). The economy's gas consumption per capita expanded to 0.56 toe/person in 2013 from 0.25 toe/person in 2000. Similar to oil, in order to establish the index for gas consumption per capita sub-indicator, the study used the highest and lowest gas consumption per capita among APEC members, as well as the changes in the economy's per capita level (highest recorded) over the historical period.

The political indicator index slightly decreased, from 41% in 2000 to 38% in 2013. The reduction was mainly contributed to by the local stability sub-indicator. The economy's political stability improved (as already discussed in the oil security), as well as the local stability index for gas exporters, which pushed the political indicator index to decline. However, when the economy started to import LNG from the Middle

East region in 2005, chokepoint risk surged, from 0% in 2000 to 16% in 2013. In addition to increasing chokepoint risk, the absence of any international/multilateral agreements (such as the ASEAN Petroleum Security Agreement [APSA]) also added to the high risk in political indicator. If such agreement exists, which the economy could lean upon during supply emergencies, the political risk could be reduced by more than 15 percentage points.

The economic indicator shows a stable risk at around 31% throughout the years. Out of the six sub-indicators (two of the sub-indicators are related to imports) that the study tracked, three of them marked an increase – the gas share to primary energy sub-indicator, from 7.0% in 2000 to 12% in 2013, gas intensity sub-indicator, from 34% in 2000 to 50% in 2013, due to the increase in gas intensity level from 10.8 toe/USD million in 2000 to 15.7 toe/USD million in 2013, and an increase in net gas imports, from 93% in 2000 to 100% in 2013. However, the increase in the economic indicator was held up by gas import source diversity, which improved from 0.52 HHI in 2000 (where there were only two LNG exporters) to 0.32 HHI (from 11 LNG exporters).

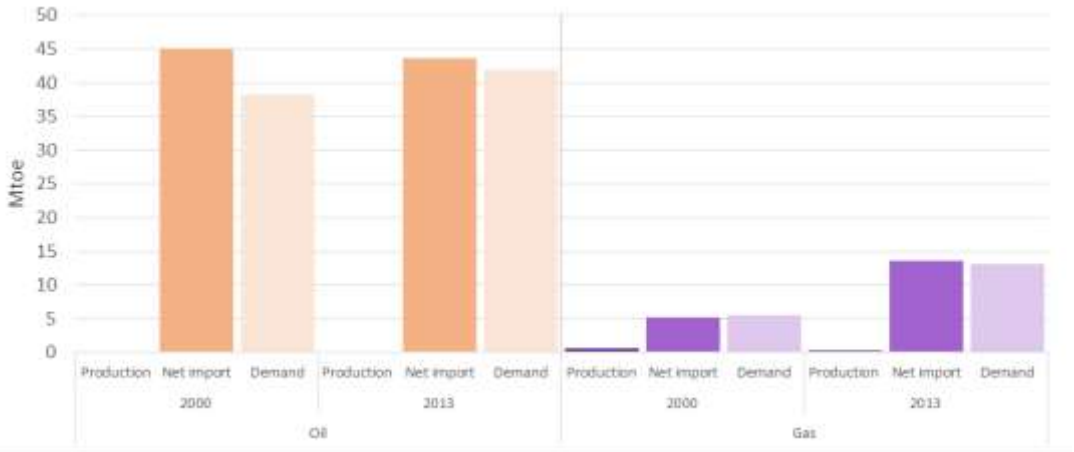
The law indicator for gas included three sub-indicators – the resource extraction regulations (which was discussed earlier in the oil security), gas emergency preparedness, and the "rule of law" as an external factor applied to gas exporters (import sources). The gas emergency preparedness sub-indicator considered four components – the availability of RGT, trans-border pipelines, underground gas storage, and gas emergency preparedness. Since the economy lacks underground gas storage and trans-border pipelines, it resulted in having a mid-exposure risk level (at 50%). On the other hand, the "rule of law" sub-indicator realised a reduction in risk, from 56% in 2000 to 41% in 2013. Most of the improvements occurred when the economy started to diversify its LNG imports sources.

The environmental indicator for gas utilised the same sub-indicators as in the oil supply security. The economy's supply risk related to environmental factors has been discussed earlier in the oil security. The gas exporter's exposure to climate change impact decreased from 54% in 2000 to 43% in 2013 due to a more diversified import sources and improved readiness by some of the gas exporters.

Import Share and Sources

Despite being one of the economy with low resource, Chinese Taipei has developed a huge refinery complex in Asia. As for gas, Chinese Taipei one of the earliest APEC members that import LNG due to very limited gas production in the economy.

Figure 21.4: Production, Net Imports and Demand, 2000-13

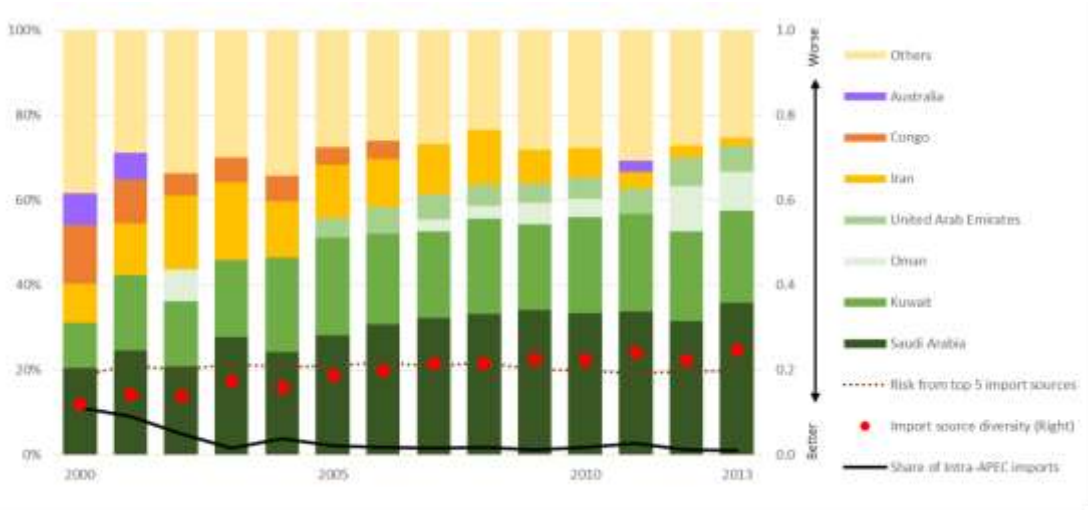


Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Crude Import Sources

The economy imported 45 Mtoe of crude oil in 2013, a decrease of 19% from its peak in 2005 with 55 Mtoe. The import share of MENA to total imports steadily increased from 40% in 2000 to 75% in 2013. Saudi Arabia, Kuwait and Iran had been consistently appeared as among the major exporters (top five exporters) to the economy, securing around half of the total imports post 2001. As oil imports from MENA continue to increase, the diversity index of oil import sources decreased from 0.12 HHI in 2000 to 0.25 HHI in 2013 (Figure 21.5). Meanwhile, crude oil imports from APEC economies declined to 1.0% in 2013 (from 11% in 2000), mainly from Australia.

Figure 21.5: Crude Oil Import Sources, 2000-13



Source: APERC analysis and BOE, 2016.

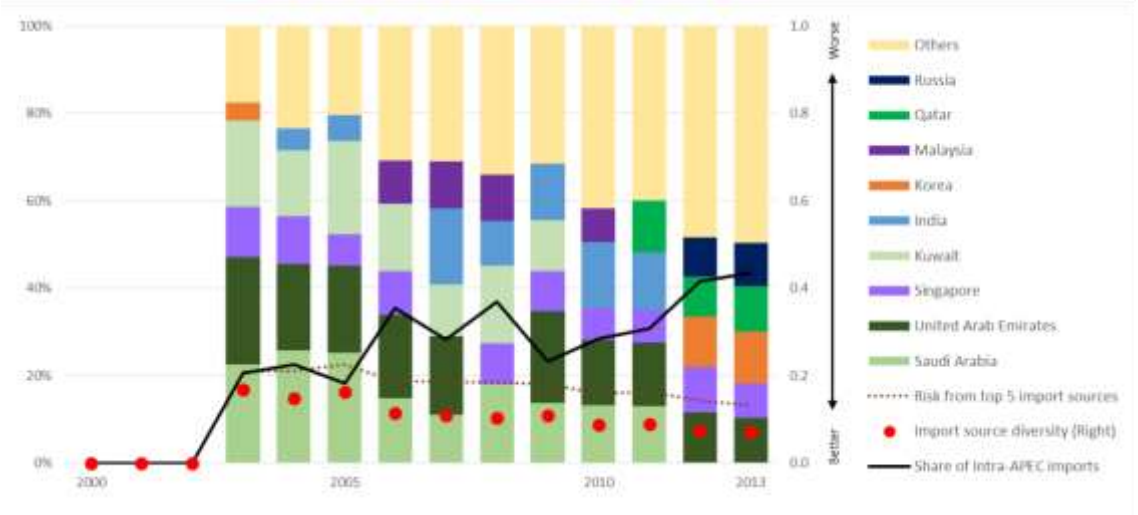
In terms of risk associated with the major crude oil exporters, a slight increase was noted (19% in

2000 to 20% in 2013) caused by higher share from the Middle East. Exporter's stability and chokepoint risks were identified as the main reasons for the increase in risk.

Oil Product Import Sources

The economy imported 16 Mtoe of oil products in 2013, a two-fold increase from the 2000 level. Saudi Arabia, the United Arab Emirates and Singapore had been consistent major exporters of oil product to the economy over the historical period. In terms of import source diversity, the economy managed to improve this sub-indicator, from 0.52 HHI in 2003[34] to 0.32 HHI in 2013 (Figure 21.6).

Figure 21.6: Oil Product Import Sources, 2000-13



Source: APERC analysis and CA, 2016.
Note: The Customs Administration, Ministry of Finance trade data only shows data from 2003 onward.

Oil product import source risk (based on the top five import sources) revealed a slightly different picture from crude oil, as more than 40% of total oil products imports came from APEC region. As for risk associated with the major import sources, it clearly showed that higher intra-APEC imports resulted in lower risk level. The better stability (political stability) and fewer chokepoints from exporters in the APEC region were the primary factors for the risk reduction.

Gas Import Sources

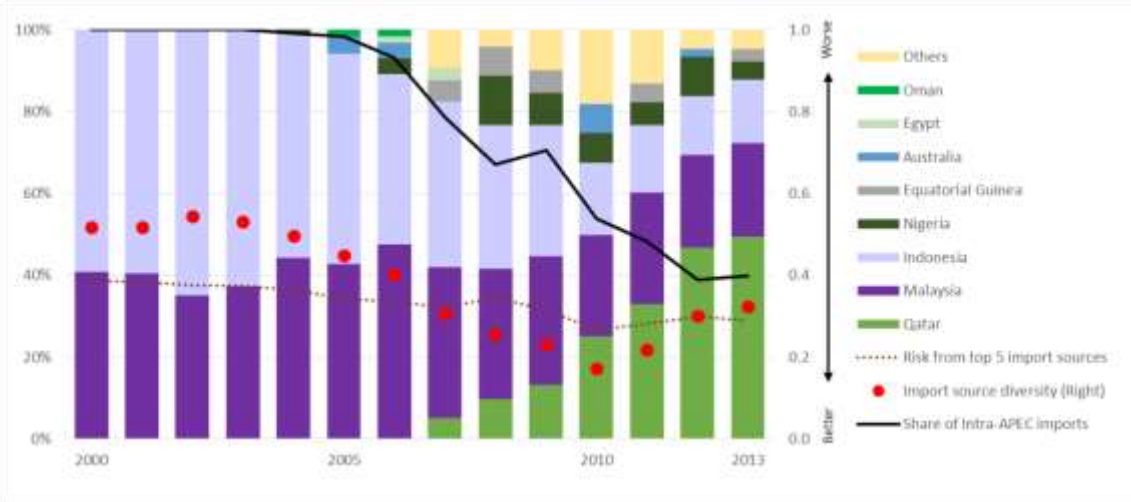
The economy imported most of its gas from Malaysia and Indonesia in LNG form, thus intra-APEC imports remained at 100% for the period 2000-2004. By 2013, the economy imported LNG from 12 economies, led by Qatar with a 50% share of total imports, which reduced the intra-APEC import share to about 40% in the same time. LNG import source diversity improved tremendously from 0.52 HHI

[34] Data collected from the Customs Administration, Ministry of Finance only show the import and export of oil products starting from 2003.

in 2000 to 0.17 HHI in 2010, before going up to 0.32 HHI in 2013 (Figure 21.7).

In terms of supply risk (from the top five exporters), the associated risk declined to 29% in 2013 from 39% in 2000. Although some of the import sources, such as Qatar and Nigeria, increased the chokepoint risk, such was not high enough to offset some of the benefits gained by diversifying the import sources.

Figure 21.7: Natural Gas Import Sources, 2000-2013



Source: APERC analysis and Cedigaz, 2016.

THAILAND

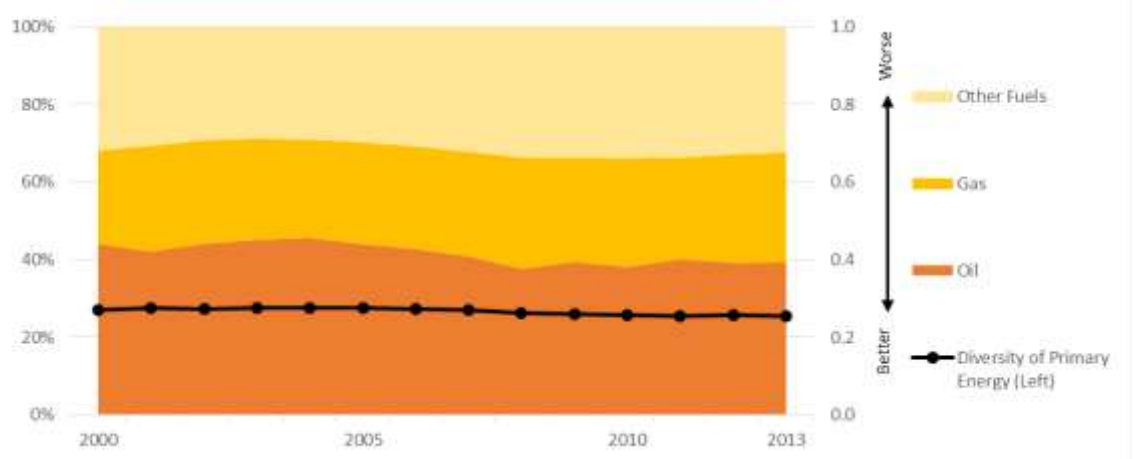
Economy-Energy Overview

Thailand is surrounded by fast growing economies such as Myanmar, the Lao People's Democratic Republic and Cambodia to the north and east, and shares a border with Malaysia to the south. Thailand has an area of 513,115 square kilometres (km2) and a population of about 67.5 million in 2013.

In 2013, the economy's gross domestic product (GDP) reached USD 915 billion (2010 USD and Purchasing Power Parity [PPP]), a 4.0% annual increase from USD 546 billion in 2010. In the same period, GDP per capita increased annually at 2.5%, from USD 8,709 (2010 USD PPP) to USD 13,561 (2010 USD PPP). The largest contributors to its GDP were the services (41%) and manufacturing (29%) industries (NESDB, 2015).

The economy's total primary energy supply in 2013 was 134 Mtoe, almost two-fold increase from 74 Mtoe in 2000. Oil accounted for 39% of the total primary supply, while gas provided 28%, followed by other fuels with a 33% share (IEA, 2015). The economy's primary energy diversity improved slightly from 0.27 HHI in 2000 to 0.26 HHI in 2013 due to a higher gas share in 2013 in primary energy (Figure 22.1).

Figure 22.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

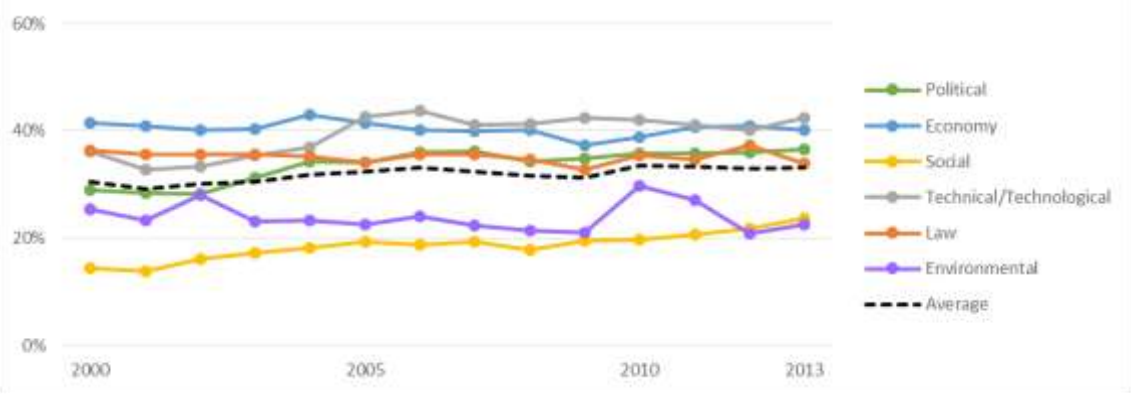
The economy has limited energy resources. At the end of 2013, proven oil reserves stood at 427 million barrels (Mmbbl), natural gas at 285 billion cubic metres (Bcm), and coal at 1,239 million tonnes (Mt). Based on the economy's production rate in 2013, reserves are seen to deplete very soon – oil resources within three years and natural gas in six years (BP, 2015).

As a developing economy, Thailand's energy intensity had continuously increased to 146.6 toe/million 2010 USD in 2013, an increase of 11% from the 2000 level of 132.4 toe/million 2010 USD. On the other hand, the primary energy per capita increased from 0.5 toe/person in 2000 to 0.8 toe/person in 2013 (IEA, 2015 and EGEDA, 2015).

Oil Security

Based on the six indicators (political, economic, social, technical/technology, law and environmental) evaluated, Thailand's oil supply security index increased from 30% in 2000 to 33% in 2013 (Figure 22.2). From the scale of 1.0% to 100% for each indicator, where 1.0% means the lowest risk, while 100% means the highest risk, the economy's security index falls within the moderate-low exposure to risk category. Three of the indicators (economic, law and environmental) displayed a decreased in index, while the rest increased.

Figure 22.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economy's technical/technology indicator (a combination of six sub-indicators that are related to reserves and technical capabilities) showed the highest risk compared with other indicators. The oil production increased by more than two-folds, from 8.1 Mtoe in 2000 to 19.4 Mtoe in 2013, although oil reserves did not increase as much. The oil reserves only increased from 54.6 Mtoe in 2000 to 81.9 Mtoe in 2004 before going down again to 54.6 Mtoe in 2013 (EIA, 2015). Due to limited oil reserves, the economy's reserves-production (R/P) ratio sub-indicator rose to 67% in 2013 from 21% index in 2000. The sudden increase in 2004-2005 period was because of an abrupt drop in R/P ratio, from 7.5 years to 3.2 years of oil reserves. On the other hand, as oil production rose (amid tight oil reserves), it resulted in improving the oil self-sufficiency from 20% in 2000 to 39% in 2013. For oil products, the economy's refinery utilisation rate went up to 96% in 2013 from 83% in 2000. This increase added another constraint to the

technical/technology indicator.

The political indicator, composed of six sub-indicators, exhibited a steadily increase from 29% in 2000 to 37% in 2013. The local stability sub-indicator, which is derived from World Governance Index (WGI) – Political Stability and Absence of Violence/Terrorism indicator, jumped from 42% in 2000 to 76% in 2013. On the other hand, the stability of the oil exporters to the economy improved from 50% in 2000 to 41% in 2013. The improvement in oil exporter's stability could be attributed largely to the shift in oil import sources from relatively unstable economies (using WGI) to stable economies, such as the United Arab Emirates (UAE). As economy is part of the ASEAN Petroleum Security Agreement (APSA), it contributed to lowering the risk in political indicator by nearly 12 percentage points. Under the chokepoint sub-indicator, which is calculated based on the route taken by oil tankers to the economy, the risk increased from 15% in 2000 to 19% in 2013.

As for the social indicator with oil consumption per capita as the only one sub-indicator, the index displayed an upward trend in risk from 14% in 2000 to 24% in 2013. The economy's oil consumption per capita continuously increased, albeit at a slow pace, from 0.51 toe/person in 2000 to 0.78 toe/person in 2013. Although the economy's oil consumption per capita had kept on increasing, it was still low than the APEC average of 0.80 toe/person in 2013. It should be noted that in determining the index, the study compared the oil consumption per capita levels (highest and lowest levels) among the APEC economies, as well as the historical changes (highest recorded) in the economy's per capita level. The economy's per capita level was slightly lower than the APEC average of 0.80 toe/person.

The law indicator showed a slight decrease in risk, from 37% in 2000 to 34% in 2013, which was made up of four sub-indicators (resource extraction regulations, emergency preparedness, strategic oil stockpiling and rule of law for importers). The decrease was mainly contributed to by an improvement in the resource extraction regulation sub-indicator (which is derived from the Global Petroleum Survey [GPS] data), as well as the reduction of risk from the "rule of law" sub-indicator (as an external risk from oil exporters), from 47% in 2000 to 38% in 2013.

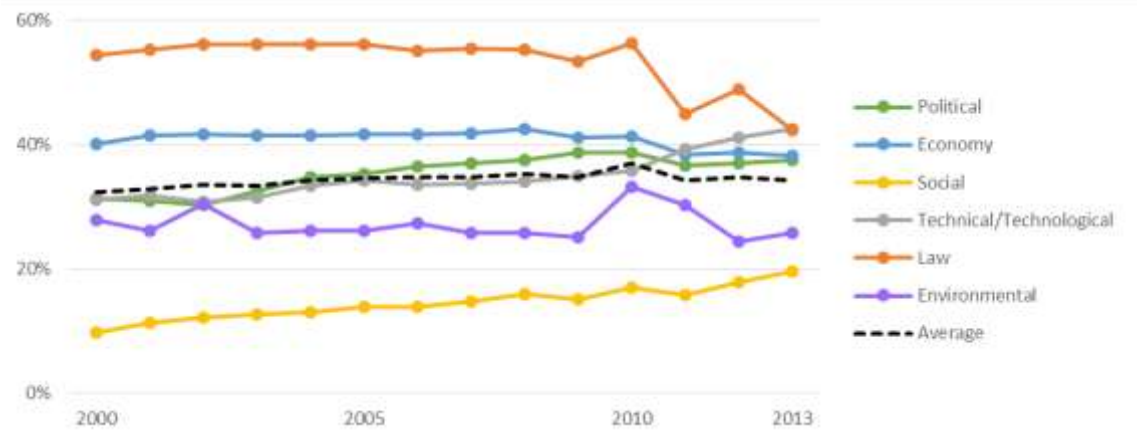
A slight improvement was also realised in the economic indicator (covering 11 sub-indicators), from 41% in 2000 to 40% in 2013. Among the factors that contributed to the decreasing risk in this indicator were: the improvement in the "Ease of Doing Business" sub-indicator; a decrease of oil share in the primary energy from 44% in 2000 to 39% in 2013; a reduction in oil intensity from 58.4 toe/million 2010 USD in 2000 to 57.7 toe/million 2010 USD in 2013; and, lower net oil imports from 86% in 2000 to 65% in 2013 because of an increase in crude oil production and oil product output. In coming up with index for oil intensity, the same methodology was applied as in oil consumption per capita. However, some of the gains were offset by lower diversity of crude import sources, up to 0.24 HHI in 2013 from 0.13 HHI in 2000. In 2000, oil imports from Qatar and the UAE constituted about 37% of total imports, and it increased to 62% in 2013.

The environmental indicator considered two sub-indicators – the readiness and vulnerability to climate change impact, and natural disaster risk both used as internal and external factors. In this indicator, the risk improved from 25% in 2000 to 23% in 2013, partly because of the economy's better index in readiness and reduced vulnerability towards climate change (as reported by the Notre Dame Global Adaptation Index (ND GAIN)). The ND GAIN showed that economy's vulnerability was down to 0.38 in 2103 from 0.41 in 2000, while the readiness went up to 0.55 in 2013 (from 0.51 in 2000) (ND GAIN, 2016). However, the environmental indicator spiked in 2010 and 2011 due to the major floods that occurred during these periods, which actually pushed the environmental risk from 21% in 2009 to 30% in 2010, and 27% in 2011 (CRED, 2016).

Gas Security

Thailand's earned a higher gas security risk than oil with an increasing trend. The gas security index demonstrated an increasing trend, from 32% in 2000 and to 34% in 2013. The increase was triggered mainly by the political, social and technical/technology indicators. Although other indicators exhibited improvements, such as the law and economic indicators, these were not enough to offset increases in other indicators, which eventually brought the average gas security index to go up (Figure 22.3).

Figure 22.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The political indicator showed an increase from 31% in 2000 to 38% in 2013. In addition to increased risk in local stability (as discussed in the oil security), chokepoint risk went up to 11% in 20111 (from 0% in 2000) as the economy started to import liquefied natural gas (LNG), for which most of the shipments need to go through multiple chokepoints. However, the introduction of regasification terminal (RGT) improved the exporter's stability from 76% in 2010 (a year before RGT was completed) to 71% in

2011 and further downward to 67% in 2013. Although the completion of RGT helped reduce risk in political indictor, it contributed to increasing the risk in other indicators, such as technical/technology, which is discussed below.

The economic indicator increased from 41% in 2000 to 43% in 2005 before going down to 39% in 2013. The jump in 2005 was because of the rise in gas demand, which saw expanding gas share in the primary energy, from 24% in 2000 to 26% in 2005. The increase in gas share subsequently pushed the gas intensity up to 37 toe/USD million in 2005 and 41 toe/USD million in 2013 from 32 toe/USD million in 2000. On the other hand, the introduction of RGT in 2011 improved the diversity of import sources from a high of 1.0 HHI in 2000 (Myanmar was the only gas exporter to the economy before the completion of RGT) to 0.69 HHI in 2013 with six economies exporting gas and LNG.

The social indicator with only one sub-indicator (gas consumption per capita) demonstrated a significant increase in index (4.0% in 2000 to 23% in 2013. The economy's gas consumption per capita steadily increased from 0.28 toe/person in 2000 to 1.65 toe/person in 2013. Similar methodology in oil consumption per capita was used in order to establish the index for gas consumption per capita. The economy's gas consumption per capita was almost three times higher than the APEC average of 0.58 toe/person in 2013 as Thailand expand its gas-fired power generation over the years.

Technical/technology indicator also exhibited an increasing trend in risk from 31% in 2000 to 43% in 2013. One contributing factor was the decreasing gas R/P ratio from 20.5 years to only 7.5 years. The decline in R/P ratio was because of declining gas reserves, down to 214 Mtoe (193 Bcm) in 2013 from 324 Mtoe (292 Bcm) in 2000, coupled with rising gas production from 16 Mtoe (14 Bcm) in 2000 to 28 Mtoe (25 Bcm) in 2013. Meanwhile, the introduction of RGT in 2011 added another constraint to the technical/technology indicator as its utilisation rate significantly rose to 15% in 2011 and 28% in 2013 from 0% in 2010. Another factor that pushed the risk up was the trans-border pipeline utilisation rate (imports from Myanmar), which was already at 70% in 2013 from 11% in 2000. The only sub-indicator that showed improvement was the gas production rate of exporters, which used to have a high risk of 77% in 2000 (as Myanmar was only exporter), but went down to 6.0% in 2013 when the economy started to import gas (in LNG form) from economies endowed with huge and continuous gas production, such as Qatar.

The law indicator for gas considered three sub-indicators – the resource extraction regulations (which was discussed in the oil chapter), gas emergency preparedness, and "rule of law" as an external factor (applied to import sources). The gas emergency preparedness sub-indicator included a combination of four components – availability of RGT, trans-border pipelines, and underground gas storage, and gas emergency preparedness. As the missing component for this sub-indicator is the availability of underground gas storage, the economy received fairly low index compared with other APEC economies (which lack more than one of this sub-indicator's components). Overall, the law indicator dropped to 42% in 2013 from 54% in 2000, partly attributed to the introduction of RGT in 2011, and the improvement gained in the "rule of law"

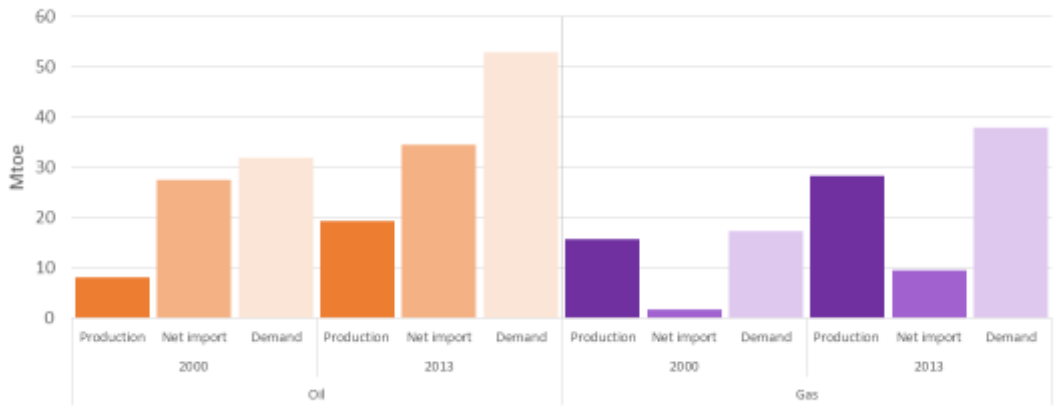
sub-indicator.

As for the environmental indicator (same sub-indicators as in the oil supply security), the economy's internal environmental risks remained the same as discussed in the oil security. As regards the environmental risks from import sources, the risks related to climate change impact decreased from 68% in 2000 to 61% in 2013 as the economy started to diversify its import sources, from one economy to six economies in 2013.

Import Share and Sources

In 2013, Thailand produced around 19 Mtoe of oil, while net imports stood at 35 Mtoe to meet its domestic oil demand of 54 Mtoe (an increase of more than 21 Mtoe from the 2000 level) (IEA, 2015). As for gas, although domestic production almost doubled, the demand rose by more than two-fold, which prompted the economy to build RGT as an alternative means to receive gas imports. Gas imports went up by nearly five times, from 2.0 Mtoe in 2000 to nearly 10 Mtoe in 2013 (Figure 22.4).

Figure 22.4: Production, Net Imports and Demand, 2000-13



Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

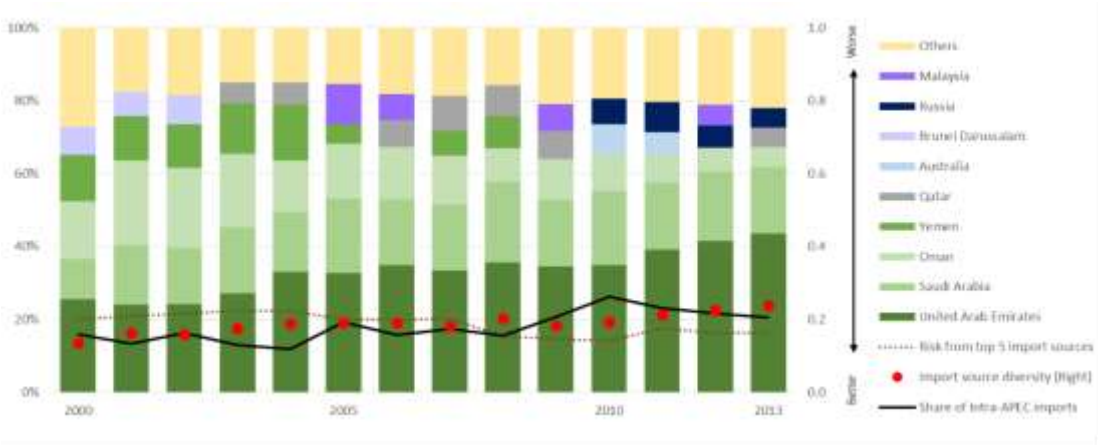
Crude Import Sources

The economy imported about 45 Mtoe of crude oil in 2013, an increase of 43% from the 2000 level (31 Mtoe) (IEA, 2015). There were at least three economies that consistently appeared as top five crude oil exporters – the UAE, Qatar and Nigeria. The aggregate share from these three economies had been increasing from 52% in 2000 to 67% in 2013, which led to import source diversity deterioration from 0.13 HHI in 2000 to 0.24 HHI in 2013 (Figure 22.5).

When it comes to the risk associated with the major import sources (the top five imports sources), the risk declined from 20% in 2000 to 16% in 2013. The reduction in risk was because of the increase in exporter's oil production, better stability and "rule of law" of import sources. However, there was an increase

in risk on chokepoints due to a higher import share from MENA.

Figure 22.5: Crude Oil Import Sources, 2000-13



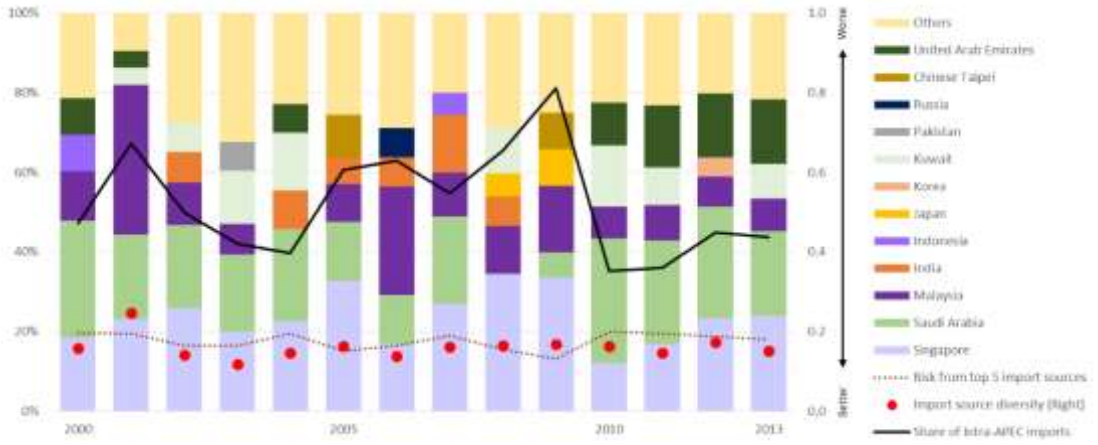
Source: APERC analysis and UN Comtrade, 2016.

In terms of intra-APEC trade, APEC economies, such as Australia; Brunei Darussalam and Malaysia supplied a combined share of 16% to total crude oil imports in 2000. By 2013, intra-APEC imports increased to 21% as Russia started to export a huge amount of crude to the economy.

Oil Product Import Sources

The economy imported 3.0 Mtoe of oil products in 2013 (IEA, 2015). Singapore; Malaysia; and Saudi Arabia had been the major exporters (among the top five exporters) of oil products with combined shares of 53% in 2013from 60% in 2000 (the highest share was 80% in 2001) (UN Comtrade, 2016). With the decreasing from these major exporters, the diversity of import sources improved from 0.16 HHI in 2000 to 0.15 HHI (Figure 22.6). The share of intra-APEC varied every year, from 81% in 2009 (the highest) to 35% in 2010 (the lowest).

Figure 22.6: Oil Product Import Sources, 2000-13



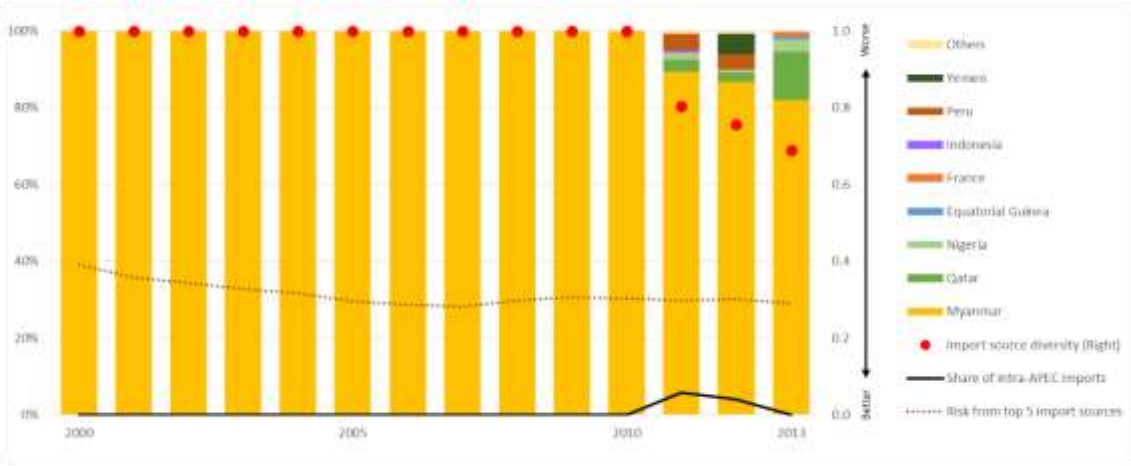
Source: APERC analysis and UN Comtrade, 2016.

Oil product import source risk (based on the top five import sources) also varies every year due to changing shares of different import sources. However, a few noticeable trends could be observed, such as the risk dropped to its lowest level in 2009 when the share of intra-APEC was at the highest (primarily because of the increased imports from Singapore), while the year after saw the risk at the highest when the Intra-APEC imports were at the lowest. Three main factors that contributed to the increase in risk for the 2009-2010 period: higher chokepoints risk (3.0% in 2009 to 16% in 2010); lower stability level (exporter's stability risk increased from 29% in 2009 to 34% in 2010); and, higher "rule of law" risk (21% in 2009 to 30% in 2010).

Gas Import Sources

As mentioned earlier in this chapter, the economy imported most of its gas from Myanmar through pipelines until the completion of RGT in 2011. Prior to 2011, there were no intra-APEC imports (although there was production from the Malaysia-Thailand Joint Development Authority where the gas produced is considered to be indigenous). However, post 2011 saw Indonesia and Peru exporting LNG to the economy resulting in increased intra-APEC imports from 0% to 6.0% in 2011 and 4.0% in 2012. Import source diversity improved significantly as the economy would no longer be relying on a single import source, while risk from top import sources improved from nearly 40% in 2000 to 29% in 2013 (Figure 22.7).

Figure 22.7: Natural Gas Import Sources, 2000-2013



Source: APERC analysis and Cedigaz, 2016.

UNITED STATES

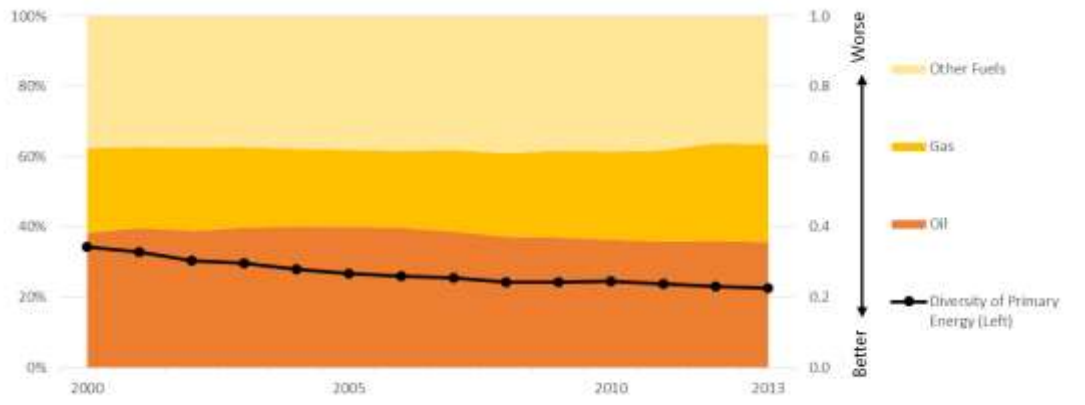
Economy-Energy Overview

The United States (U.S.) is the world's largest economy with a GDP of USD 15.9 trillion (2010 USD and Purchasing Power Parity [PPP]) in 2013 (EGEDA, 2015). The U.S. spans 9.9 million square kilometres (km2) and has a population of 316.5 million people. The economy's population growth rate modestly increased at 0.8% annually from 2000-2013 period (EGEDA, 2015).

The U.S. is the second-largest producer and consumer of energy in APEC. The economy is also rich in energy resources. In 2013, the economy had 49 billion barrels (Bbbl) of proven oil reserves, 9.6 trillion cubic metres (Tcm) of natural gas reserves, and 237 billion tonnes (Bt) of coal reserves (BP, 2015).

The total primary energy supply (TPES) reached 2,188 Mtoe in 2013, a decrease of 4.0% from 2,273 Mtoe in 2000. In terms of fuel type, 36% of the supply came from crude oil and petroleum products, 28% from natural gas, 20% from coal, and the rest from other sources, such as nuclear energy, hydropower and geothermal energy (IEA, 2015). The economy's primary energy diversity improved from 0.34 HHI in 2000 to 0.23 HHI in 2013 because of an increase of gas share to total primary energy supply (Figure 23.1).

Figure 23.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

The U.S. showed a constant reduction in import dependency since 2006, recording an average annual decline of 11% over the last seven years (from 2006-2013) which was brought about by the increase in crude oil production from North Dakota and Onshore Texas, mainly from shale and other tight (having very low permeability) formations (EIA, 2013). In 2013, the economy remained the third-largest crude oil, natural gas liquids and condensates producer in the world with production of about 10 million barrels per day

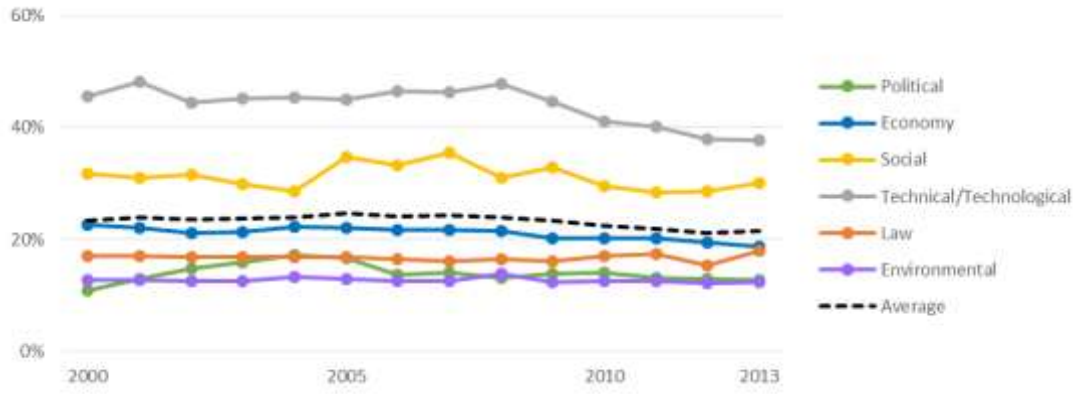
(bbl/d), a 13% increase from the previous year level (BP, 2015).

The US's energy intensity showed a continuous downward trend, a drop of 23% from 178.8 toe/million 2010 USD in 2000 to 137.8 toe/million 2010 USD in 2013. The same trend was seen in primary energy per capita, which decreased from 8.9 toe/person in 2000 to 6.9 toe/person in 2013 (IEA, 2015; EGEDA, 2015).

Oil Security

Based on the six oil security indicators evaluated for this study – political, economic, social, technical/technology, legal and environmental, the United States' oil security index had been stable over the 13-year period (2000-2013) with a slight decrease from 23% in 2000 to 21% in 2013. From the scale of 1.0% to 100% index for each indicator, where 1.0% means the lowest risk, while 100% means the highest risk, the economy's oil security risk is within the category of moderate-low exposure to supply disruption. Out of the six indicators, three registered a decrease, while the others recorded a slight increase or were unchanged. The technical indicator got the highest index (Figure 23.2).

Figure 23.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The economy's technical/technology indicator (a combination of six sub-indicators that are related to reserves and technical capabilities) showed the highest risk compared with other indicators, albeit decreasing from 46% in 2000 to 38% in 2013. While economy's oil production expanded by 30%, from 366 Mtoe in 2000 to 476 Mtoe in 2013, the oil reserves increased by more than 50% for the same time period (from 3,274 Mtoe in 2000 to 5,048 Mtoe in 2013) (EIA, 2016). Based on these factors, the economy's oil reserves-production ratio (R/P) ratio (as a sub-indicator) improved from nine years in 2000 to 11 years in 2013. In addition to this sub-indicator, the utilisation rate of refineries decreased from 100% in 2000 to 92% in 2013, which could provide a little room for the refineries to expand output.

On the economic indicator consisting of 10 sub-indicators, the economy displayed a deceasing risk with an index of 19% in 2013 from 23% in 2000. The improvement was caused by some factors: higher diversity level of primary energy (0.34 HHI in 2000 to 0.23 HHI in 2013); decreasing oil share in primary energy (38% in 2000 to 36% in 2013); oil intensity reduction (from 68.5 toe/million 2010 USD in 2000 to 49 toe/million 2010 USD in 2013); and, a decrease in net oil imports (63% in 2000 to 43% in 2013) due to increasing domestic crude oil production. However, risk related to import source diversity went up to 0.16 HHI in 2013 (from 0.11 HHI in 2000) for crude, and 0.12 HHI (from 0.09 HHI in 2000) for oil product imports.

As for the social indicator with oil consumption per capita as the only sub-indicator, the index dwindled to 30% in 2013 from 32% in 2000. The economy's oil consumption per capita had continuously declined from 3.1 toe/person in 2000 to 2.5 toe/person in 2013. Although the oil consumption per capita was on decreasing trend, it was still three times higher than the APEC average of 0.80 toe/person in 2013. It should be noted that in determining the index for oil consumption per capita, the study compared the oil consumption per capita levels among APEC economies (highest and lowest level), as well as the historical changes (highest recorded) in the economy's oil consumption per capita level (same methodology was applied to oil intensity).

The political indicator (made up of six sub-indicators) exhibited a slight increase from 11% in 2000 to 13% in 2013 (one of the lowest in APEC). The local stability sub-indicator, which is derived from World Governance Index (WGI) – Political Stability and Absence of Violence/Terrorism indicator, increased from 30% in 2000 to 37% in 2013, while oil exporter's stability remained almost unchanged at 39%. One of the reasons that kept the political indicator index low was the existence of the International Energy Agency-International Energy Program (IEA-IEP), which the economy is a member. As this multilateral agreement covers oil security agreement, it contributed to keeping the political risk at low level. Other contributing factor were imports from neighbouring economies, such Canada and Mexico, both could be considered stable with no chokepoint risk.

The law indicator likewise showed small increase in risk, from 17% in 2000 to 18% in 2013. This sub-indicator covered four sub-indicators – the resource extraction regulations, emergency preparedness, strategic oil stockpiling and "rule of law" for importers. The increase could be attributed to increasing index in the resource extraction regulation sub-indicator, which is derived from the Regulatory Climate Index of the Global Petroleum Survey [GPS] data. In the resource extraction regulation sub-indicator, the economy obtained an index of 31%, an increase from 24% in 2000. The Regulatory Climate Index includes costs of regulatory compliance, uncertainty on anticipated changes in environmental regulations, enforcement of regulations, and legal system fairness and transparency, among others. Based on the GPS, perceptions on resource extraction regulation deteriorated in almost all states surveyed (21 states and three offshore areas) except five states – Alabama, Montana, North Dakota, Oklahoma and West Virginia. On the other hand, the

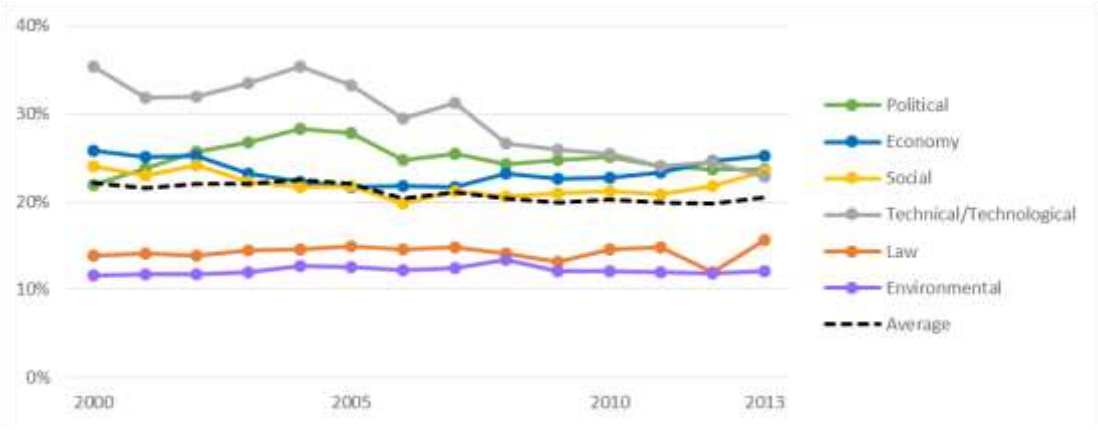
"rule of law" of import sources improved slightly, from 33% in 2000 to 32% in 2013.

The final indicator is the environment with two sub-indicators – the readiness and vulnerability to climate change impact, and natural disaster risk, which both applied as internal and external factors. The index for this indicator decreased, from 33% in 2000 to 28% in 2013, because of the economy's improved index in vulnerability towards climate change (as reported by the Notre Dame Global Adaptation Index [ND GAIN]). The ND GAIN showed that the economy's vulnerability slightly decreased to 0.25 in 2013 from 0.26 in 2000 (ND-GAIN, 2016). However, the economy's climate change readiness decreased from 0.80 in 2000 to 0.78 in 2013. In ND-GAIN, higher index means higher readiness to climate change. The economy's readiness index is one of the highest among the APEC economies.

Gas Security

The United States gained a slightly lower risk in gas than oil and on a decreasing trend. The average gas security index was 20% in 2013 from 22% in 2000. Among the indicators, the technical/technology, economic and social indicators contributed to the decrease in gas security risk, while others displayed a little increase in risk (Figure 23.3).

Figure 23.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

The technical/technology indicator obtained the largest reduction in risk, from 36% in 2000 to 23% in 2013, resulting from almost a two-fold increase in gas reserves, from 4,522 Mtoe in 2000 to 8,615 Mtoe in 2013. With this, the economy's gas R/P ratio increased from 10.1 years in 2000 to 15.2 years in 2013 (Cedigaz, 2016). Gas production also increased by 27% from the 2000 level, which subsequently improved the level of gas self-sufficiency from 82% in 2000 to 93% in 2013. However, the largest risk reduction was realised in the regasification terminal (RGT) utilisation rate sub-indicator. Prior to the "gas revolution," the utilisation rate was only 63% in 2000 and it dropped to only 1.0% by 2013. Although from the economic

point of view, these RGTs could be considered as stranded assets as the economy will no longer import LNG. However, these could also be seen as extra capacity, which could be utilised in case of gas supply disruptions occur in the future. Some APEC economies have very high RGT utilisation rate, up to the point that there is no buffer capacity left for emergency purposes. The availability of underground gas storage was a factor in reduced risk under the technical/technology indicator. In 2014, the year of the Polar Vortex, the economy sharply drew down its gas stored due to higher than normal demand (API, 2016).

The economic indicator risk decreased from 27% in 2000 to 26% in 2013, although far more risk reduction was seen during the 2005-2007 period at 22%. The decline in risk was brought by lower gas share in primary energy and gas intensity that occurred between 2005-2007. In 2000, gas share in primary energy was 24%, before going down to 22% in 2005 and went up to 28% by 2013, while gas intensity followed almost the same trend with 43.1 toe/USD million in 2000 to 33.9 toe/USD million in 2006 before going up to 38.3 toe/USD million in 2013. However, the gas import source diversity level worsened, from 0.69 HHI in 2007 (the year where the U.S. had the most diverse import sources) to 0.93 HHI in 2013. The higher diversity index was caused by high import dependency on Canada with 97% share to total import share (Cedigaz, 2016). Looking at a larger picture, being dependent on a single import source is not something that can be considered to be high risk in some cases. In the economy's situation, although 97% of gas imports came from Canada, it helped reduced other risks associated with imports, such as the "rule of law" and local stability of import sources. Other than security risks, proximity, infrastructure and price are the other factors that influence the decision on where to source imports.

On the social indicator (gas consumption per capita as a sub-indicator), the economy received a relatively stable of 60%, on average. The economy's gas consumption per capita was quite steady during the historical period, but could eventually go up because of abundant shale gas reserves. The economy's gas consumption per capita decreased from 1.94 toe/person in 2000 to 1.68 toe/person in 2006 before going back to 1.93 toe/person in 2013 (IEA, 2015 and EGEDA, 2015). Similar methodology used in oil consumption per capita (and intensity) was applied to determine the index for gas consumption per capita. The economy's gas consumption per capita was about three times higher than the APEC average of 0.58 toe/person in 2013.

The political indicator showed an increase index from 22% in 2000 to 24% in 2013. In addition to increased risk in local stability (as discussed in the oil chapter), the lack of some sort of international agreement on gas emergency supply (such as for oil under IEA-IEP) caused the index for political indicator in gas higher than oil. Theoretically, any sort of such agreement could help reduce the political indicator risk by 10 percentage points (based on 2013 level).

The law indicator for gas considered three sub-indicators – the resource extraction regulations (as discussed in the oil security), gas emergency preparedness and "rule of law" as an external factor (import sources). Under gas emergency preparedness (sub-indicator), the economy received the lowest index (0%) as

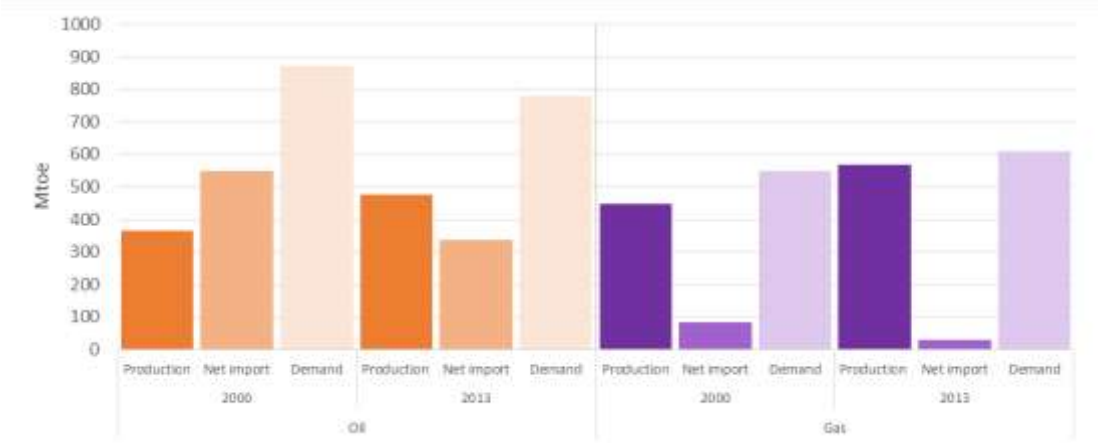
the four components considered in this sub-indicator – availability of RGT, trans-border pipelines, and underground, gas emergency preparedness (policy) – all exist in the economy. In addition, as most of the gas imports came from Canada (as discussed earlier), external risk (rule of law) was low. Combining all these factors resulted in a very low risk in the law indicator, 14% in 2000 and 16% in 2013. The increase in index was attributed to a slight increase in the index of the resource extraction regulations sub-indicator.

The environmental indicator utilised the same sub-indicators and data as in the oil security. The economy's index on internal environmental risks remained the same as in oil security. As for the environmental risk from import sources, specifically on climate change, was relatively unchanged at around 25%. Most of the climate change risk for gas imports was closely linked to Canada's climate change readiness and vulnerability.

Import Share and Sources

In 2013, the United States produced 476 Mtoe of oil, while domestic demand stood at 780 Mtoe. As such, net oil importer reached 336 Mtoe in the same year, a reduction from 550 Mtoe recorded in 2000(IEA, 2015). Most of the net oil import reduction occurred because of the increase in shale oil production coupled with the decrease in demand. As for gas, although the gas reserves in 2013 doubled from the 2000 level (EIA, 2016), the production only increased by 27%, while at the same time the gas demand only grew by 2.5% (from 548 Mtoe in 2000 to 610 Mtoe in 2013). The expanding gas production led to reduce in net gas imports from a high of 82 Mtoe in 2000 to 32 Mtoe in 2013 (IEA, 2015) (Figure 23.4).

Figure 23.4: Production, Net Imports and Demand, 2000 and 13



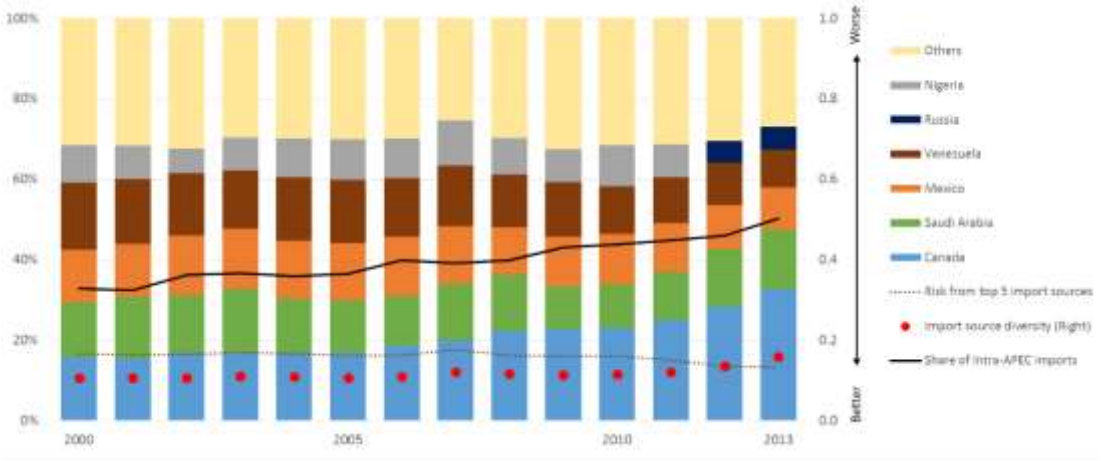
Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015

Crude Import Sources

The economy's diversity index for crude import sources was at 0.11 HHI (low concentration/high diversity) in 2010. The index increased to 0.16 HHI in 2013 because of an increase in oil imports from Canada, 16% in 2000 to 33% of total imports in 2013. The expanding share of imports from Canada reduced the shares of other oil exporters, particularly Venezuela (from a 17% share in 2000 to 9.0% share in 2013). Saudi Arabia was also among the major import sources for the economy providing about 15% of total imports in 2013. Other major exporters of crude were Mexico and Russia (which started exporting crude to the economy in 2012)

The risks covered by the major exporters (the top five import sources) improved from 17% in 2000 to 13% in 2013 (Figure 23.5). Better stability and a higher degree of "rule of law" of the exporters, as well as lower risk on climate change exposure were the identified factors that helped reduce the risk. However, some of these gains were offset slightly by a higher risk on chokepoints.

Figure 23.5: Crude Oil Import Sources, 2000-13



Source: APERC analysis and UN Comtrade 2016.

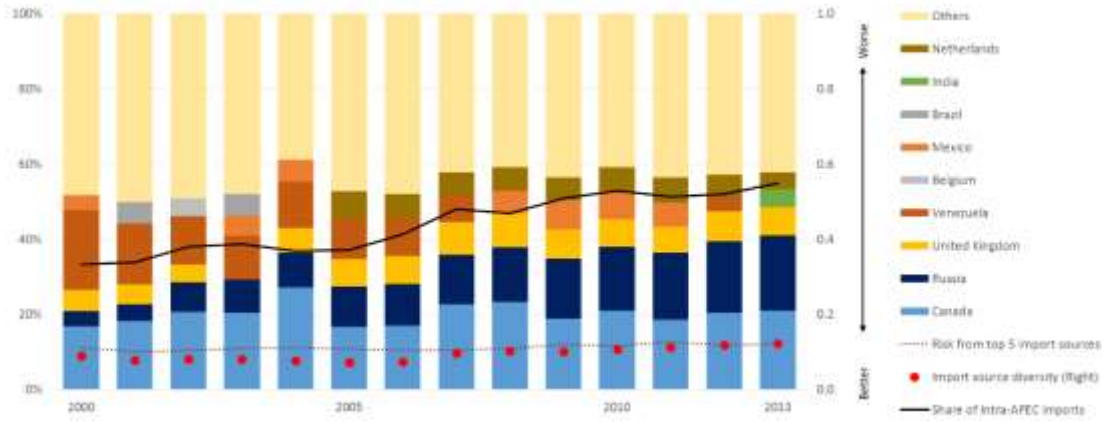
The intra-APEC imports had continuously expanded, from 33% in 2000 to 50% of total crude imports by 2013. Canada and Mexico consistently appeared as among the major crude oil exporters to the economy. In 2012, Russia appeared as one of the top exporters with 5.0% share of total imports.

Oil Product Import Sources

The economy imported about 66 Mtoe of oil products in 2013. Canada; Russia and the United Kingdom were among the major exporters (consistently appeared as among the top five exporters) of oil products to the economy. The combined share of these three economies steadily increased from 27% in 2000 to 49% in 2013. With the total share of the top five import sources expanded (52% in 2000 to 58% in 2013),

the economy's diversity level of the import sources fell, from 0.09 HHI in 2000 to 0.12 HHI (still could be considered to be very diverse) (Figure 23.6). The share of intra-APEC imports went up to 55% in 2013 from 33% in 2000, mainly from Canada; Mexico; and Russia.

Figure 23.6: Oil Product Import Sources, 2000-13



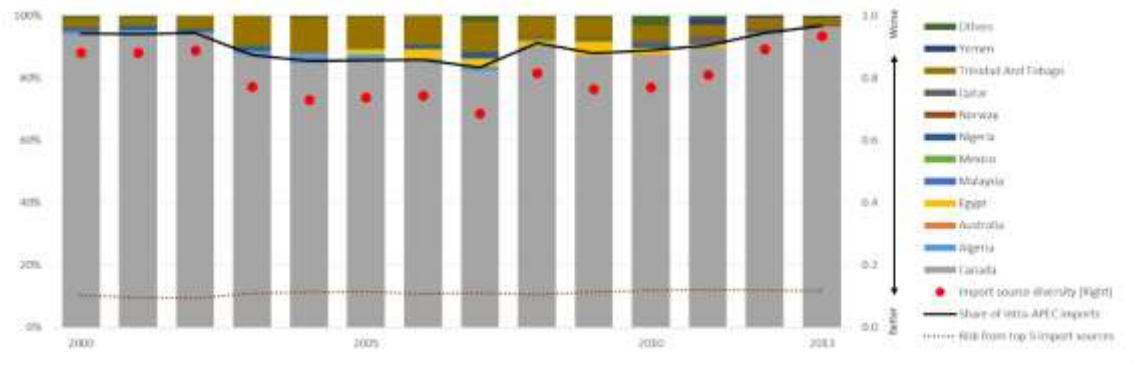
Source: APERC analysis and UN Comtrade 2016.

Oil product import source risk (based on the top five import sources) showed a very stable but low risk, at around 11%. A slight increase in risk was seen in exporter's stability, as well as the "rule of law" risk of the exporters. However, given that the economy's total oil product imports only covered 10% of total demand, the overall risk from import sources could be considered to be very low.

Gas Import Sources

As mentioned earlier, the economy imported most of its gas from Canada through pipelines. The economy likewise used to import huge volumes of LNG from Trinidad and Tobago, specifically for the period of 2004-2007, where the share of gas import from this economy reached 10%. However, as the economy started to develop shale gas, the LNG imports gradually decreased and eventually reduced the import share of Trinidad and Tobago to only 2.0%. On the other hand, Canada remained to be the major source of gas imports for the economy with a total import share of 97% in 2013. The external risk (with reference to the top five import sources) for the economy was low and stable, averaging at around 11%. The economy recorded high intra-APEC imports as most of the imported gas came from Canada (Figure 23.7).

Figure 23.7: Natural Gas Import Sources, 2000-2013



Source: APERC analysis and Cedigaz 2016.

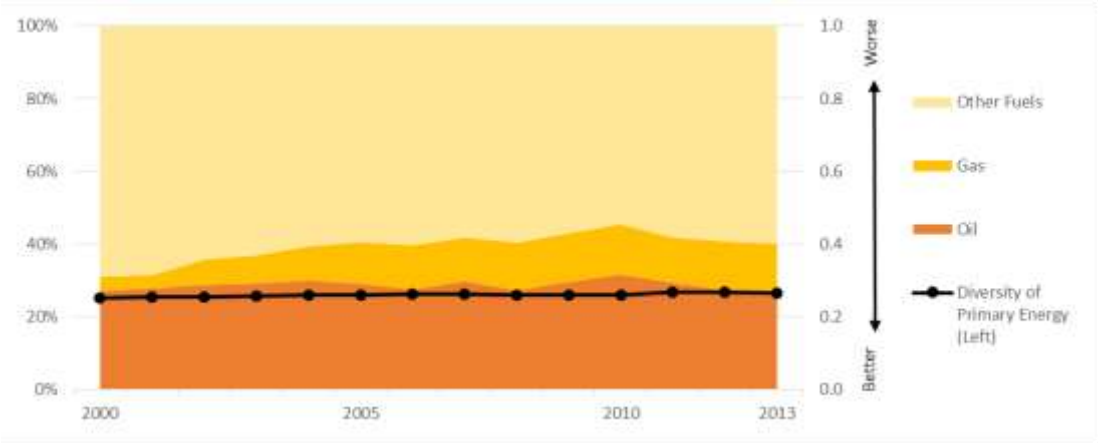
VIET NAM

Economy-Energy Overview

Viet Nam, in the centre of Southeast Asia, is bordered by China to the north, Laos and Cambodia to the west, and the East Sea and Pacific Ocean to the east and south. Viet Nam has a land area of 330,967 square kilometres (km2) with diverse geography and an exclusive economic zone stretching 200 nautical miles from its 3,260-km coastline (excluding islands). In 2013, the economy's gross domestic product (GDP) reached USD 450.4 billion (USD 2010 Price and Purchasing Power Parity [PPP]), registering a high growth rate of 6.4% annually in the last 13 years (2000-2013). In the same year, total population was 89.7 million, an increase of 15% from the 2000 level (WB, 2015; EDMC, 2015).

Viet Nam is endowed with diverse energy resources, such as oil, gas and coal, as well as renewables. Fossil energy potential is estimated to be moderate, although thorough resource assessments have yet to be carried out across the entire territory, especially in deep layers and deep-sea areas.

Figure 24.1: Primary Energy Supply, 2000-13



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure the diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.60. A higher HHI means a high concentration in one or few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-.080 is moderate-high concentration, and 0.81 and above is high concentration.

Viet Nam's total primary energy supply (TPES) in 2013 was 62 Mtoe, more than two-fold increase from the 2000 level (29 Mtoe) (IEA, 2015). Oil and gas accounted for 40% of the total supply, while other fuels made up the rest of the share at 60%. Over the historical period, the economy's primary energy diversity slightly increased from 0.25 HHI in 2000 to 0.27 HHI in 2013 due to expanding share of gas (Figure 24.1).

In terms of energy production, Viet Nam can be considered to be an energy self-sufficient economy with sufficient crude oil and gas production to meet domestic demand. However, Viet Nam had

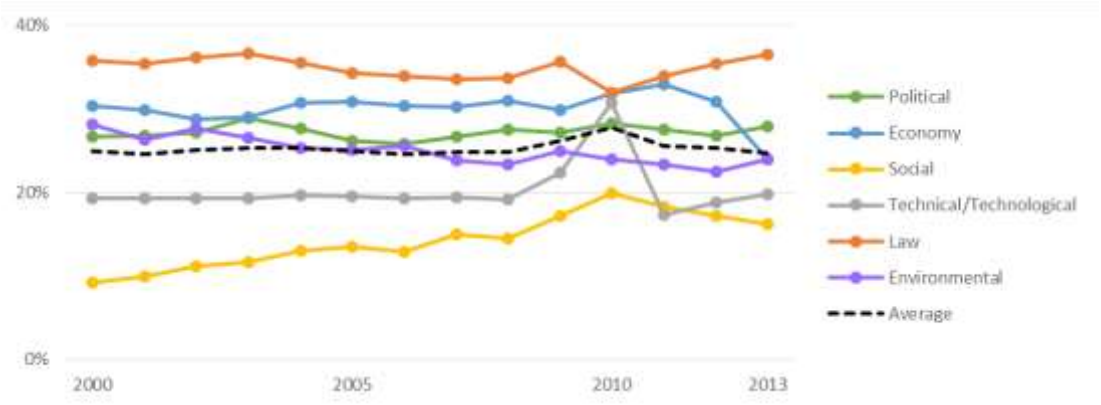
been importing oil products for most of the time until the completion of a refinery complex in 2009 with a capacity of 140 thousand barrels per day (kbbl/d) (Oil and Gas Journal, 2015).

Viet Nam's energy intensity slightly decreased to 137 toe/million 2010 USD in 2013, lower by 3.9% from the 2000 level of 142 toe/million 2010 USD. On the other hand, primary energy per capita increased from 0.37 toe/person in 2000 to 0.69 toe/person in 2013 (IEA, 2015 and WB, 2015).

Oil Security

From the six oil security indicators used in this study – political, economic, social, technical/technology, legal and environmental – Viet Nam's oil security index showed a stable trend at around 25% for most of the years (historical period), except in 2010 when the risk spiked to 28%. From scale of 1.0% to 100%, where 1.0% means the lowest risk, while 100% means the highest risk, the economy's security index falls within the category of moderate-low exposure to supply risk. It should be noted that since the economy does not import crude oil, external supply risks (import sources) only applies to oil product imports.

Figure 24.2: Oil Supply Security Index, 2000-13



Source: APERC analysis
Note: In the oil security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

Among the indicators, the law indicator received the highest risk at 37% in 2013, a slight increase from 36% in 2000. This indicator covered four sub-indicators (resource extraction regulations, oil emergency preparedness, strategic oil stockpiling, and the "rule of law" of the oil exporters as an external risk). The high index was attributed to high result on the resource extraction regulation (derived from the Global Petroleum Survey (GPS) data), which showed an increased risk trend from 50% in 2000 to 56% in 2013. However, some of the risks were trimmed down by improvement in the "rule of law" sub-indicator (which focused only oil product importers), from 31% in 2000 to 28% in 2013.

The political indicator, which covered six sub-indicators, also displayed a minor increase (from 27% in 2000 to 28% in 2013) (considered to be moderate-low risk). The local stability sub-indicator, (from the World Governance Index – Political Stability and Absence of Violence/Terrorism indicator), exhibited an increase from 44% in 2000 to 46% in 2013, while the stability of oil product exporters was stable at around 34% over the historical period. Since the economy imported most of its oil products from APEC economies in Asia, it eliminated the chokepoint risk, which helped to keep political indicator index low.

As for the social indicator (with only oil consumption per capita as a sub-indicator), the risk likewise went up to 16% in 2013 from 9.0% in 2000. The economy's oil consumption per capita had increased, albeit at a slow pace, from 0.10 toe/person in 2000 to 0.17 toe/person in 2013. However, the economy's oil consumption per capita level was far much lower than the APEC average of 0.80 toe/person in 2013. In determining the index for oil consumption per capita, the study compared the oil consumption per capita levels among APEC economies (highest and lowest level), as well as the historical changes (highest recorded) in the economy's per capita level.

The economic indicator (composed of 10 sub-indicators) exhibited the highest improvement with a 6.0 percentage point decrease, from 30% in 2000 to 24% in 2013. The contributing factors for the improvement were: better result in the "Ease of Doing Business" sub-indicator (for which the risk reduced from 50% in 2000 to 40% in 2013); decreased oil share in primary energy (from 27% in 2000 to 25% in 2013); reduction in oil intensity (from 38.7 toe/million 2010 USD in 2000 to 34.6 toe/million 2010 USD in 2013); removal of oil subsidies in 2012 (IEA, 2016); and improvement in import source diversity for oil products (from 0.42 HHI in 2000 to 0.22 HHI in 2013). The completion and operation of the economy's refinery facility in 2009 led to the decrease in oil product import dependency, from 100% in 2000 to 63% in 2013 (OGJ, 2016). On oil intensity, it must be noted that the same methodology used in oil consumption per capita was applied in computing the index.

The technical/technology indicator (a combination of six sub-indicators that are related to reserves and technical capabilities) demonstrated a stable index during the early part of the historical period (from 2000 to 2008), an average of 19%. However, it showed a huge jump to 31% in 2010 and suddenly dropped to 17% in 2011 (which affected the overall average index as mentioned earlier). This volatility was a result of two sub-indicators – the refinery utilisation rate and the inclusion of new oil reserves in the data. The first refinery started operations in 2009 with an utilisation rate of 21% and climbed to 78% in 2010. The abrupt increase in utilisation rate caused the rapid increased in the technical/technology indicator index. Meanwhile, oil reserves, which were estimated to be around 600 million barrels (mmbbl) in 2010, expanded to 4.4 Bbbls (EIA, 2016). The surged in oil reserves significantly improved the economy's reserves-production (R/P) ratio from 5.1 years in 2010 to 37 years in 2011, which subsequently decreased the oil R/P ratio sub-indicator index (87% in 2000 to 9.0% in 2013).

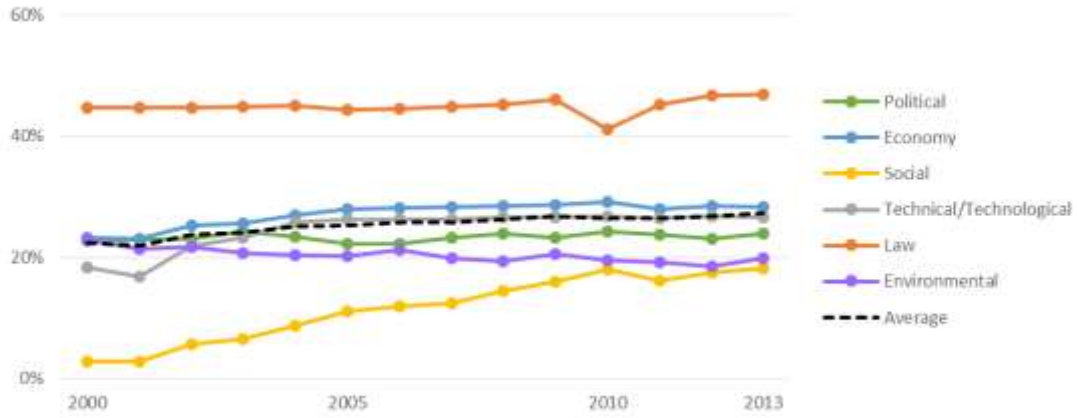
The environmental indictor considered two sub-indicators (readiness and vulnerability to climate change impact, and natural disaster risk). The index for this indicator declined to 24% in 2013 from 28% in 2000 because of the improvement in readiness and reduced vulnerability towards climate change as reported by the Notre Dame Global Adaptation Index (ND-GAIN). The ND-GAIN revealed that the economy's vulnerability to climate change was 0.49 in 2000 and decreased to 0.45 in 2013, while the readiness index in 2000 was 0.35 and went up to 0.43 in 2013 (ND GAIN, 2016).

The economy's oil supply is expected to grow by more than four-fold in 2040 as compared with 2013 due to rapid economic growth (APERC, 2016). Therefore, it will pose a challenge for the economy to manage the oil supply risk in the future. One way to maintain and improve the situation is by increasing its refinery capacity or expanding the number of oil exploration and production projects to sustain a higher level of oil self-sufficiency.

Gas Security

Viet Nam's average gas security risk was initially lower than oil in 2000 (at 22% for gas compared with 25% for oil), but surpassed the oil security index in 2013 (at 27% for gas compared with 25% for oil). Almost all the gas security indicators (except environmental indicator, contributed to the increase. Since the economy does not import gas, all the security risks are confined to internal risk (Figure 24.3).

Figure 24.3: Gas Supply Security Index, 2000-13



Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any oil supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

Similar to oil, the law indicator obtained the highest risk in gas security, 48% in 2013 from 46% in 2000. For the law indicator in gas, the three sub-indicators were included – resource extraction regulations (which was discussed in the oil security), gas emergency preparedness and "rule of law" that is applied only to import sources. On gas emergency preparedness sub-indicator, a combination of four components that are

related to law (or policy) was considered – availability of RGT, trans-border pipelines and underground gas storage, gas emergency preparedness (policy). The economy received high result for the gas emergency preparedness because of lack of underground gas storage, regasification terminal (RGT), and trans-border pipelines. However, the law indicator is expected to improve in the future once the RGT construction is completed. The inception of RGT could lower the risk to 39% (based on the 2013 level).

The political indicator showed an increase from 23% in 2000 to 24% in 2013. The economy' local stability was among the reasons for the increase in political indicator index (as already discussed in the oil security). As the economy does not import gas, the political risk in the gas security is somehow lower than oil. Since the economy plans to import LNG in 2023, this could add another risk to the political indicator, which is chokepoint risk (depending on the import source).

The economic indicator also increased from 25% in 2000 to 29% in 2013 caused by the expanding share of gas to the primary energy, from 4.0% in 2000 to 14% in 2013. This subsequently increased the gas intensity from 5.6 toe/USD million in 2000 to 18.7 toe/USD million in 2013. These two sub-indicators contributed to the economic indicator risk to go up by 5.0 percentage points.

The social indicator (gas consumption per capita as the only sub-indicator) index sharply increased to 19% in 2013 from only 3.0% in 2000. The economy's gas consumption per capita went up from 0.01 toe/person in 2000 to 0.09 toe/person in 2013. However, this level was still significantly below the APEC average of 0.58 toe/person in 2013

The increase in the technical/technology indicator (from 18% in 2000 to 27% in 2013) was a result of the decline in the economy's gas R/P ratio. The economy's gas reserves expanded from 153 Mtoe (138 Bcm) in 2000 and peak in 2002 with 207 Mtoe (186 Bcm) before going down to 195 Mtoe (176 Bcm) in 2013 (Cedigaz, 2016). However, with the increase in gas production (1.1 Mtoe [1.0 Bcm] in 2000 to 8.4 Mtoe [7.6 Bcm] in 2013), the gas R/P ratio decreased from more than 100 years in 2000 to 23 years in 2013.

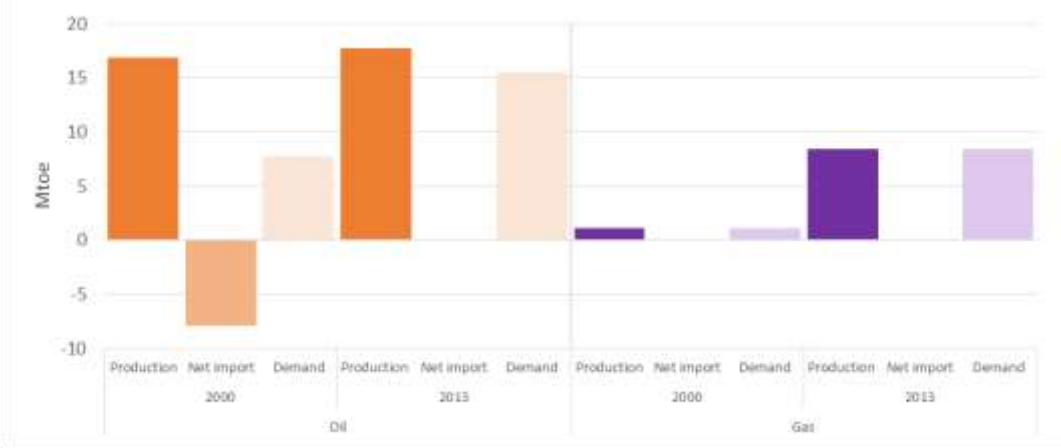
As for the environmental indicator, the same sub-indicators and data were utilised as in the oil security. With no gas imports, the index, which only covered internal risk, for the environmental indicator improved from 23% in 2000 to 20% in 2013.

Import Share and Sources

As Viet Nam does not import crude oil and gas, this analysis will focus on oil product imports, which might help better understand the risks associated with the import sources, focusing on the top five exporters. The economy produced 18 Mtoe of crude oil in 2013, almost at the same level as in 2000, but with significantly less net oil exports (because of reduced oil product imports starting 2010) (IEA, 2015). By 2013, oil demand doubled from the 2000 level. As for gas, although the production increased by more than seven

times, all the production went to local users (Figure 24.4).

Figure 24.4: Production, Net Imports and Demand, 2000-13

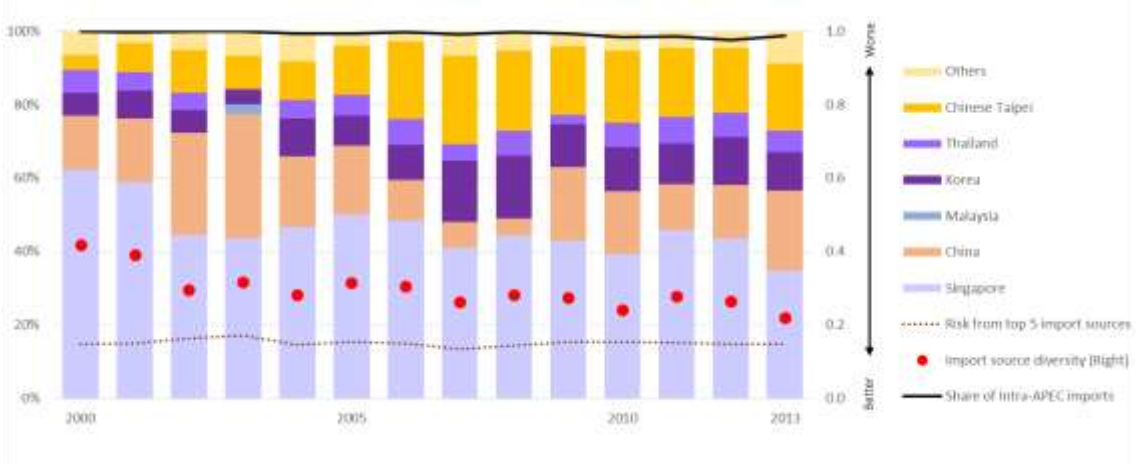


Note: Excludes international bunkers.
Source: APERC analysis and IEA World Energy Statistics 2015.

Oil Product Import Sources

The economy imported 10 Mtoe of oil products in 2013, down from the highest import level of 14.8 Mtoe in 2007 (IEA, 2015). Nearly all oil products were imported from APEC economies such as China; Korea; Malaysia; Singapore; Chinese Taipei; and Thailand. The diversity of import sources improved from 0.42 HHI in 2000 to 0.22 HHI as the import share from Singapore decreased from 62% in 2000 to 35% in 2013 (Figure 24.5).

Figure 24.5: Oil Product Import Sources, 2000-13



Source: APERC analysis and UN Comtrade, 2016.

Oil product import source risk (based on the top five import sources) could be considered low, averaging around 15% every year. The main reason for the low risk was because of no or minimal chokepoint risk (intra-APEC imports could skip risky chokepoints), as well as a higher degree of exporter's "rule of law."

ANNEX I

METHODOLOGY

In formulating the security index, the study tried to gather as much data and information as possible related to energy security and use them to come up with the sub-indicators for each element of the PESTLE analysis (with six elements or indicators) and their corresponding indices. Some of these data were sourced from wide-established and publicly available global indices. The data obtained from these external sources were modified in order to turn them into index (for the sub-indicators) using the scale of 1.0% to 100%, where 1.0% represents lowest risk (0% no risk), while 100% represents highest risk. Based on PESTLE analysis, the study identified a combination of 59 sub-indicators for both oil and gas (some of the sub-indicators were applied on both oil and gas). To further evaluate the risk, the study divided the indicators into two groups – internal factor and external factor (please see Figure 1.3 in Chapter 1). It should be noted that the selection of sub-indicators was subject to availability of data, and thus should be considered as a non-exhaustive list (of risk sub-indicators).

Each sub-indicator is either derived from another index (external source) that has been established or based on calculations made internally. For the oil supply security index, 23 internal sub-indicators and eight external sub-indicators were utilised to determine the overall oil supply security risk of an individual APEC economy. Each of the sub-indicators was assigned an equal weight. However, as the internal factor included more sub-indicators, it thus covered 76% (weight) of the overall oil supply security risk, while the external factors captured the remaining 24% (weight) of the risk. As for gas, 28 sub-indicators (20 internal sub-indicators and eight external sub-indicators) were considered to determine the overall gas supply security risk, of which the internal factor carried 73% of the risk, while the external factor covered the rest.

As mentioned above, oil security included eight external sub-indicator assigned in five PESTLE elements/indicators (economic, political, law, technical/technology and environmental). Meanwhile, gas security also considered eight external sub-indicators distributed in four PESTLE elements/indicators (political, law, technical/technology and environmental). All these external sub-indicators were applied to each exporter (oil and gas) based on share to total imports to calculate the risks from import sources (please see Figure 1.3 in Chapter 1).

POLITICAL INDICATOR

Under IEA policy, all members are committed to undertake joint measures in the event of supply emergencies, and agree to share information, coordinate their energy policies, as well as cooperate in the development of rational energy programmes. Each IEA member is likewise required to contribute in collective action based on its assessed share to total IEA oil consumption. Holding of oil stocks equivalent to

90 days of prior year's net imports is also set as an obligation for IEA members (IEA, 2014).

International agreement on oil and gas emergency supply (internal risk)

Table 13 • Sub-indicators used in external group

	Agreement	Oil	Gas	Notes
Australia	IEA-IEP	✓		No agreement for gas but due to huge gas surplus, considered as having 50% risk for gas
Brunei Darussalam	APSA	✓	✓	
Canada	IEA-IEP	✓		No agreement for gas but due to huge gas surplus, considered as having 50% risk for gas
Chile	None			
China	None			
Hong Kong, China	None			
Indonesia	APSA	✓	✓	
Japan	IEA-IEP	✓		
Korea	IEA-IEP	✓		
Malaysia	APSA	✓	✓	
Mexico	None			No agreement for oil but due to huge oil surplus, considered as having 50% risk for oil
New Zealand	IEA-IEP	✓		
Papua New Guinea	None			
Peru	None			
Philippines	APSA	✓	✓	
Russia	None			No agreement for oil and gas but due to huge production surplus, considered as having 50% risk
Singapore	APSA	✓	✓	
Chinese Taipei	None			
Thailand	APSA	✓	✓	
USA	IEA-IEP	✓		No agreement for gas but due to huge gas surplus, considered as having 50% risk for gas
Viet Nam	APSA	✓	✓	

Note: As of 2013 agreements.
Source: ACE, 2015 and IEA, 2014

The APSA–Coordinated Emergency Response Measure (CERM) stipulates that all member states are endeavoured to supply petroleum to the ASEAN Member State in Distress at an aggregate amount equal to 10.0 percent of the Normal Domestic Requirement of the said member state for a continuous period of at

least 30 days. However, the member state in distress must first implement short-term measures to reduce oil demand before requesting assistance under CERM (ACE, 2015).

For sub-indicators indexation, the study has undertaken a simplified approach, of which if the economy has signed any international or multilateral agreement, an index of 0% (lowest risk) is assigned and for an economy that has not entered into any international agreement, the index is 100% (highest risk). However, taking into consideration the implementation of the agreement, specifically for APSA, the study assigned 50% risk for those economies covered by this agreement related to oil and gas as it has not yet been tested in actual supply disruption (Table 14).

Local stability and exporter's stability (internal and external risks)

The study adopted the World Governance Index (WGI) published by World Bank in order to establish the local stability (exporter's stability) sub-indicator. Under WGI, there are six sub-indices: (1) Voice and Accountability, (2) Political Stability and Absence of Violence/Terrorism, (3) Government Effectiveness, (4) Regulatory Quality, (5) Rule of Law and (6) Control of Corruption. The study used the Political Stability and Absence of Violence/Terrorism sub-indices to gauge the risk of political threat (political stability on supply) (WB, 2016a).

The WGI uses the scale of -2.5 (weak) to 2.5 (strong) governance performance. For the WGI sub-index, the risk score is set (transformed) as 0 to 1, where 1 is the riskiest (equivalent to -2.5 in WGI) and 0 is the least risky (equivalent to 2.5 in WGI). However, WGI index indicates a number lower than -2.5 for extremely unstable economies. This WGI sub-index is used to gauge the political stability of APEC members, as well as import source stability as sub-indicators for the study ***(Equation 1).*** On political stability sub-indicator, 100% means the highest risk on supply disruption caused by political stability, while 0% means there is no risk.

Equation 1: Local stability sub-indicator

$$S = \left(\frac{(100\ a_i - 250)}{500}\right) \times -1$$

Where:

a_i = WGI data of economy i.

As for oil and gas exporters, the results of the local stability of the exporters will be applied on export share to APEC members as in ***Equation 2.***

Equation 2: Exporter's stability sub-indicator

$$S_{is} = S_l \times F_{ae}$$

Where:

G_{is} = Exporter stability extracted from WGI and converted to index by using Equation 25.1.

F_{ae} = Shares of total import to receiving economy$e$ from economy a

Piracy threat (internal and external risks)

This sub-indicator was derived from data provided by International Chamber of Commerce - International Maritime Bureau (ICC-IMB). The IMB is a non-profit making organisation, established in 1981 to act as a focal point in the fight against all types of maritime crime and malpractice. One of the ICC-IMB's principal areas of expertise is in the suppression of piracy that led to the creation of the IMB Piracy Reporting Centre in 1992 (ICC-IMB, 2016). The ICC-IMB produced quarterly and annual report on pirate attacks that happened around the world.

From the data gathered (ICC-IMC), the study established the piracy threat sub-indicator (internal and external factors), specifically towards energy related tankers and shipments. The ICC-IMB reports provided the data on the number of pirate attacks occurred within economy's water borders and international sea routes. The ICC-IMB reports also provided data on type of tankers that were attacked. Among tankers listed in the report are asphalt/bitumen tanker, crude oil tanker, LNG tanker, LPG tanker and chemical/product tanker. However, the report does not provide further data whether the tankers are with energy cargo or empty.

For this sub-indicator purposes, the study established an index by taking the share of attacks on energy related tankers and applied the share on the total number of attacks that happened in each economy ***(Equation 3).*** From this approach, the average risk of pirate attacks was established on energy related shipments in each economy. Similarly, an index of 100% means highest risk on supply disruption from piracy incidents, while 0% means no risk from piracy.

Equation 3: Piracy threat sub-indicator

$$P_l = \left(\left(\frac{T_e}{T_i}\right) \times T_l\right) \times 100$$

Where:

T_e = Total piracy incidents on energy ships.

T_i = Total piracy incidents on all ships.

T_l = Total piracy incidents on all ships in l economy.

As for external factors (import sources), the study utilised the same formula for the exporters (piracy incidents) and multiply the results to their respective shares to total imports ***(Equation 4).***

Equation 4: Exporter's piracy threat sub-indicator

$$P_e = P_l \times F_{ae}$$

Where:

P_l = Local piracy incidents index.

F_{ae} = Shares of total import to receiving economy e from economy a

The study is aware that piracy may not be considered as a big threat to energy supply disruptions, especially oil supply due to the nature of efficient and well established oil trade. However, it may have a big impact for smaller economies and for economies that don't have large oil stockpiling facilities.

Chokepoints risk (external risk)

World chokepoints for maritime transit of oil are critical part of global energy security, and assessing these chokepoints risk is vital to know the security of oil and LNG supply. As such, the study established the chokepoint sub-indicator by combining two indices (external sources), the WGI Report and ICC-IMB. Only six major chokepoint risks were calculated in this study – the Suez Canal, Panama Canal, Bab-El-Mandab, Straits of Hormuz, Straits of Malacca and Cape of Good Hope.

Table 14 • Surrounding economy and piracy attacks around chokepoints

Chokepoint	Surrounding Economy	Piracy on nearby seas
Suez Canal	Egypt	Arabian Gulf
Panama Canal	Panama	Caribbean
Bab-El-Mandab	Yemen Djibouti Eretria Somalia	Arabian Gulf Arabian Sea Gulf of Oman
Straits of Hormuz	Iran UAE Oman	Arabian Sea Red Sea / Gulf of Aden
Straits of Malacca	Singapore Indonesia Malaysia Thailand	Malacca Straits
Cape of good hope	South Africa	

Source: APERC Analysis.

The calculation of risk was made based on the adjacent economies that surround the chokepoints and the piracy attacks that happened near the chokepoints. For example, Bab-El Mandab is surrounded by Yemen, Djibouti, Eretria and Somalia (Table 15).

Data from WGI is used to assess the stability risk for the surrounding economies. The risk pose by the surrounding economy will determine 90% of the chokepoints risk ***(Equation 5)***. The other 10% of the risk came from the number of pirate attacks that occurred in the surrounding international water. As for Bab El-Mandeb case, surrounding international waters are Arabian Gulf, Arabian Sea and Gulf of Oman (the selection of the international water is based on ICC-IMB report).

Equation 5: Chokepoints risk sub-indicator

$$CR = \left(\left(\frac{\sum_{c=1}^{N} \left(\frac{(100\, a_c - 250)}{500} \right) \times -1}{N} \right) \times 0.9 + \left(\left(\frac{T_e}{T_i} \right) \times T_s \right) \times 0.1 \right) \times F_{ae}$$

Where:

N = Number of surrounding economy in chokepoints.

a_c = WGI data of surrounding economy c.

T_e = Total piracy incidents on energy ships.

T_i = Total piracy incidents on all ships.

T_s = Total piracy incidents on all ships in s nearby seas.

F_{ae} = Shares of total import to receiving economy e from economy a

Once the risk has been quantified, the study assigned every economy in the world with certain risk by determining the shortest sea route from the import source to each APEC economy. However, the study is likewise aware that in reality, the sea route for each oil and LNG tanker can be far more complicated than what is assumed in this study.

This sub-indicator can be generally used as chokepoints assessment. The combination of piracy and stability threat from surrounding economies around the chokepoints can also be used not only for energy cargoes, but for other goods as well. For this sub-indicator, 100% poses the highest chokepoints risk while 0% means no risk.

ECONOMIC INDICATOR

Total primary energy supply diversity (internal risk)

The total primary energy supply diversity sub-indicator was calculated based on the Herfindahl–Hirschman Index, or HHI. It is an economic concept widely applied in competition law where market shares are compared. For energy security index purposes, this analytical method was chosen in order to measure the concentration of primary energy supply for each economy. This index is calculated per ***Equation 6.***

Equation 6: Herfindahl–Hirschman Index

$$H = \sum_{i=1}^{N} s_i^2$$

Where:

s_i = market share of fuel type i in the total primary energy supply

N = the number of fuel types

For the purpose of this study, the value (index) of H ranges from 0.01 to 1.00 as an index, where the lower the value the more diversified the primary energy supply. This sub-indicator could serve as a gauge to assess the current and future diversity of primary energy supply.

Ease of Doing Business (internal risk)

The "Ease of Doing Business" sub-indicator is adopted directly from the Doing Business Report (DBR) published by World Bank Group (WB, 2016b). This report provided insights of doing business in most APEC economies. The "Ease of Doing Business" sub-indicator was included as part of energy security index so as a more holistic view on energy security issues could be covered. There are 10 sub-indices under DBR which are (1) starting a business, (2) dealing with construction permits, (3) getting electricity, (4) registering property, (5) getting credit, (6) protecting minority investors, (7) paying taxes, (8) trading across borders, (9) enforcing contracts and (10) resolving insolvency.

Some of the sub-indices, such as trading across borders and enforcing contracts, are directly related to energy security, while others may be or are not. However, this sub-indicator can also serve as a rough guidance on investment in energy supply sector. The DBR has data for each of the sub-indices with an overall index called as Distance to Frontier (DTF). The DTF is an average score based on the sub-indices. The study converted and inversed the DTF score in order to determine the risk ***(Equation 7).***

Equation 7: Ease of doing business sub-indicator

$$DB_n = 1 - B_e$$

Where:

B_e = DTF score for economy e.

n = Number of years

The overall DTF was available after 2010 onwards. The study utilised the average of sub-indices results to determine the scores prior to 2010. In addition, since Doing Business Report only started in 2004, the study used moving average of two years to determine 2000-2003 risk. It should be noted that the study used Shanghai data for China, Jakarta data for Indonesia, Tokyo data for Japan, Mexico City data for Mexico and Moscow data for Russia. For this study, the risk was determined by the range of 0% - 100% based on DTF, where 100% represents the highest risk and 0% no risk.

Oil and gas share to total primary energy supply (internal risk)

The oil and gas share to total primary energy supply was calculated separately based on the total oil supply and gas supply as primary energy over total primary supply. For this sub-indicator, all data were taken from IEA World Energy Statistic 2016 (IEA, 2016).

The higher share of oil and gas to total primary energy is assumed as possessing higher energy security risk as the nature of these fuels is finite. The shares of fuels were also considered under the diversity index sub-indicator of energy sources. However, the study recognized that further analysis should be done by

adding coal in this sub-indicator. This could help policymakers to understand better the risk of having fossil fuels as part of domestic energy supply.

Oil and gas intensity (internal risk)

The oil and gas intensity was calculated based on oil and gas as primary energy for each economy over gross domestic product (GDP). To establish the index for this sub-indicator, the study used the average of the highest and lowest intensity recorded by the economy from 2000-2013 as maximum and minimum benchmarks, and compared with the highest and lowest intensity recorded among APEC economies on that particular year. The maximum benchmark is set at 100%. The intensity level evaluated for a particular year is then divided by the maximum benchmark and thus provide an indication of the economy's efficiencies in using energy (or depends on resource endowments) ***(Equation 8).*** By comparing the maximum benchmark, the study established the sub-indicator with 100% as having the highest risk, while 0% is considered no risk.

Equation 8: Oil and gas intensity sub-indicator

$$I = \left(\frac{\frac{F_{et}}{G_{et}}}{Max\ \frac{F_{at}}{G_{at}} - Min\ \frac{F_{at}}{G_{at}}} \right) \times 0.5 + \left(\frac{\frac{F_{et}}{G_{et}}}{Max\ \frac{F_{eT}}{G_{eT}}} \right) \times 0.5$$

Where:

F_{et} = Oil/Gas in primary energy of economy e in year t.

G_{et} = GDP of economy e in year t.

F_{at} = Oil/Gas in primary energy of each APEC economy in year t.

G_{at} = GDP of each APEC economy in year t.

F_{eT} = Oil/Gas in primary energy of economy e in T period

G_{eT} = GDP of economy e in T period

Domestic oil product and gas pricing (internal risk)

The study used the IEA energy subsidy database as guidance to establish this sub-indicator (IEA, 2016). The IEA energy subsidy database provided detailed data on the types of fuels that have been subsidised by governments around the world. One of the best ways to calculate the risk of having subsidy in energy supply security is by comparing projected demand when there is no subsidy available, and the actual demand where energy subsidies exist. However, there is no data and study for each APEC economy that has been made on projected demand when there is no subsidy.

To simplify the index calculation, the study divided this sub-indicator into three stages: (1) no subsidy that carries 0% risk; (2) subsidy only in transformation sector with 50% risk; and, (3) subsidy in both transformation and retail sector poses 100% risk. This study did not take into account the other opportunity costs that could be derived from the subsidy, such as the allocation of the subsidy could be used to

strengthen energy supply networks.

Oil export over GDP (internal and external risk)

Though some major oil exporters may have high political risk, which is one of the major concerns for importers, the oil exporters need the oil trade (both crude and product) to be done in order to ensure stable income for their governments. Therefore, this sub-indicator was included in the supply security index to balance the political risk. However, this sub-indicator may not be able to serve the objective (balancing act) due to volatility of the oil prices. Other publications, such as from the World Bank, call this sub-indicator as Oil-Rent, but only covers crude oil.

Data for this sub-indicator was derived from World Economic Outlook (WEO) 2013 (IMF, 2013) database which published the value of oil exports data ***(Equation 9).*** However, IMF has stopped providing the data post WEO 2013 publication.

Equation 9: Oil export over GDP for internal sub-indicator

$$E = \frac{F_{et}}{G_{et}}$$

Where:

F_{et} = Oil export data from World Economic Outlook of economy e in year t.

G_{et} = GDP of economy e in year t.

As for external sub-indicator, the study combined the risk of crude oil exporters and oil product exporters in order to establish the index by using ***Equation 10.***

Equation 10: Oil export over GDP for internal sub-indicator

$$E = \frac{FX_{et}}{G_{et}} \times F_{ae}$$

Where:

FX_{et} = Oil export data from World Economic Outlook of exporter economy e in year t.

GX_{et} = GDP of exporter economy e in year t.

F_{ae} = Shares of total import to receiving economy e from economy a

Oil and gas net import (internal risk)

The shares of crude oil, oil product and gas imports were obtained from IEA World Energy Statistics 2015. Higher shares represent higher risk for importing economies ***(Equation 11).***

Equation 11: Oil and gas net import sub-indicator

$$N_{im} = \frac{IM_t - EX_t}{D_t}$$

Where:

IM_t = Oil/gas import of economy$e$ in year t.

EX_{et} = Oil/gas export of economy$e$ in year t.

D_t = Oil/gas demand of economy$e$ in year t.

Oil and gas import source diversity (internal risk)

The study utilised data from United Nation (UN) Comtrade to determine the sources and the shares of crude oil and oil product imports. For gas, the study used the data from Cedigaz to determine the natural gas (including LNG) import sources. For this sub-indicator, the applied the same calculation method in determining the diversity by using HHI.

Table 15 • Classification of HS Code for crude and oil product

HS Code	Description
2709	Crude oil from petroleum and bituminous minerals
2710	Oil (not crude) from petrol & bitumen mineral etc. There are 20 sub HS group under this code.

Source: UN Comtrade, 2016

Under the UN Comtrade data, the crude and oil products have separate classifications based on Harmonized System Codes (HS Code) (Table 16).

This sub-indicator will determine the level of import source diversity for each economy, which subsequently helped this study to understand how well the risk of supply disruption from the source is spread. For this sub-indicator, the higher the HHI (in percentage) means higher risk for importers due to over reliance to a single import source while lower HHI means lower risk due to diversification of import sources ***(Equation 12).***

Equation 12: Oil and gas import source diversity (HHI)

$$H = \sum_{i=1}^{N_t} E_i^2$$

Where:

E_{it} = export share of economy I in total export in year t

N_t = the number of exporters in year t

SOCIAL INDICATOR

Oil and gas consumption per capita (internal risk)

This is the only sub-indicator that the study proposed to be part of the social indicator. The calculation was based on total oil and gas primary energy demand over the total population. In the determining the risk, the same formula used for oil and gas intensity was applied – benchmarked against highest and lowest oil/gas consumption per capita recorded over time for the economy, and the highest and lowest oil/gas consumption per capita among APEC economies ***(Equation 13).***

Equation 13: Oil and gas consumption per capita sub-indicator

$$C = \left(\frac{\frac{F_{et}}{P_{et}}}{Max\ \frac{F_{at}}{P_{at}} - Min\ \frac{F_{at}}{P_{at}}} \right) \times 0.5 + \left(\frac{\frac{F_{et}}{P_{et}}}{Max\ \frac{F_{eT}}{P_{eT}}} \right) \times 0.5$$

Where:

F_{et} = Oil/Gas in primary energy of economy e in year t.

P_{et} = Population of economy e in year t.

F_{at} = Oil/Gas in primary energy of each APEC economy in year t.

P_{at} = Population of each APEC economy in year t.

F_{eT} = Oil/Gas in primary energy of economy e in T period

P_{eT} = Population of economy e in T period

The study recognized that oil and gas consumption per capita may not entirely represent the social indicator as it comprises energy demand from all economy's sectors. But oil and gas consumption per capita can serve as a sub-indicator to show the economic progress and demographic changes over time in each economy. For this sub-indicator, 100% poses the highest risk, while 0% no risk on supply interruption.

TECHNICAL AND TECHNOLOGICAL INDICATOR

Logistic efficiency (internal risk)

Logistic efficiency sub-indicator was derived from the Logistic Performance Index (LPI) published by World Bank, which is used as an interactive benchmarking tool to help economies identify the challenges and opportunities they face in their performance on trade logistics and what they can do to improve their performance (WB, 2016c). There are six sub-index under LPI: (1) customs, (2) infrastructure, (3) international shipments, (4) logistics quality and competence, (5) tracking and tracing and (6) timeliness. The LPI is a survey based index which has both qualitative and quantitative results. The study chose LPI as one of the sub-indicators for energy security because efficient logistics system could be one of the main criteria to overcome energy supply disruptions, particularly oil product supply disruption.

Transferring oil product in massive quantities during shortages can be a nightmare to many economies. Therefore, LPI was included in this index so that the governments and regulators should also look into the logistic preparation in case fuel supply disruption occurs.

The LPI provided scores to all APEC economies except Brunei Darussalam. Since LPI is based on a survey, it is hard for the study to estimate the risk score for Brunei Darussalam. Therefore, the study made use of the average scores of Singapore and Hong Kong, China to determine Brunei Darussalam's index due to the land size. Land area of Brunei Darussalam is only slightly bigger than Singapore and Hong Kong, China and the GDP per capita of these economies are in the same band. However, for this sub-indicator, the study did not consider other government interventions for smoother logistics performance, such as the use of military equipment like ships and trucks to deliver fuel.

In LPI, the most efficient logistical performance is given a score of 5, while the most inefficient gets 0. The study converted the score into percentage form and inverse the score to create the sub-indicator where 100% poses highest risk and 0% no risk ***(Equation 14).***

Equation 14: Logistic efficiency sub-indicator

$$L = \frac{1 - LPI_{et}}{5}$$

Where:

LPI_{et} = LPI score of economy I in year t

Reserves/Production ratio for oil and gas (internal risk)

To establish this sub-indicator, the study utilised data from Energy Information Agency (EIA) to determine oil reserves and production, and Cedigaz data for gas (EIA, 2016 and Cedigaz, 2016). The study established the reserves/production (R/P) ratio sub-indicator (oil and gas) for each economy from 2000-2013. In order to create the index, the study considered the highest R/P ratio recorded between 2000-2013 as benchmark ***(Equation 15).*** From this, the study established the index ranging from 0%-100% (100% as the highest risk and 0% no risk).

Equation 15: Oil and gas R/P ratio sub-indicator

$$RP = 1 - \frac{\frac{R_{et}}{P_{et}}}{Max\ \frac{R_{eT}}{P_{eT}}}$$

Where:

F_{et} = Oil/gas reserves of economy e in year t (EIA, 2016 and Cedigaz, 2016).

P_{et} = Oil/gas production of economy e in year t.

F_{eT} = Oil/gas in primary energy of economy e in T period

P_{eT} = Oil/gas production of economy e in T period

Refineries utilisation (internal risk)

This sub-indicator considered the refinery utilisation rate. The study did not look into the types of oil products that each of economies produced or even the specific oil product demand. The refinery capacities were derived from 2015 BP Statistical Review of World Energy (BP, 2016), while the oil product demand data was derived from IEA Energy Statistic 2016. For this sub-indicator, a 100% utilisation rate is translated to having the highest risk ***(Equation 16).***

Equation 16: Refineries utilisation sub-indicator

$$U = \frac{P_{et}}{C_{et}}$$

Where:

P_{et} = Oil product output of economy$e$ in year t.

C_{et} = Refinery capacity of economy$e$ in year t.

However, the 2015 BP Statistical Review of World Energy data only provides half of APEC member's refinery capacity. Therefore, the study utilised data collected from various sources, such as Oil and Gas Journals. Economies that are not listed in 2015 BP Statistical Review of World Energy are Brunei Darussalam; Chile; Hong Kong, China; Malaysia; New Zealand; Papua New Guinea; Peru; the Philippines; and Viet Nam.

Trans-border oil and gas pipelines utilisation (internal risk)

Trans-border oil and gas pipelines utilisation sub-indicator was derived from the capacity of pipelines to carry oil or gas for import purposes. The study found that China and the USA are the only economies in APEC that import crude oil through pipelines. The USA data was collected from EIA (EIA, 2016), while for China, the data was obtained from the China National Petroleum Corporation (CNPC) websites (CNPC, 2016) and Xinhua news website (Xinhua, 2015). As for gas, the import data was taken from Cedigaz database, while gas pipeline capacity was obtained from various government and company websites.

The study established this sub-indicator from both data on imports through pipelines and pipeline capacity in order to assess the rate of the pipeline utilisation. For this study purposes, APERC assume that higher utilisation rate means that higher security risk for importers. The main reason of this assumption is - in case of domestic supply shortages occurs, one of the quickest ways to recover supply disruption is by importing oil and gas through pipelines. If the cross-border pipeline is being utilise 100%, which subsequently gives an index of 100%, it means that there is no room for importers to increase the oil or gas if fuel supply shortages happen ***(Equation 17).***

Equation 17: Trans-border oil and gas pipelines utilisation sub-indicator

$$U_{og} = \frac{IM_{et}}{C_{et}}$$

Where:

IM_{et} = Oil/gas import through pipelines of economy e in year t.

C_{et} = Oil/gas pipelines capacity of economy e in year t.

Oil and gas self-sufficiency (internal risk)

As published in APEC Energy Demand and Supply Outlook 6th Edition, the study assessed the energy security of APEC economies based on oil and gas production over primary demand (i.e. oil and gas self-sufficiency) as shown below ***(Equation 18).***

Equation 18: Oil/gas fuel self-sufficiency sub-indicator

$$S_x = \frac{F_p}{F_d}$$

Where:

F_p = Oil/gas production of economy e in year t.

F_d = Oil/gas demand of economy e in year t.

Oil and gas production (external risk)

This sub-indicator was created to measure the risk in crude oil and gas production over the historical period (2000 to 2013). For crude oil, the study obtained data collected from EIA, while for gas from Cedigaz database. The highest production achieved over the period was set as benchmark as the lowest risk, with no potential or limited production disruption. The disruption that occurred could be due to technical glitches, depleting reserves, political instability and any other types of interruptions that hampered production ***(Equation 19).***

Equation 19: Oil and gas production external sub-indicator

$$P_{og} = \frac{P_{et}}{Max\ P_{eT}} \times F_{ae}$$

Where:

P_{et} = Oil/gas production of exporter e in year t (EIA, 2016 and Cedigaz, 2016).

P_{eT} = Oil/gas in primary energy of economy e in T period

F_{ae} = Shares of total import to receiving economy e from economy a

Liquefaction and regasification terminal utilisation (internal and external risk)

One of the main concerns raised on gas supply security is the available infrastructure and capacity to produce liquefied natural gas (LNG) and regasification (RGT) capacity. Based on data from Cedigaz, the

study established a sub-indicator on the utilisation rate for both LNG terminal (for exporter) and RGT (for importer) ***(Equation 20).***

Equation 20: Regasification terminal utilisation internal sub-indicator

$$U_{rgt} = \frac{IM_{et}}{C_{et}}$$

Where:

IM_{et} = LNG import through of economy e in year t.

C_{et} = RGT capacity of economy e in year t.

The study assumed that higher LNG terminal utilisation at the producer side means higher security risk for importers because it means that the importers will have limited room to buy extra cargoes in case supply disruptions happened from other import sources ***(Equation 21)***

Equation 21: Liquefaction terminal utilisation external sub-indicator

$$U_{lng} = \frac{E_{et}}{C_{et}} \times F_{ae}$$

Where:

E_{et} = LNG production of exporter e in year t.

C_{eT} = Liquefaction capacity of exporter e in year t.

F_{ae}= Shares of total import to receiving economy e from economy a

Underground gas storage utilisation (internal risk)

There are three types of underground gas storage facilities: (1) depleted natural gas or oil fields, (2) aquifers, and (3) salt caverns (API, 2016). There were seven APEC economies that have underground gas storage facilities in 2013, the United States represented a56% share of total storage capacity in APEC followed by Russia with 29% (Cedigaz, 2016).

Underground gas storage usage is closely related to season variations. Gas is typically withdrawn from storage during winter to meet heating demand. Natural gas storage enables supply to match demand on any given day throughout the year. The study considered storage as one of the options that could help reduce the risk in the event of gas supply disruption. Higher utilisation rate of the storage could pose higher risk for the economy ***(Equation 22).***

Equation 22: Underground gas storage utilisation sub-indicator

$$U_s = \frac{C_{et}}{D_{et}}$$

Where:

C_{et} = Underground gas storage of economy e in year t.

D_{et} = Gas demand of economy e in year t.

LAW/LEGAL INDICATOR

Resource extraction (internal risk)

Fraser Institute has been conducting Global Petroleum Survey (GPS) since 2007 with the objective to examine barriers on investment in upstream oil and gas exploration and production in various jurisdictions around the globe. The survey questionnaire, which comprised of 16 factors such as taxation, quality of geological database and environmental, was sent to petroleum industry executives and managers (FI, 2016).

The GPS report evaluated 17 APEC economies (Hong Kong, China; Korea; Singapore; and Chinese Taipei are not included having very little or no fossil fuels production at all). Some large economies, such as the Australia; Canada; Russia and United States were divided into smaller regions/states with no single number that represent the economy. With this, the simple average was applied to determine the index. For Mexico, the results were only provided for 2014 and 2015, thus the average (from these years) was obtained to determine the results for the period 2000-2013. From the GPS results, Fraser Institute established the Policy Perception Index on deterrence to investment – from mild to not pursue investment. There was no conversion done for this study.

Oil and gas emergency preparedness (internal risk)

Oil emergency preparedness sub-indicator was derived from the information gathered during the Oil and Gas Security Forum (OGSF) hosted by APERC. Based on the information given by each economy, all APEC members has some sort of emergency plan in case of an oil supply disruption happened. Therefore, APERC gave all economies 0% (lowest) risk due to the availability of emergency plan.

As for gas, the sub-indicator considered four factors in giving an index to each economy. Each factor carries the same weight (25%) and these factors are: (1) availability of regasification terminal, (2) existence of trans-border pipelines, (3) the existence of underground storage and (4) existence of policy with regards to gas emergency preparedness. This means if an economy possesses all factor above, the economy will get 0% index.

Oil strategic stockpiling policy (internal risk)

Information gathered on oil strategic stockpiling policy covered 17 APEC economies – Malaysia; Mexico; Papua New Guinea and Russia have no information available (APERC, 2015). For this sub-indicator, the study utilised 2013 data as proxy for the whole historical period of the study (2000-2013).

The risk was calculated by comparing the levels of stockpiling in each economy, of which the highest level was given 0% risk, while the rest was based on the levels as compared to the highest ***(Equation 23)***.

Equation 23: Oil stockpiling sub-indicator

$$OS = \frac{C_{et}}{Max\ C_{at}}$$

Where:

C_{et} = Oil stockpiling capacity of economy e in year t.

C_{at} = Oil stockpiling capacity of each APEC economy in year t.

With the exception of Russia, other economies (Mexico; Malaysia and Papua New Guinea) that do not have oil stockpiling facilities (or have no available information) are given 100% risk.

Rule of law (external risk)

For this sub-indicator, the study also utilised one of the WGI sub-indices, the "Rule of Law." This sub-indicator was created with intention to reflect perceptions of the confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts (WB, 2016a).

Similar to other sub-indicators using WGI), the WGI index on the level of governance ranges from -2.5 (weak) to 2.5 (strong) governance performance. For this index, the formula was set (transformed) as 0 to 1, where 1 is the riskiest (equivalent to -2.5 in WGI) with 0 the least risky (equivalent to 2.5 in WGI). However, WGI index indicates number lower than -2.5 for extremely unstable economies ***(Equation 24).*** For this sub-indicator, 100% means risk of supply disruption is at the maximum, while 0% means there is no risk.

Equation 24: Exporter rule of law sub-indicator

$$R = \left(\left(\frac{(100\ a_i - 250)}{500}\right) \times -1\right) \times F_{ae}$$

Where:

a_i = WGI data of economy i (WB, 2016a)

F_{ae} = Shares of total import to receiving economy e from economy a

ENVIRONMENT INDICATOR

Readiness and vulnerability to climate change impacts (internal and external risk)

Readiness and vulnerability to climate change impacts (sub-indicator) was also considered in this study to gauge the long-term risk of supply disruptions from climate change. Though most importing economies will not see the immediate impact on supply disruptions, it will be useful if this sub-indicator is included as part of the security indexation.

The study utilised the Notre Dame Global Adaptation Index (ND-GAIN), which is a non-profit organisation that summarises an economy's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. The ND-GAIN is an index that has two major sub-indices – readiness and vulnerability towards facing climate change.

In vulnerability sub-index of ND-GAIN, three components are measured: (1) exposure, (2) sensitivity, and (3) adaptive capacity. On the other hand, the readiness sub-index also consisted of three components: (1) economic, (2) governance and (3) social readiness (ND-GAIN, 2016). The ND-GAIN adopted scores from 0 to 100 that combined both vulnerability and readiness of each economy in facing and adapting to the climate change. The index is open for public utilisation and has data from 1995 to 2014. The study used the score and applied them inversely to indicate the risk of energy supply disruption in each APEC economy, as well as for the exporters ***(Equation 25 and Equation 26).***

Equation 25: Domestic readiness and vulnerability of climate change impact internal sub-indicator

$$CC_e = 1 - ND_{et}$$

Where:

ND_{et} = Readiness and vulnerability on climate change impact of economy e in year t (ND-GAIN, 2016).

and;

Equation 26: Exporters readiness and vulnerability of climate change impact sub-indicator

$$CC_{ex} = 1 - ND_{at} \times F_{ae}$$

Where:

ND_{at} = Readiness and vulnerability on climate change impact of exporter a in year t.

F_{ae} = Shares of total import to receiving economy e from economy a

Natural disaster (internal and external risk)

Natural disaster risk was calculated based on the number of affected people over total population. For this sub-indicator, the study generated the data from International Natural Disaster Database established by the Centre for Research on the Epidemiology of Disasters (CRED) in 1973. CRED has been working with World Health Organization (WHO) Collaborating Centre in 1980 and has expanded its support to the WHO Global Programme for Emergency Preparedness and Response (CRED, 2016).

There are 14 types of natural disaster under this database. However, the study excluded four types of disasters: (1) epidemic, (2) wildfire, (3) insect infestation and (4) animal accident. As for total population, the data was obtained from the World Bank.

The idea behind this sub-indicator is to show the risk of natural disaster towards energy supply disruptions for APEC economies. For this sub-indicator, 100% means highest risk on supply disruption and 0% means no risk ***(Equation 27 and Equation 28).***

Equation 27: Domestic natural disaster internal sub-indicator

$$D = \frac{A_{et}}{P_{et}}$$

Where:

A_{et} = People affected with natural disaster of economy e in year t (CRED, 2016)

P_{et} = Total population of economy e in year t.

and;

Equation 28: Exporters natural disaster sub-indicator

$$CC_{ex} = \frac{A_{at}}{P_{at}} \times F_{ae}$$

Where:

A_{at} = People affected with natural disaster in exporter a in year t.

P_{at} = Total population of exporter a in year t.

F_{ae} = Shares of total import to receiving economy e from economy a

ANNEX II

INDEXATION RESULTS

AUSTRALIA

Australia	Unit	2000	2005	2010	2013
GDP real term (2010 price and 2010 PPP)	USD Billions	638.6	749.1	861.1	936.9
GDP per capita	2010 USD PPP/Person	33,340	36,732	39,086	40,515
Population	million	19	20	22	23
Crude oil production	Mtoe	34	26	24	20
Oil product output	Mtoe	38	34	31	31
Gas production	Mtoe	29	31	44	52
Crude oil import	Mtoe	22	21	22	25
Oil product import	Mtoe	4	10	16	20
Total oil import	Mtoe	26	31	38	45
Gas import	Mtoe	0	0	5	6
Crude oil export	Mtoe	19	13	15	13
Oil product export	Mtoe	3	3	2	2
Total oil export	Mtoe	23	16	18	16
Gas export	Mtoe	9	12	21	28
Crude oil demand	Mtoe	37	34	31	32
Total oil as primary supply	Mtoe	34	37	40	46
Oil product demand	Mtoe	35	37	39	41
Gas demand	Mtoe	19	19	28	30
Other types of fuel demand	Mtoe	55	58	56	54
Total primary energy supply	Mtoe	108	113	124	129
Oil reserves	Mtoe	396	191	450	191
Gas reserves	Mtoe	1,983	2,185	3,383	3,392
Oil reserves/production ratio	years	12	7	19	10
Gas reserves/production ratio	years	69	70	76	65
Refinery capacities	Mtoe/yr	41	35	37	33
Oil intensity	toe/million 2010 USD	53	49	46	49
Gas intensity	toe/million 2010 USD	30	25	33	32
Oil consumption per capita	toe/person	1.8	1.8	1.8	2.0
Gas consumption per capita	toe/person	1.0	0.9	1.3	1.3

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Australia	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	24.8	32.4	32.6	29.7
		Piracy	0.3	0.0	0.0	0.0
		International agreement on oil emergency	0.0	0.0	0.0	0.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	7.5	2.2	3.1	4.6
		Exporter stability	42.1	38.1	38.4	39.6
Political Index			**10.4**	**11.5**	**11.6**	**11.1**
Economic	Internal	Primary energy diversity	33.2	33.8	32.2	30.6
		Ease of doing business	14.1	15.2	19.8	18.4
		Oil shares to primary energy	31.6	32.5	32.2	35.5
		Oil intensity	67.0	54.8	53.9	56.7
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	1.1	0.7	0.8	0.7
		Total oil net import over demand	10.4	39.6	51.3	64.8
		Crude oil import source diversity	13.4	14.8	12.8	10.7
		Oil product import source diversity	19.1	43.6	38.6	28.6
	External	Oil export over GDP	16.5	19.3	18.0	19.2
Economic Index			**20.0**	**24.4**	**24.6**	**25.3**
Social	Internal	Oil consumption per capita	24.8	26.4	27.0	31.1
Social Index			**24.8**	**26.4**	**27.0**	**31.1**
Technical/ technology	Internal	Logistic efficiency	23.9	23.8	23.2	24.6
		Oil reserves/production	38.0	60.5	0.0	49.5
		Refinery utilisation	92.8	97.1	85.3	94.5
		Trans-border pipelines utilisation	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	7.3	24.4	21.6	37.8
	External	Oil production	15.7	14.6	19.1	21.7
Technical/technology Index			**28.2**	**34.5**	**24.3**	**36.4**
Law/Legal	Internal	Resource extraction policy	28.1	27.6	23.0	40.2
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	81.6	81.6	81.6	81.6
	External	Rule of law	42.0	34.4	33.3	35.3
Law Index			**37.9**	**35.9**	**34.5**	**39.3**
Environmental	Internal	Climate change	23.9	24.7	23.9	23.2
		Natural disaster	0.0	0.0	0.8	0.0
	External	Climate change	44.5	38.0	33.8	33.7
		Natural disaster	1.0	0.2	0.6	0.3
Environmental Index			**14.6**	**14.0**	**13.6**	**13.0**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			**16.7**	**16.7**	**17.4**	**18.2**
	Internal	Local stability	24.8	32.4	32.6	29.7
		Piracy	0.3	0.0	0.0	0.0
		International agreement on gas emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	0.0
		Exporter stability	0.0	0.0	0.0	0.0
Political Index			18.3	20.1	17.9	19.6
	Internal	Primary energy diversity	33.2	33.8	31.8	30.6
		Ease of doing business	14.1	15.2	19.2	18.4
		Gas shares to primary energy	17.8	16.7	22.8	23.0
		Gas intensity	46.7	39.8	52.3	50.5
		Gas pricing	0.0	0.0	0.0	0.0
		Gas import source diversity	0.0	0.0	0.0	0.0
Economic Index			13.3	12.6	15.0	14.6
	Internal	Gas consumption per capita	16.5	15.6	20.4	20.8
Social Index			16.5	15.6	20.4	20.8
	Internal	Logistic efficiency	23.9	23.8	23.2	24.6
		Gas reserves/production	15.7	15.5	7.7	21.1
		Regasification terminal utilisation	0.0	0.0	0.0	0.0
		Nat underground gas storage over demand	94.4	95.5	88.0	76.9
		Trans-border pipelines utilisation gas	0.0	0.0	0.0	0.0
		Gas self-sufficiency	0.0	0.0	0.0	0.0
	External	Liquefaction terminal utilisation	0.0	0.0	0.0	0.0
		Gas production	0.0	0.0	0.0	0.0
Technical/technology Index			16.0	16.0	14.2	14.6
	Internal	Resource extraction policy	28.1	27.6	23.0	40.2
		Gas emergency preparedness	50.0	50.0	50.0	50.0
	External	Rule of law	0.0	0.0	0.0	0.0
Law Index			27.9	27.7	26.1	32.2
	Internal	Climate change	23.9	24.7	23.9	23.2
		Natural disaster	0.0	0.0	0.8	0.0
	External	Climate change	0.0	0.0	0.0	0.0
		Natural disaster	0.0	0.0	0.0	0.0
Environmental Index			8.5	8.8	8.8	8.3

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

BRUNEI DARUSSALAM

Brunei Darussalam	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	24.2	26.8	27.7	28.4
GDP per capita	2010 USD PPP/Person	73,244	74,129	70,486	69,108
Population	million	0.3	0.4	0.4	0.4
Crude oil production	Mtoe	10.2	11.1	8.3	6.8
Oil product output	Mtoe	0.6	0.6	0.6	0.5
Gas production	Mtoe	9.5	10.0	10.3	10.2
Crude oil import	Mtoe	0.0	0.0	0.0	0.0
Oil product import	Mtoe	0.0	0.0	0.1	0.3
Total oil import	Mtoe	0.0	0.0	0.2	0.3
Gas import	Mtoe	0.0	0.0	0.0	0.0
Crude oil export	Mtoe	9.7	10.5	7.9	6.4
Oil product export	Mtoe	0.0	0.0	0.0	0.0
Total oil export	Mtoe	9.7	10.5	7.9	6.4
Gas export	Mtoe	7.6	8.2	7.6	7.7
Crude oil demand	Mtoe	0.6	0.5	0.6	0.5
Total oil as primary supply	Mtoe	0.5	0.4	0.6	0.6
Oil product demand	Mtoe	0.4	0.4	0.6	0.6
Gas demand	Mtoe	1.8	1.8	2.7	2.5
Other types of fuel demand	Mtoe	0.0	0.0	0.0	0.0
Total primary energy supply	Mtoe	2.4	2.2	3.2	3.0
Oil reserves	Mtoe	191	191	150	150
Gas reserves	Mtoe	329	300	271	243
Oil reserves/production ratio	years	19	17	18	22
Gas reserves/production ratio	years	35	30	26	24
Refinery capacity	Mtoe/yr	0.5	0.5	0.5	0.5
Oil intensity	toe/million 2010 USD	22	14	20	21
Gas intensity	toe/million 2010 USD	76	69	97	86
Oil consumption per capita	toe/person	1.6	1.1	1.4	1.4
Gas consumption per capita	toe/person	5.6	5.1	6.8	6.0

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis

Brunei Darussalam		Oil Security Index (%)	2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	25.2	24.9	25.2	28.4
		Piracy	0.0	0.0	0.0	0.0
		International agreement on oil emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.3	0.0	0.1
		Exporter stability	49.1	34.1	35.6	35.5
Political Index			**22.9**	**21.6**	**21.8**	**22.6**
Economic	Internal	Primary energy diversity	65.2	71.6	68.4	68.9
		Ease of doing business	41.4	41.2	41.6	37.6
		Oil shares to primary energy	22.4	17.1	17.4	19.2
		Oil intensity	59.2	35.4	53.8	54.3
		Oil product pricing	100	100	100	100
		Oil export over GDP	0.0	0.0	0.0	0.0
		Total oil net import over demand	0.0	0.0	0.0	0.0
		Crude oil import source diversity	0.0	0.0	0.0	0.0
		Oil product import source diversity	100	43.5	51.2	49.4
	External	Oil export over GDP	6.3	17.9	22.4	23.0
Economic Index			**42.3**	**38.5**	**41.6**	**41.5**
Social	Internal	Oil consumption per capita	23.4	16.0	22.2	23.2
Social Index			**23.4**	**16.0**	**22.2**	**23.2**
Technical/ technology	Internal	Logistic efficiency	18.8	19.1	20.3	19.6
		Oil reserves/production	15.5	22.0	18.3	0.0
		Refinery utilisation	100	100	100	100
		Trans-border pipelines utilisation	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	0.0	0.0	0.0	0.0
	External	Oil production	0.0	0.0	0.0	0.0
Technical/technology Index			**20.2**	**21.2**	**20.8**	**17.9**
Law/Legal	Internal	Resource extraction policy	36.0	35.0	30.5	35.8
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	82.4	82.4	82.4	82.4
	External	Rule of law	43.8	26.2	25.9	27.3
Law Index			**40.5**	**35.9**	**34.7**	**36.4**
Environmental	Internal	Climate change	49.1	46.3	43.6	41.8
		Natural disaster	0.0	0.0	0.0	0.0
	External	Climate change	0.0	0.3	0.0	0.1
		Natural disaster	0.0	0.3	0.1	0.1
Environmental Index			**18.4**	**17.4**	**16.3**	**15.7**

		Gas Security Index (%)	2000	2005	2010	2013
Average Gas Security Index			26.3	26.9	27.8	25.8
	Internal	Local stability	25.2	24.9	25.2	28.4
		Piracy	0.0	0.0	0.0	0.0
		International agreement on gas emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	0.0
		Exporter stability	0.0	0.0	0.0	0.0
Political Index			**18.4**	**18.3**	**18.4**	**19.2**
	Internal	Primary energy diversity	65.2	71.6	71.3	68.9
		Ease of doing business	41.4	41.2	39.1	37.6
		Gas shares to primary energy	77.6	82.9	82.6	80.8
		Gas intensity	53.4	79.2	99.5	0.0
		Gas pricing	50.0	50.0	50.0	50.0
		Gas import source diversity	0.0	0.0	0.0	0.0
Economic Index			**35.2**	**39.7**	**41.8**	**29.0**
	Internal	Gas consumption per capita	31.2	30.0	34.0	32.1
Social Index			**31.2**	**30.0**	**34.0**	**32.1**
	Internal	Logistic efficiency	18.8	19.1	20.3	19.6
		Gas reserves/production	0.0	13.9	24.2	31.6
		Regasification terminal utilisation	0.0	0.0	0.0	0.0
		Nat underground gas storage over demand	100	100	100	100
		Trans-border pipelines utilisation gas	0.0	0.0	0.0	0.0
		Gas self-sufficiency	0.0	0.0	0.0	0.0
	External	Liquefaction terminal utilisation	0.0	0.0	0.0	0.0
		Gas production	0.0	0.0	0.0	0.0
Technical/technology Index			**14.5**	**16.2**	**17.7**	**18.5**
	Internal	Resource extraction policy	36.0	35.0	30.5	35.8
		Gas emergency preparedness	75.0	75.0	75.0	75.0
	External	Rule of law	0.0	0.0	0.0	0.0
Law Index			**40.7**	**40.3**	**38.7**	**40.6**
	Internal	Climate change	49.1	46.3	43.6	41.8
		Natural disaster	0.0	0.0	0.0	0.0
	External	Climate change	0.0	0.0	0.0	0.0
		Natural disaster	0.0	0.0	0.0	0.0
Environmental Index			**18.0**	**17.0**	**16.0**	**15.3**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

CANADA

Canada	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	1,128	1,279	1,362	1,458
GDP per capita	2010 USD PPP/Person	36,657	39,575	40,055	41,470
Population	million	31	32	34	35
Crude oil production	Mtoe	128	146	161	195
Oil product output	Mtoe	96	105	100	95
Gas production	Mtoe	148	154	132	130
Crude oil import	Mtoe	47	47	39	37
Oil product import	Mtoe	7	14	11	11
Total oil import	Mtoe	54	61	50	48
Gas import	Mtoe	1	8	19	22
Crude oil export	Mtoe	78	87	104	139
Oil product export	Mtoe	15	22	20	25
Total oil export	Mtoe	93	109	125	164
Gas export	Mtoe	83	87	79	69
Crude oil demand	Mtoe	97	104	95	93
Total oil as primary supply	Mtoe	87	95	85	78
Oil product demand	Mtoe	80	91	92	95
Gas demand	Mtoe	74	81	79	87
Other types of fuel demand	Mtoe	90	95	88	88
Total primary energy supply	Mtoe	252	270	251	253
Oil reserves	Mtoe	641	24,420	23,874	23,602
Gas reserves	Mtoe	1,515	1,469	1,530	1,887
Oil reserves/production ratio	years	5	167	148	121
Gas reserves/production ratio	years	10	10	12	14
Refinery capacity	Mtoe/yr	93	94	95	98
Oil intensity	toe/million 2010 USD	77	74	62	54
Gas intensity	toe/million 2010 USD	66	63	58	60
Oil consumption per capita	toe/person	2.8	2.9	2.5	2.2
Gas consumption per capita	toe/person	2.4	2.5	2.3	2.5

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Canada	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	27.9	34.2	31.9	29.4
		Piracy	0.0	0.0	0.0	0.0
		International agreement on oil emergency	0.0	0.0	0.0	0.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.1	3.2	3.2	3.6
		Exporter stability	35.5	51.2	50.8	47.3
Political Index			**10.0**	**13.1**	**12.5**	**11.6**
Economic	Internal	Primary energy diversity	24.6	24.6	24.6	25.0
		Ease of doing business	15.1	16.6	17.7	19.2
		Oil shares to primary energy	34.6	35.0	33.7	31.0
		Oil intensity	70.9	62.7	56.1	48.5
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	4.7	6.0	5.0	5.9
		Total oil net import over demand	0.0	0.0	0.0	0.0
		Crude oil import source diversity	48.0	11.1	8.3	10.4
		Oil product import source diversity	30.2	17.4	22.8	52.5
	External	Oil export over GDP	11.4	18.5	16.5	13.3
Economic Index			**21.8**	**19.1**	**18.3**	**19.4**
Social	Internal	Oil consumption per capita	29.9	33.2	28.9	27.7
Social Index			**29.9**	**33.2**	**28.9**	**27.7**
Technical/ technology	Internal	Logistic efficiency	21.9	22.0	22.5	23.0
		Oil reserves/production	97.2	7.2	17.7	32.8
		Refinery utilisation	100	100	100	97.3
		Trans-border pipelines utilisation	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	0.0	0.0	0.0	0.0
	External	Oil production	7.4	14.0	14.5	12.5
Technical/technology Index			**34.7**	**22.9**	**24.7**	**26.1**
Law/Legal	Internal	Resource extraction policy	34.7	34.4	30.1	34.2
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	0.0	0.0	0.0	0.0
	External	Rule of law	28.0	38.8	40.5	34.5
Law Index			**15.7**	**18.3**	**17.7**	**17.2**
Environmental	Internal	Climate change	23.7	24.0	24.0	24.2
		Natural disaster	0.0	0.0	0.0	0.3
	External	Climate change	29.0	36.1	36.8	33.0
		Natural disaster	0.0	0.2	0.2	0.0
Environmental Index			**12.5**	**13.6**	**13.6**	**13.3**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			22.9	24.5	22.0	22.2
	Internal	Local stability	27.9	34.2	31.9	29.4
		Piracy	0.0	0.0	0.0	0.0
		International agreement on gas emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.3	1.0
		Exporter stability	29.7	51.8	41.6	37.1
Political Index			**21.7**	**25.2**	**23.8**	**22.8**
	Internal	Primary energy diversity	24.6	24.6	24.5	25.0
		Ease of doing business	15.1	16.6	20.2	19.2
		Gas shares to primary energy	29.5	29.8	31.3	34.4
		Gas intensity	55.1	55.0	54.9	54.4
		Gas pricing	0.0	0.0	0.0	0.0
		Gas import source diversity	100	100	88.4	92.3
Economic Index			**27.4**	**27.6**	**26.8**	**27.5**
	Internal	Gas consumption per capita	25.5	27.2	23.1	25.6
Social Index			**25.5**	**27.2**	**23.1**	**25.6**
	Internal	Logistic efficiency	21.9	22.0	22.5	23.0
		Gas reserves/production	29.5	34.2	20.2	0.0
		Regasification terminal utilisation	0.0	0.0	10.9	8.6
		Nat underground gas storage over demand	74.1	73.1	73.7	75.2
		Trans-border pipelines utilisation gas	5.4	26.3	51.0	62.8
		Gas self-sufficiency	0.0	0.0	0.0	0.0
	External	Liquefaction terminal utilisation	0.0	0.0	6.1	4.0
		Gas production	21.1	25.8	12.0	0.0
Technical/technology Index			**18.8**	**22.5**	**24.2**	**21.3**
	Internal	Resource extraction policy	34.7	34.4	30.1	34.2
		Gas emergency preparedness	25.0	25.0	0.0	0.0
	External	Rule of law	19.3	19.5	19.3	19.9
Law Index			**27.0**	**27.0**	**16.2**	**17.9**
	Internal	Climate change	23.7	24.0	24.0	24.2
		Natural disaster	0.0	0.0	0.0	0.3
	External	Climate change	22.6	23.7	24.3	24.4
		Natural disaster	0.0	0.3	0.0	0.1
Environmental Index			**17.0**	**17.6**	**17.7**	**17.9**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

CHILE

Chile	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	213.0	261.7	310.6	361.4
GDP per capita	2010 USD PPP/Person	14,041	16,259	18,256	20,560
Population	million	15.2	16.1	17.0	17.6
Crude oil production	Mtoe	0.4	0.4	0.6	0.5
Oil product output	Mtoe	9.7	11.1	8.9	9.6
Gas production	Mtoe	1.6	1.6	1.5	0.8
Crude oil import	Mtoe	10.0	10.5	8.7	9.6
Oil product import	Mtoe	1.9	3.8	7.3	7.7
Total oil import	Mtoe	11.9	14.3	16.0	17.3
Gas import	Mtoe	3.7	5.3	3.0	3.3
Crude oil export	Mtoe	0.0	0.0	0.0	0.0
Oil product export	Mtoe	0.9	1.7	0.6	0.9
Total oil export	Mtoe	0.9	1.7	0.6	0.9
Gas export	Mtoe	0.0	0.0	0.0	0.0
Crude oil demand	Mtoe	10.2	10.9	9.3	10.0
Total oil as primary supply	Mtoe	10.5	11.6	15.0	15.8
Oil product demand	Mtoe	9.2	9.6	12.1	13.5
Gas demand	Mtoe	5.2	6.8	4.5	4.1
Other types of fuel demand	Mtoe	9.5	10.0	11.4	18.8
Total primary energy supply	Mtoe	25.2	28.4	30.8	38.7
Oil reserves	Mtoe	27.3	27.3	27.3	27.3
Gas reserves	Mtoe	15.7	11.3	7.5	6.3
Oil reserves/production ratio	years	63.9	76.9	44.6	50.6
Gas reserves/production ratio	years	9.8	7.1	4.8	7.8
Refinery capacity	Mtoe/yr	11.2	11.2	11.2	11.2
Oil intensity	toe/million 2010 USD	49.2	44.2	48.3	43.8
Gas intensity	toe/million 2010 USD	24.4	26.0	14.4	11.2
Oil consumption per capita	toe/person	0.7	0.7	0.9	0.9
Gas consumption per capita	toe/person	0.3	0.4	0.3	0.2

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Chile	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	41.4	33.0	36.5	42.5
		Piracy	0.0	0.0	0.0	0.0
		International agreement on oil emergency	100	100	100	100
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	4.6	4.3	2.7	1.8
		Exporter stability	53.3	55.0	48.6	44.9
Political Index			**40.2**	**38.2**	**38.4**	**39.5**
Economic	Internal	Primary energy diversity	27.0	26.8	33.5	28.2
		Ease of doing business	44.6	40.8	33.0	28.3
		Oil shares to primary energy	41.6	40.8	48.7	41.0
		Oil intensity	66.6	54.6	64.3	58.2
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	0.0	0.0	0.0	0.0
		Total oil net import over demand	100	100	100	100
		Crude oil import source diversity	49.5	25.8	21.5	21.4
		Oil product import source diversity	24.6	48.0	38.0	81.4
	External	Oil export over GDP	7.0	15.5	2.1	4.4
Economic Index			**31.3**	**31.9**	**28.4**	**31.0**
Social	Internal	Oil consumption per capita	16.2	17.4	21.6	22.8
Social Index			**16.2**	**17.4**	**21.6**	**22.8**
Technical/ technology	Internal	Logistic efficiency	36.1	36.4	38.1	35.7
		Oil reserves/production	18.5	2.0	43.1	35.4
		Refinery utilisation	86.9	98.9	79.2	85.9
		Trans-border pipelines utilisation	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	95.8	96.7	93.4	94.6
	External	Oil production	11.3	20.4	12.7	10.5
Technical/technology Index			**38.4**	**40.2**	**41.2**	**40.4**
Law/Legal	Internal	Resource extraction policy	24.9	24.1	19.6	26.6
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	88.2	88.2	88.2	88.2
	External	Rule of law	52.5	47.9	38.1	36.6
Law Index			**41.4**	**40.1**	**36.5**	**37.9**
Environmental	Internal	Climate change	42.0	37.5	35.0	33.8
		Natural disaster	1.2	0.2	15.7	0.0
	External	Climate change	47.7	42.2	34.9	33.7
		Natural disaster	0.1	0.1	0.5	0.2
Environmental Index			**22.2**	**19.4**	**23.4**	**16.9**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			30.0	31.0	29.4	28.9
	Internal	Local stability	41.4	33.0	36.5	42.5
		Piracy	0.0	0.0	0.0	0.0
		International agreement on gas emergency	100	100	100	100
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	6.9	8.1	10.5	11.9
		Exporter stability	49.0	50.3	51.9	52.5
Political Index			**39.5**	**37.7**	**38.9**	**40.5**
	Internal	Primary energy diversity	27.0	26.8	30.8	28.2
		Ease of doing business	44.6	40.8	31.5	28.3
		Gas shares to primary energy	20.7	24.0	14.5	10.5
		Gas intensity	48.4	52.7	29.5	23.2
		Gas pricing	0.0	0.0	0.0	0.0
		Gas import source diversity	100	100	26.1	71.9
Economic Index			**29.4**	**29.9**	**16.2**	**19.8**
Internal		Gas consumption per capita	15.4	19.1	11.6	10.3
Social Index			**15.4**	**19.1**	**11.6**	**10.3**
	Internal	Logistic efficiency	36.1	36.4	38.1	35.7
		Gas reserves/production	0.0	27.9	50.7	20.8
		Regasification terminal utilisation	0.0	0.0	53.9	64.2
		Nat underground gas storage over demand	100	100	100	100
		Trans-border pipelines utilisation gas	32.8	49.2	2.7	0.2
		Gas self-sufficiency	69.3	76.4	65.4	80.0
	External	Liquefaction terminal utilisation	0.0	0.0	90.0	99.5
		Gas production	18.9	1.0	6.5	3.5
Technical/technology Index			**31.6**	**35.6**	**50.9**	**50.5**
	Internal	Resource extraction policy	24.9	24.1	19.6	26.6
		Gas emergency preparedness	50.0	50.0	25.0	25.0
	External	Rule of law	54.0	61.6	63.3	55.5
Law Index			**41.9**	**43.6**	**33.2**	**33.7**
	Internal	Climate change	42.0	37.5	35.0	33.8
		Natural disaster	1.2	0.2	15.7	0.0
	External	Climate change	48.7	47.8	54.3	47.9
		Natural disaster	0.1	0.0	0.0	0.0
Environmental Index			**22.3**	**20.2**	**25.8**	**18.8**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

CHINA

China	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	4,550	7,250	12,359	15,700
GDP per capita	2010 USD PPP/Person	3,604	5,561	9,239	11,566
Population	million	1,263	1,304	1,338	1,357
Crude oil production	Mtoe	163.1	181.4	203.2	210.1
Oil product output	Mtoe	199.9	285.5	408.3	467.6
Gas production	Mtoe	22.8	41.3	79.4	101.1
Crude oil import	Mtoe	70.3	126.8	237.7	281.7
Oil product import	Mtoe	25.0	41.5	49.7	53.8
Total oil import	Mtoe	95.2	168.3	287.4	335.5
Gas import	Mtoe	0.0	0.0	12.6	41.7
Crude oil export	Mtoe	10.3	8.1	3.0	1.6
Oil product export	Mtoe	10.2	16.7	30.9	33.2
Total oil export	Mtoe	20.5	24.8	33.9	34.8
Gas export	Mtoe	2.0	2.5	3.4	2.3
Crude oil demand	Mtoe	213.9	301.0	428.9	486.9
Total oil as primary supply	Mtoe	221.1	317.6	428.3	485.8
Oil product demand	Mtoe	178.3	267.3	378.6	446.8
Gas demand	Mtoe	20.8	38.8	88.6	140.5
Other types of fuel demand	Mtoe	919	1,419	1,952	2,383
Total primary energy supply	Mtoe	1,161	1,775	2,469	3,009
Oil reserves	Mtoe	3,274	2,456	2,729	3,274
Gas reserves	Mtoe	1,142	1,521	2,020	2,120
Oil reserves/production ratio	years	20.1	13.5	13.4	15.6
Gas reserves/production ratio	years	50.2	36.9	25.5	21.0
Refinery capacity	Mtoe/yr	269.2	356.8	513.0	662.5
Oil intensity	toe/million 2010 USD	48.6	43.8	34.7	30.9
Gas intensity	toe/million 2010 USD	4.6	5.3	7.2	8.9
Oil consumption per capita	toe/person	0.2	0.2	0.3	0.4
Gas consumption per capita	toe/person	0.0	0.0	0.1	0.1

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

China	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	55.5	59.5	63.1	60.9
		Piracy	0.5	1.0	0.3	0.0
		International agreement on oil emergency	100	100	100	100
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	10.3	10.8	11.1	11.5
		Exporter stability	52.5	54.3	54.8	55.6
Political Index			**44.2**	**45.6**	**46.4**	**45.8**
Economic	Internal	Primary energy diversity	42.1	47.5	48.8	48.7
		Ease of doing business	50.6	50.8	45.7	40.1
		Oil shares to primary energy	19.0	17.9	17.3	16.1
		Oil intensity	82.5	67.1	57.7	51.4
		Oil product pricing	100	100	100	100
		Oil export over GDP	0.4	0.4	0.3	0.3
		Total oil net import over demand	33.8	45.2	59.2	61.9
		Crude oil import source diversity	9.8	9.2	9.2	9.4
		Oil product import source diversity	31.9	16.3	13.0	12.6
	External	Oil export over GDP	22.0	28.3	23.3	24.7
Economic Index			**36.4**	**36.6**	**34.9**	**34.6**
Social	Internal	Oil consumption per capita	9.9	14.0	18.5	21.0
Social Index			**9.9**	**14.0**	**18.5**	**21.0**
Technical/ technology	Internal	Logistic efficiency	32.3	32.0	30.2	29.5
		Oil reserves/production	0.0	32.6	33.1	22.4
		Refinery utilisation	74.3	80.0	79.6	70.6
		Trans-border pipelines utilisation	0.0	0.0	43.2	100
		Crude oil self-sufficiency	23.8	39.7	52.6	56.8
	External	Oil production	17.0	13.1	8.6	7.4
Technical/technology Index			**23.8**	**30.9**	**38.0**	**43.8**
Law/Legal	Internal	Resource extraction policy	51.8	51.3	51.7	57.2
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	82.4	82.4	82.4	82.4
	External	Rule of law	48.0	50.8	50.8	52.4
Law Index			**45.5**	**46.1**	**46.2**	**48.0**
Environmental	Internal	Climate change	49.0	48.6	42.5	41.2
		Natural disaster	2.0	6.4	13.5	2.0
	External	Climate change	43.9	42.8	40.9	40.2
		Natural disaster	0.5	0.1	0.5	0.1
Environmental Index			**24.7**	**26.0**	**26.2**	**21.3**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			21.8	24.9	32.0	33.2
	Internal	Local stability	55.5	59.5	63.1	60.9
		Piracy	0.5	1.0	0.3	0.0
		International agreement on gas emergency	100	100	100	100
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	4.4	6.2
		Exporter stability	0.0	0.0	46.2	45.8
Political Index			**38.1**	**39.2**	**44.5**	**44.0**
	Internal	Primary energy diversity	42.1	47.5	48.3	48.7
		Ease of doing business	50.6	50.8	43.5	40.1
		Gas shares to primary energy	1.8	2.2	3.6	4.7
		Gas intensity	26.9	31.9	43.0	53.9
		Gas pricing	100	100	100	100
		Gas import source diversity	0.0	0.0	19.8	27.3
Economic Index			**27.1**	**28.4**	**31.6**	**33.6**
	Internal	Gas consumption per capita	3.0	5.4	11.9	18.7
Social Index			**3.0**	**5.4**	**11.9**	**18.7**
	Internal	Logistic efficiency	32.3	32.0	30.2	29.5
		Gas reserves/production	0.0	26.6	49.3	58.2
		Regasification terminal utilisation	0.0	0.0	69.6	50.1
		Nat underground gas storage over demand	94.8	96.3	98.2	97.3
		Trans-border pipelines utilisation gas	0.0	0.0	23.7	42.0
		Gas self-sufficiency	0.0	0.0	10.4	28.0
	External	Liquefaction terminal utilisation	0.0	0.0	77.3	46.6
		Gas production	0.0	0.0	15.7	1.3
Technical/technology Index			**15.5**	**18.9**	**46.8**	**43.7**
	Internal	Resource extraction policy	51.8	51.3	51.7	57.2
		Gas emergency preparedness	25.0	50.0	0.0	0.0
	External	Rule of law	0.0	0.0	45.4	58.7
Law Index			**28.2**	**37.2**	**31.1**	**36.7**
	Internal	Climate change	49.0	48.6	42.5	41.2
		Natural disaster	2.0	6.4	13.5	2.0
	External	Climate change	0.0	0.0	42.8	50.8
		Natural disaster	0.0	0.0	0.3	0.0
Environmental Index			**18.7**	**20.2**	**26.3**	**22.6**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

HONG KONG, CHINA

Hong Kong, China	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	222.1	273.2	331.1	363.8
GDP per capita	2010 USD PPP/Person	33,329	40,095	47,135	50,611
Population	million	6.7	6.8	7.0	7.2
Crude oil production	Mtoe	0.0	0.0	0.0	0.0
Oil product output	Mtoe	0.0	0.0	0.0	0.0
Gas production	Mtoe	0.0	0.0	0.0	0.0
Crude oil import	Mtoe	0.0	0.0	0.0	0.0
Oil product import	Mtoe	14.5	16.1	21.8	18.3
Total oil import	Mtoe	14.5	16.1	21.8	18.3
Gas import	Mtoe	2.5	2.2	3.1	2.2
Crude oil export	Mtoe	0.0	0.0	0.0	0.0
Oil product export	Mtoe	1.6	2.3	0.5	0.7
Total oil export	Mtoe	1.6	2.3	0.5	0.7
Gas export	Mtoe	0.0	0.0	0.0	0.0
Crude oil demand	Mtoe	0.0	0.0	0.0	0.0
Total oil as primary supply	Mtoe	6.5	3.4	3.4	2.9
Oil product demand	Mtoe	5.6	3.1	3.0	2.9
Gas demand	Mtoe	2.5	2.2	3.1	2.2
Other types of fuel demand	Mtoe	4.6	7.3	7.2	8.9
Total primary energy supply	Mtoe	13.6	12.8	13.7	13.9
Oil reserves	Mtoe	0.0	0.0	0.0	0.0
Gas reserves	Mtoe	0.0	0.0	0.0	0.0
Oil reserves/production ratio	years	0.0	0.0	0.0	0.0
Gas reserves/production ratio	years	0.0	0.0	0.0	0.0
Refinery capacity	Mtoe/yr	0.0	0.0	0.0	0.0
Oil intensity	toe/million 2010 USD	29.4	12.3	10.1	8.0
Gas intensity	toe/million 2010 USD	11.0	8.0	9.5	5.9
Oil consumption per capita	toe/person	1.0	0.5	0.5	0.4
Gas consumption per capita	toe/person	0.4	0.3	0.4	0.3

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis

Hong Kong, China	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	33.2	24.3	32.3	32.3
		Piracy	0.0	0.0	0.0	0.0
		International agreement on oil emergency	100	100	100	100
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.8	0.2	0.1	0.0
		Exporter stability	50.3	33.2	39.2	36.2
Political Index			**37.6**	**33.9**	**36.4**	**36.1**
Economic	Internal	Primary energy diversity	34.1	36.8	36.0	39.7
		Ease of doing business	13.0	13.8	13.5	10.7
		Oil shares to primary energy	48.2	26.2	24.6	20.8
		Oil intensity	64.0	25.3	21.8	17.1
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	0.2	0.3	0.2	0.2
		Total oil net import over demand	100	100	100	100
		Crude oil import source diversity	0.0	0.0	0.0	0.0
		Oil product import source diversity	91.3	50.7	31.2	21.4
	External	Oil export over GDP	6.4	19.8	16.2	12.0
Economic Index			**30.8**	**26.0**	**22.6**	**20.5**
Social	Internal	Oil consumption per capita	23.0	12.0	11.7	10.2
Social Index			**23.0**	**12.0**	**11.7**	**10.2**
Technical/ technology	Internal	Logistic efficiency	20.7	21.0	22.5	20.5
		Oil reserves/production	100	100	100	100
		Refinery utilisation	0.0	0.0	0.0	0.0
		Trans-border pipelines utilisation	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	0.0	0.0	0.0	0.0
	External	Oil production	0.0	0.0	0.0	0.0
Technical/technology Index			**18.1**	**18.2**	**18.4**	**18.1**
Law/Legal	Internal	Resource extraction policy	0.0	0.0	0.0	0.0
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	91.8	91.8	91.8	91.8
	External	Rule of law	45.1	21.0	28.7	29.1
Law Index			**34.2**	**28.2**	**30.1**	**30.2**
Environmental	Internal	Climate change	49.0	48.6	42.5	41.2
		Natural disaster	0.0	0.0	0.2	0.0
	External	Climate change	46.6	30.3	29.5	27.0
		Natural disaster	0.0	0.6	3.6	0.8
Environmental Index			**24.2**	**22.1**	**20.1**	**18.9**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			27.0	27.3	27.7	24.8
	Internal	Local stability	33.2	24.3	32.3	32.3
		Piracy	0.0	0.0	0.0	0.0
		International agreement on gas emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	0.0
		Exporter stability	55.5	59.5	63.1	60.9
Political Index			**25.3**	**23.5**	**25.7**	**25.5**
	Internal	Primary energy diversity	34.1	36.8	32.9	39.7
		Ease of doing business	13.0	13.8	11.7	10.7
		Gas shares to primary energy	18.1	17.0	22.9	15.5
		Gas intensity	51.5	37.6	44.6	28.1
		Gas pricing	0.0	0.0	0.0	0.0
		Gas import source diversity	100	100	100	100
Economic Index			**26.5**	**25.1**	**25.9**	**23.7**
	Internal	Gas consumption per capita	16.3	14.4	19.5	13.3
Social Index			**16.3**	**14.4**	**19.5**	**13.3**
	Internal	Logistic efficiency	20.7	21.0	22.5	20.5
		Gas reserves/production	100	100	100	100
		Regasification terminal utilisation	0.0	0.0	0.0	0.0
		Nat underground gas storage over demand	100	100	100	100
		Trans-border pipelines utilisation gas	95.1	84.9	91.5	63.2
		Gas self-sufficiency	100	100	100	100
	External	Liquefaction terminal utilisation	0.0	0.0	0.0	0.0
		Gas production	0.0	57.4	20.7	0.0
Technical/technology Index			**50.8**	**57.3**	**53.3**	**46.9**
	Internal	Resource extraction policy	0.0	0.0	0.0	0.0
		Gas emergency preparedness	50.0	50.0	50.0	50.0
	External	Rule of law	0.0	0.0	0.0	0.0
Law Index			**18.3**	**18.3**	**18.3**	**18.3**
	Internal	Climate change	49.0	48.6	42.5	41.2
		Natural disaster	0.0	0.0	0.2	0.0
	External	Climate change	49.0	48.6	42.5	41.2
		Natural disaster	2.0	6.4	13.5	2.0
Environmental Index			**24.8**	**25.2**	**23.1**	**20.9**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

INDONESIA

Indonesia	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	1,203	1,516	2,004	2,382
GDP per capita	2010 USD PPP/Person	5,688	6,700	8,294	9,479
Population	no. in million	211.5	226.3	241.6	251.3
Crude oil production	Mtoe	71.6	53.4	48.4	42.2
Oil product output	Mtoe	50.8	48.3	46.7	45.5
Gas production	Mtoe	61.1	65.6	74.8	62.9
Crude oil import	Mtoe	12.8	18.2	20.0	23.4
Oil product import	Mtoe	12.8	22.5	26.0	31.8
Total oil import	Mtoe	25.6	40.7	45.9	55.2
Gas import	Mtoe	0.0	0.0	0.0	0.0
Crude oil export	Mtoe	30.2	21.4	17.8	15.9
Oil product export	Mtoe	8.6	6.6	5.2	4.3
Total oil export	Mtoe	38.8	28.0	23.0	20.2
Gas export	Mtoe	34.6	36.3	36.0	30.2
Crude oil demand	Mtoe	54.2	50.3	50.9	49.7
Total oil as primary supply	Mtoe	57.9	65.4	70.4	76.6
Oil product demand	Mtoe	46.9	51.4	59.6	66.3
Gas demand	Mtoe	26.6	29.3	38.8	32.7
Other types of fuel demand	Mtoe	71.2	85.1	100.2	104.3
Total primary energy supply	Mtoe	156	180	209	214
Oil reserves	Mtoe	682	587	546	505
Gas reserves	Mtoe	2,347	2,393	2,667	2,579
Oil reserves/production ratio	years	9.5	11.0	11.3	12.0
Gas reserves/production ratio	years	38.4	36.5	35.7	41.0
Refinery capacity	Mtoe/yr	56.1	52.6	56.7	53.4
Oil intensity	toe/million 2010 USD	48.1	43.2	35.1	32.2
Gas intensity	toe/million 2010 USD	22.1	19.3	19.4	13.7
Oil per capita	toe/person	0.3	0.3	0.3	0.3
Gas per capita	toe/person	0.1	0.1	0.2	0.1

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis

Indonesia	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	90.7	79.7	67.1	59.9
		Piracy	31.7	20.0	13.3	53.4
		International agreement on oil emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	10.6	8.3	7.6	8.1
		Exporter stability	44.8	43.4	45.8	48.7
Political Index			**47.4**	**41.5**	**36.8**	**45.3**
Economic	Internal	Primary energy diversity	27.9	25.8	23.6	24.6
		Ease of doing business	69.6	64.6	45.4	41.2
		Oil shares to primary energy	37.2	36.4	33.6	35.9
		Oil intensity	91.8	73.0	65.5	59.8
		Oil product pricing	100	100	100	100
		Oil export over GDP	4.8	3.3	2.2	1.8
		Total oil net import over demand	0.0	19.3	32.5	45.7
		Crude oil import source diversity	18.7	21.0	21.0	16.9
		Oil product import source diversity	29.3	39.0	30.1	31.9
	External	Oil export over GDP	22.6	28.2	27.6	30.2
Economic Index			**37.1**	**38.8**	**36.1**	**37.3**
Social	Internal	Oil per capita	17.8	19.1	19.3	20.4
Social Index			**17.8**	**19.1**	**19.3**	**20.4**
Technical/ technology	Internal	Logistic efficiency	41.6	42.0	44.8	39.7
		Oil reserves/production	24.4	12.9	10.6	5.0
		Refinery utilization	90.5	91.8	82.3	85.3
		Trans-border pipelines utilization	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	0.0	0.0	4.8	15.2
	External	Oil production	21.6	8.6	9.2	12.1
Technical/technology Index			**28.8**	**24.0**	**23.5**	**24.7**
Law/Legal	Internal	Resource extraction policy	66.3	65.7	65.1	74.4
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	82.4	82.4	82.4	82.4
	External	Rule of law	43.6	36.4	37.3	40.2
Law Index			**48.0**	**46.0**	**46.1**	**49.1**
Environmental	Internal	Climate change	59.7	56.3	52.2	50.3
		Natural disaster	0.4	0.1	0.1	0.3
	External	Climate change	46.1	40.5	37.7	37.9
		Natural disaster	0.7	0.7	0.5	0.1
Environmental Index			**28.3**	**26.2**	**24.3**	**23.7**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			27.3	26.0	25.2	24.9
	Internal	Local stability	90.7	79.7	67.1	59.9
		Piracy	31.7	20.0	13.3	53.4
		International agreement on gas emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	0.0
		Exporter stability	0.0	0.0	0.0	0.0
Political Index			**41.1**	**35.7**	**31.0**	**38.9**
	Internal	Primary energy diversity	27.9	25.8	23.6	24.6
		Ease of doing business	69.6	64.6	43.0	41.2
		Gas shares to primary energy	17.1	16.3	18.5	15.3
		Gas intensity	57.2	51.8	52.8	37.9
		Gas pricing	50.0	50.0	50.0	50.0
		Gas import source diversity	0.0	0.0	0.0	0.0
Economic Index			**26.4**	**24.8**	**22.4**	**20.1**
Internal		Gas per capita	14.4	14.8	18.3	14.9
Social Index			**14.4**	**14.8**	**18.3**	**14.9**
	Internal	Logistic efficiency	41.6	42.0	44.8	39.7
		Gas reserves/production	16.4	20.5	22.4	10.8
		Regasification terminal utilization	0.0	0.0	0.0	36.0
		Nat gas underground storage over demand	100	100	100	100
		Trans-border pipelines utilization gas	0.0	0.0	0.0	0.0
		Gas self-sufficiency	0.0	0.0	0.0	0.0
	External	Liquefaction terminal utilization	0.0	0.0	0.0	0.0
		Gas production	0.0	0.0	0.0	0.0
Technical/technology Index			**18.8**	**19.4**	**19.9**	**22.2**
	Internal	Resource extraction policy	66.3	65.7	65.1	74.4
		Gas emergency preparedness	50.0	50.0	50.0	25.0
	External	Rule of law	0.0	0.0	0.0	0.0
Law Index			**41.5**	**41.3**	**41.1**	**35.5**
	Internal	Climate change	59.7	56.3	52.2	50.3
		Natural disaster	0.4	0.1	0.1	0.3
	External	Climate change	0.0	0.0	0.0	0.0
		Natural disaster	0.0	0.0	0.0	0.0
Environmental Index			**21.4**	**20.1**	**18.7**	**18.1**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

JAPAN

Japan	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	4,005	4,250	4,321	4,448
GDP per capita	2010 USD PPP/Person	31,572	33,262	33,741	34,928
Population	million	127	128	128	127
Crude oil production	Mtoe	0.8	0.7	0.7	0.5
Oil product output	Mtoe	214	212	185	178
Gas production	Mtoe	2.3	2.9	3.2	2.7
Crude oil import	Mtoe	221	216	185	182
Oil product import	Mtoe	53.2	51.1	44.9	47.1
Total oil import	Mtoe	275	267	229	229
Gas import	Mtoe	63.5	67.8	82.8	103.7
Crude oil export	Mtoe	0.0	0.0	0.0	0.0
Oil product export	Mtoe	4.5	9.0	17.6	17.0
Total oil export	Mtoe	4.5	9.0	17.6	17.0
Gas export	Mtoe	0.0	0.0	0.0	0.0
Crude oil demand	Mtoe	220	216	185	182
Total oil as primary supply	Mtoe	255	243	202	202
Oil product demand	Mtoe	206	198	169	165
Gas demand	Mtoe	66	71	86	106
Other types of fuel demand	Mtoe	198	207	211	146
Total primary energy supply	Mtoe	519	521	499	455
Oil reserves	Mtoe	0.0	0.0	0.0	0.0
Gas reserves	Mtoe	36	35	33	30
Oil reserves/production ratio	years	0.0	0.0	0.0	0.0
Gas reserves/production ratio	years	16	12	10	11
Refinery capacity	Mtoe/yr	249	226	214	205
Oil intensity	toe/million 2010 USD	64	57	47	46
Gas intensity	toe/million 2010 USD	16	17	20	24
Oil consumption per capita	toe/person	2.0	1.9	1.6	1.6
Gas consumption per capita	toe/person	0.5	0.6	0.7	0.8

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis

Japan	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	27.4	30.3	32.9	30.1
		Piracy	0.0	0.0	0.0	0.0
		International agreement on oil emergency	0.0	0.0	0.0	0.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	13.8	17.0	16.7	15.5
		Exporter stability	46.1	50.5	52.1	49.7
Political Index			**11.9**	**13.2**	**14.0**	**13.0**
Economic	Internal	Primary energy diversity	31.9	30.5	28.0	32.5
		Ease of doing business	20.6	23.0	22.6	21.8
		Oil shares to primary energy	49.2	46.7	40.6	44.5
		Oil intensity	66.4	55.9	48.2	46.8
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	0.0	0.0	0.0	0.0
		Total oil net import over demand	100	100	100	100
		Crude oil import source diversity	16.1	19.0	17.4	18.3
		Oil product import source diversity	24.0	13.2	11.5	16.3
	External	Oil export over GDP	20.5	28.1	25.3	24.8
Economic Index			**30.8**	**31.1**	**28.5**	**29.5**
Social	Internal	Oil consumption per capita	27.5	27.5	23.3	24.7
Social Index			**27.5**	**27.5**	**23.3**	**24.7**
Technical/ technology	Internal	Logistic efficiency	20.0	20.1	20.7	21.5
		Oil reserves/production	100	100	100	100
		Refinery utilisation	85.7	93.9	86.5	86.7
		Trans-border pipelines utilisation	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	99.6	99.7	99.6	99.7
	External	Oil production	21.2	11.2	11.5	4.4
Technical/technology Index			**51.1**	**49.8**	**48.9**	**47.3**
Law/Legal	Internal	Resource extraction policy	37.2	37.9	42.1	39.1
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	0.0	0.0	0.0	0.0
	External	Rule of law	42.4	45.8	45.6	42.7
Law Index			**19.9**	**20.9**	**21.9**	**20.4**
Environmental	Internal	Climate change	30.8	29.3	28.3	27.0
		Natural disaster	0.5	0.2	0.0	0.1
	External	Climate change	45.2	43.7	41.5	39.0
		Natural disaster	0.3	0.3	0.5	0.2
Environmental Index			**17.4**	**16.6**	**15.9**	**15.1**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			29.0	29.1	28.3	29.0
	Internal	Local stability	27.4	30.3	32.9	30.1
		Piracy	0.0	0.0	0.0	0.0
		International agreement on gas emergency	100	100	100	100
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	5.0	5.7	6.7	9.7
		Exporter stability	53.0	45.3	45.3	43.1
Political Index			**36.3**	**36.4**	**37.1**	**36.5**
	Internal	Primary energy diversity	31.9	30.5	27.1	32.5
		Ease of doing business	20.6	23.0	21.6	21.8
		Gas shares to primary energy	12.6	13.6	17.2	23.4
		Gas intensity	36.0	36.9	44.5	53.6
		Gas pricing	0.0	0.0	0.0	0.0
		Gas import source diversity	20.3	17.0	14.2	13.2
Economic Index			**14.8**	**14.8**	**15.2**	**17.6**
Internal		Gas consumption per capita	13.1	14.1	16.6	20.9
Social Index			**13.1**	**14.1**	**16.6**	**20.9**
	Internal	Logistic efficiency	20.0	20.1	20.7	21.5
		Gas reserves/production	0.5	23.4	34.5	31.6
		Regasification terminal utilisation	32.9	34.3	39.2	47.3
		Nat underground gas storage over demand	100	100	98.8	99.0
		Trans-border pipelines utilisation gas	0.0	0.0	0.0	0.0
		Gas self-sufficiency	96.5	95.9	96.3	97.4
	External	Liquefaction terminal utilisation	100	100	99.9	99.8
		Gas production	33.5	19.9	7.0	2.3
Technical/technology Index			**48.3**	**49.4**	**49.6**	**49.9**
	Internal	Resource extraction policy	37.2	37.9	42.1	39.1
		Gas emergency preparedness	50.0	50.0	25.0	25.0
	External	Rule of law	44.8	41.9	40.7	39.6
Law Index			**43.9**	**43.4**	**35.4**	**34.0**
	Internal	Climate change	30.8	29.3	28.3	27.0
		Natural disaster	0.5	0.2	0.0	0.1
	External	Climate change	47.6	43.5	40.1	38.5
		Natural disaster	0.1	0.1	0.2	0.1
Environmental Index			**17.8**	**16.6**	**15.8**	**15.1**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

KOREA

Korea	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	977	1,231	1,505	1,643
GDP per capita	2010 USD PPP/Person	20,774	25,562	30,465	32,711
Population	no. in million	47	48	49	50
Crude oil production	Mtoe	0.7	0.5	0.7	0.6
Oil product output	Mtoe	126	123	123	130
Gas production	Mtoe	0.0	0.4	0.5	0.4
Crude oil import	Mtoe	126	117	122	126
Oil product import	Mtoe	25	21	33	40
Total oil import	Mtoe	150	138	155	166
Gas import	Mtoe	17	26	39	48
Crude oil export	Mtoe	0.1	0.0	0.5	0.3
Oil product export	Mtoe	41	36	45	57
Total oil export	Mtoe	41	36	46	57
Gas export	Mtoe	0.0	0.0	0.0	0.0
Crude oil demand	Mtoe	126	119	121	127
Total oil as primary supply	Mtoe	99	92	95	97
Oil product demand	Mtoe	80	80	82	85
Gas demand	Mtoe	17	27	39	48
Other types of fuel demand	Mtoe	72	90	116	120
Total primary energy supply	Mtoe	188	210	250	264
Oil reserves	Mtoe	0.0	0.0	0.0	0.0
Gas reserves	Mtoe	0.0	2.7	0.9	1.1
Oil reserves/production ratio	years	0.0	0.0	0.0	0.0
Gas reserves/production ratio	years	0.0	6.1	1.9	2.6
Refinery capacity	Mtoe/yr	129	129	135	144
Oil intensity	toe/million 2010 USD	101	75	63	59
Gas intensity	toe/million 2010 USD	17	22	26	29
Oil per capita	toe/person	2.1	1.9	1.9	1.9
Gas per capita	toe/person	0.4	0.6	0.8	0.9

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Korea	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	44.0	40.9	44.3	45.0
		Piracy	0.0	0.0	0.0	0.0
		International agreement on oil emergency	50.0	0.0	0.0	0.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	14.1	16.8	16.9	17.8
		Exporter stability	51.0	49.7	53.1	50.2
Political Index			**28.8**	**15.8**	**17.0**	**17.0**
Economic	Internal	Primary energy diversity	35.8	29.9	28.4	27.3
		Ease of doing business	25.6	27.2	23.5	16.0
		Oil shares to primary energy	52.6	44.0	38.0	36.6
		Oil intensity	95.7	62.4	58.1	54.0
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	0.0	0.0	0.0	0.0
		Total oil net import over demand	0.0	0.0	0.0	0.0
		Crude oil import source diversity	14.6	15.9	16.7	17.7
		Oil product import source diversity	9.7	9.3	6.7	6.2
	External	Oil export over GDP	24.1	29.5	25.2	29.5
Economic Index			**25.5**	**23.2**	**20.2**	**20.6**
Social	Internal	Oil per capita	27.6	26.7	27.2	28.8
Social Index			**27.6**	**26.7**	**27.2**	**28.8**
Technical/ technology	Internal	Logistic efficiency	28.7	28.5	27.3	26.4
		Oil reserves/production	100	100	100	100
		Refinery utilization	97.1	95.4	91.4	90.7
		Trans-border pipelines utilization	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	99.5	99.6	99.4	99.5
	External	Oil production	19.7	11.8	12.0	5.5
Technical/technology Index			**53.3**	**51.0**	**50.3**	**48.4**
Law/Legal	Internal	Resource extraction policy	0.0	0.0	0.0	0.0
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	0.0	0.0	0.0	0.0
	External	Rule of law	45.9	42.2	43.0	42.0
Law Index			**11.9**	**10.9**	**11.1**	**10.8**
Environmental	Internal	Climate change	30.7	28.8	26.2	25.2
		Natural disaster	0.0	0.0	0.1	0.0
	External	Climate change	47.9	43.1	41.4	38.8
		Natural disaster	0.3	0.5	0.5	0.2
Environmental Index			**17.6**	**16.3**	**15.2**	**14.4**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			27.9	28.3	29.4	29.9
	Internal	Local stability	44.0	40.9	44.3	45.0
		Piracy	0.0	0.0	0.0	0.0
		International agreement on gas emergency	100	100	100	100
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	8.9	12.6	13.4	15.9
		Exporter stability	58.3	44.8	49.9	49.8
Political Index			**40.7**	**39.0**	**40.4**	**40.8**
	Internal	Primary energy diversity	35.8	29.9	27.9	27.3
		Ease of doing business	25.6	27.2	18.4	16.0
		Gas shares to primary energy	9.0	13.0	15.4	18.0
		Gas intensity	33.6	44.0	51.3	58.4
		Gas pricing	0.0	0.0	0.0	0.0
		Gas import source diversity	27.1	21.9	13.6	17.4
Economic Index			**15.6**	**16.2**	**15.1**	**16.3**
	Internal	Gas per capita	8.0	12.7	16.8	20.7
Social Index			**8.0**	**12.7**	**16.8**	**20.7**
	Internal	Logistic efficiency	28.7	28.5	27.3	26.4
		Gas reserves/production	0.0	33.7	79.9	71.9
		Regasification terminal utilization	41.8	35.7	42.4	40.4
		Nat gas underground storage over demand	100	100.0	100	100
		Trans-border pipelines utilization gas	0.0	0.0	0.0	0.0
		Gas self-sufficiency	100	98.4	98.7	99.1
	External	Liquefaction terminal utilization	99.6	100	99.8	99.5
		Gas production	42.5	33.0	10.9	2.6
Technical/technology Index			**52.5**	**54.3**	**57.3**	**54.8**
	Internal	Resource extraction policy	0.0	0.0	0.0	0.0
		Gas emergency preparedness	50.0	50.0	50.0	50.0
	External	Rule of law	50.2	44.8	46.8	46.2
Law Index			**32.2**	**30.7**	**31.2**	**31.1**
	Internal	Climate change	30.7	28.8	26.2	25.2
		Natural disaster	0.0	0.0	0.1	0.0
	External	Climate change	52.8	47.4	45.5	46.0
		Natural disaster	0.2	0.0	0.1	0.1
Environmental Index			**18.5**	**17.1**	**15.9**	**15.6**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

MALAYSIA

Malaysia	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	360.1	454.0	565.1	657.7
GDP per capita	2010 USD PPP/Person	15,377	17,598	20,097	22,321
Population	million	23	26	28	29
Crude oil production	Mtoe	32	37	34	30
Oil product output	Mtoe	21	21	21	25
Gas production	Mtoe	43	55	51	58
Crude oil import	Mtoe	7.7	8.2	8.1	9.2
Oil product import	Mtoe	6.6	8.0	10.4	19
Total oil import	Mtoe	14	16	18	29
Gas import	Mtoe	0.0	1.7	3.3	3.6
Crude oil export	Mtoe	17	19	17	11
Oil product export	Mtoe	8.5	8.4	8.4	12
Total oil export	Mtoe	26	27	26	23
Gas export	Mtoe	18	25	27	29
Crude oil demand	Mtoe	23	27	25	29
Total oil as primary supply	Mtoe	19	24	25	31
Oil product demand	Mtoe	18	21	23	28
Gas demand	Mtoe	25	32	31	38
Other types of fuel demand	Mtoe	5.7	10	18	20
Total primary energy supply	Mtoe	49	67	74	89
Oil reserves	Mtoe	532	409	546	546
Gas reserves	Mtoe	1,970	2,111	2,101	2,350
Oil reserves/production ratio	years	16	11	16	18
Gas reserves/production ratio	years	46	38	41	40
Refinery capacity	Mtoe/yr	28	28	28	28
Oil intensity	toe/million 2010 USD	53	54	44	47
Gas intensity	toe/million 2010 USD	69	70	55	58
Oil consumption per capita	toe/person	0.8	0.9	0.9	1.0
Gas consumption per capita	toe/person	1.1	1.2	1.1	1.3

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Malaysia	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	49.1	39.0	47.5	49.0
		Piracy	5.6	0.8	6.0	4.5
		International agreement on oil emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	10.1	11.6	10.6	10.4
		Exporter stability	35.8	41.7	42.7	42.7
Political Index			**30.0**	**26.9**	**30.3**	**30.3**
Economic	Internal	Primary energy diversity	40.4	37.7	34.8	33.6
		Ease of doing business	38.3	35.9	28.0	20.5
		Oil shares to primary energy	38.6	36.8	33.4	34.8
		Oil intensity	84.1	75.5	68.1	72.6
		Oil product pricing	100	100	100	100
		Oil export over GDP	6.3	8.5	7.5	8.3
		Total oil net import over demand	0.0	0.0	0.0	18.6
		Crude oil import source diversity	21.6	17.1	12.3	10.6
		Oil product import source diversity	97.2	52.8	53.2	31.4
	External	Oil export over GDP	23.6	30.7	28.9	28.3
Economic Index			**41.4**	**38.0**	**35.0**	**34.6**
Social	Internal	Oil consumption per capita	18.1	21.8	20.6	25.3
Social Index			**18.1**	**21.8**	**20.6**	**25.3**
Technical/ technology	Internal	Logistic efficiency	30.7	30.7	31.2	29.2
		Oil reserves/production	10.2	40.4	13.6	0.0
		Refinery utilisation	74.5	76.2	75.4	87.9
		Trans-border pipelines utilisation	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	0.0	0.0	0.0	0.0
	External	Oil production	14.8	9.2	14.3	8.3
Technical/technology Index			**21.0**	**24.4**	**21.6**	**19.6**
Law/Legal	Internal	Resource extraction policy	42.8	42.1	39.7	43.6
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	100	100	100	100
	External	Rule of law	35.7	36.0	38.6	39.0
Law Index			**44.6**	**44.5**	**44.6**	**45.6**
Environmental	Internal	Climate change	45.8	42.5	39.7	37.9
		Natural disaster	0.0	0.1	0.0	0.3
	External	Climate change	41.6	40.4	37.9	36.1
		Natural disaster	0.5	0.3	0.5	0.5
Environmental Index			**22.5**	**21.1**	**19.7**	**18.9**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			25.1	29.4	28.0	27.7
	Internal	Local stability	49.1	39.0	47.5	49.0
		Piracy	5.6	0.8	6.0	4.5
		International agreement on gas emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	4.7
		Exporter stability	0.0	39.8	33.5	29.0
Political Index			**25.6**	**25.5**	**28.3**	**28.3**
	Internal	Primary energy diversity	40.4	37.7	32.7	33.6
		Ease of doing business	38.3	35.9	25.9	20.5
		Gas shares to primary energy	49.9	47.9	41.9	42.9
		Gas intensity	71.8	78.9	64.0	68.8
		Gas pricing	100	100	100	100
		Gas import source diversity	0.0	50.0	50.0	23.3
Economic Index			**36.7**	**42.8**	**38.4**	**35.3**
	Internal	Gas consumption per capita	17.4	20.7	17.6	21.0
Social Index			**17.4**	**20.7**	**17.6**	**21.0**
	Internal	Logistic efficiency	30.7	30.7	31.2	29.2
		Gas reserves/production	8.1	24.3	18.3	19.8
		Regasification terminal utilisation	0.0	0.0	0.0	39.6
		Nat underground gas storage over demand	50.0	50.0	50.0	50.0
		Trans-border pipelines utilisation gas	0.0	97.8	100	48.5
		Gas self-sufficiency	0.0	0.0	0.0	0.0
	External	Liquefaction terminal utilisation	0.0	0.0	0.0	62.0
		Gas production	0.0	5.4	0.0	4.5
Technical/technology Index			**10.9**	**25.5**	**24.4**	**31.7**
	Internal	Resource extraction policy	42.8	42.1	39.7	43.6
		Gas emergency preparedness	75.0	50.0	50.0	25.0
	External	Rule of law	0.0	33.2	31.4	27.6
Law Index			**43.2**	**42.6**	**41.3**	**32.5**
	Internal	Climate change	45.8	42.5	39.7	37.9
		Natural disaster	0.0	0.1	0.0	0.3
	External	Climate change	0.0	28.1	26.1	25.0
		Natural disaster	0.0	0.0	0.0	0.1
Environmental Index			**16.8**	**19.4**	**18.0**	**17.3**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

MEXICO

Mexico	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	1,451	1,574	1,732	1,900
GDP per capita	2010 USD PPP/Person	14,116	14,344	14,599	15,355
Population	no. in million	103	110	119	124
Crude oil production	Mtoe	171	194	155	150
Oil product output	Mtoe	65	71	67	71
Gas production	Mtoe	27	31	42	40
Crude oil import	Mtoe	0.4	0.4	0.4	0.4
Oil product import	Mtoe	21	19	30	29
Total oil import	Mtoe	21	19	30	29
Gas import	Mtoe	2.4	7.7	12	21
Crude oil export	Mtoe	92	103	77	67
Oil product export	Mtoe	4.4	5.1	10	9.0
Total oil export	Mtoe	97	109	87	76
Gas export	Mtoe	0.2	0.2	0.7	0.1
Crude oil demand	Mtoe	78	91	78	83
Total oil as primary supply	Mtoe	90	100	95	99
Oil product demand	Mtoe	62	69	74	72
Gas demand	Mtoe	29	38	53	62
Other types of fuel demand	Mtoe	26	30	28	31
Total primary energy supply	Mtoe	145	169	176	191
Oil reserves	Mtoe	3,820	1,774	1,364	1,364
Gas reserves	Mtoe	752	371	318	312
Oil reserves/production ratio	years	22	9	9	9
Gas reserves/production ratio	years	28	12	8	8
Refinery capacity	Mtoe/yr	74	73	73	80
Oil intensity	toe/million 2010 USD	62	64	55	52
Gas intensity	toe/million 2010 USD	20	24	31	32
Oil per capita	toe/person	0.9	0.9	0.8	0.8
Gas per capita	toe/person	0.3	0.3	0.4	0.5

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Mexico	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	54.6	58.7	64.8	64.6
		Piracy	0.0	0.0	0.0	0.0
		International agreement on oil emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.8	1.2	0.8	0.6
		Exporter stability	32.3	50.5	41.5	36.5
Political Index			**28.7**	**31.3**	**32.0**	**31.5**
Economic	Internal	Primary energy diversity	43.2	41.2	39.9	37.8
		Ease of doing business	31.8	32.6	34.2	28.9
		Oil shares to primary energy	62.0	59.4	53.7	51.7
		Oil intensity	81.2	75.0	70.3	66.8
		Oil product pricing	100	100	100	100
		Oil export over GDP	2.4	3.8	4.0	4.0
		Total oil net import over demand	0.0	0.0	0.0	0.0
		Crude oil import source diversity	0.0	0.0	0.0	0.0
		Oil product import source diversity	77.3	38.3	51.8	67.5
	External	Oil export over GDP	1.6	3.2	3.1	3.1
Economic Index			**33.2**	**29.7**	**29.9**	**30.2**
Social	Internal	Oil per capita	21.5	23.2	20.5	21.1
Social Index			**21.5**	**23.2**	**20.5**	**21.1**
Technical/ technology	Internal	Logistic efficiency	41.3	41.0	39.1	38.1
		Oil reserves/production	0.0	59.0	60.6	59.3
		Refinery utilization	88.3	97.7	92.4	88.8
		Trans-border pipelines utilization	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	0.0	0.0	0.0	0.0
	External	Oil production	0.0	0.0	0.0	0.0
Technical/technology Index			**19.2**	**29.3**	**28.5**	**27.6**
Law/Legal	Internal	Resource extraction policy	69.2	69.2	68.7	67.8
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	100	100	100	100
	External	Rule of law	23.0	26.7	20.4	19.5
Law Index			**47.8**	**48.7**	**47.0**	**46.5**
Environ- mental	Internal	Climate change	48.3	48.3	45.9	43.8
		Natural disaster	0.1	2.7	1.3	0.1
	External	Climate change	25.7	28.0	25.8	24.8
		Natural disaster	0.0	0.2	0.0	0.1
Environmental Index			**21.3**	**22.6**	**20.9**	**19.5**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			28.2	31.3	32.2	31.9
	Internal	Local stability	54.6	58.7	64.8	64.6
		Piracy	0.0	0.0	0.0	0.0
		International agreement on gas emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	2.2	2.2
		Exporter stability	29.7	51.8	52.7	43.2
Political Index			**27.7**	**30.8**	**32.6**	**31.6**
	Internal	Primary energy diversity	43.2	41.2	38.6	37.8
		Ease of doing business	31.8	32.6	34.8	28.9
		Gas shares to primary energy	20.0	22.6	30.2	32.2
		Gas intensity	35.7	44.7	57.6	61.2
		Gas pricing	100	100	100	100
		Gas import source diversity	100	100	42.9	55.4
Economic Index			**39.4**	**40.6**	**36.2**	**37.6**
	Internal	Gas per capita	11.0	13.7	17.3	19.3
Social Index			**11.0**	**13.7**	**17.3**	**19.3**
	Internal	Logistic efficiency	41.3	41.0	39.1	38.1
		Gas reserves/production	0.0	56.9	73.0	72.6
		Regasification terminal utilization	0.0	0.0	32.3	29.7
		Nat gas underground storage over demand	100	100	100	100
		Trans-border pipelines utilization gas	12.9	26.2	24.1	41.1
		Gas self-sufficiency	7.6	19.6	21.3	34.2
	External	Liquefaction terminal utilization	0.0	0.0	37.8	25.0
		Gas production	21.1	25.8	15.0	1.9
Technical/technology Index			**22.3**	**32.7**	**42.0**	**41.4**
	Internal	Resource extraction policy	69.2	69.2	68.7	67.8
		Gas emergency preparedness	50.0	50.0	25.0	25.0
	External	Rule of law	19.3	19.5	34.0	28.1
Law Index			**48.1**	**48.1**	**43.2**	**41.2**
	Internal	Climate change	48.3	48.3	45.9	43.8
		Natural disaster	0.1	2.7	1.3	0.1
	External	Climate change	22.6	23.7	35.0	30.0
		Natural disaster	0.0	0.3	0.2	0.1
Environmental Index			**20.5**	**21.7**	**21.9**	**20.0**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

NEW ZEALAND

New Zealand	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	105.2	128.2	135.0	144.5
GDP per capita	2010 USD PPP/Person	27,263	31,003	31,028	32,526
Population	no. in million	3.9	4.1	4.4	4.4
Crude oil production	Mtoe	1.9	1.1	2.7	1.9
Oil product output	Mtoe	5.3	5.4	5.4	5.6
Gas production	Mtoe	5.1	3.2	3.9	4.0
Crude oil import	Mtoe	4.7	4.8	5.2	5.5
Oil product import	Mtoe	1.2	2.0	1.8	2.2
Total oil import	Mtoe	5.9	6.8	7.1	7.6
Gas import	Mtoe	0.0	0.0	0.0	0.0
Crude oil export	Mtoe	1.3	0.6	2.5	1.5
Oil product export	Mtoe	0.2	0.2	0.1	0.3
Total oil export	Mtoe	1.5	0.8	2.6	1.8
Gas export	Mtoe	0.0	0.0	0.0	0.0
Crude oil demand	Mtoe	5.4	5.2	5.5	5.7
Total oil as primary supply	Mtoe	5.7	6.1	6.2	6.4
Oil product demand	Mtoe	5.3	6.0	5.9	5.9
Gas demand	Mtoe	5.1	3.2	3.7	4.0
Other types of fuel demand	Mtoe	6.3	7.6	8.5	9.1
Total primary energy supply	Mtoe	17	17	18	20
Oil reserves	Mtoe	14	27	14	14
Gas reserves	Mtoe	51	56	47	48
Oil reserves/production ratio	years	7.0	25	5.0	7.4
Gas reserves/production ratio	years	10	17	12	12
Refinery capacity	Mtoe/yr	5.3	5.3	6.7	6.7
Oil intensity	toe/million 2010 USD	54	48	46	44
Gas intensity	toe/million 2010 USD	48	25	28	28
Oil per capita	toe/person	1.5	1.5	1.4	1.4
Gas per capita	toe/person	1.3	0.8	0.9	0.9

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

New Zealand	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	24.6	25.7	25.5	20.9
		Piracy	0.0	0.0	0.0	0.0
		International agreement on oil emergency	0.0	0.0	0.0	0.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	11.2	8.9	7.8	8.2
		Exporter stability	20.2	45.3	50.9	55.5
Political Index			**8.8**	**11.0**	**11.4**	**10.6**
Economic	Internal	Primary energy diversity	23.6	21.7	22.1	21.6
		Ease of doing business	12.1	9.7	10.4	10.5
		Oil shares to primary energy	33.4	36.2	33.7	32.7
		Oil intensity	66.5	54.9	55.5	53.4
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	0.7	0.5	1.0	0.9
		Total oil net import over demand	78.1	98.4	72.5	91.7
		Crude oil import source diversity	15.2	9.1	13.4	12.0
		Oil product import source diversity	67.0	21.4	26.7	31.1
	External	Oil export over GDP	16.7	22.3	25.7	26.5
Economic Index			**28.8**	**26.5**	**26.1**	**27.8**
Social	Internal	Oil per capita	24.4	25.5	24.9	26.3
Social Index			**24.4**	**25.5**	**24.9**	**26.3**
Technical/ technology	Internal	Logistic efficiency	25.9	26.0	27.0	29.4
		Oil reserves/production	72.7	2.1	80.7	71.4
		Refinery utilization	99.8	100	79.9	82.8
		Trans-border pipelines utilization	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	64.2	79.2	49.9	67.7
	External	Oil production	16.2	17.4	16.5	9.6
Technical/technology Index			**43.1**	**35.3**	**39.5**	**39.8**
Law/Legal	Internal	Resource extraction policy	21.4	21.2	18.3	29.6
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	23.8	23.8	23.8	23.8
	External	Rule of law	31.5	32.6	29.2	31.5
Law Index			**19.3**	**19.5**	**18.0**	**21.3**
Environmental	Internal	Climate change	21.4	20.4	18.9	18.5
		Natural disaster	0.0	0.0	6.9	0.3
	External	Climate change	38.5	38.9	33.9	32.5
		Natural disaster	0.0	0.1	0.2	0.1
Environmental Index			**12.9**	**12.6**	**14.0**	**11.2**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			15.8	12.8	13.7	12.4
	Internal	Local stability	24.6	25.7	25.5	20.9
		Piracy	0.0	0.0	0.0	0.0
		International agreement on gas emergency	0.0	0.0	0.0	0.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	0.0
		Exporter stability	0.0	0.0	0.0	0.0
Political Index			**5.9**	**6.1**	**6.1**	**5.0**
	Internal	Primary energy diversity	23.6	21.7	21.7	21.6
		Ease of doing business	12.1	9.7	11.2	10.5
		Gas shares to primary energy	29.6	19.1	20.3	20.4
		Gas intensity	55.8	30.0	33.3	33.6
		Gas pricing	0.0	0.0	0.0	0.0
		Gas import source diversity	0.0	0.0	0.0	0.0
Economic Index			**14.4**	**9.6**	**10.3**	**10.2**
Internal		Gas per capita	21.3	12.9	13.4	14.3
Social Index			**21.3**	**12.9**	**13.4**	**14.3**
	Internal	Logistic efficiency	25.9	26.0	27.0	29.4
		Gas reserves/production	43.0	2.9	31.8	33.3
		Regasification terminal utilization	0.0	0.0	0.0	0.0
		Nat gas underground storage over demand	100	100	100	94.1
		Trans-border pipelines utilization gas	0.0	0.0	0.0	0.0
		Gas self-sufficiency	0.1	0.0	0.0	0.0
	External	Liquefaction terminal utilization	0.0	0.0	0.0	0.0
		Gas production	0.0	0.0	0.0	0.0
Technical/technology Index			**20.1**	**15.3**	**18.9**	**18.7**
	Internal	Resource extraction policy	21.4	21.2	18.3	29.6
		Gas emergency preparedness	50.0	50.0	50.0	25.0
	External	Rule of law	0.0	0.0	0.0	0.0
Law Index			**25.5**	**25.4**	**24.4**	**19.5**
	Internal	Climate change	21.4	20.4	18.9	18.5
		Natural disaster	0.0	0.0	6.9	0.3
	External	Climate change	0.0	0.0	0.0	0.0
		Natural disaster	0.0	0.0	0.0	0.0
Environmental Index			**7.6**	**7.3**	**9.2**	**6.7**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

PAPUA NEW GUINEA

Papua New Guinea	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	9.8	10.9	14.5	18.3
GDP per capita	2010 USD PPP/Person	1,820	1,788	2,123	2,511
Population	no. in million	5.4	6.1	6.8	7.3
Crude oil production	Mtoe	3.7	2.5	0.9	0.8
Oil product output	Mtoe	0.0	1.0	0.9	1.3
Gas production	Mtoe	0.1	0.1	0.1	0.1
Crude oil import	Mtoe	0.0	0.9	0.1	1.3
Oil product import	Mtoe	0.9	0.9	0.6	1.1
Total oil import	Mtoe	0.9	1.8	0.7	2.3
Gas import	Mtoe	0.0	0.0	0.0	0.0
Crude oil export	Mtoe	3.7	2.3	0.9	0.8
Oil product export	Mtoe	0.0	0.4	0.0	0.4
Total oil export	Mtoe	3.7	2.8	0.9	1.2
Gas export	Mtoe	0.0	0.0	0.0	0.0
Crude oil demand	Mtoe	0.0	1.0	1.0	1.4
Total oil as primary supply	Mtoe	0.9	1.5	1.5	2.0
Oil product demand	Mtoe	0.9	0.4	0.5	0.6
Gas demand	Mtoe	0.1	0.1	0.1	0.1
Other types of fuel demand	Mtoe	0.1	0.2	0.4	0.4
Total primary energy supply	Mtoe	1.1	1.8	2.1	2.6
Oil reserves	Mtoe	41	21	14	10
Gas reserves	Mtoe	3.0	2.3	237	208
Oil reserves/production ratio	years	11	8.6	16	12
Gas reserves/production ratio	years	25	19	1,924	1,637
Refinery capacity	Mtoe/yr	0.0	1.6	1.6	1.8
Oil intensity	toe/million 2010 USD	93	136	104	108
Gas intensity	toe/million 2010 USD	12	11	8.5	6.9
Oil consumption per capita	toe/person	0.2	0.2	0.2	0.3
Gas consumption per capita	toe/person	0.0	0.0	0.0	0.0

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Papua New Guinea	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	56.5	69.4	66.9	60.9
		Piracy	0.0	0.0	0.0	0.0
		International agreement on oil emergency	100	100	100	100
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.3	0.0
		Exporter stability	61.4	38.7	36.5	32.0
Political Index			**44.2**	**45.6**	**44.8**	**42.9**
Economic	Internal	Primary energy diversity	67.0	69.3	55.9	62.4
		Ease of doing business	55.7	53.8	46.3	42.9
		Oil shares to primary energy	80.9	82.6	72.8	77.5
		Oil intensity	79.5	100	86.8	89.6
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	20.5	14.6	8.5	3.4
		Total oil net import over demand	0.0	0.0	0.0	56.3
		Crude oil import source diversity	88.5	100	79.6	68.8
		Oil product import source diversity	62.0	74.7	45.0	33.0
	External	Oil export over GDP	8.4	12.2	11.5	9.9
Economic Index			**39.9**	**44.3**	**35.5**	**38.6**
Social	Internal	Oil consumption per capita	12.4	18.1	16.5	20.4
Social Index			**12.4**	**18.1**	**16.5**	**20.4**
Technical/ technology	Internal	Logistic efficiency	-	-	-	-
		Oil reserves/production	30.4	46.6	0.0	22.4
		Refinery utilisation	100	61.8	58.3	72.8
		Trans-border pipelines utilisation	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	0.0	0.0	8.4	39.5
	External	Oil production	7.9	30.8	25.4	41.2
Technical/technology Index			**26.4**	**28.0**	**18.9**	**35.6**
Law/Legal	Internal	Resource extraction policy	59.3	59.4	65.1	70.6
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	100	100	100	100
	External	Rule of law	32.3	16.0	16.1	17.5
Law Index			**47.9**	**43.9**	**45.3**	**47.0**
Environmental	Internal	Climate change	68.1	68.8	67.8	67.3
		Natural disaster	0.1	0.3	0.0	0.5
	External	Climate change	36.1	26.3	22.7	21.9
		Natural disaster	0.0	0.0	0.4	0.1
Environmental Index			**30.1**	**29.2**	**28.3**	**28.2**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			27.8	28.1	24.8	25.2
	Internal	Local stability	56.5	69.4	66.9	60.9
		Piracy	0.0	0.0	0.0	0.0
		International agreement on gas emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	0.0
		Exporter stability	0.0	0.0	0.0	0.0
Political Index			**26.0**	**29.2**	**28.6**	**27.1**
	Internal	Primary energy diversity	67.0	69.3	56.5	62.4
		Ease of doing business	55.7	53.8	42.7	42.9
		Gas shares to primary energy	10.6	7.0	5.9	5.0
		Gas intensity	43.9	42.0	31.2	25.6
		Gas pricing	0.0	0.0	0.0	0.0
		Gas import source diversity	0.0	0.0	0.0	0.0
Economic Index			**21.7**	**21.0**	**16.7**	**16.6**
	Internal	Gas consumption per capita	15.6	14.5	12.7	12.2
Social Index			**15.6**	**14.5**	**12.7**	**12.2**
	Internal	Logistic efficiency	-	-	-	-
		Gas reserves/production	98.7	99.0	0.0	14.9
		Regasification terminal utilisation	0.0	0.0	0.0	0.0
		Nat underground gas storage over demand	100	100	100	100
		Trans-border pipelines utilisation gas	0.0	0.0	0.0	0.0
		Gas self-sufficiency	0.0	0.0	0.0	0.0
	External	Liquefaction terminal utilisation	0.0	0.0	0.0	0.0
		Gas production	0.0	0.0	0.0	0.0
Technical/technology Index			**29.1**	**29.2**	**14.7**	**16.9**
	Internal	Resource extraction policy	59.3	59.4	65.1	70.6
		Gas emergency preparedness	75.0	75.0	75.0	75.0
	External	Rule of law	0.0	0.0	0.0	0.0
Law Index			**49.3**	**49.3**	**51.4**	**53.4**
	Internal	Climate change	68.1	68.8	67.8	67.3
		Natural disaster	0.1	0.3	0.0	0.5
	External	Climate change	0.0	0.0	0.0	0.0
		Natural disaster	0.0	0.0	0.0	0.0
Environmental Index			**25.0**	**25.3**	**24.8**	**24.8**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

PERU

Peru	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	165.2	203.7	284.3	339.1
GDP per capita	2010 USD PPP/Person	6,375	7,377	9,678	11,095
Population	no. in million	26	28	29	31
Crude oil production	Mtoe	5.2	5.4	6.9	4.8
Oil product output	Mtoe	7.7	9.0	12.0	10.1
Gas production	Mtoe	0.5	1.6	7.6	12.0
Crude oil import	Mtoe	3.1	4.8	4.8	4.2
Oil product import	Mtoe	1.7	1.1	1.9	3.6
Total oil import	Mtoe	4.8	6.0	6.7	7.9
Gas import	Mtoe	0.0	0.0	0.0	0.0
Crude oil export	Mtoe	0.7	0.7	1.0	0.7
Oil product export	Mtoe	1.3	2.8	3.9	4.8
Total oil export	Mtoe	2.0	3.5	4.8	5.6
Gas export	Mtoe	0.0	0.0	2.1	6.1
Crude oil demand	Mtoe	7.6	9.7	10.8	11.0
Total oil as primary supply	Mtoe	7.4	7.2	8.0	9.8
Oil product demand	Mtoe	6.5	6.1	7.6	8.8
Gas demand	Mtoe	0.5	1.6	5.5	5.8
Other types of fuel demand	Mtoe	4.3	4.8	5.7	6.0
Total primary energy supply	Mtoe	12	14	19	22
Oil reserves	Mtoe	41	123	68	82
Gas reserves	Mtoe	221	304	318	383
Oil reserves/production ratio	years	7.9	23	10	17
Gas reserves/production ratio	years	447	187	42	32
Refinery capacity	Mtoe/yr	10	10	10	10
Oil intensity	toe/million 2010 USD	45	35	28	29
Gas intensity	toe/million 2010 USD	3.0	8.0	19	17
Oil consumption per capita	toe/person	0.3	0.3	0.3	0.3
Gas consumption per capita	toe/person	0.0	0.1	0.2	0.2

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Peru		Oil Security Index (%)	2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	72.0	69.5	69.5	65.4
		Piracy	1.1	1.5	3.3	2.0
		International agreement on oil emergency	100	100	100	100
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	3.7	2.6	1.5	1.4
		Exporter stability	66.1	59.5	55.5	52.5
Political Index			**49.1**	**47.9**	**48.0**	**46.3**
Economic	Internal	Primary energy diversity	41.9	33.7	30.2	30.9
		Ease of doing business	49.7	44.5	35.8	28.1
		Oil shares to primary energy	60.7	52.6	41.6	45.3
		Oil intensity	78.1	55.8	48.0	49.3
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	0.7	1.9	2.0	2.4
		Total oil net import over demand	37.9	34.8	23.3	23.6
		Crude oil import source diversity	28.0	32.4	26.4	35.8
		Oil product import source diversity	55.3	49.8	65.2	97.7
	External	Oil export over GDP	16.3	9.9	7.7	10.4
Economic Index			**33.4**	**27.9**	**24.2**	**28.7**
Social	Internal	Oil consumption per capita	18.0	16.5	17.3	20.7
Social Index			**18.0**	**16.5**	**17.3**	**20.7**
Technical/ technology	Internal	Logistic efficiency	44.3	44.3	44.0	42.2
		Oil reserves/production	72.6	20.8	65.7	40.6
		Refinery utilisation	76.2	88.9	100	99.8
		Trans-border pipelines utilisation	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	32.0	44.3	36.3	56.6
	External	Oil production	20.7	12.8	8.0	3.9
Technical/technology Index			**39.0**	**32.9**	**38.9**	**36.9**
Law/Legal	Internal	Resource extraction policy	50.9	50.7	48.4	59.2
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	100	100	100	100
	External	Rule of law	64.0	46.1	43.5	43.7
Law Index			**53.7**	**49.2**	**48.0**	**50.7**
Environmental	Internal	Climate change	55.9	53.1	48.7	47.3
		Natural disaster	0.0	0.0	0.5	0.9
	External	Climate change	52.6	40.8	38.8	38.8
		Natural disaster	0.1	0.2	0.6	0.1
Environmental Index			**27.5**	**25.0**	**23.4**	**23.0**

		Gas Security Index (%)	2000	2005	2010	2013
Average Gas Security Index			23.5	25.1	27.9	28.1
Internal		Local stability	72.0	69.5	69.5	65.4
		Piracy	1.1	1.5	3.3	2.0
		International agreement on gas emergency	100	100	100	100
External		Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	0.0
		Exporter stability	0.0	0.0	0.0	0.0
Political Index			**42.3**	**41.8**	**42.3**	**40.9**
Internal		Primary energy diversity	41.9	33.7	29.1	30.9
		Ease of doing business	49.7	44.5	32.3	28.1
		Gas shares to primary energy	4.0	11.9	28.6	26.9
		Gas intensity	7.9	21.5	52.7	47.3
		Gas pricing	0.0	0.0	0.0	0.0
		Gas import source diversity	0.0	0.0	0.0	0.0
Economic Index			**12.7**	**13.6**	**17.4**	**16.3**
Internal		Gas consumption per capita	1.6	5.0	15.7	16.1
Social Index			**1.6**	**5.0**	**15.7**	**16.1**
Internal		Logistic efficiency	44.3	44.3	44.0	42.2
		Gas reserves/production	0.0	58.1	90.7	92.8
		Regasification terminal utilisation	0.0	0.0	0.0	0.0
		Nat underground gas storage over demand	100	100	100	100
		Trans-border pipelines utilisation gas	0.0	0.0	0.0	0.0
		Gas self-sufficiency	0.0	0.0	0.0	0.0
External		Liquefaction terminal utilisation	0.0	0.0	0.0	0.0
		Gas production	0.0	0.0	0.0	0.0
Technical/technology Index			**17.6**	**24.7**	**28.7**	**28.7**
Internal		Resource extraction policy	50.9	50.7	48.4	59.2
		Gas emergency preparedness	75.0	75.0	75.0	75.0
External		Rule of law	0.0	0.0	0.0	0.0
Law Index			**46.2**	**46.1**	**45.2**	**49.2**
Internal		Climate change	55.9	53.1	48.7	47.3
		Natural disaster	0.0	0.0	0.5	0.9
External		Climate change	0.0	0.0	0.0	0.0
		Natural disaster	0.0	0.0	0.0	0.0
Environmental Index			**20.5**	**19.5**	**18.0**	**17.7**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

PHILIPPINES

Philippines	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	322.8	404.0	514.0	609.9
GDP per capita	2010 USD PPP/Person	4,142	4,690	5,524	6,250
Population	no. in million	78	86	93	98
Crude oil production	Mtoe	0	1	1	1
Oil product output	Mtoe	15	10	8	7
Gas production	Mtoe	0	3	3	3
Crude oil import	Mtoe	15	11	9	7
Oil product import	Mtoe	3	5	7	8
Total oil import	Mtoe	18	16	16	15
Gas import	Mtoe	0	0	0	0
Crude oil export	Mtoe	0	1	1	1
Oil product export	Mtoe	2	1	1	1
Total oil export	Mtoe	2	2	2	1
Gas export	Mtoe	0	0	0	0
Crude oil demand	Mtoe	15	11	9	7
Total oil as primary supply	Mtoe	16	14	14	14
Oil product demand	Mtoe	13	12	11	12
Gas demand	Mtoe	0	3	3	3
Other types of fuel demand	Mtoe	24	22	24	28
Total primary energy supply	Mtoe	40	39	40	45
Oil reserves	Mtoe	41	14	14	14
Gas reserves	Mtoe	81	74	61	53
Oil reserves/production ratio	years	725	17	14	18
Gas reserves/production ratio	years	9,261	27	20	18
Refinery capacity	Mtoe/yr	17	17	17	17
Oil intensity	toe/million 2010 USD	50	34	26	22
Gas intensity	toe/million 2010 USD	0	7	6	5
Oil per capita	toe/person	0.2	0.2	0.1	0.1
Gas per capita	toe/person	0.0	0.0	0.0	0.0

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Philippines	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	78.3	74.4	82.6	71.1
		Piracy	2.4	0.0	1.7	1.5
		International agreement on oil emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	12.0	12.2	10.4	10.0
		Exporter stability	41.1	37.0	37.5	34.2
Political Index			**36.9**	**35.0**	**37.3**	**34.1**
Economic	Internal	Primary energy diversity	28.2	23.8	22.3	22.4
		Ease of doing business	60.5	58.6	49.3	44.1
		Oil shares to primary energy	40.1	35.9	33.7	30.3
		Oil intensity	91.9	56.4	47.8	39.9
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	0.5	0.6	0.2	0.2
		Total oil net import over demand	100	98.3	100	100
		Crude oil import source diversity	23.3	39.4	27.0	25.9
		Oil product import source diversity	38.1	32.9	22.3	26.0
	External	Oil export over GDP	18.5	24.7	21.7	19.9
Economic Index			**36.3**	**34.9**	**30.3**	**28.9**
Social	Internal	Oil per capita	19.4	15.4	13.9	13.3
Social Index			**19.4**	**15.4**	**13.9**	**13.3**
Technical/ technology	Internal	Logistic efficiency	42.9	42.1	37.2	39.7
		Oil reserves/production	0.0	97.6	98.1	97.5
		Refinery utilization	89.7	60.0	50.3	44.3
		Trans-border pipelines utilization	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	99.6	92.7	89.0	89.9
	External	Oil production	19.3	5.7	11.5	2.3
Technical/technology Index			**39.5**	**44.9**	**43.7**	**40.9**
Law/Legal	Internal	Resource extraction policy	45.8	44.5	35.7	47.2
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	86.9	86.9	86.9	86.9
	External	Rule of law	37.9	31.9	31.2	29.1
Law Index			**42.6**	**40.7**	**38.4**	**40.7**
Environmental	Internal	Climate change	58.6	56.0	54.1	51.0
		Natural disaster	8.2	0.2	5.9	26.3
	External	Climate change	41.1	32.9	30.8	25.6
		Natural disaster	0.1	0.2	1.4	0.2
Environmental Index			**30.1**	**25.1**	**26.4**	**32.0**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			21.0	25.7	25.4	26.2
	Internal	Local stability	78.3	74.4	82.6	71.1
		Piracy	2.4	0.0	1.7	1.5
		International agreement on gas emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	0.0
		Exporter stability	0.0	0.0	0.0	0.0
Political Index			**31.1**	**29.6**	**32.0**	**29.2**
	Internal	Primary energy diversity	28.2	23.8	22.9	22.4
		Ease of doing business	60.5	58.6	45.7	44.1
		Gas shares to primary energy	0.0	6.9	7.5	6.5
		Gas intensity	0.2	52.6	46.9	37.8
		Gas pricing	0.0	0.0	0.0	0.0
		Gas import source diversity	0.0	0.0	0.0	0.0
Economic Index			**10.6**	**16.9**	**14.7**	**13.2**
	Internal	Gas per capita	0.1	15.9	16.6	15.1
Social Index			**0.1**	**15.9**	**16.6**	**15.1**
	Internal	Logistic efficiency	42.9	42.1	37.2	39.7
		Gas reserves/production	0.0	99.7	99.8	99.8
		Regasification terminal utilization	0.0	0.0	0.0	0.0
		Nat gas underground storage over demand	100	100	100	100
		Trans-border pipelines utilization gas	0.0	0.0	0.0	0.0
		Gas self-sufficiency	0.0	0.0	0.0	0.0
	External	Liquefaction terminal utilization	0.0	0.0	0.0	0.0
		Gas production	0.0	0.0	0.0	0.0
Technical/technology Index			**17.0**	**28.8**	**28.2**	**28.5**
	Internal	Resource extraction policy	45.8	44.5	35.7	47.2
		Gas emergency preparedness	75.0	75.0	75.0	75.0
	External	Rule of law	0.0	0.0	0.0	0.0
Law Index			**43.1**	**42.7**	**39.5**	**43.6**
	Internal	Climate change	58.6	56.0	54.1	51.0
		Natural disaster	8.2	0.2	5.9	26.3
	External	Climate change	0.0	0.0	0.0	0.0
		Natural disaster	0.0	0.0	0.0	0.0
Environmental Index			**23.9**	**20.1**	**21.4**	**27.6**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

RUSSIA

Russia	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	1,827.2	2,460.4	2,928.1	3,199.3
GDP per capita	2010 USD PPP/Person	12,464	17,143	20,498	22,294
Population	no. in million	147	144	143	144
Crude oil production	Mtoe	323	469	507	524
Oil product output	Mtoe	180	209	249	269
Gas production	Mtoe	471	516	540	563
Crude oil import	Mtoe	6	2	1	1
Oil product import	Mtoe	0	0	3	2
Total oil import	Mtoe	6	2	4	3
Gas import	Mtoe	11	6	3	7
Crude oil export	Mtoe	145	254	248	238
Oil product export	Mtoe	53	84	111	116
Total oil export	Mtoe	198	337	359	354
Gas export	Mtoe	157	167	154	174
Crude oil demand	Mtoe	184	217	257	286
Total oil as primary supply	Mtoe	126	129	140	160
Oil product demand	Mtoe	90	92	109	122
Gas demand	Mtoe	319	350	383	395
Other types of fuel demand	Mtoe	174	173	166	176
Total primary energy supply	Mtoe	619	652	690	731
Oil reserves	Mtoe	6,685	8,186	8,186	10,914
Gas reserves	Mtoe	39,428	40,374	41,400	44,402
Oil reserves/production ratio	years	21	17	16	21
Gas reserves/production ratio	years	84	78	77	79
Refinery capacity	Mtoe/yr	276	269	274	300
Oil intensity	toe/million 2010 USD	69	53	48	50
Gas intensity	toe/million 2010 USD	175	142	131	123
Oil consumption per capita	toe/person	0.9	0.9	1.0	1.1
Gas consumption per capita	toe/person	2.2	2.4	2.7	2.8

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Russia	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	78.4	75.0	68.3	64.7
		Piracy	0.0	0.0	0.0	0.0
		International agreement on oil emergency	0.0	0.0	0.0	0.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	0.0
		Exporter stability	0.0	0.0	0.0	0.0
Political Index			**19.6**	**18.8**	**17.1**	**16.2**
Economic	Internal	Primary energy diversity	34.8	36.1	36.5	36.6
		Ease of doing business	37.8	38.7	43.2	41.6
		Oil shares to primary energy	20.4	19.8	20.3	21.9
		Oil intensity	93.4	62.7	63.3	65.9
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	13.9	15.3	13.5	12.6
		Total oil net import over demand	0.0	0.0	0.0	0.0
		Crude oil import source diversity	0.0	0.0	0.0	0.0
		Oil product import source diversity	0.0	0.0	0.0	0.0
	External	Oil export over GDP	0.0	0.0	0.0	0.0
Economic Index			**16.7**	**14.4**	**15.0**	**14.9**
Social	Internal	Oil consumption per capita	17.4	18.9	20.9	24.7
Social Index			**17.4**	**18.9**	**20.9**	**24.7**
Technical/ technology	Internal	Logistic efficiency	50.8	50.4	47.8	47.2
		Oil reserves/production	4.2	19.1	25.2	3.6
		Refinery utilisation	65.3	77.7	90.6	89.8
		Trans-border pipelines utilisation	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	0.0	0.0	0.0	0.0
	External	Oil production	0.0	0.0	0.0	0.0
Technical/technology Index			**18.1**	**22.1**	**24.5**	**21.1**
Law/Legal	Internal	Resource extraction policy	83.4	84.1	91.4	83.7
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	0.0	0.0	0.0	0.0
	External	Rule of law	0.0	0.0	0.0	0.0
Law Index			**20.8**	**21.0**	**22.9**	**20.9**
Environmental	Internal	Climate change	39.2	38.7	36.7	33.7
		Natural disaster	0.1	0.0	0.0	0.2
	External	Climate change	0.0	0.0	0.0	0.0
		Natural disaster	0.0	0.0	0.0	0.0
Environmental Index			**14.7**	**14.5**	**13.8**	**12.7**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			23.7	24.1	24.3	23.6
Internal		Local stability	78.4	75.0	68.3	64.7
		Piracy	0.0	0.0	0.0	0.0
		International agreement on gas emergency	0.0	0.0	0.0	0.0
External		Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	0.0
		Exporter stability	0.0	0.0	0.0	0.0
Political Index			**19.2**	**18.3**	**16.7**	**15.8**
Internal		Primary energy diversity	34.8	36.1	37.7	36.6
		Ease of doing business	37.8	38.7	45.1	41.6
		Gas shares to primary energy	51.5	53.6	55.6	54.1
		Gas intensity	100.0	90.7	87.5	85.4
		Gas pricing	100	100	100	100
		Gas import source diversity	0.0	0.0	0.0	0.0
Economic Index			**39.6**	**39.0**	**39.8**	**38.8**
Internal		Gas consumption per capita	21.5	24.9	25.0	26.7
Social Index			**21.5**	**24.9**	**25.0**	**26.7**
Internal		Logistic efficiency	50.8	50.4	47.8	47.2
		Gas reserves/production	3.1	9.5	11.4	8.8
		Regasification terminal utilisation	0.0	0.0	0.0	0.0
		Nat underground gas storage over demand	82.5	83.9	84.0	84.1
		Trans-border pipelines utilisation gas	0.0	0.0	0.0	0.0
		Gas self-sufficiency	0.0	0.0	0.0	0.0
External		Liquefaction terminal utilisation	0.0	0.0	0.0	0.0
		Gas production	0.0	0.0	0.0	0.0
Technical/technology Index			**16.7**	**17.6**	**17.5**	**17.1**
Internal		Resource extraction policy	83.4	84.1	91.4	83.7
		Gas emergency preparedness	0.0	0.0	0.0	0.0
External		Rule of law	0.0	0.0	0.0	0.0
Law Index			**30.6**	**30.8**	**33.5**	**30.7**
Internal		Climate change	39.2	38.7	36.7	33.7
		Natural disaster	0.1	0.0	0.0	0.2
External		Climate change	0.0	0.0	0.0	0.0
		Natural disaster	0.0	0.0	0.0	0.0
Environmental Index			**14.4**	**14.2**	**13.5**	**12.4**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

SINGAPORE

Singapore	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	203.9	258.8	358.4	411.1
GDP per capita	2010 USD PPP/Person	50,618	60,669	70,598	76,149
Population	no. in million	4	4	5	5
Crude oil production	Mtoe	0	0	0	0
Oil product output	Mtoe	42	59	51	51
Gas production	Mtoe	0	0	0	0
Crude oil import	Mtoe	43	60	47	46
Oil product import	Mtoe	39	48	102	103
Total oil import	Mtoe	81	108	150	149
Gas import	Mtoe	1	6	7	9
Crude oil export	Mtoe	0	0	0	1
Oil product export	Mtoe	42	63	87	84
Total oil export	Mtoe	42	64	88	85
Gas export	Mtoe	0	0	0	0
Crude oil demand	Mtoe	43	60	47	45
Total oil as primary supply	Mtoe	17	16	18	16
Oil product demand	Mtoe	6	10	11	14
Gas demand	Mtoe	1	6	7	9
Other types of fuel demand	Mtoe	0	0	1	1
Total primary energy supply	Mtoe	19	22	25	26
Oil reserves	Mtoe	0	0	0	0
Gas reserves	Mtoe	0	0	0	0
Oil reserves/production ratio	years	0	0	0	0
Gas reserves/production ratio	years	0	0	0	0
Refinery capacity	Mtoe/yr	65	71	71	70
Oil intensity	toe/million 2010 USD	85	60	49	40
Gas intensity	toe/million 2010 USD	5	22	20	22
Oil consumption per capita	toe/person	4.3	3.7	3.5	3.0
Gas consumption per capita	toe/person	0.3	1.3	1.4	1.6

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Singapore	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	29.1	27.4	27.2	23.1
		Piracy	1.3	1.8	1.0	4.5
		International agreement on oil emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	18.5	15.3	15.0	16.0
		Exporter stability	44.5	46.4	46.5	48.0
Political Index			**25.4**	**24.9**	**24.7**	**24.7**
Economic	Internal	Primary energy diversity	86.7	59.0	54.2	50.6
		Ease of doing business	8.4	11.4	8.5	7.6
		Oil shares to primary energy	92.9	72.3	69.3	62.4
		Oil intensity	83.1	51.4	46.8	37.6
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	14.2	27.5	32.8	36.4
		Total oil net import over demand	100	100	100	100
		Crude oil import source diversity	15.8	18.9	18.5	18.5
		Oil product import source diversity	10.8	6.7	6.9	7.1
	External	Oil export over GDP	26.3	26.5	22.1	25.4
Economic Index			**40.9**	**35.6**	**33.7**	**33.0**
Social	Internal	Oil consumption per capita	32.2	30.2	29.6	28.2
Social Index			**32.2**	**30.2**	**29.6**	**28.2**
Technical/ technology	Internal	Logistic efficiency	16.9	17.1	18.2	18.7
		Oil reserves/production	100	100	100	100
		Refinery utilisation	64.0	83.8	71.3	72.3
		Trans-border pipelines utilisation	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	100	100	100	100
	External	Oil production	23.0	11.1	12.6	2.6
Technical/technology Index			**47.9**	**47.9**	**46.6**	**44.3**
Law/Legal	Internal	Resource extraction policy	0.0	0.0	0.0	0.0
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	51.6	51.6	51.6	51.6
	External	Rule of law	44.5	41.3	40.3	43.3
Law Index			**23.8**	**23.0**	**22.7**	**23.5**
Environmental	Internal	Climate change	28.9	27.4	24.3	22.3
		Natural disaster	0.0	0.0	0.0	0.0
	External	Climate change	48.8	42.9	39.4	39.6
		Natural disaster	0.5	0.4	1.0	0.3
Environmental Index			**17.0**	**15.7**	**14.2**	**13.3**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			24.0	26.6	26.0	25.8
	Internal	Local stability	29.1	27.4	27.2	23.1
		Piracy	1.3	1.8	1.0	4.5
		International agreement on gas emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	1.6
		Exporter stability	49.1	72.4	63.7	56.4
Political Index			**24.0**	**25.8**	**24.8**	**24.1**
	Internal	Primary energy diversity	86.7	59.0	56.1	50.6
		Ease of doing business	8.4	11.4	8.2	7.6
		Gas shares to primary energy	6.0	25.8	28.4	34.0
		Gas intensity	13.8	55.3	52.2	56.4
		Gas pricing	0.0	0.0	0.0	0.0
		Gas import source diversity	100	70.5	71.4	53.7
Economic Index			**26.3**	**27.1**	**26.4**	**24.7**
	Internal	Gas consumption per capita	4.0	19.3	19.7	23.4
Social Index			**4.0**	**19.3**	**19.7**	**23.4**
	Internal	Logistic efficiency	16.9	17.1	18.2	18.7
		Gas reserves/production	0.0	0.0	0.0	0.0
		Regasification terminal utilisation	0.0	0.0	0.0	26.6
		Nat underground gas storage over demand	100	100	100	100
		Trans-border pipelines utilisation gas	97.8	59.5	73.1	93.2
		Gas self-sufficiency	100	100	100	100
	External	Liquefaction terminal utilisation	0.0	0.0	0.0	10.5
		Gas production	36.1	11.2	0.9	6.3
Technical/technology Index			**43.3**	**35.3**	**35.7**	**43.6**
	Internal	Resource extraction policy	0.0	0.0	0.0	0.0
		Gas emergency preparedness	50.0	50.0	50.0	25.0
	External	Rule of law	43.8	61.4	58.8	57.7
Law Index			**30.0**	**34.7**	**34.0**	**24.5**
	Internal	Climate change	28.9	27.4	24.3	22.3
		Natural disaster	0.0	0.0	0.0	0.0
	External	Climate change	45.8	53.8	50.0	48.4
		Natural disaster	0.0	0.1	0.1	0.2
Environmental Index			**16.7**	**17.2**	**15.6**	**14.7**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

CHINESE TAIPEI

Chinese Taipei	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	514.3	626.7	773.2	837.5
GDP per capita	2010 USD PPP/Person	23,086	27,523	33,384	35,831
Population	no. in million	22	23	23	23
Crude oil production	Mtoe	0	0	0	0
Oil product output	Mtoe	37	54	46	45
Gas production	Mtoe	1	0	0	0
Crude oil import	Mtoe	39	55	47	45
Oil product import	Mtoe	8	8	17	16
Total oil import	Mtoe	47	64	64	61
Gas import	Mtoe	5	8	13	14
Crude oil export	Mtoe	0	0	0	0
Oil product export	Mtoe	2	16	16	17
Total oil export	Mtoe	2	16	16	17
Gas export	Mtoe	0	0	0	0
Crude oil demand	Mtoe	39	55	46	45
Total oil as primary supply	Mtoe	38	43	44	42
Oil product demand	Mtoe	28	35	39	37
Gas demand	Mtoe	6	9	13	13
Other types of fuel demand	Mtoe	41	50	54	54
Total primary energy supply	Mtoe	85	102	111	109
Oil reserves	Mtoe	0	0	0	0
Gas reserves	Mtoe	5	4	3	3
Oil reserves/production ratio	years	0	0	0	0
Gas reserves/production ratio	years	9	9	14	10
Refinery capacity	Mtoe/yr	36	58	60	60
Oil intensity	toe/million 2010 USD	74	69	57	50
Gas intensity	toe/million 2010 USD	11	14	17	16
Oil per capita	toe/person	1.7	1.9	1.9	1.8
Gas per capita	toe/person	0.2	0.4	0.6	0.6

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Chinese Taipei	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	40.6	37.6	33.3	32.7
		Piracy	0.0	0.0	0.0	0.0
		International agreement on oil emergency	100	100	100	100
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	16.1	19.9	18.6	17.1
		Exporter stability	41.2	43.9	45.0	43.3
Political Index			**39.7**	**39.5**	**38.4**	**38.0**
Economic	Internal	Primary energy diversity	34.6	33.6	32.8	31.2
		Ease of doing business	30.6	30.9	30.5	20.8
		Oil shares to primary energy	45.1	42.4	39.5	38.6
		Oil intensity	86.9	71.3	64.9	57.0
		Oil product pricing	100	100	100	100
		Oil export over GDP	0.5	2.4	3.3	4.6
		Total oil net import over demand	100	100	100	100
		Crude oil import source diversity	12.1	18.9	22.6	24.7
		Oil product import source diversity	0.0	16.3	8.7	7.1
	External	Oil export over GDP	15.8	35.4	27.4	28.1
Economic Index			**42.1**	**43.4**	**39.7**	**38.9**
Social	Internal	Oil per capita	23.3	27.3	27.8	27.7
Social Index			**23.3**	**27.3**	**27.8**	**27.7**
Technical/ technology	Internal	Logistic efficiency	26.7	26.6	25.9	25.8
		Oil reserves/production	100	100	100	100
		Refinery utilization	100	92.8	77.4	75.7
		Trans-border pipelines utilization	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	99.9	99.9	100	100
	External	Oil production	9.6	4.9	7.9	1.5
Technical/technology Index			**50.9**	**48.7**	**47.0**	**45.1**
Law/Legal	Internal	Resource extraction policy	0.0	0.0	0.0	0.0
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	14.2	14.2	14.2	14.2
	External	Rule of law	21.3	39.3	38.5	36.3
Law Index			**9.0**	**13.7**	**13.5**	**12.9**
Environmental	Internal	Climate change	30.8	29.3	28.3	27.0
		Natural disaster	0.0	0.0	0.0	0.0
	External	Climate change	21.8	42.6	39.1	34.9
		Natural disaster	0.0	0.1	0.2	0.3
Environmental Index			**14.2**	**16.4**	**15.6**	**14.6**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			30.2	30.5	29.9	30.0
	Internal	Local stability	40.6	37.6	33.3	32.7
		Piracy	0.0	0.0	0.0	0.0
		International agreement on gas emergency	100	100	100	100
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.4	11.0	15.5
		Exporter stability	73.7	59.5	48.7	41.9
Political Index			**40.5**	**38.5**	**37.4**	**37.1**
	Internal	Primary energy diversity	34.6	33.6	31.8	31.2
		Ease of doing business	30.6	30.9	25.6	20.8
		Gas shares to primary energy	6.5	8.7	11.9	12.1
		Gas intensity	33.6	44.8	54.9	50.4
		Gas pricing	50.0	50.0	50.0	50.0
		Gas import source diversity	51.7	44.9	17.2	32.4
Economic Index			**24.6**	**25.3**	**22.8**	**23.4**
	Internal	Gas per capita	8.2	12.9	18.5	18.3
Social Index			**8.2**	**12.9**	**18.5**	**18.3**
	Internal	Logistic efficiency	26.7	26.6	25.9	25.8
		Gas reserves/production	36.1	35.4	0.0	24.1
		Regasification terminal utilization	59.8	80.1	93.1	100
		Nat gas underground storage over demand	100	100	100	100
		Trans-border pipelines utilization gas	0.0	0.0	0.0	0.0
		Gas self-sufficiency	89.2	95.1	98.2	97.9
	External	Liquefaction terminal utilization	100	100	100	99.0
		Gas production	25.3	12.7	9.9	3.0
Technical/technology Index			**55.0**	**56.2**	**53.5**	**56.0**
	Internal	Resource extraction policy	0.0	0.0	0.0	0.0
		Gas emergency preparedness	50.0	50.0	50.0	50.0
	External	Rule of law	56.3	52.0	44.7	41.0
Law Index			**34.0**	**32.7**	**30.6**	**29.6**
	Internal	Climate change	30.8	29.3	28.3	27.0
		Natural disaster	0.0	0.0	0.0	0.0
	External	Climate change	54.0	48.9	44.1	43.4
		Natural disaster	0.2	0.1	0.1	0.1
Environmental Index			**18.7**	**17.5**	**16.4**	**15.9**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

THAILAND

Thailand	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	546.0	700.2	834.2	914.7
GDP per capita	2010 USD PPP/Person	8,709	10,631	12,508	13,561
Population	no. in million	63	66	67	67
Crude oil production	Mtoe	8	13	17	19
Oil product output	Mtoe	37	47	54	59
Gas production	Mtoe	16	18	25	28
Crude oil import	Mtoe	32	42	43	45
Oil product import	Mtoe	1	2	2	3
Total oil import	Mtoe	33	44	45	48
Gas import	Mtoe	2	7	8	9
Crude oil export	Mtoe	1	3	2	2
Oil product export	Mtoe	5	6	11	12
Total oil export	Mtoe	5	9	13	14
Gas export	Mtoe	0	0	0	0
Crude oil demand	Mtoe	40	53	59	67
Total oil as primary supply	Mtoe	32	44	45	53
Oil product demand	Mtoe	29	39	43	50
Gas demand	Mtoe	17	26	33	38
Other types of fuel demand	Mtoe	23	30	40	43
Total primary energy supply	Mtoe	72	99	118	134
Oil reserves	Mtoe	55	41	55	55
Gas reserves	Mtoe	324	274	270	214
Oil reserves/production ratio	years	7	3	3	3
Gas reserves/production ratio	years	21	15	11	8
Refinery capacity	Mtoe/yr	45	54	61	62
Oil intensity	toe/million 2010 USD	58	62	54	58
Gas intensity	toe/million 2010 USD	32	37	40	41
Oil per capita	toe/person	0.5	0.7	0.7	0.8
Gas per capita	toe/person	0.3	0.4	0.5	0.6

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Thailand	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	42.3	67.0	78.6	76.2
		Piracy	2.1	0.3	0.7	0.0
		International agreement on oil emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	16.5	14.9	18.7	18.0
		Exporter stability	48.0	41.4	22.4	41.7
Political Index			**28.9**	**33.9**	**35.5**	**36.3**
Economic	Internal	Primary energy diversity	26.9	27.6	26.0	25.6
		Ease of doing business	34.8	33.8	27.5	26.0
		Oil shares to primary energy	44.1	44.0	38.1	39.3
		Oil intensity	94.5	87.3	84.8	90.5
		Oil product pricing	100	100	100	100
		Oil export over GDP	0.0	0.0	0.0	0.0
		Total oil net import over demand	86.3	79.6	71.2	65.4
		Crude oil import source diversity	13.5	19.0	19.3	23.9
		Oil product import source diversity	15.8	16.3	16.4	15.1
	External	Oil export over GDP	27.6	30.1	28.1	31.9
Economic Index			**41.4**	**41.4**	**38.7**	**40.0**
Social	Internal	Oil per capita	14.3	19.0	19.6	23.4
Social Index			**14.3**	**19.0**	**19.6**	**23.4**
Technical/ technology	Internal	Logistic efficiency	34.0	34.0	34.2	33.9
		Oil reserves/production	20.9	63.1	63.5	67.0
		Refinery utilization	82.5	88.2	87.5	95.8
		Trans-border pipelines utilization	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	79.8	75.4	70.2	71.1
	External	Oil production	14.7	14.1	15.1	8.8
Technical/technology Index			**36.0**	**42.3**	**41.8**	**42.0**
Law/Legal	Internal	Resource extraction policy	40.9	40.9	43.4	39.1
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	58.8	58.8	58.8	58.8
	External	Rule of law	45.9	36.9	39.5	37.7
Law Index			**36.5**	**34.2**	**35.5**	**33.9**
Environmental	Internal	Climate change	45.2	45.3	42.8	42.2
		Natural disaster	5.4	1.2	23.2	5.2
	External	Climate change	50.6	41.5	40.1	37.9
		Natural disaster	0.2	0.1	0.1	0.1
Environmental Index			**25.3**	**22.6**	**29.7**	**22.5**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			32.4	34.6	37.1	34.3
	Internal	Local stability	42.3	67.0	78.6	76.2
		Piracy	2.1	0.3	0.7	0.0
		International agreement on gas emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	8.0	8.0	8.3	10.9
		Exporter stability	84.5	69.1	75.7	67.1
Political Index			**31.3**	**35.3**	**38.8**	**37.5**
	Internal	Primary energy diversity	26.9	27.6	25.8	25.6
		Ease of doing business	34.8	33.8	25.4	26.0
		Gas shares to primary energy	24.0	26.2	28.0	28.2
		Gas intensity	50.8	62.5	68.3	72.8
		Gas pricing	100.0	100	100.0	100
		Gas import source diversity	100	100	100	68.9
Economic Index			**40.1**	**41.7**	**41.4**	**38.3**
Internal	Gas per capita		9.7	13.9	17.0	19.5
Social Index			**9.7**	**13.9**	**17.0**	**19.5**
	Internal	Logistic efficiency	34.0	34.0	34.2	33.9
		Gas reserves/production	16.1	40.1	55.8	69.4
		Regasification terminal utilization	0.0	0.0	0.0	27.9
		Nat gas underground storage over demand	100	100	100	100
		Trans-border pipelines utilization gas	11.0	73.5	73.1	70.5
		Gas self-sufficiency	10.0	28.6	25.0	25.0
	External	Liquefaction terminal utilization	0.0	0.0	0.0	16.8
		Gas production	74.9	9.8	10.9	8.7
Technical/technology Index			**31.1**	**34.3**	**35.8**	**42.5**
	Internal	Resource extraction policy	40.9	40.9	43.4	39.1
		Gas emergency preparedness	50.0	50.0	50.0	25.0
	External	Rule of law	76.6	83.0	80.2	67.9
Law Index			**54.4**	**56.2**	**56.3**	**42.3**
	Internal	Climate change	45.2	45.3	42.8	42.2
		Natural disaster	5.4	1.2	23.2	5.2
	External	Climate change	68.4	67.0	66.6	61.3
		Natural disaster	0.0	0.0	0.8	0.1
Environmental Index			**27.8**	**26.2**	**33.2**	**25.7**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

THE UNITED STATES

USA	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	12,713	14,408	14,964	15,902
GDP per capita	2010 USD PPP/Person	45,056	48,756	48,374	50,244
Population	no. in million	282	296	309	316
Crude oil production	Mtoe	366	323	347	476
Oil product output	Mtoe	844	861	839	821
Gas production	Mtoe	447	421	495	567
Crude oil import	Mtoe	524	599	540	439
Oil product import	Mtoe	76	118	83	66
Total oil import	Mtoe	600	717	623	505
Gas import	Mtoe	88	101	87	67
Crude oil export	Mtoe	6	5	9	30
Oil product export	Mtoe	44	53	106	139
Total oil export	Mtoe	51	58	115	169
Gas export	Mtoe	6	17	26	36
Crude oil demand	Mtoe	887	912	876	890
Total oil as primary supply	Mtoe	871	929	806	780
Oil product demand	Mtoe	793	842	757	729
Gas demand	Mtoe	548	507	556	610
Other types of fuel demand	Mtoe	855	883	854	798
Total primary energy supply	Mtoe	2,273	2,319	2,215	2,188
Oil reserves	Mtoe	3,274	3,138	3,411	5,048
Gas reserves	Mtoe	4,522	5,208	7,758	8,616
Oil reserves/production ratio	years	9	10	10	11
Gas reserves/production ratio	years	10	12	16	15
Refinery capacity	Mtoe/yr	826	863	883	893
Oil intensity	toe/million 2010 USD	69	64	54	49
Gas intensity	toe/million 2010 USD	43	35	37	38
Oil per capita	toe/person	3.1	3.1	2.6	2.5
Gas per capita	toe/person	1.9	1.7	1.8	1.9

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

USA	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	29.7	51.8	41.3	37.3
		Piracy	0.3	0.0	0.0	0.0
		International agreement on oil emergency	0.0	0.0	0.0	0.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	1.5	1.5	1.2	1.6
		Exporter stability	39.3	42.3	43.7	40.4
Political Index			**10.9**	**16.6**	**14.1**	**12.8**
Economic	Internal	Primary energy diversity	34.4	26.8	24.2	22.7
		Ease of doing business	14.2	12.5	14.6	15.1
		Oil shares to primary energy	38.3	40.1	36.4	35.7
		Oil intensity	72.1	62.5	55.7	50.7
		Oil product pricing	0.0	0.0	0.0	0.0
		Oil export over GDP	0.1	0.2	0.5	0.8
		Total oil net import over demand	63.1	71.0	63.1	43.0
		Crude oil import source diversity	10.6	10.7	11.5	15.8
		Oil product import source diversity	9.0	7.3	10.7	12.3
	External	Oil export over GDP	9.7	11.0	8.3	9.0
Economic Index			**22.4**	**21.9**	**20.0**	**18.5**
Social	Internal	Oil per capita	31.4	34.4	29.2	29.6
Social Index			**31.4**	**34.4**	**29.2**	**29.6**
Technical/ technology	Internal	Logistic efficiency	23.0	23.0	22.9	21.5
		Oil reserves/production	19.0	12.0	11.0	4.0
		Refinery utilization	100.0	99.8	95.0	92.0
		Trans-border pipelines utilization	100.0	84.1	66.3	80.2
		Crude oil self-sufficiency	41.2	64.6	60.4	46.5
	External	Oil production	12.3	9.4	10.7	4.5
Technical/technology Index			**45.2**	**44.5**	**40.7**	**37.4**
Law/Legal	Internal	Resource extraction policy	24.2	24.2	25.8	30.6
		Oil emergency preparedness	0.0	0.0%	0.0	0.0
		Oil strategic stockpiling policy	8.7	8.7	8.7	8.7
	External	Rule of law	35.2	34.4	33.4	32.1
Law Index			**17.2**	**17.0**	**17.2**	**18.0**
Environ- mental	Internal	Climate change	22.6	23.7	23.1	23.6
		Natural disaster	0.0	0.3	0.0	0.1
	External	Climate change	33.4	31.5	30.4	28.1%
		Natural disaster	0.1	0.3	0.4	0.2
Environmental Index			**12.7**	**13.0**	**12.5**	**12.4**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			22.1	22.0	20.2%	20.5
	Internal	Local stability	29.7	51.8	41.3	37.3
		Piracy	0.3	0.0	0.0	0.0
		International agreement on gas emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.4	0.0	0.6	0.2
		Exporter stability	29.5	37.5	35.3	30.2
Political Index			**21.9**	**27.8**	**25.2**	**23.7**
	Internal	Primary energy diversity	34.4	26.8	24.5	22.7
		Ease of doing business	14.2	12.5	14.3	15.1
		Gas shares to primary energy	24.1	21.9	25.1	27.9
		Gas intensity	56.4	47.3	50.5	52.6
		Gas pricing	0.0	0.0	0.0	0.0
		Gas import source diversity	88.1	73.8	77.1	93.4
Economic Index			**25.9**	**21.7**	**22.8**	**25.2**
Internal		Gas per capita	24.0	21.8	21.3	23.5
Social Index			**24.0**	**21.8**	**21.3**	**23.5**
	Internal	Logistic efficiency	23.0	23.0	22.9	21.5
		Gas reserves/production	36.9	22.9	2.1	5.2
		Regasification terminal utilization	63.1	51.6	7.2	1.5
		Nat gas underground storage over demand	82.9	81.5	81.6	81.6
		Trans-border pipelines utilization gas	59.1	60.3	53.6	45.3
		Gas self-sufficiency	18.4	16.9	11.0	7.0
	External	Liquefaction terminal utilization	5.9	14.6	11.6	3.3
		Gas production	5.7	4.4	17.7%	22.0
Technical/technology Index			**35.4**	**33.%**	**25.4**	**22.9**
	Internal	Resource extraction policy	24.2	24.2	25.8	30.6
		Gas emergency preparedness	0.0	0.0	0.0	0.0
	External	Rule of law	18.5	22.2	18.7	16.5
Law Index			**13.9**	**15.0**	**14.6**	**15.6**
	Internal	Climate change	22.6	23.7	23.1	23.6
		Natural disaster	0.0	0.3	0.0	0.1
	External	Climate change	25.3	27.9	27.0	24.9
		Natural disaster	0.0	0.0	0.0%	0.3
Environmental Index			**11.7**	**12.6**	**12.1%**	**12.1**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

VIET NAM

Viet Nam	Unit	2000	2005	2010	2013
GDP Real Term (2010 Price and 2010 PPP)	USD Billions	201.5	281.3	382.1	450.4
GDP per capita	2010 USD PPP/Person	2,596	3,414	4,396	5,021
Population	no. in million	78	82	87	90
Crude oil production	Mtoe	17	20	16	18
Oil product output	Mtoe	0	0	6	6
Gas production	Mtoe	1	6	8	8
Crude oil import	Mtoe	0	0	0	0
Oil product import	Mtoe	9	13	12	10
Total oil import	Mtoe	9	13	12	10
Gas import	Mtoe	0	0	0	0
Crude oil export	Mtoe	16	18	8	9
Oil product export	Mtoe	1	1	2	1
Total oil export	Mtoe	17	19	10	10
Gas export	Mtoe	0	1	0	0
Crude oil demand	Mtoe	0	0	7	8
Total oil as primary supply	Mtoe	8	12	19	16
Oil product demand	Mtoe	7	11	17	16
Gas demand	Mtoe	1	5	8	8
Other types of fuel demand	Mtoe	20	25	32	38
Total primary energy supply	Mtoe	29	41	59	62
Oil reserves	Mtoe	82	82	82	600
Gas reserves	Mtoe	153	198	205	195
Oil reserves/production ratio	years	5	4	5	34
Gas reserves/production ratio	years	137	33	25	23
Refinery capacity	Mtoe/yr	0	0	7	7
Oil intensity	toe/million 2010 USD	39	43	49	35
Gas intensity	toe/million 2010 USD	6	17	21	19
Oil consumption per capita	toe/person	0.1	0.1	0.2	0.2
Gas consumption per capita	toe/person	0.0	0.1	0.1	0.1

Source: Cedigaz (2015), OGJ (2015), EIA (2016), IEA (2015), EGEDA 2015 and APERC analysis.

Viet Nam	Oil Security Index (%)		2000	2005	2010	2013
Average Oil Security Index			38.7	36.7	35.2	36.1
Political	Internal	Local stability	43.8	40.8	47.9	45.6
		Piracy	1.6	2.5	4.0	4.5
		International agreement on oil emergency	50.0	50.0	50.0	50.0
	External	Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.1	0.1	0.0
		Exporter stability	34.5	34.4	34.1	34.3
Political Index			**26.7**	**26.2**	**28.3**	**27.9**
Economic	Internal	Primary energy diversity	25.2	26.1	25.9	26.6
		Ease of doing business	49.6	47.9	41.5	39.9
		Oil shares to primary energy	27.2	29.1	31.7	25.2
		Oil intensity	81.4	78.2	100	70.6
		Oil product pricing	100	100	100	0.0
		Oil export over GDP	11.2	14.0	4.8	12.3
		Total oil net import over demand	0.0	0.0	0.0	0.0
		Crude oil import source diversity	0.0	0.0	0.0	0.0
		Oil product import source diversity	41.8	31.5	24.1	21.9
	External	Oil export over GDP	9.1	14.3	13.2	13.4
Economic Index			**30.3**	**30.8**	**30.6**	**19.7**
Social	Internal	Oil consumption per capita	9.2	13.5	19.9	16.2
Social Index			**9.2**	**13.5**	**19.9**	**16.2**
Technical/ technology	Internal	Logistic efficiency	41.6	41.5	40.7	38.4
		Oil reserves/production	86.9	88.7	86.2	8.7
		Refinery utilisation	0.0	0.0	77.7	85.1
		Trans-border pipelines utilisation	0.0	0.0	0.0	0.0
		Crude oil self-sufficiency	0.0	0.0	0.0	0.0
	External	Oil production	0.0	0.0	0.0	0.0
Technical/technology Index			**19.3**	**19.5**	**30.7**	**19.8**
Law/Legal	Internal	Resource extraction policy	50.1	49.1	40.3	56.1
		Oil emergency preparedness	0.0	0.0	0.0	0.0
		Oil strategic stockpiling policy	62.4	62.4	62.4	62.4
	External	Rule of law	30.8	25.9	25.1	27.8
Law Index			**35.8**	**34.3**	**31.9**	**36.6**
Environmental	Internal	Climate change	57.3	55.5	52.6	50.7
		Natural disaster	6.5	1.1	1.8	4.6
	External	Climate change	32.6	29.3	24.3	24.7
		Natural disaster	0.7	1.3	3.8	0.8
Environmental Index			**28.1**	**25.0**	**23.9**	**23.9**

Gas Security Index (%)			2000	2005	2010	2013
Average Gas Security Index			23.0	26.0	27.2	28.0
Internal		Local stability	43.8	40.8	47.9	45.6
		Piracy	1.6	2.5	4.0	4.5
		International agreement on gas emergency	50.0	50.0	50.0	50.0
External		Piracy	0.0	0.0	0.0	0.0
		Chokepoints	0.0	0.0	0.0	0.0
		Exporter stability	0.0	0.0	0.0	0.0
Political Index			**23.3**	**22.8**	**24.9**	**24.5**
Internal		Primary energy diversity	25.2	26.1	26.1	26.6
		Ease of doing business	49.6	47.9	41.3	39.9
		Gas shares to primary energy	3.9	11.4	13.8	13.7
		Gas intensity	15.8	49.3	63.9	57.0
		Gas pricing	100	100	100	100
		Gas import source diversity	0.0	0.0	0.0	0.0
Economic Index			**23.8**	**28.7**	**30.0**	**29.0**
Internal		Gas consumption per capita	2.9	11.3	18.5	18.6
Social Index			**2.9**	**11.3**	**18.5**	**18.6**
Internal		Logistic efficiency	41.6	41.5	40.7	38.4
		Gas reserves/production	11.8	78.7	83.7	85.1
		Regasification terminal utilisation	0.0	0.0	0.0	0.0
		Nat underground gas storage over demand	100	100	100	100
		Trans-border pipelines utilisation gas	0.0	0.0	0.0	0.0
		Gas self-sufficiency	0.0	0.0	0.0	0.0
External		Liquefaction terminal utilisation	0.0	0.0	0.0	0.0
		Gas production	0.0	0.0	0.0	0.0
Technical/technology Index			**18.7**	**26.9**	**27.4**	**27.3**
Internal		Resource extraction policy	50.1	49.1	40.3	56.1
		Gas emergency preparedness	75.0	75.0	75.0	75.0
External		Rule of law	0.0	0.0	0.0	0.0
Law Index			**45.9**	**45.5**	**42.3**	**48.1**
Internal		Climate change	57.3	55.5	52.6	50.7
		Natural disaster	6.5	1.1	1.8	4.6
External		Climate change	0.0	0.0	0.0	0.0
		Natural disaster	0.0	0.0	0.0	0.0
Environmental Index			**23.4**	**20.7**	**19.9**	**20.3**

Note: APERC used a scale (in %) of 0 to 100 for each indicator, ***whereby 0 means no risk while 100 means highest risk.***
Source: APERC analysis

REFERENCES

ACE (ASEAN Centre of Energy) (2015), *ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025*, http://www.aseanenergy.org/wp-content/uploads/2015/12/HighRes-APAEC-online-version-final.pdf

APERC (Asia Pacific Energy Research Centre) (2016), *APEC Energy Demand and Supply Outlook, 6th Edition,* http://aperc.ieej.or.jp/file/2016/5/10/APEC_Outlook6th_VolumeII_EconomyReviews.pdf

____ (2015), *Oil Supply Security and Emergency Policy in the APEC Region*, http://aperc.ieej.or.jp/file/2016/5/13/Oil_Supply_SEcurity_and_Emergency_Policy_in_the_APEC_Region.pdf

API (American Petroleum Institute) (2016), *The Importance of Natural Gas Storage,* http://www.api.org/~/media/Files/Oil-and-Natural-Gas/Natural-Gas/Underground-NG-Storage-Brochure.pdf

BOE (Bureau of Energy, Ministry of Economic Affairs) (2016), *Energy Statistics Handbook 2014,* http://web3.moeaboe.gov.tw/ECW/english/content/SubMenu.aspx?menu_id=1537

BP (British Petroleum) (2015), *BP Statistical Review of World Energy June 2015,* www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

CEDIGAZ (2016), *Natural Gas Statistical Database*

CIPD (Chartered Institute of Personnel and Development) (2015), PESTLE analysis, https://www.cipd.co.uk/knowledge/strategy/organisational-development/pestle-analysis-factsheet

CNPC (China National Petroleum Corporation) (2016), *CNPC in Turkmenistan*, http://www.cnpc.com.cn/en/Turkmenistan/country_index.shtml

CNPC (China National Petroleum Corporation) (2015), *CNPC in Kazakhstan*, http://www.cnpc.com.cn/en/Kazakhstan/country_index.shtml

CRED (Centre for Research on the Epidemiology of Disasters) (2016), *The International Disaster Database*, http://www.emdat.be/history

EGEDA (Expert Group on Energy Data Analysis, APEC Energy Working Group) (2015), *APEC Energy Database*, http://www.ieej.or.jp/egeda/database/database-top.html.

EIA (US Energy Information Administration) (2016), *International Energy Statistics,* http://www.eia.gov/beta/international/data/browser/#/?vs=INTL.44-1-AFRC-QBTU.A&cy=2013&vo=0&v=H&start=1980&end=2014

_____ (2016a), *Petroleum & Other Liquids,* https://www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbbl_m.htm

EWG (APEC Energy Working Group) (2011), *APEC Ministers Endorse Energy Security Initiative,* http://www.ewg.apec.org/documents/ESI_2001.pdf

FI (Fraser Institute) (2016), Global Petroleum Survey 2015, https://www.fraserinstitute.org/sites/default/files/global-petroleum-survey-2015-rev.pdf

IEA (International Energy Agency) (2015), *World Energy Statistics and Balances.*

____ (2015a), *Oil Medium-Term Market Report,*

____ (2014a), *Closing Oil Stock Level in Days of Net Imports*, http://www.iea.org/netimports/?y=2014&m=12

____ (2014b), *Energy Supply Security: Emergency Response of IEA Countries* http://www.iea.org/publications/freepublications/publication/ENERGYSUPPLYSECURITY2014.pdf

____ (2011), *The IEA Model of Short-term Energy Security (MOSES)*, http://www.iea.org/publications/freepublications/publication/moses_paper.pdf

GMA News (2012), *PHL had most number of natural disasters in 2011,* http://www.gmanetwork.com/news/story/256267/news/nation/it-s-official-phl-had-most-number-of-natural-disasters-in-2011

ICC IMB (International Chamber of Commerce - International Maritime Bureau) (2015), *Piracy and Armed Robbery against Ships Report 2015,* http://www.hellenicshippingnews.com/wp-content/uploads/2016/02/2015-Annual-IMB-Piracy-Report-ABRIDGED.pdf

IEEJ (Institute of Energy Economics, Japan) (2012), *Energy Security and Challenges for Japan,* http://eneken.ieej.or.jp/data/4856.pdf.
____ (2011), *An Analysis of Major Countries' Energy Security Policies and Conditions – Quantitative Assessment of Energy Security Policies,* https://eneken.ieej.or.jp/data/3719.pdf

IGU (International Gas Union) (2015), *World LNG Report—2015 Edition,* www.igu.org/sites/default/files/node-page-field_file/IGU-World%20LNG%20Report-2015%20Edition.pdf

IMF (International Monetary Fund) (2013), *World Economy Outlook 2013,* http://www.imf.org/external/pubs/ft/weo/2013/01/weodata/index.aspx

LNG Producer-Consumer Conference (2016), *Pathway towards Development of Global LNG Marke*t, 24 November 2016, Tokyo, Japan

ND GAIN (Notre Dame Global Adaptation Initiative), *Global Adaptation Index*, http://index.gain.org/

OGJ (Oil and Gas Journal) (2000-2015), *Worldwide Refining Survey.*
____ (2015), *Worldwide Report (Dec. 7 2015 Edition).*

Time (Time Magazine) (2009), *How to Defeat Pirates: Success in the strait,* http://content.time.com/time/world/article/0,8599,1893032,00.html

UN Comtrade (2016), *UN Comtrade Database*, http://comtrade.un.org/

UNStats (UN Trade Statistics) (2010), *Taiwan, Province of China Trade data,* http://unstats.un.org/unsd/tradekb/Knowledgebase/Taiwan-Province-of-China-Trade-data

UKERC (UK Energy Research Centre) (2014), *An Investigation into Future Energy System Risks: An Industry Perspective,* http://www.ukerc.ac.uk/asset/509F4B92-C09E-4B1E-942865A4BDB10BB8/

UNDP (United Nations Development Programme) (2000), *World Energy Assessment: Energy and the Challenge of Sustainability*, http://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/Sustainable%20Energy/wea%202000/chapter4.pdf

WB (World Bank) (2016a), *Worldwide Governance Indicators*, http://info.worldbank.org/governance/wgi/index.aspx#home
_____ (2016b), *Doing Business,* http://www.doingbusiness.org/data/distance-to-frontier
____ (2016c), *Logistic Performance Index*, https://wb-lpi-media.s3.amazonaws.com/LPI_Report_2016.pdf
____ (2015), *World Development Indicators.*
____(2013), *Global Tracking Framework 2013*, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/05/28/000112742_20130528084417/Rendered/PDF/778890GTF0full0report.pdf.
____ (2005), *Energy Security Issues*, http://siteresources.worldbank.org/INTRUSSIANFEDERATION/Resources/Energy_Security_eng.pdf

WEF (World Economic Forum) (2016), *Energy Architecture Performance Index 2016,* http://www3.weforum.org/docs/WEF_Energy_Architecture_Performance_Index_2016.pdf

Xinhua (2014), *China sees record crude oil imports from Kazakhstan*, http://news.xinhuanet.com/english/china/2014-01/22/c_133066009.htm

ECONOMY REFERENCES

AUSTRALIA

EIA (Energy Information Administration) (2014), *Australia Overview,* http://www.eia.gov/beta/international/analysis_includes/countries_long/Australia/australia.pdf

OCE (Office of the Chief Economist) (2016), *Energy in Australia*, http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Pages/Energy-in-Australia.aspx.

BRUNEI DARUSSALAM

BB (Brunei Bulletin) (2016), *US$ 4B Hengyi Refinery to go on Stream in '19,* http://borneobulletin.com.bn/us4b-hengyi-refinery-to-go-on-stream-in-19/

EIA (Energy Information Administration) (2016), *Brunei Overview*, http://www.eia.gov/beta/international/analysis.cfm?iso=BRN

EIDPMO (Energy and Industry Department, Prime Minister's Office) (2014), *Energy White Paper,* http://energy.gov.bn/Shared%20Documents/Publications/Energy%20White%20Paper%202014(1).pdf.

IBT (International Business Times) (2013), "*Brunei has a Solid Economy. Thanks to Income from Oil and Gas along with steady FDI, unlike its ASEAN Neighbors,"*http://www.ibtimes.com/brunei-has-solid-economy-thanks-income-oil-gas-along-steady-fdi-unlike-its-asean-1401591

RTB News (2014), 'The United Nation Climate Summit', 24 September 2014, http://www.rtbnews.rtb.gov.bn/index.php?option=com_content&view=article&id=22638%3Athe-united-nations-climate-summit&Itemid=106/

CANADA

Canaport LNG (2015), *About Canaport LNG*, http://www.canaportlng.com/.

CAPP (Canadian Association of Petroleum Producers) (2015), *Statistical Handbook for Canada's Upstream Petroleum Industry*, www.capp.ca/publications-and-statistics/publications/258990.

EIA (Energy Information Administration) (2015), *Canada Overview,* http://www.eia.gov/beta/international/analysis_includes/countries_long/Canada/canada.pdf

NEB (National Energy Board) (2016), *Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040*, https://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2016/index-eng.html#s11.

NRCan (Natural Resources Canada) (2016), *Energy Markets Factbook 2015-2016*, http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/files/pdf/2014/14-0173EnergyMarketFacts_e.pdf.

____ (2015a), *Oil Sands,* https://www.nrcan.gc.ca/energy/oil-sands/5849.

____ (2015b), *Canadian LNG Projects*, http://www.nrcan.gc.ca/energy/natural-gas/5683
____ (2012), *Shale Gas*, www.nrcan.gc.ca/energy/natural-gas/5687/.

CHILE

EIA (Energy Information Administration) (2015), *Chile Overview,* http://www.eia.gov/beta/international/analysis.cfm?iso=CHL

ENAP (Empresa Nacional delPetróleo*)* (2015),*Directorio de ENAP aprueba Plan Estratégico 2014-2025 con inversiones de US$ 800 millonesanuales a 2020*, http://www.enap.cl/sala_prensa/noticias_detalle/general/776/directorio-de-enap-aprueba-plan-estrategico-2014-2025-con-inversiones-de-us-800-millones-anuales-a-2020
____ (2014), M*emoria anual 2014*, http://www.enap.cl/pag/547/886/memoria.

CHINA

EIA (Energy Information Administration) (2015), *China Overview,* http://www.eia.gov/beta/international/analysis_includes/countries_long/China/china.pdf

FT (Financial Times) (2015), *'China Oil Imports Surpass Those of US', May 10, 2015*, www.ft.com/intl/cms/s/0/342b3a2e-f5a7-11e4-bc6d-00144feab7de.html#axzz3xn6Bpmbr.

NBS (National Bureau of Statistics) (2015), http://www.stats.gov.cn.

Reuters (2015), *China's Strategic Oil Reserves Double to 190 mln bbl—Stats Bureau*, www.reuters.com/article/china-oil-reserves-idUSL3N1402YL20151211

HONG KONG, CHINA

EB (Environment Bureau, Government of the Hong Kong Special Administrative Region of the People's Republic of China) (2015), *Energy saving plan for Hong Kong's Built environment 2015-2025+),* http://www.enb.gov.hk/sites/default/files/pdf/EnergySavingPlanEn.pdf.

ENB (Environment Bureau), http://www.enb.gov.hk/sites/default/fil

Towngas (Hong Kong and China Gas Company Ltd) (2013), *Overview*, www.hkcg.com/eng/corp/abttg/newenergybus/eco.aspx/.

INDONESIA

EIA (Energy Information Administration) (2015), *Indonesia Overview,* http://www.eia.gov/beta/international/analysis_includes/countries_long/Indonesia/indonesia.pdf

IEA (International Energy Agency) (2014a), *Energy Supply Security: Emergency Response of Partner Countries (Indonesia),* https://www.iea.org/publications/freepublications/publication/ESS_Indonesia_2014.pdf

Jakarta Post (2012), *'Chevron kicks off Duri field expansion in Sumatra',* http://www.thejakartapost.com/news/2012/10/27/chevron-kicks-duri-field-expansion-sumatra.html#sthash.2QWXDSGd.dpuf.

Platts (2014), *"Indonesia's PERTAMINA secures more US LNG as it prepares for gas shortage,"* http://www.platts.com/latest-news/natural-gas/jakarta/indonesias-pertamina-secures-more-us-lng-as-it-21843381

JAPAN

EIA (Energy Information Administration) (2015), *Japan Overview,* http://www.eia.gov/beta/international/analysis_includes/countries_long/Japan/japan.pdf

METI (Ministry of Economy, Trade and Industry, Japan) (2016), *Energy White Paper*, 2016, http://www.enecho.meti.go.jp/about/whitepaper/2016html/
____ (2012), *Amended Oil Stockpiling Act to be enforced in November 2012,* http://www.meti.go.jp/english/press/2012/1030_01.htm
OGJ (Oil and Gas Journal) (2014), *Worldwide Look at Reserves and Production* http://www.ogj.com/articles/print/volume-112/issue-1/drilling-production/worldwide-look-at-reserves-and-production.html

KOREA

EIA (Energy Information Administration) (2015), *Korea Overview,* http://www.eia.gov/beta/international/analysis_includes/countries_long/Korea_South/south_korea.pdf.
____ (2014), *Proved Reserves of Natural Gas 2013,* http://www.eia.gov/beta/international/rankings/#?product=3-6&cy=2013.

IEA (International Energy Agency) (2012), *Korea In-depth Overview*, https://www.iea.org/countries/membercountries/korea/

KESIS (Korea Energy Statistics Information System) (2015), www.kesis.net

MALAYSIA

EC (Energy Commission of Malaysia) (2014), *National Energy Balance 2013*, http://www.st.gov.my/index.php/download-page/category/111-national-energy-balance.html?download=538:national-energy-balance-2013.

EPU (Economic Planning Unit) (2015), *Eleventh Malaysia Plan 2016–2020*, http://rmk11.epu.gov.my/book/eng/Elevent-Malaysia-Plan/index.html

____ (2013), *Malaysian Economy in Figures 2013*, http://www.epu.gov.my/sites/default/files/2013.pdf

MATRADE (Malaysia External Trade Development Corporation) (2015), *Top 10 Major Export Products, 2014*, www.matrade.gov.my/en/malaysia-exporters-section/33-trade-statistics/3184-top-10-major-export-products-2014

MOF (Ministry of Finance) (2015), *Economic Report 2013/2014*, www.treasury.gov.my/pdf/economy/er/1314/economy2014.pdf

MEXICO

EIA (Energy Information Administration) (2015), *U.S. Imports by Country of Origin*, www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbblpd_a.htm

PEMEX (PetróleosMexicanos) (2014), *AnuarioEstadístico 2014*, www.pemex.com.

NEW ZEALAND

MBIE (Ministry of Business Innovation and Employment) (2015), *Energy in New Zealand 2015,* http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/publications/energy-in-new-zealand/
____ (2013), *Energy in New Zealand 2013*, www.med.govt.nz/sectors-industries/energy/energy-modelling/publications/energy-in-new-zealand/Energy-in-New-Zealand-2013-print.pdf/

PAPUA NEW GUINEA

MRA (Mineral Resources Authority) (2012), *Mineral and Exploration Bulletin July to December 2012*, http://www.mra.gov.pg/Portals/2/Publications/Bulletin/julydec2012/Issue%202.pdf

PNG LNG (2014), *About PNG LNG*, http://pnglng.com/project/about/

PERU

BCRP (Banco Central de Reservadel Perú) (2014), *Memoria Anual 2014*, www.bcrp.gob.pe/publicaciones/memoria-anual/memoria-2014.html

MEM (Ministerio de Energía y Minas) (2014), *Plan Estratégico Nacional 2014–2025*

New York Times (2016), Colombia Signs Peace Agreement with FARC after 5 Decades of War http://www.nytimes.com/2016/09/27/world/americas/colombia-farc-peace-agreement.html?_r=0

PHILIPPINES

DOE (Department of Energy) (2015), *Fossil Fuel Proven Reserves*, DOE-Energy Resource Development Bureau
____ (2015a), *2014 Energy Sector Accomplishment Report*, https://www.doe.gov.ph/doe_files/pdf/Transparency_Seal/Annual%20Report%20-%20Energy%20Sector%20Accomplishment%20Report%202014.pdf.
____ (2014), *Energy Sector Accomplishment Report 2013,* www.doe.gov.ph/doe_files/pdf/Transparency_Seal/Annual%20Report%20-%20Energy%20Sector%20Accomplishment%20Report%202013.pdf.
____ (2014a), *Oil Supply/Demand Report 2013,* http://www.doe.gov.ph/downstream-oil-industry/484-oil-supply-demand-report-2013/2399-oil-supply-demand-report-2013

WB (World Bank) (2014), *World Population Ranking*, IBRD-IDA, http://data.worldbank.org/data-catalog/Population-ranking-table.

RUSSIA

NEA (Nuclear Energy Agency) (2014), *Uranium 2014: Resources, Production and Demand*, https://www.oecd-nea.org/ndd/pubs/2014/7209-uranium-2014.pdf

IEA (International Energy Agency) (2016), *Energy Subsidies*, http://www.worldenergyoutlook.org/resources/energysubsidies/fossilfuelsubsidydatabase/

SINGAPORE

IMF (International Monetary Fund) (2013), *World Economy Outlook 2013,* http://www.imf.org/external/pubs/ft/weo/2013/01/weodata/index.aspx

SingStat (Singapore Department of Statistics), (2015a), *M013841 - Gross Domestic Product at Current Market Prices, By Industry, Annual,* http://www.tablebuilder.singstat.gov.sg/publicfacing/createDataTable.action?refId=1425

____ (2015b). *Yearbook of Statistics Singapore 2013*, http://www.singstat.gov.sg/publications/publications_and_papers/reference/yearbook_of_stats_2013.html

SLNG (Singapore LNG Corporation) (2014). Terminal Development.www.slng.com.sg/our-developments-current.html

CHINESE TAIPEI

BOE (Bureau of Energy, Ministry of Economic Affairs) (2016), *Energy Statistics Handbook 2014*, http://web3.moeaboe.gov.tw/ECW/english/content/SubMenu.aspx?menu_id=1537

____ (2014), *2014 Annual Report,* http://web3.moeaboe.gov.tw/ECW/populace/content/ContentLink.aspx?menu_id=137

CA (Custom Administration, Ministry of Finance) (2016), *Trade Statistic Search,* https://portal.sw.nat.gov.tw/APGA/GA03E

UNStats (UN Trade Statistics) (2010), *Taiwan, Province of China Trade data,* http://unstats.un.org/unsd/tradekb/Knowledgebase/Taiwan-Province-of-China-Trade-data

THAILAND

CRED (Centre for Research on the Epidemiology of Disasters) (2016), *The International Disaster Database*, http://www.emdat.be/history

NESDB (Office of the National Economic and Social Development Board) (2015). *National Accounts of Thailand 2013, Office of the Prime Minister*, www.nesdb.go.th

UNITED STATES

API (American Petroleum Institute) (2016), *The Importance of Natural Gas Storage,* http://www.api.org/~/media/Files/Oil-and-Natural-Gas/Natural-Gas/Underground-NG-Storage-Brochure.pdf

EIA (Energy Information Administration) (2013), *website 'Today in Energy – USA' page*, www.eia.gov/todayinenergy/detail.cfm?id=10171/

VIET NAM

IEA (International Energy Agency) (2016), *Energy Subsidies*, http://www.worldenergyoutlook.org/resources/energysubsidies/