IMPACT OF OIL PRICES

on trade in the APEC region

ABARE Research Report 05.3 for the
APEC Energy Working Group

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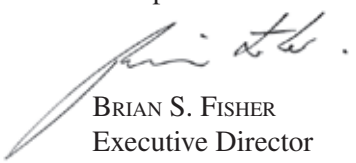
foreword

High energy prices have substantial consequences for economies in the APEC region, an issue recognised by member economies with the endorsement of the APEC Energy Security Initiative (ESI). The ESI includes both short and long term initiatives to promote sustainable development and common prosperity in the APEC region. While the initiatives supported in the ESI cover a range of different aspects of energy security, an integral component of these initiatives, especially in the current high oil price climate, is an understanding of the potential impact of rising oil prices on economies in the APEC region.

This study assesses some of the potential economic impacts in the region from sustained higher oil prices. Key components in this report include:

- a detailed analysis of the current trends in crude oil production, consumption and trade;
- an evaluation of the impacts of sustained high oil prices on economic growth and terms of trade, both for the APEC region and individual member economies;
- an analysis of the potential for alternative technologies, particularly in the transport sector, to reduce the vulnerability of economies to oil price shocks in the medium to longer term; and
- a discussion of trade and investment barriers within the region, and their impact on the ability of APEC economies to respond to high oil prices.

The study was undertaken by ABARE for the APEC Energy Working Group.



BRIAN S. FISHER
Executive Director

October 2005

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summary

The economies of APEC account for a considerable proportion of the world's oil production, and an even larger share of the world's oil consumption. As a result, if current high oil prices were to increase further and remain at a higher level for a sustained period, there could potentially be considerable impacts on economic growth and trade within the region, and globally.

Oil prices have been closely linked to the growth and development of economies for long period of time. Empirical research draws a link between the price of oil and key macroeconomic indicators, such as GNP, trade balance, unemployment, inflation and interest rates. It suggests that the price of oil can have a major impact on the health of domestic economies. Those relationships, and concerns about the effect of current and future prices, motivate analysis into the significance and likely economic effects of sustained increases in world oil prices.

Study objectives

The purpose in this study is to examine the impact of higher oil prices on trade and economic growth within APEC. The key objectives are to:

- analyse the effects of sustained increases in oil prices on macroeconomic indicators and patterns of trade within the APEC region;
- undertake detailed economic modeling to quantify these effects under a number of oil price scenarios for goods and services trade within the APEC region;
- examine the extent to which trade and investment barriers limit the capacity of regional markets to respond to changes in energy prices; and
- explore the possibilities of mitigating the impact of sustained higher oil prices through the adoption of alternative technologies.

Research methodology

ABARE's global trade and environment model (GTEM) has been used in this study to model the impacts of sustained higher oil prices within APEC, on national and regional trade and economic indicators.

Two sets of scenarios have been used to assess the impacts of sustained oil prices relative to a reference case scenario. In the first set, two scenarios are conducted to model the effect of sustained oil price increases of 30 per cent and 60 per cent above the reference case. It should be noted, however, that the recent increase in oil prices has also been accompanied by increases in the prices of other energy commodities. It is therefore important to consider the broader implications of increasing energy prices on macroeconomic aggregates, although this study is limited to a study of the effects of oil price rises alone. Given that, a third scenario modeling a sustained increase in overall energy prices is also undertaken. In the second set, the impact on oil consumption from increased adoption of more fuel efficient transport technologies is explored under two illustrative scenarios.

Oil market development issues

The rapid increase in oil prices during the recent past has raised concerns about the impact of further increases and whether the effects of previous price peaks will be repeated. Although extremely high peaks could affect economic growth, inflation, unemployment, interest rates and trade balances, many economies, particularly developed economies, have become more oil efficient in recent years compared with the situation in the 1970s and 1980s, reducing the potential adverse impact of sustained high oil prices in the future.

Increased global demand for oil

World demand for oil has increased in recent years following strong economic growth, and the growth of oil intensive sectors, such as transport.

Decrease in spare production capacity

Global spare production capacity in the oil sector has fallen to its lowest levels since 1970. Historically, high spare production capacity has been associated with low real oil prices, and low spare production capacity with high real oil prices. Furthermore, low spare production capacity has also been associated with high levels of price volatility. Spare production

capacity is likely to remain low in the short term, as current plans for expansion and replacement projects are forecast to just keep pace with demand.

Shortage of suitable refineries and tightened environmental standards

The shortage of refining capacity reflects not only low investment in such capacity, but also a mismatch between the available grades of crude oil and the prevailing refinery capacity. The demand for oil in many markets, particularly transport markets in developed economies, has increasingly been for light, sweet crude oils. This has largely been the result of environmental standards and regulations in many economies, such as the United States, Canada and Japan, mandating lower levels of sulfur in petrol and diesel fuels.

Barriers to increased production

Investment decisions to fund oil exploration, production or downstream industries are complicated by uncertainties about oil prices, demand and the lead time for new capacities to be developed. In some oil producing regions, there are significant restrictions on foreign investment. Environmental requirements may also limit potential refinery expansions to increase production capacity.

Geopolitical tension

The impact of the increasing global demand for oil, low spare production capacity of oil, a lack of refining facilities and barriers to investment in oil production, refining or transport have all been exacerbated by geopolitical tension in some oil producing regions. Turmoil in production regions, both political and economic, has disrupted supply on occasion and adversely affected the ability of oil markets to ensure a smooth supply of oil.

Oil consumption, production and trade in APEC

The twenty-one member economies of APEC vary significantly in their economic size and structure, income levels, energy consumption and production, oil endowments and access to external supplies of oil.

Oil consumption

Total primary energy consumption (TPEC) — the total energy consumed within an economy — is affected by higher oil prices. Substantial changes in world oil prices are also likely to affect the mix of fuel shares of the TPEC in the APEC region. For APEC as a whole, oil accounted for the

largest share of TPEC in 2003, at around 35 per cent. For individual economies, the share of oil in the primary energy mix varied considerably, from 79 per cent in Singapore to 19 per cent in China.

End use consumption of oil

Most of the demand for oil in APEC economies comes from three sectors: transport, industry and, to a lesser extent, agriculture. Each of these sectors is highly dependent on oil, with limited substitution options in the short to medium term.

Oil intensity

The average level of oil intensity for the different economy groupings suggests a much higher dependence in rapidly growing developing economies than in developed economies. Lower oil intensity in developed economies may reflect the adoption of less oil intensive technology as well as the expansion of the service sectors within their domestic economies.

Oil and energy production

Economies within the APEC region produce oil, gas, coal and uranium, as well as renewable energy resources. Total primary energy production in APEC in 2003 was equivalent to 53 per cent of world primary energy production, and 58 per cent of the total energy consumed in APEC in 2003.

Total crude oil production in APEC accounted for 38 per cent of world production in 2003 and was equivalent to about 67 per cent of total APEC oil consumption. Oil production in the APEC region is likely to decrease in the short to medium term unless further investment in exploration occurs.

Oil trade

Although made up of both oil exporters and importers, the APEC region is a net importer of oil. While oil was imported from a number of different economies in 2003, four of those (Iran, Saudi Arabia, United Arab Emirates and Venezuela) provided over half of the imports. Around half of oil exports by APEC economies are to other APEC economies, mostly to the United States.

There is considerable variation between APEC member economies in the net flow of oil trade. Some economies (Hong Kong China, Japan, the Republic of Korea, Singapore and Chinese Taipei) rely on imports for 100 per cent of oil consumption, while several others are large exporters.

Oil import dependence

Oil import dependence varied considerably among APEC economies in 2003. Most APEC economies are net oil importers, with some economies reliant on imports for all of their crude oil consumption. Of the oil exporting economies, Brunei Darussalam exported ten times more than it consumed domestically.

Oil security and stockpiling

As result of the potential impacts of higher oil prices, oil security has become a significant concern of both oil importing and exporting economies. Part of a secure oil supply in many economies is keeping oil stockpiles. By maintaining stockpiles, in the event of a large increase in oil prices, individual economies will have the ability to moderate the effects and volatility of the market to some degree. The ability of an individual economy to mitigate the effects of higher oil prices, however, depends on the size of their normal oil imports relative to the world oil trade. Any form of stockpile drawdown, however, remains a short term response to oil price increases or supply shortages.

Modeling approach

The impacts of sustained oil price increases are estimated in this study using ABARE's global trade and environment model (GTEM). As a dynamic general equilibrium model, GTEM requires a reference case scenario against which the impacts of alternative scenarios can be measured.

The reference case represents the likely outlook for economic activity and energy demand and supply in APEC and across the world over the period to 2015 in the absence of any changes to key energy or economic policies. Oil prices have also been modeled to reflect the most recent jump in oil prices in 2005.

Reference case projections

Total primary energy consumption in APEC is projected to grow in the reference case by 2.0 per cent a year between 2003 and 2015. Fossil fuels are projected to retain their dominant share of APEC primary energy consumption, accounting for over 90 per cent of the growth in total APEC energy consumption over the projection period.

The share of oil in APEC total primary energy consumption is assumed to remain steady at around 35 per cent throughout the projection period. APEC oil consumption is projected to grow by 1.7 per cent a year between 2003 and 2015, driven mainly by increased demand from the transport sector, where there are limited substitution possibilities. Growth in oil consumption is strongest in the rapidly growing developing APEC economies, where strong growth in the transport sector results from high economic growth and the sharp rise in private vehicle ownership.

Energy production in APEC economies

Energy production in the APEC region is projected to expand by 22 per cent between 2003 and 2015. Much of the growth in APEC energy production (70 per cent) is concentrated in the natural gas and coal sectors. In contrast, APEC oil production is projected to increase by only 15 per cent between 2003 and 2015.

APEC energy trade

APEC's net energy imports are projected to expand by 67 per cent between 2003 and 2015, exceeding 1000 million tonnes of energy equivalent (Mtoe) by 2015. The principal reason for the increase in the region's dependence on imported fuel is a large rise in net oil imports, from 716 Mtoe in 2003 to almost 1100 Mtoe by 2015. In contrast, the APEC region's position as a net exporter of coal and gas is projected to remain steady throughout the projection period. At 2015, APEC net exports amount to 42 Mtoe for natural gas and 98 Mtoe for coal.

Quantifying the economic effects of sustained high oil prices

To estimate the potential impacts of a sustained increase in world oil prices, two oil price scenarios are simulated.

Scenario 1 – world oil prices increase by 30 per cent above the reference case in 2006 and are maintained at this higher level until 2010 (moderate sustained oil price rise)

Scenario 2 – world oil prices increase by 60 per cent above the reference case in 2006 and are maintained at this higher level until 2010 (high sustained oil price rise).

In each of the scenarios it is assumed that world oil prices increase from reference case values by the level indicated above for five years from 2006 to 2010 before gradually returning to reference case levels for the remainder of the simulation period.

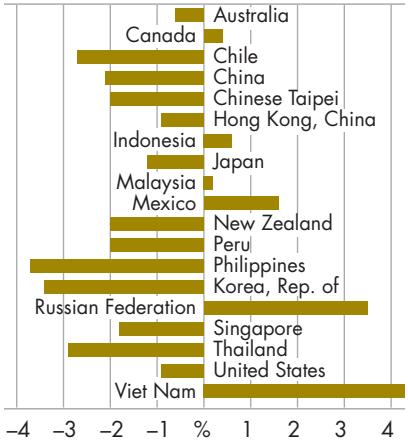
Impacts on oil consumption

The results from scenarios 1 and 2 indicate that a sustained increase in oil prices could have significant impacts on APEC economies and their energy sectors. The extent of these impacts on an economy will depend on the economy's net oil import position and on the economy's reliance on oil. The percentage decline in oil consumption is typically higher in developing APEC economies because many of these economies are relatively more oil intensive and heavily reliant on oil imports.

Impacts on economic output

As a result of the sustained increase in oil prices, and the associated increase in production costs, total economic activity across APEC contracts relative to the reference case. The extent of the impacts on gross national product (GNP) is dependent on both an economy's oil intensity and import dependency. An economy with relatively high oil intensity and high reliance on imports will be more adversely affected by rising oil prices than an economy with lower oil intensity. Figure A shows the change in GNP by economy for scenario 2 in 2006.

A GNP change for scenario 2 in 2006 relative to the reference case



Impacts on trade

The increase in the value of oil imports because of significantly higher world oil prices leads to a decline in the terms of trade for net oil importing APEC economies. For net oil exporting APEC economies the change in terms of trade is positive.

Impacts of sustained energy price increases

It is important to recognise that the recent increases in oil prices have been accompanied by increases in the price of other energy commodities, such as gas and coal. This is modeled in a third scenario.

> Scenario 3 – world oil and gas prices increase by 60 per cent and thermal coal prices increase by 30 per cent above the original reference case in 2006 and remain at the higher level until the end of the simulation period in 2010.

This simulation illustrates that in many APEC economies the projected reduction in economic output is likely to be relatively greater under a sustained increase in overall energy prices than under a sustained increase in oil prices alone.

Impacts of accelerated uptake of efficient transport technologies

The transport sector is currently the largest consumer of oil in all APEC economies. In the short term, demand for oil is relatively unresponsive to price movements because of the limited availability of commercially viable oil substitutes. However, in the medium to long term a sustained increase in oil prices may lead to continued improvements in fuel efficiency of transport vehicle technologies.

Two hypothetical transport technology scenarios were conducted to analyse the potential reductions in fuel use that might arise from increased adoption of more efficient transport technologies. In establishing two hypothetical transport technology scenarios, it is assumed that extended higher oil prices contribute to the increased adoption of more fuel efficient technologies. Therefore, the technology adoption scenarios are reported against a fourth scenario.

> Scenario 4 – world oil prices increase by 60 per cent above the original reference case in 2006 and remain at the higher level until the end of the simulation period in 2015. There is no additional transport technology adoption in this scenario.

The two additional transport technology adoption scenarios incorporate the following assumed information into scenario 4:

Scenario 5 – 10 per cent of new vehicles are hybrids that are 25 per cent more fuel efficient than new nonhybrid vehicles in all APEC economies.

Scenario 6 – 20 per cent of new vehicles are hybrids that are 40 per cent more fuel efficient than new nonhybrid vehicles in all APEC economies.

It is also assumed that as a result of the sustained high oil prices and gradually improving success of hybrid vehicles in the market, particularly in some of the developed economies, the average fuel efficiency of new nonhybrid vehicles brought online from 2006 is 2.5 per cent higher than new vehicle additions in the reference case.

Impacts on fuel consumption

In both transport technology adoption scenarios 5 and 6, the more rapid uptake of hybrid vehicles and the increased fuel efficiency of new nonhybrid vehicles are projected to lead to sizable reductions in the growth of fuel consumption by the transport sector throughout APEC over the period 2006–15.

In scenario 5, APECwide fuel consumption by the transport sector is projected to grow by 21 per cent over the period 2006–15, compared with 25 per cent in scenario 3. In scenario 6, however, where more fuel efficient hybrid vehicles are more widely adopted, fuel consumption by the transport sector in APEC is projected to grow by 16 per cent between 2006 and 2015.

Role of technology in fuel supply: the case of coal-to-liquids

Currently, technologies exist that can be used to produce liquid fuels from sources other than crude oil. One technology that has generated significant interest in the APEC region is the production of liquid fuels from coal (so-called coal-to-liquid technology). Some member economies, including the United States, Japan and China, have either begun the construction of coal-to-liquids plants or devoted resources to study the viability for commercialisation of such technologies.

A major attraction of coal-to-liquids in the APEC region is the vast deposits of coal in several member economies, including the United States, China, Australia, Canada and Indonesia. Commercialisation of coal-to-liquids

technology has the potential to enhance energy security and fuel supply in the region and reduce the dependence of the region on crude oil imports.

Development of coal-to-liquids technology

Two different approaches exist for producing liquid fuels from coal: direct coal liquefaction (DCL) and indirect coal liquefaction (ICL). DCL technology involves making a partially refined synthetic crude oil from coal, which is further refined into synthetic gasoline and diesel as well as liquefied petroleum gas (LPG). ICL technology involves first gasifying coal to make synthesis gas (syngas) and then making synthetic fuels from this syngas.

Commercial readiness

The lack of cost competitiveness of the DCL process has been the primary obstacle to commercial development. In response to rising domestic demand and high and volatile world oil prices, there has been significant interest in DCL technology in China recently. There are presently also several commercial projects worldwide involving ICL technology.

Potential implications for world oil market

Higher price differentials between crude oil prices and other liquid fuel sources such as coal, if sustained, may potentially provide incentives for the development and production of liquid fuels derived from sources other than crude oil. A combination of higher fuel price differentials and technological advancements may potentially make the production of alternative fuels more economical, especially over the medium to longer term. There are, nevertheless, hurdles in developing an industry for alternative fuels. In the case of coal-to-liquids, a major hurdle facing the startup of such an industry is the high capital costs associated with the construction of commercial sized plants.

The impact of coal-to-liquids technology on world oil prices will depend on the extent to which production of liquid fuels from coal increases in the future. If coal-to-liquids technology is widely adopted commercially by the APEC economies in the long term, production of liquid fuels from coal will increase significantly. This will reduce the dependence of the APEC region on crude oil imports and provide greater security for fuel supply in the region.

Trade and investment barriers in APEC

Free and open trade and investment is one of the core principles of APEC. The impact of various international arrangements on trade and investment liberalisation has been quite significant. Although average tariffs have fallen in most APEC member economies, individual tariffs and related trade barriers on a number of products remain high. The tariffs on fossil fuels, such as coal, oil and gas, are the lowest among categories of products. Only a few member economies impose tariffs on imports of crude oil and these are at low rates. Among these are Chile (8 per cent), Chinese Taipei (2.5 per cent), Republic of Korea (5 per cent) and Mexico (10 per cent).

Although APEC economies have made significant reductions in their tariffs, there are still opportunities to obtain economic benefits from further trade reform.

Some investment barriers still remain

APEC economies have been implementing structural adjustments of their economies, including deregulation of energy markets. In these economies, both upstream and downstream reforms of energy markets have been undertaken. The major upstream reforms relate to the removal or easing of controls on private and foreign involvement. Downstream reforms have also been widely implemented, although these activities remain heavily regulated in many economies. Despite these reforms, distortions still remain in many APEC economies. Governments in all APEC economies either restrict or ban foreign ownership of domestic assets in certain sectors. In most instances these restrictions or bans apply to transport and communication, financial services and in the development of natural and energy resources particularly oil and natural gas.

Gains from trade and investment liberalisation

Analysis of the Bogor Declaration shows that the implementation of trade liberalisation according to the principles and timetable agreed in the declaration could increase total APEC GDP by around 0.75 per cent in 2020. Additionally, when liberalisation of investment regimes, including liberalisation of foreign direct investment in APEC, is undertaken, additional GDP gains ranging from 0.5 to 2.7 per cent relative to trade liberalisation only are expected by member economies. If energy sector reform alone is undertaken, it may be also expected that economic gains could be attained as the energy sector is highly regulated in many APEC economies.

Limitations in the capacity to respond to oil price increases

Barriers to investment in the APEC region are expected to have a limiting effect on the ability of APEC as a region to adjust to sustained price increases in oil. The limitations may occur in three main areas: the ability to increase oil production within APEC; the ability to substitute oil with other energy products; and the ability to develop and introduce new technologies that are less oil intensive and to develop alternative processes in producing liquid fuels.

An important intervention in the energy sector in some APEC economies is the provision of fuel subsidies, including subsidies for consumption of petrol, diesel and other oil products. This intervention may provide short term relief to consumers but distorts energy markets and exacerbates the negative impacts of oil price rises on an economy.

Investment – key to moderating adverse effects of sustained oil price increases

Investment drives economic growth. It brings more inputs into the production process and builds the productive capacity of an economy. It brings not only financial resources, but technologies and management skills that increase productivity. The significance of investment in increasing economic growth motivates governments to seek investments from both domestic and international sources.

The importance of investment is even more crucial in the energy sector because energy is an integral part of economic activity, and investment in energy facilities is essential to support economic growth. In recognition of the region's needs for investment, APEC has given priority to facilitating investment in the energy sector, fostering efficient capital markets, and engaging international financial institutions and the private sector.

By removing the investment barriers and improving the domestic environment for investment, many APEC economies, particularly developing economies, can enhance their capacity to respond to changes in energy market developments such as sustained oil price increases.

Implications and responses

Oil is a vital input to economies in APEC. Sustained higher oil prices have the potential to cause significant adverse impacts on many economies,

depending on the size and duration of the price increases, the flexibility of domestic energy markets to substitute different fuels and technology, and the oil import dependence of the domestic economy. Based on the economic modeling undertaken, the key impacts of sustained high oil prices include a reduction in economic output and deterioration in the terms of trade for most APEC economies.

The effect of sustained high oil prices on economic growth in APEC economies is influenced largely by factors such as the oil intensity and oil import dependence of individual economies, and the interplay between the income transfer and output effects associated with the oil price increases. The oil importing developing economies in the region would generally suffer the most, as some of these economies are more oil intensive and less able to cope with the financial burden brought about by higher oil import costs. These adverse impacts will be accompanied by deterioration in the terms of trade in these economies.

Emerging technologies could slow the growth in transport fuel demand

The transport sector accounts for the largest share of oil consumption in many APEC economies. Hence the improvement in fuel efficiency on the consumption side, involving emerging technologies as well as those already available, can play a crucial role in slowing the level of growth of oil consumed in many APEC economies. This is particularly relevant in APEC economies where demand for transport fuels is triggered by continuing income increases in the medium to long term.

There is a range of fuel efficient transport vehicle technologies currently available, including hybrid vehicles and fuel cell vehicles. Although some of these technologies are only just entering into the commercial market, their cost effectiveness, economic viability and market penetration are likely to continue to improve in coming years.

Potential role of technological progress on the supply side

A range of technologies currently available have the potential to produce liquid fuels from alternative sources, not requiring crude oil. Active encouragement of the development and commercialisation of such technologies is another policy response that APEC economies could consider to reduce the oil dependence of the region.

Increasing need for the removal of investment barriers

Acceleration of efforts to remove investment barriers is another key policy response that APEC economies could consider. This would facilitate timely investment in production, processing, distribution and storage capacity in the energy sector in general and could also encourage investment in more fuel efficient energy technologies that would reduce the overall energy intensity of APEC economies.

1

introduction

APEC economies (see box 1) account for a considerable proportion of the world's oil production and an even larger share of world oil consumption. As a result, if current high oil prices were to increase further and remain at a higher level for a sustained period, the potential impact on economic growth and trade within the region, and elsewhere, could be considerable.

There has been awareness in the APEC region for some time, however, of the economic and security risks posed by high oil prices. In 2002, in response to the risks posed to the world economy by volatility in the oil market, the APEC Energy Working Group developed the APEC Energy Security Initiative (ESI) (APEC EWG 2004). Following high oil prices throughout 2004, member economies committed to implement measures identified in the ESI to promote sustainable development and common prosperity. They also recognised the importance of an assessment of the economic implications of high oil prices on the APEC region, culminating in this report.

Oil prices have been closely linked to the growth and development of economies over a long period of time. Empirical research draws a link between the price of oil and significant macroeconomic indicators, such as GNP, the trade balance, unemployment, inflation and interest rates (IMF 2005a).

Box 1: **Asia Pacific Economic Cooperation**

The Asia Pacific Economic Cooperation (APEC) group was formed in 1989, with twelve member economies. Since then, membership has grown to include twenty-one economies, incorporating a range of different economic systems and levels of development. APEC agreements and dialogue span a wide range of issues, including agriculture, government, human rights, education, industry, energy and trade. Of particular importance to this report, was the formation of the APEC Energy Working Group (EWG) in 1990. The EWG has five reporting bodies that cover the areas of energy data and outlook, clean fossil energy, energy efficiency and conservation, technology cooperation, and minerals and energy exploration and development.

It suggests that the price of oil can have a major impact on the health of domestic economies. Those relationships, and concerns about the effect of current and future prices, motivate analysis into the significance and likely economic effects of sustained increases in international oil prices.

Study objectives

The purpose in this report is to examine the impact of higher oil prices on trade and economic growth in the APEC region. The key objectives are to:

- quantify the effects of sustained increases in oil prices on macroeconomic indicators and patterns of trade within the APEC region;
- undertake detailed economic modeling to quantify these effects under a number of oil price scenarios;
- examine the extent to which trade and investment barriers limit the capacity of regional markets to respond to changes in energy prices; and
- explore the possibilities of mitigating the impact of sustained higher oil prices through the adoption of alternative, energy efficient technologies.

Research methodology

ABARE's global trade and environment model (GTEM) is used in this study to model the impacts of sustained higher oil prices within APEC on national and regional trade and key economic indicators. Economies in the APEC region are grouped as either net oil importers or exporters. Key economic indicators, including economies' GDP and share of world GDP are shown in box 2.

Two sets of alternative scenarios are used to assess the trade and macroeconomic impacts of sustained oil price increases relative to a reference case scenario. In the first set, scenarios 1 and 2 model the effects of sustained oil price increases of 30 per cent and 60 per cent above reference case levels respectively, with oil prices maintained at the higher level between 2006 and 2010. A third scenario is also undertaken to illustrate the potential macroeconomic impacts of high energy prices, including a 60 per cent increase for both oil and gas prices, and a 30 per cent increase in world thermal coal prices. The rationale for scenario 3 is based on recent increases in oil prices

being accompanied by increases in the prices of other energy commodities, including gas and coal. In the second set of scenarios, potential impacts on fuel consumption from the adoption of more efficient transport technology are modeled, assuming 60 per cent higher oil prices extended until 2015.

In the short term, demand for oil is relatively insensitive to price movements as a result of a lack of suitable substitutes and the strong link between

Box 2: **Key economic and energy consumption indicators for APEC member economies, 2003**

	GDP per person **a**	GDP **a**	Share of world GDP	Net oil exports
	US$	US$ **b**	%	'000 bp/d
United States	36 520	10 626	21.0	–11 449
Canada	30 936	977	1.9	364
Australia	27 818	556	1.1	–93
Japan	27 574	3 518	7.0	–4 482
Hong Kong, China	27 239	188	0.4	na
Chinese Taipei	23 558	537	1.1	–1 009
Singapore	23 552	100	0.2	–827
New Zealand	21 038	83	0.2	–84
Korea, Rep. of	17 280	837	1.7	–2 360
Brunei Darussalam	15 407	6	0.00	201
Chile	9 992	158	0.3	–235
Malaysia	9 471	237	0.5	254
Mexico	9 070	929	1.8	2 205
Russian Federation	9 001	1 290	2.6	4 825
Thailand	7 070	454	0.9	–758
Peru	4 990	142	0.3	–59
China	4 900	6 354	12.6	–1792
Philippines	4 345	352	0.7	–275
Indonesia	3 342	730	1.4	112
Viet Nam	2 337	189	0.4	365
Papua New Guinea	2 185	12	0.02	na
APEC total	28 274	56.2	–15 097	
World	50 497	100.0	–	

a Gross domestic product based on purchasing power parity (PPP); APEC economies are ranked according to GDP per person in 2003. **na** Not available.
Source: IMF (2004).

oil consumption and economic activity. However, if high and volatile oil prices were to continue in the longer term, it is likely that more resources would be devoted to research and development of more energy efficient technologies and the production of fuels from sources other than crude oil. Consequently, a discussion of the possible future role of technologies such as coal-to-liquids is also presented in this report.

The ability of APEC economies to respond to changes in relative energy prices depends on the flexibility of individual economic structures and the degree of substitutability between fuels. Where trade and investment barriers limit such flexibilities and the associated responses, the impacts of high oil prices are likely to be more substantial in terms of macroeconomic performance and trade patterns. Consequently, an assessment of trade and investment barriers and their likely impacts on economies' abilities to respond to oil price changes over the medium to longer term is also discussed in this report.

Report structure

In chapter 2, world oil market development issues are discussed in the context of the recent higher oil prices. Both supply and demand side issues are briefly explored.

An overview of oil production and consumption in the APEC region is provided in chapter 3, including a brief description of the production and use of coal, gas, nuclear and renewable energies. Oil intensity is discussed as an indicator of how economies may be affected by higher oil prices. A summary of oil trade in the region, and an outline of the oil stockpiling polices of APEC economies are also covered in this chapter.

In chapter 4, the modeling approach for the alternative scenarios is discussed in detail and the reference case scenario is outlined. The assumptions and timeline for the reference case, and the increased oil price scenarios are also addressed.

Chapter 5 consists of two sections. The first section presents the GTEM model results for scenarios 1 and 2, compared with the reference case scenario. The second section presents the results from scenarios 3, 4 and 5, where possible implications of the accelerated uptake of more efficient transport technologies over the period to 2015 are assessed.

In chapter 6, the role of new technology in fuel supply is discussed, with a particular focus on 'coal-to-liquids' technology. This includes technical issues and the potential for development, the commercialisation process, production and operation processes associated with coal-to-liquids technologies.

A discussion of the trade and investment regimes of the APEC region, with a particular emphasis on the energy sector is provided in chapter 7, while chapter 8 provides some concluding remarks.

2

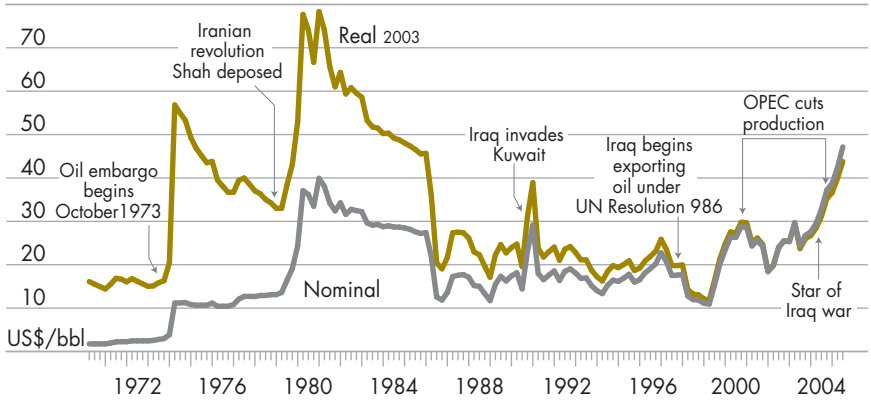
oil market development issues

Recent movements of oil prices in perspective

A key characteristic of the oil market is its price volatility. Recently, however, oil prices have followed a steep upward trend, approaching historical highs. Based on the West Texas Intermediate (WTI) oil price, both real and nominal oil prices are currently at their highest since the early 1990s (figure 1). In nominal terms, the percentage increases in prices of different grades of oil between 2002 and 2005 have been almost identical. All have more than tripled since the beginning of 2002 (box 3). While the increases are proportionally similar, the absolute difference between light, sweet oils and heavy, sour oils have been much greater in 2005 than in 2002.

Between 2000 and 2004, production of sour crude oil increased by 3 per cent, while production of medium and heavy crude oil increased by 4 per cent and 1 per cent respectively. On the other hand, production of light oils decreased by 4 per cent (OPEC 2005). Overall, average trade weighted oil prices are still lower than during either of the previous world oil crises — in the early to mid-1970s and the late 1970s to early 1980s (figure 1; EIA 2005f). The rapid increase in real oil prices during the past twelve

1 **World trade weighted average oil price**
Quarterly, ended June 2005



months, however, has raised concerns about the impact of further increases and whether the effects of previous price peaks will be repeated. Although extremely high peaks could affect economic growth, inflation, unemployment, interest rates and trade balances, many economies, particularly developed economies, have become more energy efficient than they were in the 1970s and 1980s (IMF 2005a), reducing the potential adverse impact of high oil prices.

While oil price increases of the past may have resulted from political turmoil in major oil producing regions, recent high oil prices are a result of a

Box 3: **Types of crude oil, their attributes and price differentials**

There are two attributes of crude oil generally described: viscosity (relative weight or API gravity) and sulfur content. Oils that are more viscous are considered to be 'heavy', while less viscous oils are described as being 'light'. Light oil is considered to have an API of greater than 35, medium is between 26 and 35, and heavy is less than 26 API.

Similarly, the higher the sulfur content the more 'sour' an oil is, as opposed to low sulfur oil, which is 'sweet'. Oil with a sulfur content of more than 0.5 per cent is considered to be sour.

The more viscous and high in sulfur an oil is, the more costly and complex the refining process (Hamilton 2005).

West Texas Intermediate (WTI): a light, sweet oil, ideal for producing low sulfur fuels; mainly used in the United States. As one of the most widely used benchmarks for oil prices, WTI prices have been used throughout this report

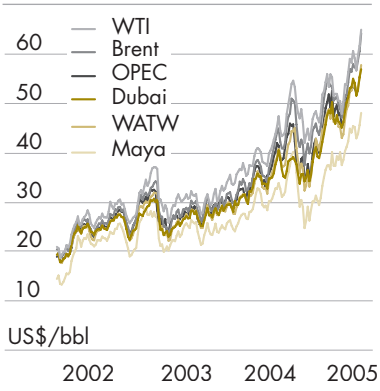
Brent: not as light or sweet as WTI, but still considered to be a high grade crude oil; mainly used in Europe.

OPEC market basket: slightly heavier and sourer than Brent; used around the world.

Mexican Maya: a heavy, sour oil.

Dubai: a medium, sour oil.

Oil price spread Nominal prices
Weekly, ended 14 August 2005



Source: EIA (2005f); OPEC (2005).

number of interrelated market factors, including increasing global demand; a decrease in spare production capacity; a lack of investment in downstream production capacity, particularly in oil refineries; environmental constraints associated with both end consumption and the establishment of new refineries; and ongoing geopolitical and economic disturbances in some of the major oil producing regions.

Increased global demand for oil

World demand for oil has grown steadily in recent years, with global oil consumption rising by 3.7 per cent in 2004 following strong economic growth and the expansion of oil intensive sectors, particularly transport (IEA 2004a; IFP 2005). Until 2005, the rapid growth in demand for oil was driven largely by economic growth in the United States and China. In China, for example, demand for oil grew by 15 per cent in 2004. Demand in the United States grew at 3.5 per cent in 2004 (Bailey, Mollard et al. 2005).

Although recent forecasts suggest that the rate of growth in world demand for oil could begin to ease in 2005, the absolute volume of oil demanded will continue to increase. Future increases in the growth of demand for oil are most likely to occur in rapidly developing economies, although the largest volume of oil will continue to be consumed in developed economies. ABARE analysis indicates that world oil consumption could rise by 1.9 per cent in 2005 and 1.8 per cent in 2006 (Bailey, Mollard et al. 2005).

Decrease in spare production capacity

Contrary to global demand, global spare crude oil production capacity has fallen to its lowest level since 1970 (figure 2a). Historically, high spare production capacity has been associated with low real oil prices, and low spare production capacity with high real oil prices (figures 2b; IMF 2005b). Since 2002, spare production capacity has been declining and oil prices have risen. Furthermore, low spare production capacity has also been associated with high levels of price volatility (figure 2c). In other words, as spare production capacity has fallen, both real prices and their volatility have increased in recent years. As shown in table 1, spare production capacity, represented as a percentage of total capacity, has fallen since December 2002. Although global oil production capacity has increased, global demand has increased at a higher rate. Combined with the increased demand for oil,

1 Global oil market: demand and capacity [a]

		December			
		2002	2003	2004	2005
Capacity	mbd	79.9	80.0	81.7	83.3
Demand	mbd	76.9	78.1	80.0	81.5–82.0
Spare production capacity	mbd	3.0	1.9	1.7	1.3–1.8
Spare production capacity as a percentage of total capacity	%	3.8	2.4	2.1	1.6–2.2

a Million barrels per day, excludes natural gas liquids
Source: IMF (2005a).

particularly from the United States and China, the historically low spare production capacity has been a major factor contributing to the recent oil price increases (IMF 2005b).

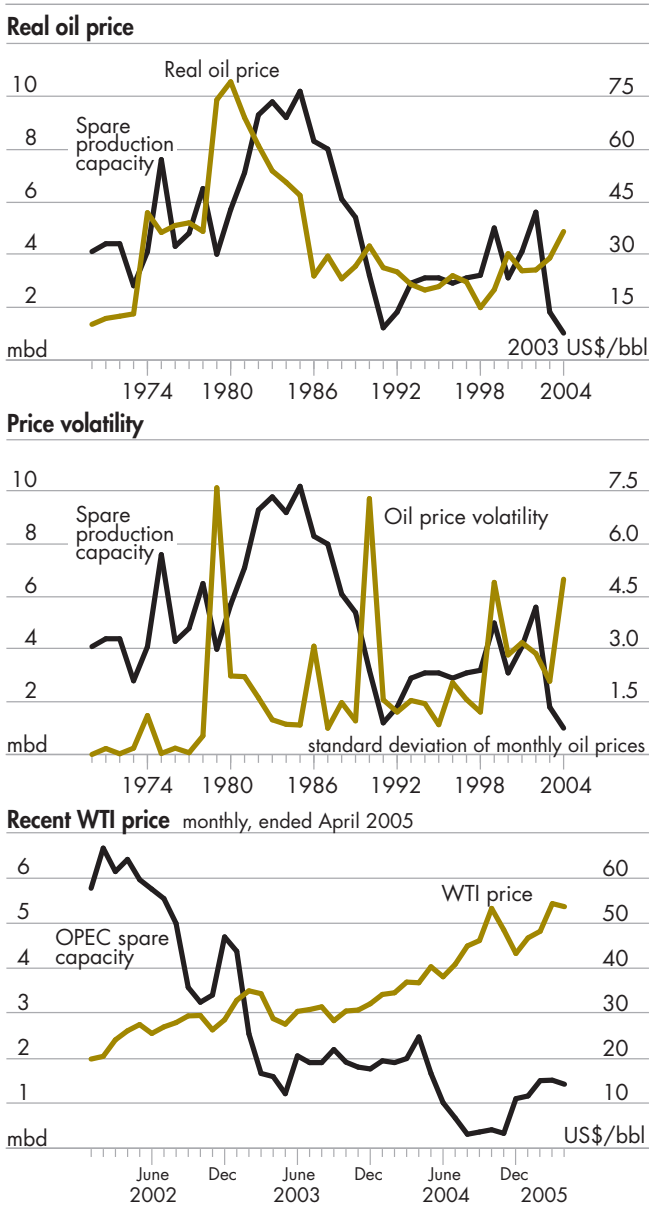
In response to the declining level of spare production capacity, OPEC has committed to maintain spare capacity of at least 1.5 million barrels a day. However, based on the oil shortages of the late 1970s, significantly higher spare production capacity, of more than 3–4 million barrels a day, would be required to stabilise current oil markets (IMF 2005b). The IMF (2005a) estimates that spare production capacity is likely to remain low, as current plans for expansion and replacement projects are forecast to just keep pace with demand. According to the IMF (2005a), projections of demand and supply of crude oil suggest that spare production capacity may remain low throughout the period to 2010.

Shortage of suitable refineries and tightened environmental standards

The current limited spare oil production capacity is partly the result of the low investment during the 1990s, owing to the low average real oil prices in that period (IMF 2005a). Furthermore, high and rising exploration costs, and high oil price volatility may also have contributed to producers' reluctance to engage in major crude oil projects with uncertain payoffs.

A shortage of refining capacity reflects not only low investment in capacity, but also a mismatch at the margin between available refineries and the type of crude oil being pumped (IMF 2005a). The mismatch between the

2 OPEC spare production capacity vs oil price indicators



Spare production capacity is defined as spare capacity of OPEC producers in millions of barrels a day. Prices are a simple average of West Texas Intermediate, Brent, and Dubai oil prices. Volatility is defined as the standard deviation of monthly real oil prices. *Source*: IMF (2005b).

available grades of crude oil and the prevailing refinery capacity has contributed to current higher oil prices in two key ways.

First, 'sour' and 'sweet' oils require different types of refining. 'Sour' grades (such as those commonly pumped in Saudi Arabia) are more costly and complex to refine into clean, low sulfur fuels than 'sweet' grades (such as those common to the United States). The upgrade of refineries to refine 'sour' oils is expensive and time consuming. Even in refineries where 'sour' oil can be processed, higher costs are involved. Oil with higher sulfur content has increased health risks associated with refining and higher overhead costs. Processing sour, heavy oil into sweet, light oils to meet market demand is also costly — the more stringent the regulations determining sulfur content and viscosity, the lower the yield of sweet, light oil products per litre of heavy, sour crude oil (Chernoff 2004).

Second, the demand for oil in many markets, particularly transport markets in developed economies, has increasingly been for light, sweet crude oils. This has largely been the result of regulations mandating lower levels of sulfur in petrol and diesel fuels. There have already been changes to regulations in Canada, Europe, Japan and United States restricting the level of sulfur in fuels. Further restrictions are scheduled in 2006 for both Japan and Europe (Chernoff 2004).

In order to increase the volume of heavy, sour crude being refined into light, sweet petroleum products, existing facilities will require upgrading, replacement and expansion. At the same time, other downstream industries, specifically pipelines and tankers, will also need to be maintained and expanded. Bottlenecks in all three of these areas have increased the pressure on oil derivative products, and will continue to do so in the short term (IMF 2005a). While estimates of the level of investment needed to meet global demand for oil vary, the IEA (2004a) projects that annual investment of US$105 billion will be required by the oil industry between 2005 and 2030. Of this projected investment, only 25 per cent would be directed toward meeting new demand; the rest would be for maintaining or replacing existing production areas, refineries, pipelines and other facilities.

Barriers to increased production

Investment decisions to fund oil exploration, production and downstream industries are complicated by uncertainties about oil prices and demand,

and the lead time (anywhere from two to eight years) for new capacities to be developed. The experience of overinvestment following record high oil prices in the 1970s is likely to increase the degree of cautiousness exercised by investors in their decisions (IMF 2005a).

In some oil producing regions, including some within APEC, there are also significant restrictions on foreign investment. These include limits on the percentage of foreign ownership, discriminatory screening processes and performance requirements. As increased oil production is only feasible at a few major oil producing areas, unless new reserves are discovered, the likelihood of new stakeholders being able to invest is uncertain, and will depend on regulatory barriers and incentives in place (IMF 2005a).

Even in areas where investment is legally permitted, there may remain certain environmental requirements that influence the level of investment. The effects of environmental regulations restricting the permissible sulfur content of oil products is an example.

Regulations on upstream investment can affect access to wilderness areas. An example is the current debate in the United States over whether or not drilling can be carried out in the Arctic National Wildlife Refuge. There are also potential issues associated with the negative environmental impact of operations, including gas flaring and the disposal of drilling mud (Stevens 2005).

Refineries, pipelines and tankers are also affected by environmental regulations and policies. The most significant effect, apart from instances where new developments are prohibited, is the increase in capital and operating costs. In some instances, even where development is permitted, these costs may render oil industry developments prohibitively expensive. In the United States, for example, the last refinery built was in 1976, and there are no current plans for new refineries (IMF 2005a). Increased refinery capacity is more likely to be the result of refineries expanding their existing capacities. Stevens (2005) also highlights that because of the high environmental costs of refinery closure, at least in the United States, it is unlikely that refineries unable to convert, refurbish or expand their refining capacities will actually close. Instead, although still designated as 'refineries' they will simply stop refining operations.

Global trends in expansion of downstream facilities demonstrate the combined effects of these barriers to investment, and suggest that there will be a lag between current high oil prices and improved refining capacity. China is embarking on a number of different projects, including two new refineries and the upgrading of several other refineries to process heavier, sourer grades of crude oil. In Brazil, significant investment in refining capacity is scheduled to occur between 2005 and 2010. Three major oil exporters — the Russian Federation, Saudi Arabia and Iran — are also planning various degrees of expansion in their downstream industries. In the short term, however, the earliest that any of these projects are anticipated to finish is 2008, with many not due for completion before 2010. This suggests that the bottlenecks and pressure on existing producers and refiners may continue for some time.

Geopolitical tension

The impact of increasing global demand for oil, low spare crude oil production capacity, a lack of refining facilities and barriers to investment in oil production, refining or transport have all been exacerbated by geopolitical tension in some oil producing regions. Turmoil, both political and economic, in producing regions has disrupted supply on occasion, and adversely affected the ability of oil markets to ensure a smooth supply of oil. As a result, oil importing economies, especially those with an increasing demand for oil and a high dependence on oil imports, are reassessing their current supply chains, and many will endeavor to establish secure supplies from a range of sources. A number of APEC economies have been pursing this path. This has been evident in ongoing negotiations between the Russian Federation and both China and Japan on the prospect of transporting oil through pipelines from eastern Siberia to Daqing (China) and Nakhodka (a port on the far eastern coast of Russia) (IEA 2004a); the pursuit of oil exploration by national oil companies in foreign production areas (APERC 2003a); and the increasing implementation of stockpiling measures within the region (Hogan et al. 2005).

3

crude oil consumption, production and trade in APEC

The twenty-one members of APEC vary significantly in the size and structure of their economies, income levels, energy consumption and production, oil endowments and access to external supplies of oil. In this chapter, the structure of oil markets in the APEC region is discussed, focusing on oil consumption, intensity, production, trade and stockpiling arrangements.

Crude oil and energy consumption

Total primary energy consumption (TPEC) measures the total energy consumed within an economy, including both renewable (wind, hydro, geothermal etc.) and nonrenewable energy sources. Although the focus in the report is on the effect of higher oil prices on trade in the APEC region, a significant change in the price of oil would invariably affect the mix of fuels consumed in the APEC region. In 2003, TPEC in APEC was 6176 million tonnes of oil equivalent (Mtoe). Developed APEC economies accounted for more than half of TPEC in the region (IEA 2005a,b).

For APEC as a whole, oil accounted for the largest share of TPEC in 2003 (2149 Mtoe), at 35 per cent (table 2). In individual economies, the share of oil in the primary energy mix varies considerably, from 79 per cent in Singapore to 19 per cent in China. On average, oil was a significant energy source in all member economies in 2003.

Coal had the second largest fuel share of TPEC for the whole of APEC in 2003, at 29 per cent. China dominates the consumption of coal, with a 60 per cent share. Other economies ranged from no use of coal (Brunei Darussalam and Singapore) to 43 per cent in Australia. The third largest source of energy in the region was natural gas, which accounted for 20 per cent of TEPC in the APEC region in 2003.

Nuclear energy was important in some economies (Canada, Chinese Taipei, Japan, Korea and the United States) but was not utilised in more than half the APEC economies. The total share of nuclear in TPEC in the APEC region was 6.2 per cent in 2003.

Finally, renewable energy resources made up 9 per cent of the APEC region's TPEC in 2003. Developing economies in the APEC region generally had the highest shares of renewable energy in TPEC, which reflected high levels of combustible/renewable waste in most cases.

2 Fuel shares in total primary energy consumption (TPEC) in APEC economies, 2003 a

	Coal	Oil	Gas	Nuclear	Hydro	Geothermal	Solar/wind etc. b	Combustible/renewable waste c	All renewable sources
	%	%	%	%	%	%	%	%	%
Net oil importers									
Australia	43	32	20	0	1.2	0	0.1	4	6
Chile	11	41	26	0	7.4	0	0	15	23
China, People's Republic	60	19	2	0.8	1.7	0	0	16	17
Chinese Taipei	37	44	7	10.3	0.6	0	0	1	2
Hong Kong, China	41	51	8	0	0	0	0.0	0	0
Japan	21	50	14	12.1	1.6	0.6	0.1	1	4
Korea, Rep. of	23	49	11	16.5	0.2	0	0	0	1
New Zealand	10	39	22	0	11.7	11.4	0.4	5	28
Philippines	11	37	5	0	1.6	20.0	0	24	46
Peru	6	57	5	0	13.3	0	0.5	19	32
Singapore	0	79	20	0	0	0	0.6	0	1
Thailand	11	46	26	0	0.7	0	0	17	17
United States	23	40	23	9.0	1.1	0.4	0.1	3	5
Net oil exporters									
Brunei Darussalam	0	27	72	0	0	0	0	1	1
Canada	12	35	30	7.5	11.1	0	0	4	16
Indonesia	12	36	22	0	0.5	3.4	0	27	31
Malaysia	7	49	39	0	0.9	0	0	5	5
Mexico	5	57	26	1.7	1.1	3.4	0	5	10
Russian Federation	17	21	53	6.2	2.1	0	0	1	3
Viet Nam	13	24	6	0	3.7	0	0	53	57
APEC d	29	35	20	6.2	1.8	0.5	0.1	7	9
World	24	34	24	6.5	2.2	0.4	0.1	11	13

a Total primary energy consumption (TPEC) is also referred to as total primary energy supply (TPES). Includes minor adjustments in electricity and heat for Canada; Hong Kong, China; and the Russian Federation. **b** Includes solar, wind, tide and wave energy. **c** Combustible renewables and waste. **d** APEC total excludes Papua New Guinea.
Source: IEA (2005a,b).

End use consumption of oil

Most of the demand for oil in APEC economies came from three sectors: transport, industry and agriculture (table 3). Each of these sectors is highly dependent on oil, with limited substitution options in the short to medium term.

3 Share of petroleum products in total final energy consumption in APEC economies, by end use activity, 2003

	Industry	Transport	Agriculture	Commercial and public services	Residential	Non-specified other energy use	Non-energy use	Total
	%	%	%	%	%	%	%	%
Net oil importers								
Australia	15	98	93	9	4	–	100	52
Chile	22	99	56	28	18	–	–	43
China, People's Republic	16	92	51	53	5	0	66	24
Chinese Taipei	52	99	82	23	23	39	84	60
Hong Kong, China	71	100	–	14	4	0	100	65
Japan	46	98	97	48	34	100	100	62
Korea, Rep. of	57	99	84	41	21	100	100	62
New Zealand	6	99	66	9	4	–	100	49
Philippines	23	100	100	51	21	0	58	51
Peru	52	100	47	92	29	–	100	60
Singapore	80	99	0	0	0	–	100	78
Thailand	24	100	99	0	20	0	100	53
United States	26	97	96	9	12	0	100	54
Net oil exporters								
Brunei Darussalam	65	100	–	0	40	0	100	68
Canada	25	92	63	27	10	–	97	44
Indonesia	31	100	100	7	20	–	100	41
Malaysia	34	100	100	27	19	–	100	60
Mexico	35	100	78	37	42	–	100	67
Russian Federation	11	58	44	6	3	65	88	21
Viet Nam	34	99	84	58	2	–	100	25
APEC a	36	97	74	27	16	30	94	52
World	35	95	62	20	12	24	94	43

a APEC total excludes Papua New Guinea.
Source: IEA (2005a,b).

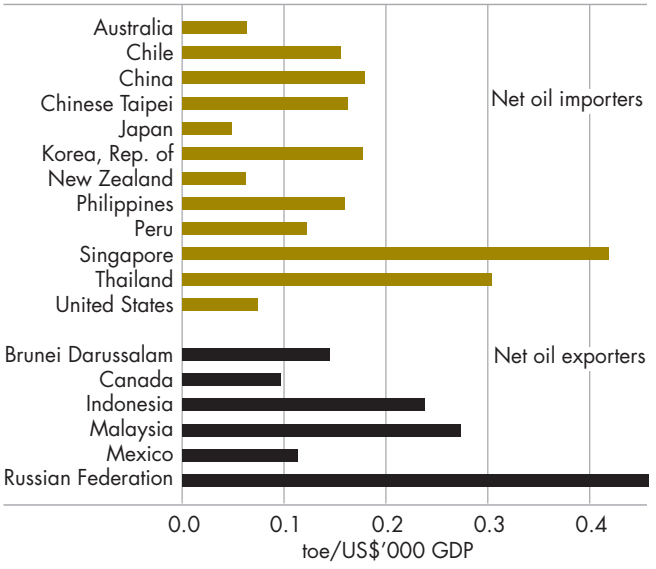
The transport sector is highly oil intensive. Within the APEC region in 2003, 97 per cent of the transport sector's energy consumption was of petroleum products (IEA 2005a,b). Based on international trends, road was the dominant mode of transport, followed by air. Rail, pipeline, international maritime and other forms of transport each make up a small proportion of the remainder. More than half of the total transport sector was used for passenger transport (IFP 2005).

The industrial and agricultural sectors were also highly oil intensive in 2003. Although the agricultural sector was more oil intensive, at 74 per cent, it accounted for only 2 per cent of total energy consumption. The industry sector, on the other hand, was the largest energy consuming sector (33 per cent for the total APEC region).

Crude oil intensity

Oil intensity is defined as domestic oil consumption per unit of gross domestic product (GDP). It helps to identify which sectors of the economy consume the largest amounts of oil per unit of output and which would be the most significantly affected by higher oil prices. High oil intensity

3 Crude oil intensity, by APEC economy, 2003
Data not available for Viet Nam and Hong Kong China



indicates that an economy is relatively more reliant on oil as an input to production than in an economy with a lower oil intensity. Figure 3 shows the oil intensity of twenty APEC economies (IEA 2005a,b; IMF 2004; data are not available for Papua New Guinea).

Developed economies tended to have lower levels of oil intensity than do developing economies, which may reflect the adoption of less oil intensive technology as well as the expansion of the service sectors within their domestic economies. In some APEC economies (for example, China, Korea, Malaysia, the Philippines and Thailand), high levels of oil intensity are the result of rapid industrial growth and increases in automobile fleets. In other cases, such as Singapore, one of the major global oil trading hubs, a high level of oil intensity reflects its role as regional importer and refiner of crude oil and exporter of petroleum products, rather than high levels of domestic oil consumption.

Crude oil and energy production

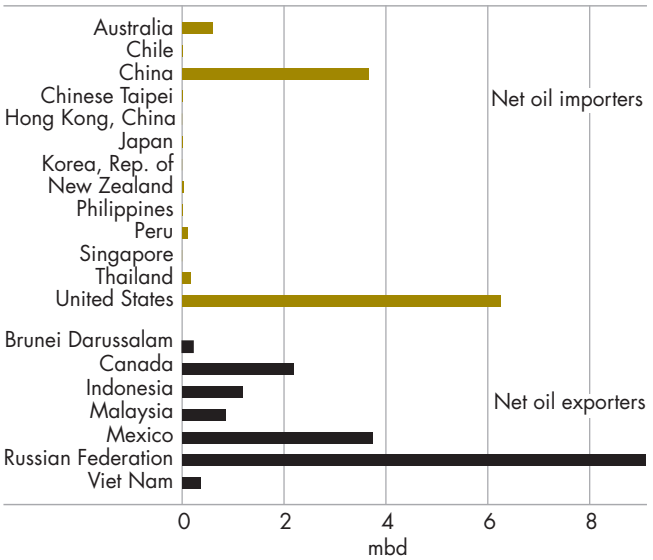
Economies within the APEC region produce oil, gas, coal and uranium, as well as renewable energy (figure 4). Total primary energy production in the APEC region — including the production of coal, oil, natural gas, nuclear and renewable energy — was 5647 Mtoe in 2003 (IEA 2005a,b). This was equivalent to 53 per cent of world primary energy production in 2003.

Seven APEC economies produced more than 37 per cent (1372 Mtoe) of world oil supply in 2003 (figure 4): the Russian Federation (11 per cent), the United States (9 per cent), Mexico (5 per cent), China (5 per cent), Canada (4 per cent), Indonesia (2 per cent) and Malaysia (1 per cent) (IEA 2005a,b).

APEC oil refinery capacity

World oil refinery capacity has been increasing since 1994, and is projected to reach slightly more than 80 million barrels a day by the end of 2005 (EIA 2005i). Refining capacity within the APEC region represents more than 50 per cent of that total, concentrated in developed economies (27 million barrels a day). Of the remainder, the Russian Federation refines 5.4 million barrels a day, and China 4.6 million barrels a day, with 6 million barrels spread across the other APEC economies.

4 Crude oil production, by APEC economy, 2003

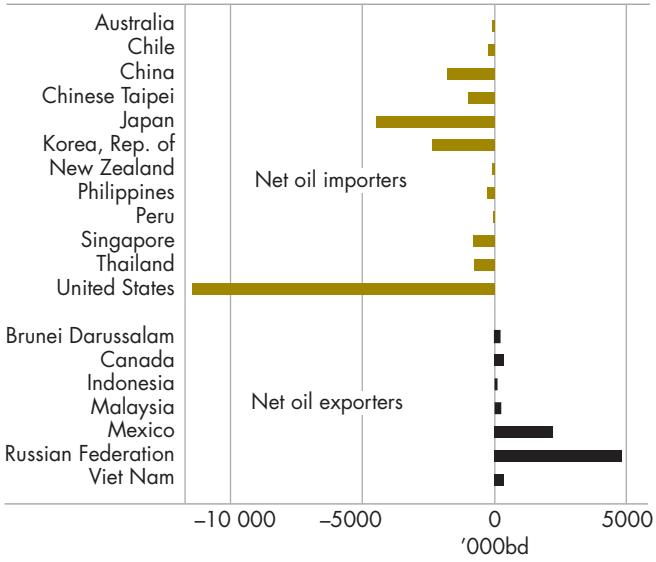


Since 1993, refining capacity in APEC has increased by 30 per cent. Further expansion is planned in Chile, China, Indonesia, Mexico, the Russian Federation, Singapore, the United States and Viet Nam. The planned expansions include both the establishment of new refinery plants, or (as in the United States) the expansion of capacity at existing plants (EIA 2005b,c, d,h,j,k,l; Bailey, Mollard et al. 2005). In the short term, however, as the demand for refined products is projected to increase faster than refining capacity is expanded, the refining sector is likely to continue to put upward pressure on the prices of refined products. This will also contribute to volatility in world oil prices (Bailey, Hanna and Penm 2005).

Crude oil trade

Although consisting of both oil exporters and importers, the APEC region is a net importer of oil. While oil was imported from a number of different sources in 2003, four economies (Saudi Arabia, United Arab Emirates, Venezuela and Iran) provided more than half of the imports (United Nations Statistics Division 2005). Over the next five years, it is anticipated that not only will reliance on non-APEC oil suppliers increase, but also the proportion of oil sourced from suppliers in the Middle East will rise (IMF 2005a).

5 Net crude oil exports, by APEC economy, 2003



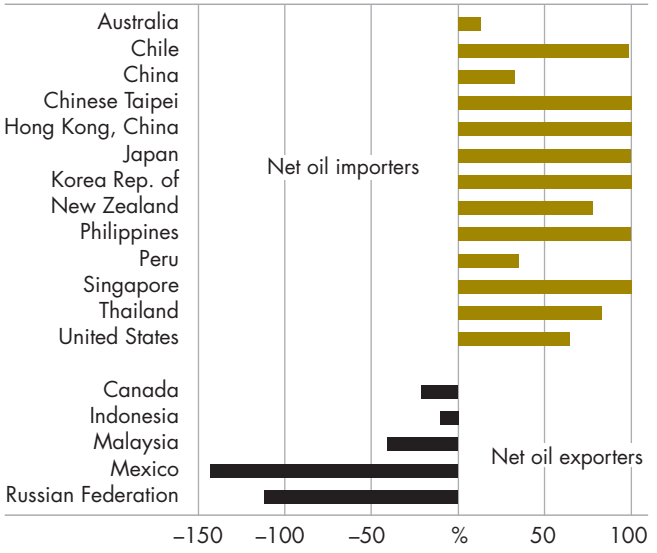
Most oil exports from APEC economies were directed to the United States (39 per cent), while 11 per cent was exported to other APEC economies. Of the remaining oil exported, most went to Europe.

There is considerable variation across APEC member economies in the net flow of oil trade. Some economies (Chinese Taipei, Hong Kong China, Japan, Korea, the Philippines and Singapore) rely on imports for almost 100 per cent of their oil consumption, while others are large exporters. As shown in figure 5, the Russian Federation, Mexico, Canada, Viet Nam and Malaysia were the largest net exporters, although Brunei Darussalam exported a much larger proportion of domestically produced oil (figure 5).

Crude oil import dependence

Oil import dependence, defined as net imports as a percentage of total domestic consumption, varied considerably among APEC economies in 2003 (figure 6). Most APEC economies were net oil importers, importing between 13 per cent and 100 per cent of oil consumed in their domestic markets. Of the oil exporting economies, Brunei Darrusalam exported more than ten times the oil consumed domestically, while Indonesia had only marginal exports.

6 Crude oil import dependence, by APEC economy, 2003 Data not available for Viet Nam; Brunei Darussalam=–1350



Oil security and stockpiling

Import dependence has a significant impact on how economies perceive oil security, and how higher oil prices will affect domestic economies. As a result of the potential impacts of higher oil prices, oil security has been a major concern of both oil importing and exporting economies since the first oil price shock in 1973. In the absence of decreasing domestic demand or large domestic oil reserves, most APEC economies are seeking to establish diversified, secure supplies of oil imports.

Oil stockpiles can play an important role in the strategies of economies attempting to establish a secure oil supply. Member economies of the International Energy Agency are required to maintain emergency aid reserves equivalent to 90 days of oil imports. The emergency aid reserves can include both commercial and government oil stocks. By maintaining stockpiles, in the event of a large increase in oil prices, individual economies may have some ability to moderate the effects and volatility of the market (Hogan et al. 2005).

Seven APEC economies (Brunei Darussalam, Canada, Malaysia, Mexico, Papua New Guinea, the Russian Federation and Viet Nam) have no

emergency stockpile measures in place. All of these economies are net exporters of oil. Of the seven, Canada has some emergency legislation in place and Malaysia operates a 'Five Fuels' policy to enhance energy diversity and security. Of the net oil importers, the United States, Korea and Japan all maintain emergency stockpiles that meet or exceed IEA requirements. Indonesia maintains emergency stockpiles in order to secure domestic supplies of oil. Australia and New Zealand do not maintain emergency stockpiles, but commercial stocks exceed IEA requirements. Singapore maintains an oil stockpile for electricity generation only. Chinese Taipei, Chile, Thailand and Peru all have varying degrees of mandated stocks held by producers, importers or wholesalers. Hong Kong China has recently developed an 'Oil Supply Contingency Plan', and the Philippines and China are currently working on an emergency contingency plan and emergency stocks respectively (Hogan et al. 2005).

Any form of stockpile drawdown, however, remains a short term response to oil price increases or supply shortages. Other short term measures can also include demand restraint, surge production, fuel switching and information sharing about market supply and demand. Long term policy measures are also important in reducing the risk and/or cost of temporary energy supply disruptions. These include achieving increased domestic energy exploration and production, diversification of oil import sources, diversification of the domestic fuel mix through investment in alternative energy sources, efficiency improvements in energy use, removal of market and policy impediments, promotion of dialogue between oil producers and consumers and long term contracts with suppliers (Hogan et al. 2005).

4

modeling approach

A key objective in this study is to quantify the impacts on APEC economies of sustained increases in oil prices. The methodology employed in the study is outlined in this chapter, together with an analysis of the reference case, thereby providing the basis for understanding the impacts of the scenarios of sustained increases in oil prices reported in the following chapter.

Global trade and environment model

The impacts of sustained oil price increases are estimated in this study using ABARE's global trade and environment model (GTEM). GTEM is a multiregion, multisector, dynamic general equilibrium model of the world economy.

GTEM is an appropriate framework for analysing sustained increases in oil prices because it takes into account the interactions between different sectors of the economy and among economies through trade and investment linkages. The model includes a high level of commodity disaggregation, including a detailed treatment of energy and energy related sectors and a sophisticated representation of technological change and interfuel substitution possibilities in the energy sector. This enhances the capacity of GTEM to analyse the impacts of sustained increases in oil prices that could influence the operation of energy markets and hence domestic and global economies.

Further information on GTEM is provided on ABARE's web site (www.abareconomics.com).

Regional and sectoral aggregation

At its most disaggregated level, the version of GTEM used in this study consists of equations and data that describe the production, consumption, trade and investment behavior of representative producers and consumers in 68 regions and 62 production sectors. In this project, the GTEM database has been aggregated to the 23 regions and 18 sectors that best capture the

macroeconomic and trade implications of sustained increases in oil prices in the APEC region (table 4).

The sectoral aggregation was chosen to include the five fossil fuels — brown steaming coal, black steaming coal, coking coal, oil and gas — together with electricity and refined petroleum products. The aggregation in the study also includes the major energy intensive industries that are likely to influence total energy consumption.

The regional aggregation separately identifies each APEC member economy other than Brunei Darussalam and Papua New Guinea. Other major energy producing and trading regions, in particular the Middle East, the rest of OPEC, Europe and the Rest of World, are also represented.

4 Regions and sectors in GTEM

Region		Sector	
1	Australia	1	Brown steaming coal
2	Canada	2	Black steaming coal
3	Chile	3	Coking coal
4	China, People's Republic	4	Oil
5	Hong Kong, China	5	Gas
6	Indonesia	6	Refined petroleum products
7	Japan	7	Electricity
8	Korea, Rep. of	8	Iron and steel
9	Malaysia	9	Nonferrous metals
10	Mexico	10	Aluminium
11	New Zealand	11	Chemicals, rubber and plastics
12	Peru	12	Nonmetallic minerals
13	Philippines, Republic of	13	Other minerals
14	Russian Federation	14	Other manufacturing
15	Singapore	15	Transport (other than marine) and trade
16	Chinese Taipei	16	Services
17	Thailand	17	Agriculture, forestry and fisheries
18	United States	18	Marine transport
19	Viet Nam		
20	Middle East		
21	Other OPEC **a**		
22	Europe **b**		
23	Rest of World		

a In the version of GTEM used here, 'Other OPEC' includes Venezuela, north Africa (representing Algeria) and subSaharan Africa (representing Nigeria). **b** Europe includes Central Asia.

Developing a reference case

As a dynamic general equilibrium model, GTEM requires a reference case scenario against which the impacts of alternative scenarios can be measured. The reference case projects the growth in key variables in a region in the absence of any significant policy changes or external shocks. In this study, for example, the reference case represents the likely outlook for economic activity and energy demand and supply in APEC and across the world over the period to 2015, in the absence of any changes to key energy or economic policies. The reference case projections also quantify possible developments in energy security indicators, such as oil import dependence.

Economic growth

In developing a reference case for APEC, a number of important assumptions have been made. The first of these is how real GDP of each economy is likely to grow over the projection period. The annual average real GDP growth rates assumed in this study are given in table 5. These assumptions project more rapid economic growth in developing APEC economies, such as China, Thailand and Viet Nam, and slower growth in developed APEC economies, such as Japan and the United States.

The historical growth rates used in the study are from the International Monetary Fund (IMF 2004). Long term projections to 2015 are from ABARE and are derived by fitting an ARIMA (autoregressive integrated moving average) forecasting model to the historical GDP data.

5 Real GDP growth rates assumed in the reference case

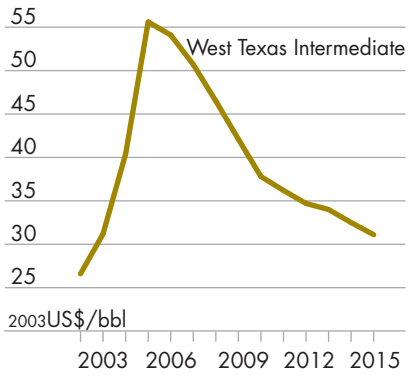
Average annual growth

	2002–15
	%
Australia	3.4
Canada	3.1
Chile	4.4
China, People's Republic	7.3
Hong Kong, China	3.7
Indonesia	4.5
Japan	1.6
Korea, Rep. of	4.2
Malaysia	5.2
Mexico	3.4
New Zealand	3.2
Peru	3.8
Philippines, Republic of	3.6
Russian Federation	5.1
Singapore	4.2
Chinese Taipei	4.1
Thailand	5.4
United States	3.4
Viet Nam	6.7
Middle East	4.1
Other OPEC	3.7
Europe	2.3
Rest of World	4.6

Oil price

In order to accurately model the impact of sustained increases in oil prices, the reference case assumes the world oil price that could be expected in the absence of any future shocks. This includes the most recent increase in the world oil price to mid-2005. Figure 7 shows the real West Texas Intermediate (WTI) price of oil in constant 2003 US dollars assumed in the reference case, for the period 2003–15. In particular, it is assumed that the real WTI price declines only gradually, reflecting strong growth in oil consumption, particularly in China, together with capacity constraints associated with low investment earlier this decade.

7 World oil prices assumed in the reference case



LNG prices

Current LNG contracts explicitly link LNG prices to crude oil prices, although recent LNG contracts signed with China set a ceiling on the oil price used to calculate LNG prices (Facts Inc. 2003). The link between the oil price and LNG prices has been represented in the reference case for Japan, Korea and Chinese Taipei, these being the only APEC economies that import LNG under long term contracts. While China will begin importing LNG under contract in this decade, it is assumed that the price of LNG imported by China is already at the ceiling price of Chinese contracts.

Oil and gas reserves

The outlook for the production and export of both oil and gas depends significantly on the abundance and location of oil and gas reserves. Assumptions about resource constraints have therefore been incorporated to represent the likely development in oil and gas reserves around the world. In particular, it is assumed that all APEC oil producers other than the Russian Federation, encounter oil production constraints throughout the projection period. In the gas sector, it is assumed that production is constrained by resource limits in Canada, China, Thailand and the United States.

While Mexico has relatively abundant oil and gas reserves, there are constitutional barriers to foreign investment in oil and gas exploration and production. These barriers are represented in the reference case as natural resource constraints.

Fuel mix in electricity generation

As electricity is a major energy consuming sector in APEC economies, the fuel mix in electricity generation is another key determinant of energy consumption (table 6). In GTEM, electricity is generated by a finite number of fuel specific technologies, with distinct fixed input requirements. The power generation technologies in the model are brown steaming coal, black steaming coal, oil, gas, nuclear, hydropower and other renewables. The share of each fuel in total electricity generation is determined exogenously

6 Fuel shares in electricity generation, reference case, 2002 and 2015

	Brown coal		Black coal		Oil		Natural gas		Nuclear		Other	
	2002	2015	2002	2015	2002	2015	2002	2015	2002	2015	2002	2015
	%	%	%	%	%	%	%	%	%	%	%	%
Australia	21.6	18.2	56.1	53.1	1	0.8	13.6	19.0	0	0.0	7.7	8.9
Canada	11.1	10.4	8.5	7.9	2.4	2.2	5.8	11.4	12.6	12.8	59.7	55.4
Chile	0	0.0	19	12.8	1.1	0.6	25.3	35.9	0	0.0	54.6	50.7
China	0	0.0	77.5	70.4	3	1.4	0.3	5.4	1.5	5.4	17.7	17.4
Hong Kong, China	0	0.0	63.6	65.0	0.4	0.4	35.7	34.3	0	0.0	0.3	0.3
Indonesia	0	0.0	39.6	43.2	23.2	13.1	22	29.9	0	0.0	15.2	13.8
Japan	0	0.0	26.5	24.7	13.2	9.5	22.3	25.5	26.9	30.8	11	9.5
Korea, Rep. of	0	0.0	39.7	37.8	9.5	2.8	12.7	11.2	36.2	46.1	1.9	2.1
Malaysia	0.6	0.3	5.4	28.6	9.3	0.2	77.3	61.7	0	0.0	7.4	9.2
Mexico	12.1	7.0	0	0.0	36.9	21.0	32.1	59.9	4.5	2.9	14.4	9.2
New Zealand	0	0.0	4	3.0	0	0.0	25.1	17.1	0	0.0	70.9	79.9
Peru	0	0.0	2.3	3.0	10.3	10.2	4.5	20.3	0	0.0	83	66.5
Philippines	0	0.0	33.2	32.5	13	7.8	18	31.2	0	0.0	35.8	28.5
Russian Fed.	6.3	6.3	12.8	12.6	3.1	2.6	43.2	47.8	15.9	13.7	18.8	16.9
Singapore	0	0.0	0	0.0	39.6	21.2	58.3	75.8	0	0.0	2.1	3.0
Chinese Taipei	0	0.0	55.3	57.9	12.5	4.6	9.9	18.5	19	15.6	3.4	3.3
Thailand	15.3	5.5	1.1	10.0	2.6	1.0	72.2	77.0	0	0.0	8.7	6.5
United States	2.4	2.0	48.6	46.4	2.5	2.5	17.7	22.8	20	16.6	8.8	9.7
Viet Nam	0	0.0	13.6	12.2	12.2	3.4	23.2	31.0	0	0.0	51	53.4

(outside the model) in the reference case, using government, IEA and other projections.

Electricity fuel shares reflect a wide range of factors, including relative fuel prices, energy endowments and levels of development, as well as concerns about energy security. For example, the share of natural gas in electricity generation is projected to increase relative to coal in many developed economies. This is because it is assumed that the relatively low capital costs of natural gas turbines will ensure that natural gas fired capacity remains competitive for the provision of peak load electricity. This is expected to account for a greater proportion of electricity demand in many developed economies where economic growth is slower and base load demand is more adequately met by existing capacity. On the other hand, it is projected that black steaming coal fired capacity will remain cost effective for base load capacity in many economies, because of its relatively low fuel costs. This is expected to result in increased shares of black steaming coal fired capacity in many rapidly growing developing APEC economies, where a greater amount of new capacity is expected to be base load.

Other key assumptions

In the reference case, other key assumptions are that:

- new LNG trade contracts are realised – in particular, China commences LNG imports from Australia and Indonesia by 2007.
- the efficiency of energy use in the electricity sector improves over time – this assumption represents the likely trend in energy efficiencies given the rates of capacity growth projected in the reference case and are identical to those reported and explained in Heaney et al. (2005).

Reference case projections

The reference case projections presented here represent a possible outlook for energy demand and supply in APEC economies over the period to 2015 in the absence of any major policy changes or external shocks. The results, however, are not forecasts of what will actually happen in the APEC region. They are conditional on the set of assumptions outlined earlier that are considered plausible at the present time. Subject to these assumptions being realised, the projections provide a reasonable estimate of energy market developments in APEC economies.

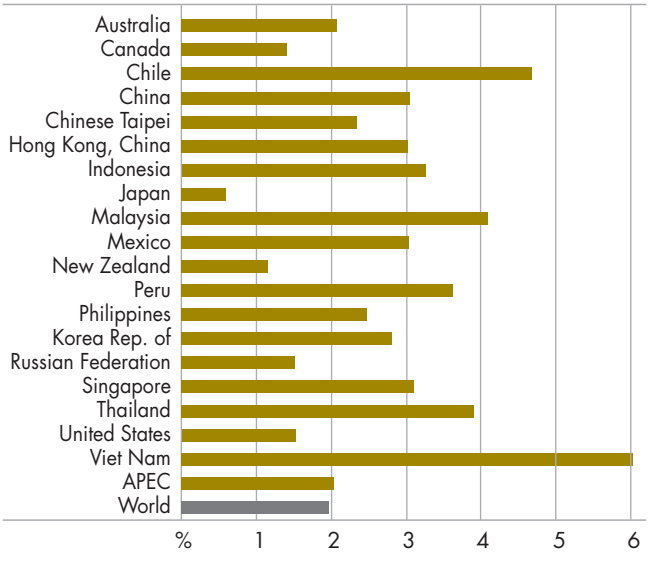
Primary energy consumption in APEC

Total primary energy consumption in APEC is projected to grow in the reference case by 2.0 per cent a year between 2003 and 2015, to reach 7285 Mtoe (figure 8). Growth in energy consumption varies considerably among APEC economies. Energy consumption is projected to expand most strongly in the rapidly growing developing APEC economies, as a result of relatively high economic growth and increased demand for personal services such as transport and air conditioning. In contrast, energy consumption is projected to grow more slowly in developed economies, such as Japan and the United States. Significant improvements in energy efficiency in the Russian Federation contribute to low growth in energy consumption in that economy.

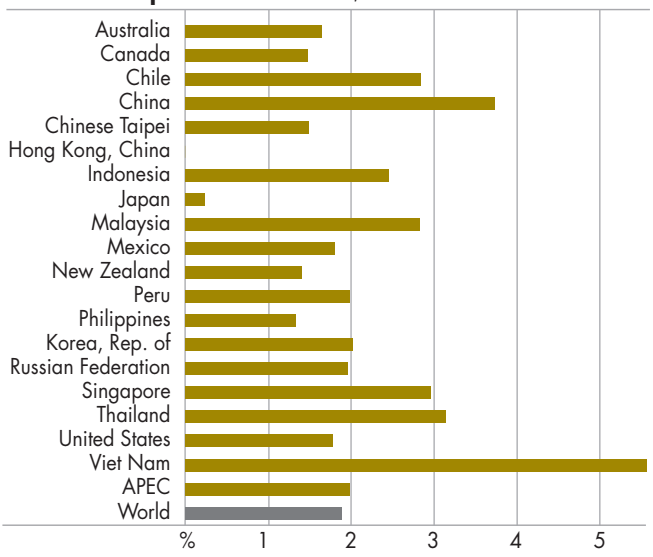
Fossil fuels are projected to retain their dominant share of APEC primary energy consumption, accounting for around 90 per cent of the growth in total APEC energy consumption over the projection period.

Natural gas is projected to be the fastest growing fuel in APEC, particularly because of increased demand for gas for electricity generation in developing economies. Similarly, increased demand for coal in the electricity sector

8 Average annual growth in total primary energy consumption reference case, 2003–15



9 Average annual growth in total primary oil consumption reference case, 2003–15



in developing APEC economies is the main driver of the growth in APEC coal consumption.

The share of oil in APEC total primary energy consumption remains steady at around 35 per cent throughout the projection period. APEC oil consumption grows by 1.7 per cent a year between 2003 and 2015, driven mainly by increased demand from the transport sector, where there are limited substitution possibilities (figure 9). Growth in oil consumption is strongest in the rapidly growing developing economies, such as China, where robust growth in the transport sector results from rapid economic growth and the sharp rise in private vehicle ownership.

Oil consumption, by sector

Growth in refined oil consumption in APEC is projected to be concentrated in the transport sector and, to a lesser extent, the industrial sector. In APEC, the transport sector is projected to account for 60 per cent of the increase in refined oil consumption between 2003 and 2015. Industry is the other large oil consuming sector in APEC, and is projected to account for around 26 per cent of the rise in consumption of refined oil over the same period.

In the transport sector, demand for oil is expected to expand more in the rapidly growing developing APEC economies. In China, for example, which is the world's fastest growing market for new cars, oil consumption in the transport sector is projected to grow by over 5 per cent a year on average between 2003 and 2015.

Oil consumption is also projected to grow strongly in the industrial, residential and commercial sectors of developing APEC economies, with industrial consumption of refined oil, for example, expected to grow by over 4 per cent a year on average between 2003 and 2015.

Only in the electricity sector does oil consumption decline over time in the APEC region. In most economies oil accounts for a decreasing share in the electricity fuel mix. In many economies this reflects concerns about the reliability of world oil supplies. However, in Mexico and Indonesia, two oil exporting economies, it is government policy to reduce domestic consumption of oil for power generation in order to maintain or raise oil export revenues.

Oil intensity

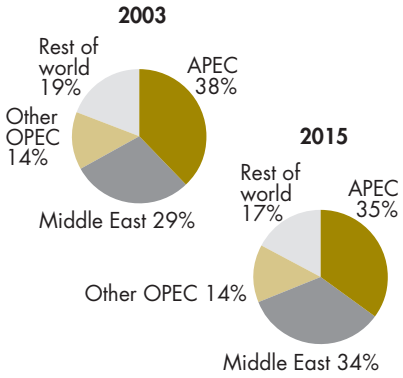
By 2015, APEC is expected to require 17 per cent less oil per unit of output than in 2003. This decline in oil intensity is largely a result of a shift in economies away from oil fired power, together with an improvement in the efficiency of oil use in transport and in other oil-intensive sectors. In absolute terms, the oil required to produce 2003US$1000 of output declines from over 0.1 toe in 2003 to around 0.08 toe in 2015.

Oil intensity tends to be lower in the developed economies. In part this is because economic development is characterised by a transition toward more fuel efficient technologies. Developed economies typically also rely much less on oil fired power generation.

Energy production in APEC economies

Energy production in the APEC region is expected to expand by 22 per cent between 2003 and 2015. Much of the growth in APEC energy production (70 per cent) is concentrated in the natural gas and coal sectors. Natural gas production, for example, expands by 33 per cent between 2003 and 2015.

10 Shares of world oil production reference case



In contrast, APEC oil production increases by 15 per cent between 2003 and 2015.

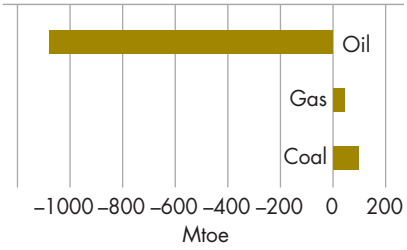
Slow growth in APEC oil production over the projection period occurs as a result of natural resource constraints that are assumed to develop in most APEC economies, and indeed in most major oil producing economies. As a result of this slow growth, the share of APEC in world oil production declines over the projection period (figure 10). In 2003, APEC accounted for 38 per cent of world crude oil production, compared with the Middle East share of 30 per cent. However, by 2015, the Middle East share of world crude oil production increases to 34 per cent, while that of APEC falls to 35 per cent.

APEC energy trade

Net energy trade indicates an economy's dependence on international energy markets. Net energy exports are the volume of exports that exceed the volume of imports. If this number is negative, the economy is importing more energy than it exports and is a net energy importer.

The APEC region as a whole is a net energy importer, importing almost 630 Mtoe more than it exported in 2003. APEC's net energy imports are projected to expand by 67 per cent between 2003 and 2015, to exceed 1000 Mtoe by 2015 (figure 11).

11 APEC net energy exports, 2015 reference case



The principal reason for the increase in APEC's dependence on imported fuel is a large rise in net oil imports, from 716 Mtoe in 2003 to almost 1100 Mtoe by 2015. In contrast, the APEC region's position as a net exporter of coal and gas remains steady throughout the projection period. In 2015,

APEC net exports amount to 42 Mtoe for natural gas, and 98 Mtoe for coal.

One of the most significant increases in net oil imports is projected to occur in China, where net oil imports more than double between 2003 and 2015, reaching around 180 Mtoe by 2015. This is a result of significant growth in China's oil consumption, which outpaces domestic oil production.

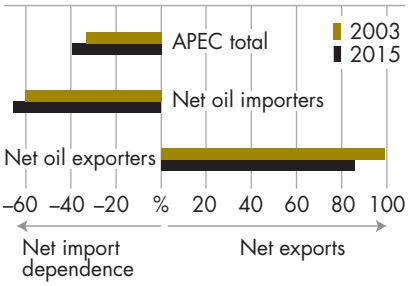
Net oil imports also rise strongly in other rapidly growing developing APEC economies, such as Thailand, where domestic resources are unable to keep pace with the rapid growth in oil consumption associated with rapid economic development.

Nonetheless, the United States remains the largest net importer of oil, and indeed of energy in total. While growth in oil consumption in the United States is moderate, resource constraints lead to a contraction in US oil production over the reference case. Net oil imports in the United States therefore increase from 557 Mtoe in 2003 to 770 Mtoe in 2015. Among developed APEC economies generally, net oil imports increase by around 30 per cent between 2003 and 2015.

Net oil imports only partially illustrate how much APEC economies depend on oil imports. A more complete measure is given by expressing net oil imports as a percentage of domestic oil consumption, giving net oil import dependence (figure 12). For net oil importers, this indicates the degree of reliance on international markets to supply domestic oil requirements.

The share of APEC's oil consumption that is supplied by net imports is projected to increase from 33 per cent in 2003 to 40 per cent in 2015. A significant proportion of the change is accounted for by growing import dependence in APEC's two largest oil consuming economies, the United States and China. The share of net oil imports in consumption increases between 2003 and 2015 from 62 per cent to 69 per cent in the United States and from 33 per cent to 46 per cent in China. Among net oil import-

12 APEC net oil import dependence, 2015 reference case



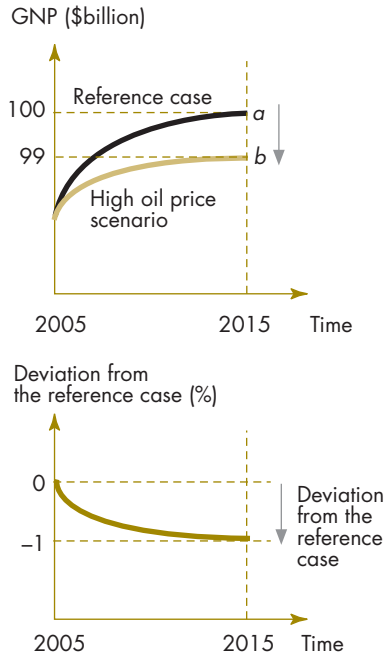
ing APEC economies, overall, net oil import dependence increases from 60 per cent to 66 per cent between 2003 and 2015.

The corresponding indicator for net oil exporters is the percentage share of net oil exports in domestic oil consumption. A decline in this indicator reveals the extent to which domestic oil requirements are absorbing an increasing share of domestic oil output. Over the reference case, there is a decline in the importance of export markets and a rise in the importance of the domestic market as net oil exports decrease from 99 per cent to 86 per cent.

Interpreting simulation results

The GTEM reference case provides a benchmark against which the impacts of sustained increase in oil prices can be measured. In this study, simulation results are reported as deviations from the reference case. For example, the impact of a 30 per cent increase in oil prices can be isolated by comparing economic growth, energy consumption and trade, and other variables in the simulation against those in the reference case scenario.

13 Deviation from the reference case in a GTEM simulation



To illustrate the point, suppose that GNP in a certain economy in the reference case in 2015 was US$100 billion (point *a* in the top diagram of figure 13). Following an increase in the world oil price, GNP in 2015 is projected to be US$99 billion (point *b*), or US$1 billion less than in the reference case. Hence, the effect of the high oil price in this example would be to reduce GNP by 1 per cent relative to the reference case at 2015. This percentage deviation from the reference case is represented in the lower diagram of figure 13.

5

quantifying the economic effects of sustained high oil prices

The purpose in this chapter is to discuss the likely impacts on APEC economies from a sustained increase in world oil prices. The chapter consists of two sections. In the first, the impacts of a sustained increase in oil prices over a five year period are modeled using GTEM and the potential effects on APEC economies are discussed. Two different scenarios representing a high and moderate increase in world oil prices are analysed. A third scenario, illustrating the potential macroeconomic effects of sustained high energy prices, is also undertaken.

In recent times, there has been improvement in the fuel efficiency of internal combustion engines and the development of alternative transport technologies, such as hybrid vehicles. If their cost effectiveness improves and economic viability improves over time, some of these new technologies, including hybrid vehicles, will be capable of reducing fuel consumption in the transport sector considerably in the future, with increased uptake of this technology. In this context, the second part of the chapter contains an exploratory analysis into the possible impact on oil consumption in the

Box 4: **Economic impacts of higher oil prices**

- Economic output: Increases in oil prices will reduce economic growth in many economies leading to higher unemployment. Impacts on individual economies will vary depending on their domestic macroeconomic and sectoral policies (see below for recent empirical estimates of economic activity in a selected group of economies). Higher prices result in large income transfers from oil importing economies to net oil exporting economies. The negative impacts are therefore largest in oil importing economies with high oil intensity. While oil exporting economies will benefit from higher export earnings from higher oil prices, it is possible that economic growth may slow for some oil exporters as a result of flow-on effects from other economies, such as reduced demand for other exports.

conrtinued…

Box 4: **Economic impacts of higher oil prices** *continued*

- Inflation/wages: Higher oil prices lead to increased wage and inflationary pressures in many economies, although the magnitude will in part depend on the fiscal and monetary policy responses employed by individual economies. There could be upward pressure on interest rates as central banks attempt to limit inflation. Overly contractionary policies could exacerbate the decline in economic growth and increase unemployment in some economies.
- Trade balance: For net oil importing economies, the increase in the price of oil imports will cause trade balances to worsen — that is, the value of imports will increase more than the value of exports. Conversely, oil exporting economies will experience an improvement in their trade balance.
- Exchange rates: Higher world oil prices are likely to place downward pressure on exchange rates in some oil importing economies as their balance of payments deteriorates.

Recent oil price analyses: impact on economic output

Key assumptions	**IEA (2004d)** Oil price increases 40% in 2004 from US$25 to US$35. Reported for 2004.	**IMF (2005a)** Oil price increases to US$80 in 2005 from base case price (unspecified). Reported for 2005.	**ADB (2004)** Oil price increases 33% from base case in 2005 from US$30 to US$40. Reported for 2005.
	%	%	%
OECD	–0.4		
All industrialised economies		–0.6	
United States		–0.8	
Japan		–0.7	–0.5
China	–0.8		–0.8
Malaysia	–0.4		–0.9
Philippines	–1.6		–1.9
Thailand	–1.8		–2.2
Hong Kong, China			–0.6
Indonesia			0.1
Korea, Rep. of			–0.5
Singapore			–1.7
Chinese Taipei			–0.4
Chile	–0.4		

transport sectors of APEC economies from the increased adoption of hybrid vehicles under two different technology uptake scenarios.

Because of the importance of oil in the global economy, there is a substantial body of literature on the economic impacts of changing oil prices. The potential impacts that can be expected from an increase in oil prices on a range of macroeconomic variables are highlighted in box 4.

Impacts of sustained high oil prices

To estimate the potential impacts of a sustained increase in world oil prices, two oil price scenarios are simulated. These are:

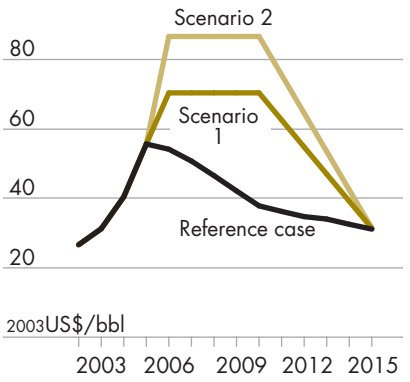
Scenario 1 – a 30 per cent increase in world oil prices above the reference case in 2006 and maintained at this higher level until 2010 (moderate sustained oil price rise)

Scenario 2 – a 60 per cent increase in world oil prices above the reference case in 2006 and maintained at this higher level until 2010 (high sustained oil price rise)

In each of the scenarios it is assumed that world oil prices increase from reference case values by the level indicated above for five years from 2006 to 2010 before gradually returning to reference case levels for the remainder of the simulation period as shown in (figure 14).

The higher prices in these scenarios reflect the varying degree of a range of factors that could influence oil supply and demand over the reference case period. These include: increasing demand for transport fuels triggered by income increases in a range of APEC economies; ongoing capacity constraints in the oil refinery sector that place additional pressure on petroleum product prices and in turn feed back into higher prices for crude oil; continuing reduced spare production capacity in world oil production;

14 World oil prices (WTI)
scenario analyses



and a continuing unsettled geopolitical environment in regions where much of the world's oil production is located.

Impacts on energy consumption

The results from scenarios 1 and 2 demonstrate that a sustained increase in oil prices could have significant impacts on APEC economies and their energy sectors. The extent of these impacts on an economy will depend on the economy's net oil import position and on the economy's reliance on oil. The impacts are also larger in 2010 as the differential between oil prices in the scenarios and reference case is larger than in 2006 because of the projected fall in real oil prices in the reference case.

As a result of the oil price increases in each of the scenarios, there is a decline in oil consumption (relative to the reference case) in all world economies, including in the APEC region (table 7). The percentage decline in oil consumption is larger in economies that are relatively more oil intensive and heavily reliant on oil imports and have large energy intensive manufacturing sectors.

7 Change in energy consumption, relative to the reference case

	Oil		Gas		Thermal coal	
	2006	2010	2006	2010	2006	2010
	%	%	%	%	%	%
Scenario 1 – 30% higher oil prices						
APEC total	–3.5	–8.4	**a**	**a**	**a**	0.1
– net oil importers	–3.4	–8.1	0.1	0.3	**a**	0.1
– net oil exporters	–4.1	–9.6	–0.2	–0.7	–0.2	–0.6
World	–4.0	–9.6	0.2	0.5	0.1	0.1
Scenario 2 – 60% higher oil prices						
APEC total	–6.2	–11.0	**a**	**a**	0.1	0.1
– net oil importers	–6.0	–10.7	0.2	0.5	0.1	0.2
– net oil exporters	–7.1	–12.5	–0.4	–0.8	–0.4	–0.8
World	–7.0	–12.4	0.4	0.7	0.1	0.2

a Less than +/–0.1 per cent.

In both scenarios, increases in oil prices also lead to an increase in the prices of other fuels. Most LNG cargoes supplied in the Asia Pacific region are supplied under long term contracts that link LNG prices to the price of crude oil. This contractual arrangement means the rise in crude oil prices can be expected to lead to higher LNG prices. In addition, in response to a higher relative price of oil, demand rises for alternative energy sources and this contributes to higher prices for other fuels such as natural gas other than LNG, relative to the reference case scenario.

As a result of the decrease in oil consumption as oil prices increase, there is substitution, albeit limited, to other energy sources (table 7). This substitution is influenced by relative price changes of fuel types. As discussed earlier, assumptions have been made about the relativities in oil price and LNG price changes to more accurately reflect market conditions.

As a result of the increase in the price of oil in each of the scenarios, there is some increase in gas consumption, globally, and for the net oil importing group of APEC economies. There is some switching from oil to gas in both transport and electricity generation. The opportunities to switch toward coal in response to higher oil prices are limited and, as such, changes in coal consumption in response to higher oil prices are small.

Impacts on economic output

As a result of the sustained increase in oil prices, and the associated increase in production costs, the level of economic activity across APEC contracts relative to the reference case.

The impact that higher oil prices have on the level of economic activity may be divided into two effects — an income transfer effect and an output effect. The income transfer effect can be either positive or negative depending on the oil trade position of an economy. The output effect is generally negative.

The income transfer effect occurs because the rise in oil prices increases the value of oil exports (imports) relative to that of other traded commodities. This leads to an improvement (deterioration) in the terms of trade for economies that are net oil exporters (importers), contributing to an income transfer from net importing to net exporting economies. On the other hand, the output effect is the decline in output, particularly in oil intensive

industries, because of the increase in the costs of production associated with the rise in oil prices.

The extent of the impacts on gross national product (GNP) is dependent on both an economy's oil intensity and import dependency. An economy with relatively high oil intensity and high reliance on imports will be more adversely affected by rising oil prices than an economy with lower oil intensity. Table 8 shows the change in GNP, by economy, for scenarios 1 and 2. The impacts of the 60 per cent oil price increase are slightly less than double the impact of the 30 per cent price increase. The magnitude of the impact on GNP is typically larger in 2010, because the difference in real world oil

8 Change in GNP, relative to the reference case

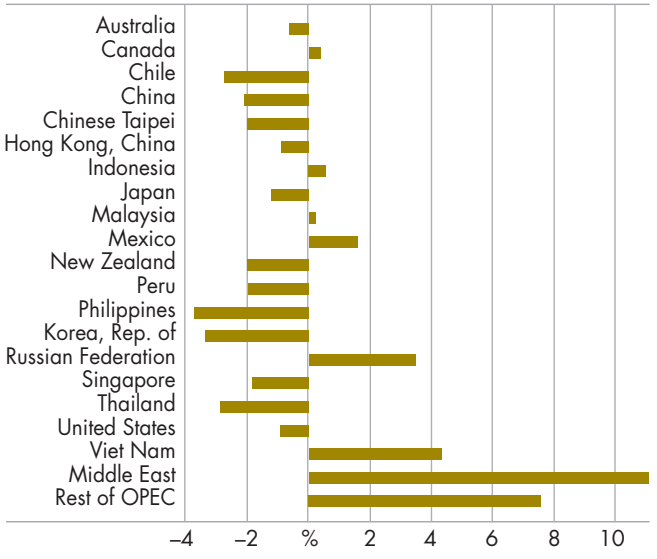
	Scenario 1 30% oil price increase		Scenario 2 60% oil price increase	
	2006	2010	2006	2010
	%	%	%	%
Net oil importers				
Australia	–0.3	–0.8	–0.6	–1.2
Chile	–1.4	–2.9	–2.7	–4.3
China	–1.1	–2.2	–2.1	–3.2
Chinese Taipei	–1.0	–2.1	–2.0	–3.1
Hong Kong, China	–0.5	–0.7	–0.9	–1.0
Japan	–0.6	–1.3	–1.2	–1.9
New Zealand	–1.0	–2.0	–2.0	–2.9
Peru	–1.0	–2.0	–2.0	–2.9
Philippines	–1.9	–3.8	–3.7	–5.5
Korea, Rep. of	–1.7	–3.4	–3.4	–5.0
Singapore	–0.9	–1.9	–1.8	–2.9
Thailand	–1.5	–3.1	–2.9	–4.5
United States	–0.5	–1.0	–0.9	–1.5
Net oil exporters				
Canada	0.2	0.5	0.4	0.8
Indonesia	0.3	0.5	0.6	0.8
Malaysia	0.1	0.0	0.2	0.1
Mexico	0.8	1.8	1.6	2.7
Russian Federation	1.8	3.8	3.5	5.5
Viet Nam	2.2	4.6	4.3	6.7
APEC total	–0.5	–1.0	–0.9	–1.4
World	–0.3	–0.6	–0.6	–0.8

prices from the reference case in scenarios 1 and 2 increases to 86 per cent and 129 per cent respectively. This is because of the projected decline in real world oil prices in the reference case from 2006. However, the difference in the impacts in 2010 compared with 2006 will also be affected by changes in projected net oil exports and oil intensity.

There is some variation in the impacts of higher oil prices on economic output in individual APEC economies and key oil producing economies. Figure 15 shows the impact on GNP in 2006 of a 60 per cent increase in oil prices. The interplay of the income transfer and output effects partially explains why aggregate output impacts vary considerably among different economies.

Another important factor that influences aggregate output impacts is the oil intensity of individual economies. For example, in the United States, the low level of oil intensity (see figure 3 in chapter 3) helps partly to moderate the adverse impact on GNP of high oil prices. The economies likely to be the most affected by higher world oil prices, as demonstrated by these scenarios, are the heavily oil import dependent economies, such as the Philippines, the Republic of Korea and Thailand, where oil intensity is relatively high.

15 **GNP change for scenario 2 in 2006**
relative to the reference case



While most APEC economies are worse off from the oil price increases, GNP in the oil exporting economies rises, relative to the reference case. The magnitude of the increase in GNP is determined by the importance of oil exports to that particular economy, hence the relatively large GNP gains for larger net oil exporters, such as Viet Nam and the Russian Federation. GNP gains are lower for economies with lower net exports, such as Malaysia and Indonesia. Economies such as Indonesia also benefit from higher gas prices that arise because of contractual links between oil and gas prices. There are also substantial increases in GNP in the non-APEC oil exporting regions, the Middle East and rest of OPEC.

Impacts on trade

The increase in the value of oil imports because of significantly higher world oil prices leads to a decline in the terms of trade — that is, the average price of imports increases more than the average price of exports — for net oil importing APEC economies (table 9). For oil exporting APEC economies, the change in terms of trade is positive. The impacts on the terms of trade are largest in economies with substantial net imports, or exports, of oil or petroleum products.

In reality, the vulnerability of some of the oil importing developing economies to higher oil prices is likely to be exacerbated by the limited ability, particularly in the short term, to switch to alternative fuels, the prices for which may increase less than that for oil. An increase in the cost of oil imports also tends to adversely affect the trade balance and increase inflation more in developing economies where institutions responsible for economic management and investor confidence are more fragile. The deterioration in some developing economies' terms of trade may also be magnified by sharp currency depreciations, as capital inflows slump. Higher oil prices and the subsequent depreciation of developing economies' currencies against the US dollar also raise the cost of servicing external debt in those economies. This problem is likely to be most pronounced in economies that are already running large current account deficits (IEA 2004d).

Impacts on real wages

It is assumed in the GTEM modeling framework that the imposition of any policy change does not raise unemployment above the so-called natural rate of unemployment for any economy. Any downward shift in the demand

9 Change in terms of trade, relative to the reference case

	Scenario 1 30% oil price increase		Scenario 2 60% oil price increase	
	2006	2010	2006	2010
	%	%	%	%
Net oil importer				
Australia	–0.3	–1.1	–0.7	–1.4
Chile	–3.3	–6.9	–6.2	–9.8
China	–3.6	–7.6	–6.9	–10.8
Chinese Taipei	–2.3	–4.9	–4.5	–7.0
Hong Kong, China	–0.8	–1.6	–1.4	–2.2
Japan	–4.3	–8.8	–8.1	–12.5
New Zealand	–2.3	–4.6	–4.4	–6.6
Peru	–3.2	–6.6	–6.1	–9.3
Philippines	–2.3	–4.6	–4.4	–6.6
Korea, Rep. of	–4.3	–9.0	–8.1	–12.6
Singapore	–0.5	–1.0	–0.9	–1.5
Thailand	–2.6	–5.6	–5.0	–7.9
United States	–3.3	–7.1	–6.2	–10.0
Net oil exporters				
Canada	1.5	3.3	2.8	4.8
Indonesia	1.8	4.0	3.3	5.8
Malaysia	0.6	1.2	1.1	1.7
Mexico	4.6	10.4	9.0	15.2
Russian Federation	13.2	30.9	26.3	46.0
Viet Nam	6.4	14.2	12.7	21.3

for labor is assumed to be offset by reductions in real wages growth sufficient to prevent the emergence of unemployment above natural levels. This assumption is often known as the 'full employment assumption'.

Sustained higher oil prices lead to increased production costs in many APEC economies, with the magnitudes depending in part on the extent of labor market rigidities and the ability of producers to pass on cost increases to consumers. In the short term it is likely that there will be some rigidity in wage levels, and therefore the reduced demand for labor may result in a fall in employment. However, with sustained oil price rises, there are potential impacts on real wages. Under both oil price scenarios real wages are estimated to fall, with a relatively larger impact in the net oil exporting group

10 Change in real wages, relative to the reference case

	Scenario 1 30% oil price increase		Scenario 2 60% oil price increase	
	2006	2010	2006	2010
	%	%	%	%
APEC total	–1.4	–2.8	–2.7	–4.1
– net oil importers	–1.4	–2.8	–2.7	–4.0
– net oil exporters	–1.7	–3.4	–3.3	–4.8

of APEC economies because of the higher average oil intensity of some of these economies such as the Russian Federation (table 10).

As discussed earlier, in practice, however, it could be expected that changes in patterns of production caused by sustained oil price increases could lead to the emergence of some unemployment, especially if oil price increases have negative impacts in sectors where the skills of the labor force are not easily transferable.

Sectoral impacts

The negative impact on APEC economies of the increase in oil prices is concentrated in sectors that rely heavily on petroleum inputs, specifically the transport industry and the chemicals, rubber and plastics sector (table 11). The higher cost of oil leads to higher prices and lower demand for these oil intensive commodities relative to the reference case.

The Russian Federation, in particular, which accounts for the dominant share of energy intensive production in the net oil exporter group, is less efficient in the use of energy. Russian energy intensive commodities therefore lose competitiveness relative to the same commodities produced in other major world economies.

The impacts of higher oil prices on the transport sector are most severe in the developing economies within APEC. This is because of the greater relative importance of oil in the transport sector of developing economies as a result of their less energy efficient forms of transport.

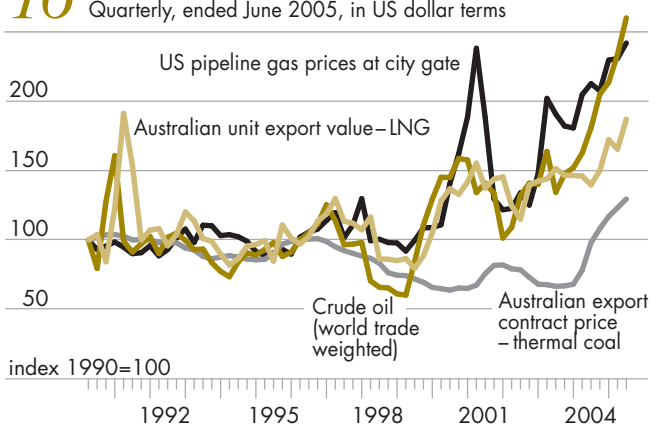
11 Change in production of selected commodities in the APEC region, relative to the reference case

	Chemicals, rubber and plastics		Transport	
	2006	2010	2006	2010
	%	%	%	%
Scenario 1 – 30% higher oil prices				
APEC total	–0.5	–1.0	–0.9	–2.0
– net oil importers	–0.4	–1.0	–0.9	–1.9
– net oil exporters	–0.5	–1.4	–1.1	–2.3
Scenario 2 – 60% higher oil prices				
APEC total	–0.9	–1.4	–1.7	–2.8
– net oil importers	–0.9	–1.4	–1.7	–2.7
– net oil exporters	–1.0	–1.9	–2.0	–3.3

Impacts of sustained high energy prices

Since 1990, LNG and crude oil prices have followed similar trends, reflecting the role of oil prices as a factor in determining the price of LNG. Since 2003, thermal coal prices have also moved in a similar direction, with the prices of all three energy commodities increasing substantially (figure 16). These simultaneous energy price movements provide the rationale for undertaking scenario 3 to illustrate the potential impacts of a sustained increase in energy prices.

16 Energy commodity prices
Quarterly, ended June 2005, in US dollar terms



Scenario 3 – world oil and gas prices increase by 60 per cent and thermal coal prices increase by 30 per cent above the original reference case in 2006 and remain at the higher level until 2010.

Because of lower substitutability with oil, thermal coal prices are assumed to increase by only half as much as the rise in oil prices, rising 30 per cent above the reference case in 2006 and remaining at that level till 2010.

As a result of sustained energy price increases, GNP, both in the APEC region and globally, declines from the reference case relatively more than under scenario 2 (table 12). At the individual economy level, the effect of the simultaneous increase in oil, coal and gas prices is to increase GNP,

12 Change in GNP under scenario 3
relative to the reference case

	2006	2010
	%	%
Net oil importers		
Australia	–0.4	–0.9
Chile	–2.7	–4.2
China	–2.2	–3.3
Chinese Taipei	–2.3	–3.4
Hong Kong, China	–1.3	–1.3
Japan	–1.3	–2.0
New Zealand	–2.2	–3.2
Peru	–1.9	–2.8
Philippines	–3.9	–5.6
Korea, Rep. of	–3.8	–5.2
Singapore	–2.3	–3.4
Thailand	–3.5	–5.3
United States	–1.1	–1.6
Net oil exporters		
Canada	0.7	1.1
Indonesia	2.2	1.7
Malaysia	–0.1	–0.5
Mexico	1.2	2.1
Russian Federation	3.5	5.6
Viet Nam	4.0	6.4
APEC total	–1.0	–1.6
World	–0.7	–1.0

13 Change in terms of trade under scenario 3
relative to the reference case

	2006	2010
	%	%
Net oil importers		
Australia	1.5	0.6
Chile	–6.1	–9.7
China	–6.9	–10.7
Chinese Taipei	–5.1	–7.5
Hong Kong, China	–2.0	–2.8
Japan	–8.9	–13.0
New Zealand	–4.6	–6.8
Peru	–6.0	–9.3
Philippines	–4.7	–6.9
Korea, Rep. of	–9.0	–13.1
Singapore	–1.1	–1.7
Thailand	–5.8	–8.7
United States	–6.5	–10.4
Net oil exporters		
Canada	4.6	7.0
Indonesia	9.8	9.9
Malaysia	1.6	1.9
Mexico	8.2	14.0
Russian Federation	34.9	56.6
Viet Nam	12.9	21.6

relative to scenario 2 in some economies that are net exporters of gas or thermal coal, such as Indonesia. In some energy exporting economies such as Australia, the reduction in GNP is smaller in scenario 3 than in scenario 2, reflecting the favorable impacts of increases in gas and coal prices. Conversely GNP is further decreased in economies that are net importers of coal or gas, such as Japan and the United States, under scenario 3 compared with scenario 2.

The increase in world energy prices in scenario 3 leads to an improvement in the terms of trade for net energy exporters such as Australia relative to the reference case and compared with scenario 2 (table 13).

Impacts of accelerated uptake of efficient transport technologies

The transport sector is currently the largest consumer of oil in all APEC economies. As a consequence, efforts in the transport sector to reduce oil consumption can be expected to have important implications for oil consumption in these economies. In the short term, however, demand for oil by the transport sector is relatively less sensitive to price movements. This is because of the limited availability of commercially viable oil substitutes and the associated technologies in the transport sector in the short term and the essential nature of transport services across all sectors of the economy. However, in the medium to longer term a sustained increase in oil prices may lead to continued improvements in fuel efficiency of transport vehicle technologies (see box 5).

Extended high oil price scenario

As indicated earlier, one form of emerging transport technology that has attracted increasing interest, particularly in some of the developed APEC economies is the hybrid motor vehicle. Recent increases in hybrid vehicle sales in the United States have shown that hybrid vehicles are gradually becoming competitive with traditional vehicles and that consumers are willing to adopt this new technology.

In establishing the hypothetical transport technology scenarios, it is assumed that persistent higher oil prices contribute to the increased adoption of more fuel efficient technologies. Therefore, the two transport technology adoption scenarios are assumed to occur in an environment of extended high

Box 5: **Transport technologies that offer fuel efficiency advantages**

Internal combustion engines: There is continuing scope to increase the fuel economy of internal combustion engine vehicles by, for example, improving vehicle design and using lighter materials. Diesel vehicles are about 10–20 per cent more efficient than similar petrol vehicles as a result of the higher energy density of diesel (Gielen and Unander 2005; MacLean and Lave 2003). Recent estimates (IEA 2001, 2004b; NRC 2002) indicate that by 2015, new car fuel consumption could be reduced by up to 25 per cent at low cost by fully exploiting available technologies.

Electric vehicles/hybrid electric vehicles: Electric vehicles can be designed as 'pure' electric vehicles or as a hybrid. Hybrid vehicles are, however, able to overcome many of the obstacles confronting pure electric vehicles. In a hybrid vehicle, the ICE is combined with a battery and an electric motor(s). Hybrid vehicles are able to compete with conventional vehicles in terms of driving range, with some vehicles currently being produced able to double the driving range of conventional vehicles (EERE 2005).

Hybrid vehicles can reduce fuel use by up to 60 per cent when compared with conventional internal combustion engine vehicles (IEA 2005c) as both the electric power train and internal combustion engine are highly efficient.

Although hybrid vehicles are available from commercial car manufacturers, they are still more expensive to manufacture and buy than an identical internal combustion engine vehicle. However, by 2004 Toyota had sales of more than 100 000 hybrid vehicles, with most sales being in north America and Japan. There are now indications that Toyota is beginning to break even on the cost of the hybrids (IEA 2004b).

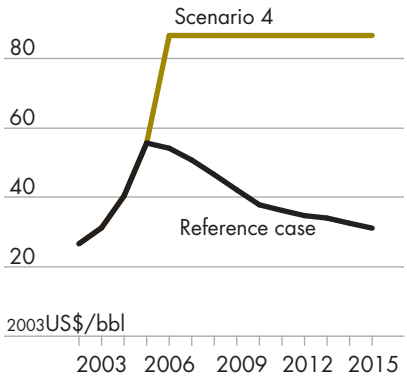
Sales of hybrid vehicles in the United States increased nearly tenfold from 9350 in 2000 to 88 000 in 2004. Sales are expected to more than double in 2005 to over 200 000 (J.D. Power and Associates 2005).

Fuel cell vehicles: In a fuel cell vehicle the internal combustion engine is replaced by a fuel cell stack that generates electricity for use in an electric motor. Fuel cell vehicles offer high efficiency levels and can convert 40–60 per cent of a fuel's energy to useful power depending on the fuel and components used (EERE 2005). Hydrogen fuel cell vehicles can potentially achieve a level of fuel economy three times greater than conventional internal combustion engine vehicles (IEA 2005c). Fuel cell vehicles face a number of significant challenges, including the high cost of fuel cells that must be overcome before they are available for large scale commercial sales.

oil prices where world oil prices are 60 per cent above reference case levels. To provide a point of comparison, scenario 4 represents the extended high oil price scenario where no additional transport technology improvements are assumed (figure 17).

Scenario 4 – world oil prices increase by 60 per cent above the original reference case in 2006 and remain at the higher level until the end of the simulation period in 2015. There is no additional transport technology adoption in this scenario.

17 Extended high oil prices (WTI)



Analysis of the two transport technology adoption scenarios

To investigate the potential impact that transport technologies could have on APEC oil consumption, two different transport technology adoption scenarios are simulated. These scenarios represent two sets of assumed potential adoption rates for hybrid vehicles and fuel efficiency improvements. They are meant as illustrative examples only, given the paucity of detailed information available at present on future transport technology adoption rates and fuel efficiency improvements across a wide range of economies.

To model the improved fuel efficiency of the transport sector in APEC resulting from the accelerated uptake of more fuel efficient transport technologies in the two scenarios, assumptions are made about the fuel efficiency of new hybrid and nonhybrid vehicles, the share of hybrid vehicles in vehicle sales and the average vehicle life in various regions, on the basis of information from the literature (box 6) (Fulton and Eads 2004; IEA 2005c).

The two additional transport technology adoption scenarios incorporate the following assumed information:

Scenario 5 – 10 per cent of new vehicles are hybrids that are 25 per cent more fuel efficient than new nonhybrid vehicles in all APEC economies.

Scenario 6 – 20 per cent of new vehicles are hybrids that are 40 per cent more fuel efficient than new nonhybrid vehicles in all APEC economies.

In both of these scenarios, adoption of the new technology occurs from 2006 onwards and is assumed to occur uniformly across all APEC economies.

It is also assumed that as a result of the extended high oil prices and gradually improving success of hybrid vehicles in the market, particularly in some of the developed economies, the average fuel efficiency of new nonhybrid vehicles improves by 2.5 per cent. This efficiency improvement for

Box 6: **Estimating fuel efficiency improvements resulting from the accelerated uptake of hybrid vehicles in APEC**

Assumptions about average vehicle life are taken from Fulton and Eads (2004). In the OECD economies, average vehicle life is assumed to range from 16.2 years in 2006 to 16.3 years in 2015, while in non-OECD economies, average vehicle life is assumed to decrease from 20.5 years in 2006 to 20.1 years in 2015.

In order to calculate the improvement in fuel consumption efficiency of the transport sector in each economy resulting from the accelerated uptake of hybrid vehicles in the scenarios, it is necessary to calculate vehicle turnover in each economy in each year. To estimate the fuel efficiency improvements in the transport sector for each economy, vehicle turnover is split according to the share of hybrid vehicles in total vehicle sales. The assumed fuel consumption efficiency improvements for hybrid and nonhybrid vehicles are then applied to the hybrid and nonhybrid vehicle turnover estimates.

Finally, the overall fuel efficiency of the vehicle fleet is calculated as a weighted average of the fuel efficiency of three groups of vehicle types; existing vehicles, newly purchased hybrid vehicles and newly purchased nonhybrid vehicles.

Vehicle turnover in each economy in each year is calculated as the growth in the size of the vehicle fleet in that region over the year plus the vehicle sales associated with the replacement of vehicles that were retired during the year.

The growth in the share of new more efficient hybrid and nonhybrid vehicles will be higher where there is higher growth in the total vehicle fleet or where old vehicles are turned over more quickly. In each APEC economy, average fuel efficiency of vehicles will therefore continue to increase over the analysis period as additional hybrid vehicles are phased in each year.

new nonhybrid vehicles reflects the more rapid uptake of existing technologies, including direct injection systems and other engine improvements, as well as the use of lightweight materials, which are estimated to have the potential to reduce new car fuel consumption by up to 25 per cent between 2000 and 2015 (IEA 2004b).

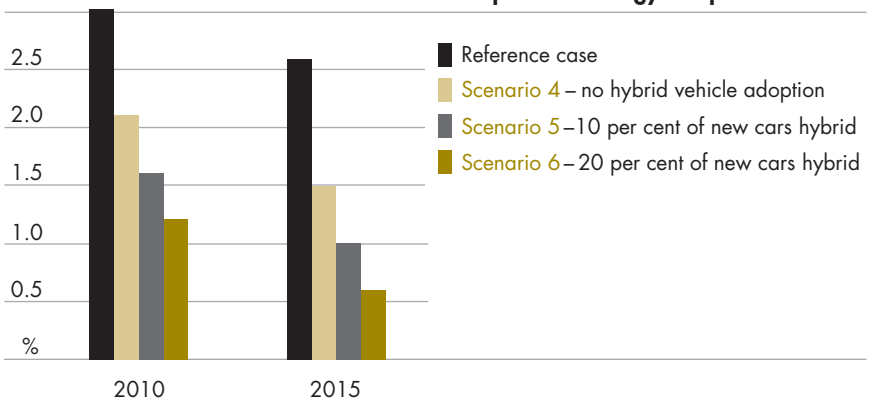
Impacts on fuel consumption

In both transport technology adoption scenarios 5 and 6, the more rapid uptake of hybrid vehicles and the increased fuel efficiency of new nonhybrid vehicles are projected to lead to sizable reductions in the growth of fuel consumption by the transport sector throughout APEC over the period 2006–15 compared with scenario 4 where no additional transport technology adoption is assumed (figure 18).

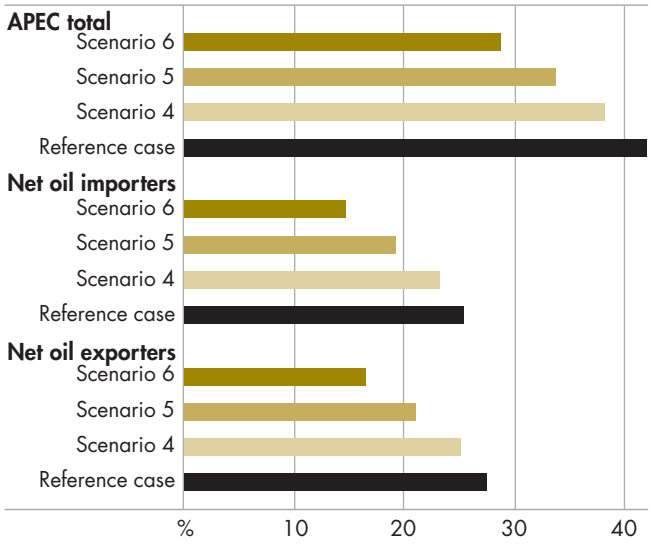
In scenario 4, fuel consumption is lower than in the reference case because of the higher oil prices assumed in scenario 4. The most rapid growth in transport sector fuel consumption is expected to occur in the rapidly growing developing APEC economies, as demand for transport services expands in line with higher economic growth in these economies.

In scenarios 5 and 6, fuel consumption in the transport sector is further reduced from that in scenario 4 as a result of the adoption of more fuel efficient vehicles. In scenario 5, where hybrid vehicles comprise 10 per cent of vehicle sales over the period and reduce fuel consumption by 25 per cent

18 Annual growth in consumption of petrolem products by the transport sector in APEC under alternative transport technology adoption scenarios



19 Growth in consumption of petroleum products by the transport sector in APEC under alternative transport technology adoption scenarios, 2006–15



relative to nonhybrid vehicles, APECwide fuel consumption by the transport sector is projected to grow by 21 per cent over the period 2006–15, compared with 25 per cent in scenario 4 (figure 19). In scenario 6, however, where more fuel efficient hybrid vehicles are more widely adopted, fuel consumption by the transport sector in APEC is projected to grow by 16 per cent between 2006 and 2015. At 2015, as a result of this slower growth in fuel use by the transport sector in APEC, consumption of petroleum is projected to be around 8 per cent lower than in scenario 4.

In absolute terms, around half of the fuel savings evident in scenarios 5 and 6 at 2015 are projected to occur in the United States, which has the largest transport sector of any APEC economy.

While these scenarios indicate the potential for new transport technologies to reduce fuel consumption growth in the transport sector over the medium term, it should be noted that they are based on very general assumptions about the fuel efficiency and uptake of hybrid vehicles in the region. In practice it is likely that the uptake of hybrid vehicles will be greater in developed APEC economies and slower elsewhere.

6

the role of technology in fuel supply: the case of coal-to-liquids

Currently, technologies exist that can be used to produce liquid fuels from sources other than crude oil (box 7). One technology that has generated significant interest in the APEC region is the production of liquid fuels from coal (so-called coal-to-liquid technology). Some member economies, including the United States, Japan and China, have either begun the construction of coal-to-liquids plants or devoted resources to study the viability for commercialisation of such technologies.

Box 7: **Oil substitutes**

Technologies exist to produce transport fuels from sources other than crude oil. In addition to coal-to-liquids technology, these include natural gas, biofuels, hydrogen and electricity. Technology also exists to produce oil from nonconventional sources, such as tar sands and oil shales.

Compressed natural gas

Gasoline vehicles can be converted to natural gas fueled vehicles after minor modifications to gasoline engines and the installation of a gas tank. Natural gas fueled vehicles currently account for about 0.5 per cent of the world vehicle stock (Gielen and Unander 2005). The expansion of natural gas cars is limited by the availability of natural gas supply, refueling stations and the strong correlation between gas and oil prices. The power output of the car and life of the engine may also be reduced after modification (Gielen and Unander 2005).

Biofuels

Biofuels are generated from biological sources, including grain and sugar crops, cellulosic materials, including grasses and trees, and municipal solid waste. The most widely used transport biofuels are ethanol, biodiesel and methanol. In 2003, world ethanol production was approximately equal to 0.5 per cent of global oil consumption (Gielen and Unander 2005).

Biofuels can be used in conventional vehicles after modification and can also be blended with petroleum fuels. Biofuels can be blended with or exclusively used in conventional diesel engines (IEA 2004c). The blending ability of bio-

continued…

Box 7: **Oil substitutes** *continued*

fuels can avoid major changes to the current fueling infrastructure or vehicle stock (IEA 2004b).

The global use of biofuels remains relatively low. One reason is the relatively high production cost relative to petroleum fuels in some regions (IEA 2004c). In Brazil, however, ethanol is competitively priced and represents around 30 per cent of transport fuel consumption in that economy (IEA 2004b).

Hydrogen

The focus of hydrogen transport research has been on its role in fuel cell vehicles. Hydrogen can be separated from hydrocarbons including natural gas, coal, methanol and residual oil through electrolysis which uses an electric current to split water into its components of hydrogen and oxygen. The cheapest and most commonly used hydrogen production process is the steam reforming of natural gas that converts methane into hydrogen and carbon monoxide.

Hydrogen can be produced for use in transport at large centralised facilities and distributed via pipelines or trucks or produced at a large number of decentralised refueling stations. Hydrogen could also be produced on board the vehicle by reforming a hydrocarbon such as natural gas or methanol.

The potential of hydrogen use in transport depends on the ability to establish economic production and transport infrastructure and fuel cell vehicles. Current research and development on fuel cell vehicles is focused on reducing costs, improving reliability and lowering the weight of the vehicle. The onboard storage of hydrogen presents a challenge because of the low energy content of hydrogen on a volume basis.

Electricity

The current focus of research for using electricity in transport is on gasoline–electric hybrids. Batteries currently used in electric vehicles have relatively low energy density and, therefore, require a larger mass to give a vehicle the same performance and range as conventional vehicles (MacLean and Lave 2003). If significant breakthroughs are made in battery performance, electric vehicles may emerge as an important transport mode in some developed economies (IEA 2004b).

Nonconventional oil sources

Nonconventional oil sources generally refer to heavy oil, tar sands, bitumen and oil shales. Reserves of extra heavy oils are concentrated in Venezuela, while the Russian Federation and Canada both have large reserves of tar sands and bitumen. The United States also has large reserves of oil shales. Recoverable reserves of these nonconventional oils are estimated to exceed conventional oil reserves in the Middle East (IEA 2002, 2004a).

A major attraction of coal-to-liquids in the APEC region is the vast deposits of coal in several member economies, including the United States, China, Australia, Canada and Indonesia. Commercialisation of coal-to-liquids technology has the potential to enhance energy security and fuel supply in the region and reduce the dependence of the region on crude oil imports.

Development of coal-to-liquids technology

Two different approaches exist for the production of liquid fuels from coal: direct coal liquefaction (DCL) and indirect coal liquefaction (ICL). DCL technology involves making a partially refined synthetic crude oil from coal, which is further refined into synthetic gasoline and diesel as well as liquefied petroleum gas (LPG). ICL technology involves first gasifying coal to make synthesis gas (syngas) and then making synthetic fuels from this syngas.

Fuels obtained from coal-to-liquids technology generally have some air quality advantages relative to diesel and gasoline derived from crude oil. Technology is also being developed to capture and store greenhouse gas emissions from the manufacture of liquid fuels from coal.

Direct coal liquefaction (DCL)

DCL technology was invented in the early 1900s and adopted in Germany to provide liquid fuels during World War II. The availability of low cost oil from the Middle East resulted in this activity being abandoned in the early 1950s. Research and development was revived in the United States, Germany and Japan after the oil price shocks in the 1970s. However, interest declined once again in the mid-1980s with the fall in world oil prices. None of the industrialised economies have recently actively pursued DCL technology to meet their own liquid fuel demand (Williams and Larson 2003).

In DCL technology, pulverised coal is reacted with hydrogen (usually in the presence of a liquid solvent) to produce a synthetic crude oil (syncrude). No intermediate gasification is needed. DCL involves temperatures above 400°C, pressures of more than one hundred atmospheres and an appropriate catalyst. Syncrude can be refined to produce gasoline, diesel and other fuels at conventional refineries.

Commercial readiness

The lack of cost competitiveness of the DCL process has been the primary obstacle to commercial development. Compared with ICL technology, production costs for the DCL process were higher and associated with greater uncertainty. Initial studies in the United States in the early 1980s estimated that the equivalent oil price for products obtained from DCL would exceed US$27 a barrel and could be as high as US$45 a barrel (Anastasi 1980).

In the three decades to 1999, research to make fuel from DCL processes carried out by the US Department of Energy led to significantly higher yields and quality of the liquid fuels and accompanying improvements in the economics of direct coal liquefaction. Despite these improvements, the high production cost remains a primary concern for DCL.

Indirect coal liquefaction (ICL)

ICL technology involves the gasification of coal in the presence of steam and oxygen to produce a mixture of carbon monoxide and hydrogen, called synthesis gas. The synthesis gas can then be purified and converted into liquid hydrocarbons using one of several conversion technologies, such as the Fischer-Tropsch (F-T) liquefaction process or the methanol-to-gasoline process. At present the most common options for the final products are the F-T liquids (both diesel and gasoline), methanol and dimethyl ether (DME).

There are several commercial projects worldwide involving ICL technology at present (see box 8).

Commercialisation of coal-to-liquids

DCL projects in China

In response to rising domestic demand and high and volatile world oil prices, there has been significant interest in DCL technology in China. With its rich coal deposits, China is developing DCL technology as an alterative source of liquid fuels to increase its energy security.

Shenhua Group Corporation (Shenhua), China's largest coal producer, is constructing the world's first commercial DCL facility in the Inner Mon-

Box 8: **Output from indirect coal liquefaction (ICL)**

Fischer-Tropsch liquids

Fischer-Tropsch (F-T) technology is well established and is the focus of global gas-to-liquids efforts to exploit low cost 'stranded' natural gas to make synthetic liquid transport fuels (Williams and Larson 2003). Development of F-T technology has emphasised the production of synthetic diesel because the raw distillate product is an excellent diesel fuel, while substantial subsequent refining will be needed to make an acceptable gasoline. Sasol in South Africa has extensive construction and operating experience with F-T technology based on coal gasification and the conversion of coal into synthetic fuels.

There is growing interest in coal based F-T technology in major APEC economies, including the United States and China. Sasol F-T synthesis technology, together with a Shell gasifier, has been used in a demonstration project in Gilberton, Pennsylvania sponsored by the US Department of Energy. This project offers an integration of several technologies to convert around 4775 tonnes a day of coal waste materials (anthracite culm in this case) into 41 megawatts of clean electricity and over 5000 barrels a day of ultraclean transport fuels (DOE 2004). In China, Synfuels China has been cooperating with industrial partners to develop the technology for case study (Li 2004).

Methanol

Methanol is a well established chemical commodity used around the world. It can also be used directly as a fuel or further processed to make gasoline and DME (Williams and Larson 2003). Because of its high octane rating, methanol is well suited for use in cars powered by a spark-ignition-engine with relatively modest modifications.

Under the Clean Coal Technology Program sponsored by the US Department of Energy, the commercial readiness for methanol production has been proven (Heydorn, Diamond and Lilly 2003). The technology was successfully demonstrated at near commercial scale (3 million litres a day capacity) at a coal gasification facility in Kingport, Tennessee in the late 1990s (William and Larson 2003).

Dimethyl ether (DME)

DME is a clean oxygenated synthetic fuel that can be made from any carbonaceous feedstock. It is a gas at ambient conditions but can be stored as a liquid in mildly pressurised canisters like those used for LPG (Williams and Larson 2003). DME is well suited for use as a transport fuel for vehicles with a compression-ignition-engine, a cooking fuel and a fuel for gas turbines and gas and steam turbine combined cycles for power generation. An important feature of

continued…

Box 8: **Output from indirect coal liquefaction (ICL)** *continued*

DME is that the infrastructure already established for LPG can be adopted, essentially without modification.

Current global DME production amounts to 150 000 tonnes a year. Its main use is as aerosol propellant. Two coal based DME plants are in operation in China, with a total capacity of 40 000 tonnes a year. Rapid expansion of DME production is planned in China, to more than 1 million tonnes a year by 2009 (Fleisch 2004). DME Development Co. Inc., a Japanese consortium, is currently in the design/build stage for a 100 tonnes a day DME pilot plant in Kushiro, Hokkaido (JFE Holdings 2005). This effort builds on initial testing of a 5 tonnes a day capacity reactor that was completed in 1999. A number of gas based projects are also planned in the Middle East (Gielen and Unander 2005).

Coproduction with electricity

There is also growing interest in the coproduction of electricity and synfuels in ICL. In coproduction, synfuels are produced together with electricity, which is generated using integrated coal gasification combined cycle (IGCC) technology. Coproduction of electricity and F-T fuels can also facilitate the capture and subsequent storage of carbon dioxide and contribute to a reduction in carbon dioxide emissions compared with production of conventional fuels (Yamashita and Barreto 2003).

A study by Sasol indicates that the coproduction of F-T transport fuels and electricity from coal raises the energy conversion efficiency compared with the same plant without electricity coproduction. Coproduction could also reduce the capital cost per unit of product. Static analysis suggests that synfuel production costs may be reduced by around 10 per cent if a coproduction strategy is adopted (Yamashita and Barreto 2003).

golia Autonomous Region. An estimated US$850 million investment in the initial phase of the project is expected to transform 7110 tonnes of subbituminous coal into 20 000 barrels of ultraclean, low sulfur, diesel and gasoline a day by 2007. Two trains are planned for the first phase, with an additional seven trains in the second phase and a total investment in excess of US$5 billion (Fletcher et al. 2004).

As part of the development, Shenhua has built a pilot plant with capacity of 6 tonnes a day in Shanghai based on processes proposed for the commercial plant for studying, fine tuning and improving the technology. The startup of the pilot plant was initiated in November 2004 and the plant successfully produced liquid fuels in January 2005 (Sun et al. 2005).

Concerns about DCL

As the world's first commercial DCL plant, a number of factors could change the economics of the Shenhua project, as the technology has not been demonstrated at a commercial scale.

For example, environmental, safety and technical issues could lead to a significant increase in actual costs. Direct coal liquefaction plants may generate and release hazardous materials during operation in addition to potential water and air contamination (NIOSH 1981). Stricter environmental protection regulations may therefore significantly increase the capital and operation costs. There are also concerns about the lack of experience in the manufacturing processes for the large equipment required by the plant as well as the operation of DCL facilities. Successful development and operation remain significant challenges for the Shenhua project (Fletcher et al. 2004). Also, the costs of construction and operation (and hence the required selling prices) may differ for plants built in other regions and economies.

ICL production and operation costs

Construction and operation costs for indirect coal liquefaction depend on a variety of factors, including the technology adopted in the production process, the price of the feedstock and the ability to access capital. An ICL plant, in principle, needs several subprocesses — oxygen production, coal preparation and gasification, syngas purification and syngas conversion. These subprocesses require high fixed capital investment.

The costs will also vary depending on the system configurations for carbon dioxide (CO_2) treatment and coproduction of electricity. Because some CO_2 must be removed, together with all hydrogen sulphide (H_2S) from the syngas before the synthesis reactor[1], this CO_2 could be vented to the atmosphere. Alternatively, it could be captured alone or together with the H_2S and compressed for pipeline transport to an underground storage site.

[1] Because synthesis catalysts are poisoned by hydrogen sulphide, essentially all hydrogen sulphide must be removed upstream. Upstream removal of CO_2 from the synthesis gas is also desirable to maximise synthesis productivity, and it provides an opportunity for partial decarbonisation of the process (Williams and Larson 2003).

Syngas can be converted to liquid fuel by synthesis over appropriate catalysts. Recycling of unconverted syngas back to the synthesis reactor enables a larger fraction of the coal's energy to be converted to liquid fuel (the so-called recycle configuration). Passing synthesis gas only once over the synthesis catalyst, with unconverted synthesis gas used to generate electricity in a gas turbine combined cycle, leads to less liquid fuel production, but provides for a significant second revenue stream from the sale of electricity (the so-called once-through configuration).

Williams and Larson (2003) estimated the costs of construction and operation of ICL facilities in the United States under different system configurations (table 14). Assuming coal prices of around US$29 a tonne and an electricity price of US4.29c a kilowatt-hour (in 2002 dollars), the estimated costs for methanol production under the once-through configuration were equivalent to around US$34 a barrel of crude oil with CO_2 vented (H_2S converted to element sulfur), US$45 a barrel with CO_2 captured and stored (H_2S converted to element sulfur) and US$36 a barrel with both CO_2 and H_2S co-captured and stored[2]. For the recycle configuration (coproduction of electricity), the estimated costs (crude oil price equivalents) were US$32 a barrel with CO_2 vented, US$37 a barrel with CO_2 captured and stored and US$33 a barrel with CO_2 and H_2S co-captured and stored.

For DME production based on construction in the United States, lower production costs were estimated for the once-through design — equivalent to around US$40 a barrel with CO_2 vented (H_2S converted to element sulfur), US$47 a barrel with CO_2 captured and stored (H_2S converted to element sulfur) and US38 a barrel with CO_2 and H_2S co-captured and stored. This compares with US$44, US$50 and US$45 a barrel respectively in a recycle configuration (scenario 1 in table 14).

In table 14, another set of crude oil price equivalents are presented (denoted as scenario 2). These estimates of crude oil price equivalents took into account the fact that a spark-ignition-engine optimised for methanol can extract 15 per cent more useful work than the same engine operating on gasoline. Similarly, a DME fuelled compression-ignition-engine can deliver

[2] Other assumptions in the calculation include four year construction of plant, with a real annual interest rate of 10 per cent, annual operation and maintenance costs of around 4 per cent of the construction cost and an annual capital charge rate of 15 per cent. The share of coal input in total production cost was estimated to be around 18–22 per cent for both methanol and DME. For other technical assumptions, see Williams and Larson (2003).

18.5 per cent more useful work compared with a spark-ignition-engine operating on gasoline. Because of these advantages, the so-estimated crude oil price equivalents are lower than those under scenario 1.

The above cost estimates are broadly in line with those reported by some industry groups and government agencies. For example, recent studies by the US Department of Energy place the estimated cost of producing coal liquids at approximately US$30 a barrel (DOE 2005). Another report completed for the US Office of Fossil Energy by Mitretek Systems indicate that coal liquefaction is expected to become viable if the world oil price remains above US$25 a barrel in 1998 dollars (Gray and Tomlinson 2001). Adjusted by movements in the US consumer price index, this is equivalent to around US$30 a barrel in 2005 dollars. Readers are referred to the above reports for the underlying assumptions and other details.

14 Breakeven crude oil price equivalents for fuel liquids produced from ICL

	Scenario 1	Scenario 2
	US$/bbl	US$/bbl
Methanol		
OT–V	34.3	28.3
RC–V	31.8	26.1
OT–C/S	45.2	37.9
RC–C/S	37.3	30.9
OT–CC/CS	35.6	29.6
RC–CC/CS	33.0	27.2
DME		
OT–V	39.8	25.3
RC–V	44.4	28.7
OT–C/S	47.4	30.9
RC–C/S	49.5	32.5
OT–CC/CS	37.5	23.5
RC–CC/CS	44.5	28.8

OT = once-through configuration, RC = recycle configuration, V = CO_2 vented, C/S = CO_2 captured and stored, CC/CS = CO_2 and H_2S co-captured and co-stored.
Source: Williams and Larson (2003).

It is, however, important to recognise that these estimates of crude oil price equivalents are likely to be higher under the current environment of higher coal prices. For example, Australian unit export returns for bituminous coal were around US$50 a tonne in mid-2005, a rise of around 97 per cent from the same period two years earlier.

Potential implications for world oil market

Higher price differentials between crude oil and other liquid fuel sources such as coal, if sustained, may potentially provide incentives for the development and production of liquid fuels derived from sources other than crude oil. A combination of higher fuel prices and technological advancements will make the production of alternative fuels more economical, especially over the medium to longer term. Increased availability and production of

alternative fuels would also constrain upward pressure on world crude oil prices.

There are, nevertheless, hurdles in developing an industry for alternative fuels. In the case of coal-to-liquids, a major hurdle facing the startup of such an industry is the high capital costs associated with the construction of a commercial sized plant. For example, the US Department of Energy estimates the capital costs of an ICL facility in the United States with electricity generating capacity of 1000 megawatts and daily liquids production capacity of 33 200 barrels at approximately US$2.2 billion (DOE 2005). Thus, an industry capable of producing 1 million barrels of coal derived liquids per day would require a total capital cost of US$66 billion (30 plants). In 2004, the United States imported around 11.9 million barrels of crude oil a day. Other factors that can constrain the commercialisation of coal-to-liquids technology include plant siting issues, such as waste disposal and water availability, and challenges in development and operation. Uncertainty surrounding future crude oil price movements would also be a concern.

While the startup costs could be lower in other APEC member economies, they would still be substantial. Based on Williams and Larson (2003), for example, the construction costs for an ICL plant in China could be around 20 per cent lower than in the United States.

If higher world oil prices were to persist over the coming years, the possibility of production of liquid fuels from coal is likely to increase gradually over the medium to longer term. Assuming oil prices (in 2003 US dollars, where 'oil price' is defined as the US average refiner's acquisition cost of imported crude oil) at about US$34 a barrel through to 2015 and then increasing to more than US$39 a barrel by 2025, the US Department of Energy projects that around 49 million tonnes of coal will be consumed for producing liquid fuels in the United States by 2025, yielding around 62 million barrels of liquid fuels and 34 billion kilowatt-hours of electricity (EIA 2005g). If higher oil prices are assumed (US$37 a barrel by 2010 and US$48 a barrel by 2025), around 212 million tonnes of coal are projected to be consumed for liquid fuels in the United States, producing around 1 million barrels a day of synthetic liquid fuels by 2025.

While these production projections are small relative to oil consumption in the United States (estimated at around 20.7 million barrels a day in 2004),

production could increase markedly, if world oil prices were to remain significantly higher for an extended period.

The impact of coal-to-liquids technology on world oil prices will depend on the extent to which production of liquid fuels from coal increases in the future. If coal-to-liquids technology is widely adopted commercially by the APEC economies in the long term, production of liquid fuels from coal will increase significantly. This will reduce the dependence of the APEC region on crude oil imports, provide greater security for fuel supply in the region and, potentially, reduce upward pressure on world oil prices.

7

trade and investment barriers in APEC

A secure and sustainable supply of oil is required to sustain the economic growth of APEC economies. As a net oil importing region, energy security is among the key concerns of APEC. The ability to ensure adequate supply of oil in APEC economies and respond appropriately to sustained increases in oil prices is influenced by each economy's trade and investment policies. This chapter examines the trade and investment barriers in APEC across major sectors, with a focus on the energy sector. First the framework under which trade and investment policy reforms in the APEC region are undertaken is discussed. The progress of these reforms is then examined. The extent to which trade and investment barriers limit the capacity to respond to oil price increases in the region is also discussed. Reflecting the large capital requirements of the energy sector in APEC, the key role of investment in minimising the adverse effects of sustained increases in oil prices and the issues related to attracting investment to finance the capital requirements in the energy sector are also discussed.

APEC framework for trade and investment policy reform

Free and open trade and investment is one of the core principles of APEC. This was articulated in 1993 when the leaders of APEC issued a vision statement at Blake Island, Seattle, in the United States, in which they pledged to continue to reduce barriers to trade and investment to enable goods, services and capital to flow freely among their economies. In the following year, a significant declaration known as the 'Bogor Declaration' was made by APEC leaders in Bogor, Indonesia. This declaration reiterated the objective of enhancing trade and investment in the Asia Pacific and agreed to adopt the long term goal of free and open trade and investment in the region. Most significantly, the Bogor Declaration established the broad framework and timetable for trade and investment liberalisation in the APEC region.

Under the Bogor Declaration, APEC aims to achieve the goal of free and open trade and investment in the region no later than 2020. In recognition of the differing levels of economic development among APEC economies,

the goal was set at different timetables, with the developed member economies achieving the objective no later than 2010 and the developing member economies no later than 2020. Under the Bogor Declaration, individual investment plans are formulated by member economies on a voluntary basis as a vehicle to achieve the objectives of the declaration. APEC's commitment to free and liberalised trade and investment was reaffirmed at Osaka in 1995 and in Manila in 1996.

In addition to the provisions of the Bogor Declaration, a number of APEC economies have aimed to liberalise their trade and investment regimes through several international frameworks such as the World Trade Organisation (WTO) and regional arrangements, including the ASEAN Free Trade Area (AFTA) and the North American Free Trade Agreement (NAFTA) (table 15). Several APEC economies have also undertaken

15 Major arrangements through which APEC economies aim to liberalise their trade and investment regimes

	WTO	OECD	AFTA	FTAA	NAFTA
Australia	✓	✓			
Brunei Darussalam	✓		✓		
Canada	✓	✓		✓	✓
Chile	✓			✓	
China	✓				
Hong Kong, China	✓				
Indonesia	✓		✓		
Japan	✓	✓			
Korea, Rep. of	✓	✓			
Malaysia	✓		✓		
Mexico	✓	✓		✓	✓
New Zealand	✓	✓			
Papua New Guinea	✓				
Peru	✓			✓	
Philippines	✓		✓		
Russian Federation					
Singapore	✓		✓		
Chinese Taipei	✓				
Thailand	✓		✓		
United States	✓	✓		✓	✓
Viet Nam			✓		

WTO – World Trade Organisation; OECD – Organisation for Economic Cooperation and Development; AFTA – ASEAN Free Trade Area; FTAA – Free-Trade Area of the Americas; NAFTA – North American Free Trade Agreement.

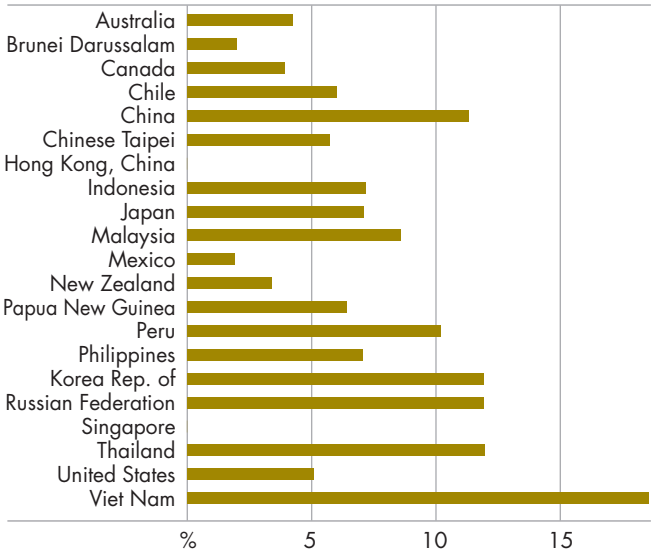
measures through bilateral arrangements and also via unilateral reforms to remove impediments to trade and investment.

Declining trade barriers

The impact of various international arrangements on trade and investment liberalisation is quite significant. In APEC, no member economy had an average tariff of more than 14 per cent in 2004 except Viet Nam (figure 20, based on APEC Individual Action Plan 2004). And only seven economies had an average tariff of more than 8 per cent.

The reduction in tariffs in APEC economies is also notable after the implementation of the Bogor Declaration. For example, Indonesia had an average tariff of 13 per cent in 1996 compared with 7.2 per cent in 2004. The Philippines reduced its average tariffs from 14 per cent to 7 per cent over the same period. Although the progress of trade and investment liberalisation under the Bogor Declaration has been slow because of the voluntary nature of the offerings and the absence of real negotiations under the Individual Action Plan (IAP) mechanism (Lincoln 2001), it can be expected that the rate of reform will accelerate as deadlines approach.

20 Simple average applied tariffs in APEC, 2004

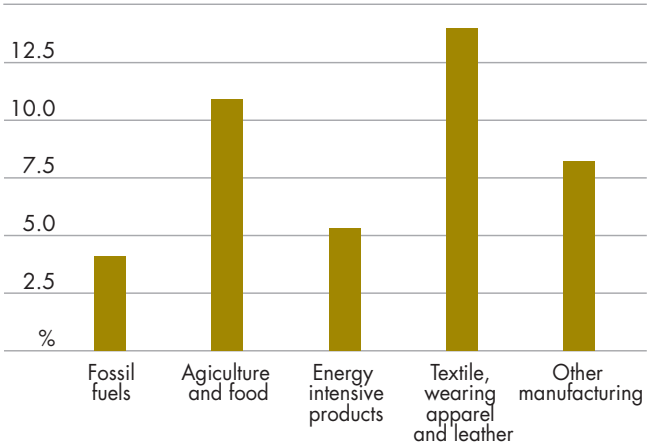


Although average tariffs have fallen in most APEC member economies, individual tariffs and related trade barriers on a number of products remain high. These relate to categories of agriculture and textile clothing and footwear in some developed member economies (figure 21). The tariffs on fossil fuels such as coal, oil and gas are the lowest among categories of products. Only a few member economies impose tariffs on imports of crude oil and they are at low rates. Among these are Chile (8 per cent), Chinese Taipei (2.5 per cent), the Republic of Korea (5 per cent) and Mexico (10 per cent).

Mexico's relatively high tariff on crude oil imports reflects its 'strategic' treatment of the oil industry. As Mexico is an oil exporting economy, the significance of the tariff is in ensuring that domestic oil production is protected to some degree from imported oil if world oil prices fell below the price of Mexican oil.

The zero tariffs on crude oil in many economies reflect the importance of this raw material in driving economic activities of APEC economies. It is recognised that the availability of energy such as oil is a prerequisite to economic development (IEA 2004a).

21 Simple average applied tariffs in APEC, by sector, 2004



For each category, the simple average applied tariff is calculated by summing the MFN applied tariff for all tariff items that belong to the product category and dividing by the number of tariff items. Estimated tariffs do not include tariff quotas, specific tariffs and nontariff barriers.
Source: WTO (2005).

Although APEC economies have made significant reductions in their tariffs, there are still opportunities to obtain economic benefits from further trade reform. In particular, reduction in tariffs can be undertaken for trade in textile, clothing and footwear, agriculture and manufactured products in a range of APEC economies. If such reform is undertaken, it can be expected that the energy sector will also benefit (through a more efficient allocation of resources within economies) as it is one of the least protected sectors in APEC.

Some investment barriers still remain

Oil industries in APEC are characterised by extensive state involvement in upstream activities. For example, in the oil producing economies of Chile, China, Malaysia, Mexico, Thailand and Viet Nam, oil production involves state owned firms. Governments are also involved in downstream activities in a variety of ways, including ownership of facilities, regulation of prices, control of trade in petroleum products and regulation of retail supply activities (Fairhead et al. 2002).

APEC members have been implementing structural adjustments to their economies, including deregulation of energy markets. In these economies, both upstream and downstream reforms of energy markets have been undertaken, for example, by moving from public ownership of energy assets to private ownership. The major upstream reforms relate to the removal or easing of controls on private and foreign involvement (Fairhead et al. 2002). Downstream reforms have also been widely implemented, although these activities remain heavily regulated in many economies. Some controls on imports of refined products have been lifted to promote competition and some restrictions on retail prices and other retail activities, such as petrol station location and ownership, have been eased. Downstream activities have been deregulated over the past decade in Hong Kong China, Japan, Malaysia, the Philippines, Chinese Taipei and Thailand. Further major upstream and downstream reforms are planned in Indonesia, with legislation passed by the parliament in October 2001.

The Japan National Committee for Pacific Economic Cooperation Council has also documented substantial liberalisation in APEC, particularly of foreign direct investment (FDI) from 1996 to 1999. One of the main findings of this study is that developing economies have more restrictive regimes than developed member economies within the region (JANCPEC 2003).

Despite these reforms, distortions still remain in many APEC economies. In table 16, selected foreign investment measures compiled from the latest guide to APEC investment regimes are provided (APERC 2003c). It is shown in this table that governments in all APEC economies either restrict or ban foreign ownership of domestic assets in certain sectors. In most instances these restrictions or bans apply to transport and communication, financial services and in the development of natural and energy resources, particularly oil and natural gas. In some instances, the bans apply not only to foreign investors but also to domestic companies. Other distortions relate to the use of taxation incentives, screening/notification and the application of performance requirements.

16 Selected major distortions to foreign direct investment in APEC

	Screening/ notification	Restricted/ closed sectors	Performance requirements	Non-tax fiscal incentives	Taxation incentives	Priority sectors	Exchange controls
Australia	yes	yes	no	no	yes	yes	no
Brunei Darussalam	yes	yes	ni	yes	yes	yes	no
Canada	yes	yes	no	no	no	no	no
Chile	yes	yes	yes	ni	yes	no	no
China	yes	yes	no	ni	yes	yes	yes
Hong Kong, China	no	yes	no	yes	yes	no	no
Indonesia	yes	yes	no	ni	yes	yes	no
Japan	yes	yes	no	yes	yes	ni	no
Korea, Rep. of	yes	yes	no	ni	ni	yes	no
Malaysia	yes	yes	no	yes	yes	yes	no
Mexico	yes	yes	no	yes	yes	yes	no
New Zealand	yes	yes	no	yes	ni	yes	no
Papua New Guinea	yes	yes	no	yes	yes	yes	yes
Peru	no	yes	no	no	yes	yes	no
Philippines	yes	yes	no	no	yes	yes	no
Russian Federation	yes	yes	yes	ni	yes	yes	yes
Singapore	no	yes	no	yes	yes	no	no
Chinese Taipei	yes	yes	no	yes	yes	yes	yes
Thailand	yes	yes	yes	yes	yes	yes	no
United States	no	yes	no	no	no	no	no
Viet Nam	no	yes	yes	yes	yes	yes	ni

ni Not indicated.
Source: APERC (2003c).

Another distortion to foreign investment that acts in a similar way as restrictions or bans on certain activities is the identification of priority sectors. Here, APEC governments identify priority sectors which, in most cases, are biased in favor of activities that are export oriented. Most APEC economies use this type of regulation to attract foreign investment in designated sectors. To induce the flow of capital to priority sectors, APEC governments provide incentives such as fiscal or taxation incentives. Fiscal incentives come in the form of investment promotion, support to training, and state sponsored favorable prices of land. Taxation incentives are in the form of tax concessions involving research and development, investment tax allowances, accelerated depreciation and duty free import of inputs.

In addition to bans on private or foreign participation, restrictions on participation or ownership of assets are also commonly applied in the energy sectors of APEC economies. Several examples of specific distortions in selected APEC economies are provided in box 9.

While the APEC investment guide provides information on the investment regimes in APEC and the extent of liberalisation, it does not always capture the investment regimes completely, partly because regulations are not always practised in the ways that are stated or recommended in some member economies (JANCPEC 2003). According to the World Bank (2005), 90 per cent of firms in developing economies in general report gaps between

Box 9: **Examples of specific distortions in the energy sector in APEC economies**

Mexico

In Mexico, some activities are considered to be 'strategic activities' that are reserved exclusively for the state. These activities include energy sectors such as oil production and oil refining, basic petrochemical production, sale of electricity to the public and nuclear power. In addition to the regulation of energy production, retail trade in gasoline and liquefied natural gas is reserved exclusively to Mexicans or to Mexican companies with a Foreigners Exclusion Clause.

State owned monopolists dominate Mexico's energy sector. Petroleos Mexicanos (Pemex), the state owned oil and gas company, has exclusive rights to oil and gas exploration and production in Mexico. The company's financial capacity to invest in exploration and production has been severely curtailed by

continued

Box 9: **Examples of specific distortions in the energy sector in APEC economies** *continued*

its financial responsibility to the Mexican Government. As a result, there has been insufficient investment in the upstream oil and gas sectors, contributing to the sharp and recent declines in proven reserves of both oil and gas (Hogan et al. 2005).

Canada

In Canada, the approval of the Minister of Energy, Mines and Resources of a 'benefits plan' is required to receive authorisation to proceed with any oil and gas development project under the *Canada Oil and Gas Operations Act*. A 'benefits plan' is a plan for the employment of Canadians and for providing Canadian manufacturers, consultants, contractors and service companies with a full and fair opportunity to participate on a competitive basis in the supply of goods and services used in any proposed work or activity referred to in the benefits plan. The Act permits the Minister to impose an additional requirement on the applicant, as part of the 'benefits plan', to ensure that disadvantaged individuals or groups have access to training and employment opportunities or can participate in the supply of goods and services used in any proposed work referred to in the 'benefits plan'.

China

China identifies specific activities in the energy sector for foreign investment. In most cases these activities require joint venture arrangements with Chinese partners. For example, the prospecting and exploitation of oil and natural gas should be in cooperation with Chinese partners only. The Chinese Government is also involved in oil and gas production, having a majority stake in the economy's three largest oil and gas firms.

Indonesia

Based on Law No. 22 of 2000, the oil and gas sectors are divided into upstream and downstream sectors. In the upstream oil and gas industry, production sharing contracts between foreign investors and domestic institutions appointed by the Indonesian Government are required, whereas investment in downstream oil and gas industry activities is regulated by Law No. 1 of 1967.

Russian Federation

Foreign participation in the privatised oil and gas industry is also restricted. In the electricity sector, foreign participation is limited to 25 per cent, while in the gas industry the limit is 14 per cent. The state is also involved in oil production and distribution, having large stakes in the economy's major oil and gas companies.

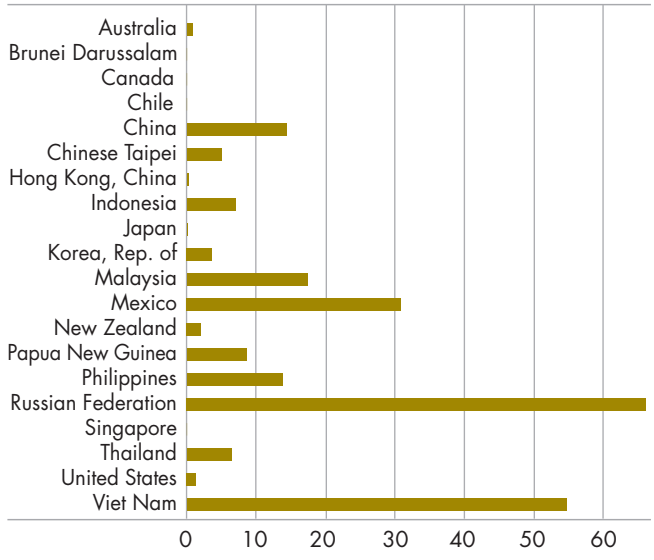
Source: APERC (2003c).

formal policies and what happens in practice in investment activities. Based on a survey conducted by the Japan Business Council for Trade and Investment Facilitation, JANCPEC (2003) has documented the incidence of FDI impediments in APEC (figure 22). The impediments surveyed include market access, equity restriction, examination procedure, work permits and performance requirements. According to the JANCPEC (2003) analysis, the highest number of incidence, by type of impediment, is performance requirements. This incidence of application of performance requirements is an example of policy not implemented in practice because, according to the investment guide in APEC, most economies do not have performance requirements for investors (see table 16).

The incidence of impediments is highest in the Russian Federation and Viet Nam, followed by Mexico, Malaysia and China (figure 22).

An interesting observation that can be drawn from the survey (see JANCPEC 2003) is that economies that are producing, and/or exporting, oil have a higher incidence of impediments — for example, the Russian Federation, Mexico and Indonesia. Another finding of the survey is that, as a group, the developing APEC member economies have an incidence of impediments to

22 Incidence of impediments to foreign direct investment in APEC economies per thousand FDI cases



foreign direct investment of 7.81 per thousand, while the developed economies' average is only 0.26. This finding is similar to that of the World Bank (2005) which reported that impediments to investment are more of a problem in developing economies than in developed economies.

Gains from trade and investment liberalisation

Analysis of the Bogor Declaration by Schneider et al. (2000) shows that the implementation of trade liberalisation according to the principles and timetable agreed in the declaration could provide significant additional economic output in the region in 2020 of approximately US$225 billion (at 1995 prices). This is about a 0.75 per cent increase in regional GDP relative to a reference case. On average, newly industrialised and developed APEC economies experienced smaller increases in GDP because they have generally lower levels of protection. With the inclusion of productivity gains, the benefits can be expected to increase to US$345 billion (at 1995 prices).

A significant finding of that study is that as a region, trade liberalisation in APEC could result in increased regional production of fossil fuels in 2020. In particular, oil production in major producing economies such as Canada, Mexico and the United States is expected to increase when trade is liberalised. In these economies, the liberalisation of trade results in releasing the resources from previously protected industries such as agriculture, and to some degree manufacturing, into less protected sectors such as energy production.

When liberalisation of investment regimes, including liberalisation of foreign direct investment in APEC, is undertaken, additional GDP gains ranging from 0.5 to 2.7 per cent relative to trade liberalisation only are expected for member economies. And most significantly, energy production is expected to be larger than in a scenario where only trade regimes are liberalised. For example, energy supply responses in oil exporting economies in APEC are greater under trade and investment liberalisation than with trade reform alone. This highlights the importance of investment liberalisation in increasing oil production in the region.

If energy sector reform alone is undertaken, it may be also expected that economic gains could be attained as the energy sector is highly regulated in many APEC economies. Fairhead et al. (2002) analysed the economic and sectoral impacts of liberalising the electricity, natural gas and downstream

oil markets in APEC economies. Their findings indicate that reforming APEC's energy market translates into an increase in regional economic output of around US$71 billion (in 1999 prices). The highest gains are attained by developing member economies, reflecting the currently highly regulated regimes affecting energy sectors in these economies and the relatively large contribution of oil and gas sectors to their economic output. In such economies, energy production increased relatively more than outputs of other sectors. For example, oil production in Mexico and Indonesia significantly increased relative to other sectors.

Limitations in the capacity to respond to oil price increases

The effects of barriers to trade in the oil sector on the ability of APEC economies to respond to oil price increases is expected to be small. As discussed earlier, tariffs on oil and other energy products are generally low in the APEC region. In fact most APEC economies do not impose tariffs on crude oil, so the effect of tariffs is expected to be insignificant. However, the elimination of trade barriers (tariff and nontariff) for some other products that are protected in many APEC economies, including agriculture and manufacturing, and reform of domestic support programs in some APEC economies can affect oil production capacities in the region indirectly through improved resource allocation and, to some extent, the availability of funds for investment through effects on incomes. Such reform is expected to transfer productive resources out of the protected sectors into less protected activities such as the oil sector. This would expand the production capacity in APEC economies that are currently producing oil but are devoting resources for the protection and support of activities other than the oil sector.

The restrictions on investment in the APEC region, such as those discussed previously, are expected to have a more limiting effect on the ability of APEC as a region to adjust to sustained price increases in oil. The limitations may occur in three main areas: the ability to increase oil production within APEC; the ability to substitute oil with other energy products; and the ability to develop and introduce new technologies that are less oil intensive and to develop alternative processes in producing liquid fuels.

- Production, processing and distribution capacity. Investments in the oil sector, such as in oil exploration, will increase proven reserves, which can potentially improve domestic supplies in APEC oil produc-

ing economies. This will potentially reduce the import dependence of the APEC region as a whole and reduce its vulnerability to disruptions in supply from outside the region. At the same time, investments in facilities such as refineries and pipelines are important to produce and deliver petroleum products. With the expected increase in demand for petroleum products in the APEC region, investments in such facilities will help the region avoid the bottlenecks that may occur in downstream activities.

- Oil substitution. Barriers to investment are expected to constrain investment in alternative fuels, such as natural gas and coal, and renewable energy sources, which will limit their availability and usefulness. The limited availability of alternative fuels is expected to limit the ability of APEC economies to substitute oil with other fuels in the event of a sustained oil price increase.
- Research and development. R&D on the wider use of other traditional energy sources, the development of alternative processes in producing liquid fuels from sources other than crude oil, and the harnessing of renewable energy sources, such as solar, wind and hydro power, will be limited when investments are restricted.
- Use of energy efficient technologies. Barriers to investment will limit the introduction and use of new energy saving technologies that can be adapted in high oil intensive areas such as transport and other oil intensive activities. Barriers will also reduce investments in technologies that reduce energy intensity in other products, including household appliances, industrial equipment and machineries.

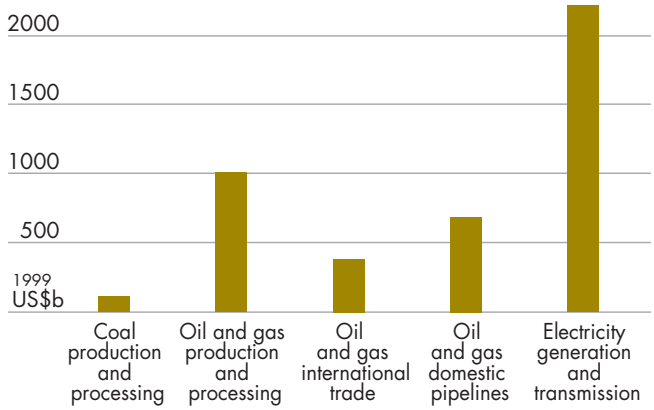
In addition, an important intervention in the energy sector in some APEC economies that affects responses to oil price increases is the provision of fuel subsidies such as subsidies on consumption of petrol, diesel and other oil products. This intervention can provide short term relief to some consumers but it is not sustainable in the long run, distorting the economy and reducing economic growth. The subsidy tends to encourage consumption and increases the oil intensity of economic activities. For example, of the three fuel-subsidising economies of Indonesia, Thailand and Malaysia, the highest petroleum consumption per unit of gross domestic product (GDP) is in Indonesia (The Economist 2005). Indonesia has the largest fuel subsidy among the above mentioned economies in 2004.

Large investment needs in APEC energy sector

High economic growth in the APEC economies is expected to drive increases in the demand for energy. To meet this increasing demand, investment will be required for the production of energy, including its delivery and distribution throughout the APEC region. APERC (2003b) estimates that in the twenty years to 2020, a total of US$3.4–4.4 trillion in investment in energy will be required in the APEC region to meet the region's growing energy demand. During that period, the yearly investment needs are projected to be US$149–252 billion. About half of the total requirement, or US$2.2 trillion, is needed for electricity generation and transmission infrastructure alone (figure 23; APEC 2003b).

APERC (2003b) projects that the bulk of the investment needs are in China (US$1307 billion), the United States (US$762 billion) and the Russian Federation (US$689 billion). Of the total requirement, the investment needs for oil and gas production, processing and the petrochemical industry account for 23 per cent, or about US$1 trillion. Four economies require more than US$100 billion in investments in the oil and gas sectors. The United States requires US$231 billion, the Russian Federation US$146 billion, Canada US$145 and China US$127 billion. Mexico needs investment into the oil and gas sector of US$64 billion (details in box 10).

23 Energy investment requirements in the APEC region, 20 years to 2020



In general, investment requirements in absolute amounts are lower in developing economies than in developed economies. However, because the economies of developing economies, excluding China, are small, the burden of financing the requirements for energy investment is heavier there than in developed economies as developing economies tend to have limited domestic sources of capital. In figure 24, where investment requirements are presented as a percentage of GDP, the highest requirement is for Papua New Guinea, Viet Nam and the Russian Federation. This raises an issue on whether sufficient financial resources can be mobilised in those economies to support the demand for investment capital. It is argued that it will be

Box 10: **Some details of investment requirements in major APEC oil producing economies**

APERC (2003b) projects that expenditure on oil exploration and production on deepwater field developments will account for a large share of oil and gas exploration and production in the future. For the period 2003–07, 148 new deepwater fields are expected to come onstream in the APEC region, more than twice the number during the previous five years.

The Russian Federation and Canada are expected to increase their production of oil through to 2020. Investment in these two economies is related to upstream activities, for example oil mining activities. Canada, the seventh largest oil producer in the world, has the capacity to boost its production by tapping into its vast oil sands deposits, which account for 95 per cent of its proven oil reserves. Oil production from oil sands has already played a role in increasing oil production and will start replacing aging fields. Analysts predict that oil sands production will increase significantly in coming years and offset the decline in Canada's conventional crude oil production (EIA 2005a).

In the Russian Federation, the required investment in the oil and gas sectors is similar to that of Canada. Projections by the EIA (2005d) indicate that Russia needs investments for increasing crude oil processing capacity and in modernising its inefficient and aging refineries. According to the draft plan for economic development for 2005–08, the reconstruction and upgrading of refineries will be a priority for future oil refinery development in Russia (EIA 2005d).

The United States has the largest investment requirement for oil and gas. One area requiring investment is in increasing US refining capacity, which fell significantly in the 1980s. From 1981 to 1986 the number of refineries in the

continued

Box 10: **Some details of investment requirements in major APEC oil producing economies** *continued*

United States dropped by 123 operating plants (APERC 2003b). In 2003 the number of operable refineries was 149 (EIA 2005e). As utilisation rates increase with rising demand, refining capacity will need to be increased.

Investment needs in the United States are expected to increase further after oil rigs, pipelines and refineries in the Gulf of Mexico were rendered inoperable or damaged by Hurricane Katrina in late August 2005.

In China, where oil demand is projected to increase by 4.3 per cent a year over the period 2000–20, upstream and downstream investment in oil and gas is estimated to amount to US$127 billion. Through its Tenth Five Year Plan, the Chinese Government is encouraging exploration and development of oil and gas fields both domestically and abroad. While China's gas market remains at an early stage of development, the Chinese Government has set a target to raise the share of natural gas in total primary energy supply from the current 2 per cent to 10 per cent in 2020 (APERC 2003b). Although a number of projects are currently under way in partnership with foreign companies, achieving this target will require a large amount of investment.

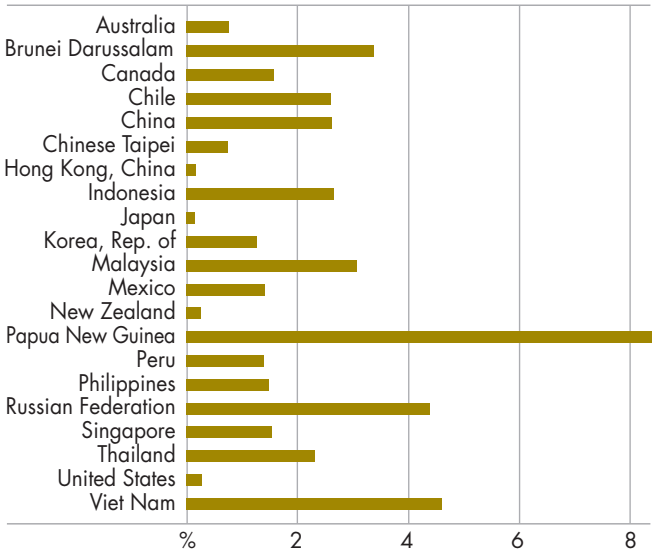
Although Mexico is reported to have the third largest proven conventional crude oil reserves in the western hemisphere after Venezuela and the United States, it has one of the most regulated oil sectors. It is also the second largest oil exporter in APEC after the Russian Federation. However, as investment over the past twenty years has been insufficient, Mexico could be importing oil after 2013. To avoid this possibility, the Mexican Government has advocated US$130 billion of investment in Mexico's oil sector over the next ten years, including permitting investment by foreigners (EIA 2005c).

In particular, Pemex plans to increase crude oil production to 4 million barrels a day and to achieve a 75 per cent reserve replacement by 2006. In order to meet these goals, Pemex has estimated that it will need to make capital expenditures of approximately US$45.3 billion in exploration and production over the next five years, in addition to US$16.1 billion refinery upgrades over the next ten years in order to meet anticipated growth in domestic and international oil market demand.

Pemex is also expected to spend $29.8 billion to develop a planned 13 500 wells and has already signed a $500 million oil field services contract with ICA Fluor Daniels and Schlumberger to drill 250 wells (EIA 2005c).

In other oil producing economies, such as Indonesia and Viet Nam, upstream investments are necessary to find additional reserves and downstream investment activities are required to increase refining and distribution facilities.

24 Energy investment requirements as a percentage of GDP, 2000–20



necessary for developing economies to tap international capital through foreign direct investment.

Investment – key to moderating adverse effects of sustained oil price increases

Investment drives economic growth. It brings more inputs into the production process and builds the productive capacity of an economy. It brings not only financial resources, but technologies and management skills that increase productivity. The significance of investment in increasing economic growth motivates governments to seek investments both from domestic and international sources. At times, governments themselves undertake investments but their abilities are limited by the extent of tax and other government revenue available.

The importance of investment is even more crucial in the energy sector because energy is an integral part of economic activity, and investment in energy facilities is essential to support economic growth (APERC 2003b). In recognition of the region's needs for investment, APEC has given priority to facilitating investment in the energy sector, fostering efficient capital

markets, and engaging international financial institutions and the private sector (Choi Seok Young 2005).

A range of investment options would be required to increase the ability of APEC economies to respond to changes in energy markets and minimise any adverse effects of energy market developments. As suggested in Hogan et al. 2005, these options include:

- adoption of a diversified portfolio of interchangeable energy forms and energy supply sources – for example, increased investment in domestic exploration for oil and other energy forms, investment in fuel switching systems and, in many economies, increased use of natural gas.
- interconnection of energy systems – interconnection reduces vulnerability to system failure.
- encouragement of investment in more efficient energy technologies – these technologies reduce the energy intensity of economies by, for example, reducing fuel use in transport.

Investing in developing cost effective alternative processes for producing liquid fuels and in developing nontraditional energy sources is another option for APEC.

Implementation of the above options would further increase the estimated investment requirements for the energy sector in APEC. Harnessing the resulting vast amount of capital requirement through public funds is arguably beyond the capacity of many of the governments of APEC member economies. Private capital both from domestic and/or foreign sources must be mobilised to meet the investment requirements. Thus, the challenge for member economies is how they may attract investors so that investment requirements are met. Dollar et al. (2003) found that there is a strong link between the investment climate and the level of productivity, wages and profit at the firm level. This suggests that an important strategy to attract investment is to provide an environment in the energy sector that is conducive to investment.

By removing investment barriers and improving the domestic environment for investment, many APEC economies, particularly developing economies, can enhance their capacity to respond to changes in energy market develop-

ments, such as sustained oil price increases, in many different ways. These include:

- Direct oil sector response. If investments in the oil sector, including upstream and downstream activities, are in place within APEC, sustained oil price increase could be cushioned in the region through appropriate supply responses. This would be possible, if, as a result of investments, spare production capacity in the region were developed. APEC has five of the ten largest oil producing economies, so that investments in this sector will increase the capacity of the region to respond to adverse market developments.
- Fuel substitution. The investment requirements estimated by APERC (2003b) cover both the upstream and downstream activities in the APEC energy sector. This includes coal, oil and gas exploration, trade, pipelines and generation and transmission of electricity. This broad coverage of investment ensures that production and distribution capacity is increased not only by the oil sector, but by other alternative fuels. With the availability of alternative fuels, temporary or even sustained oil price increases would have a much lesser impact within APEC, as oil would be substituted with other relevant sources such as gas, coal or even clean energy sources, such as solar or wind, as appropriate. However, the ability to use other sources of energy would be affected by ability to substitute oil with other fuel alternatives. For example, investments should also be made into fuel switching systems, as suggested earlier.
- Increasing efficiency. In addition to direct investments in the energy sector, it has been recognised that investments in more energy efficient technologies should be encouraged, for example, in transport systems, household appliances, and heating and cooling systems. This will contribute to reducing the oil intensity of many APEC economies.
- Use of alternative processes. As discussed in chapter 6, liquid fuels can be produced from sources other than crude oil — for example, with the use of direct coal liquefaction, where synthetic crude oil can be produced from coal. Investments by a number of APEC economies, including the United States, Japan and China, have already been made into such processes either for construction of coal-to-liquids plants or to study the viability for commercialisation of such technologies.

- Nonfossil fuel sources. Another important area of investment is in other energy sources, such as solar, wind and hydro–thermal, that may lessen dependence on oil in certain activities.

A key aspect of the above investment options is the development and use of technologies in the production and utilisation of fossil fuels, including the use of renewable energy sources. As much of the innovation of these technologies occurs in a few developed economies, most APEC economies will be dependent on others for access to such technologies. Speeding up the rate of transfer and adoption of new or leading edge technologies from innovating economies to economies that are less technologically advanced is a key aspect of realising the potential for technology to reduce growth in energy consumption in APEC economies. This may be realised through foreign direct investment and regional cooperation, including arrangements within the APEC framework.

Improving the environment for investment

Investments in the energy sector are often large and have the characteristics of being 'locked into' as they cannot be moved elsewhere easily. In addition, the majority of costs when undertaking investments is borne immediately, while the benefits are spread over time. Reflecting this characteristic, investors in many sectors including the energy sector make every effort to ensure that their decisions to invest are motivated by the viability of the undertaking, which is influenced by the costs, risks and barriers to competition (World Bank 2005). Behavior of governments through their investment policies and regulatory control could influence the opportunities and incentives for firms to invest, in general.

In this context, a number of approaches can be used to improve the investment environment for firms. These include the following.

Reducing risk

Risks and returns are drivers of energy investment (APERC 2003b). Minimising risks to potential investors is important if investments are to be attracted. Governments have an important role in minimising risks as they influence stability and security of investment environment through economic and regulatory policies. Policies affecting taxation, and fair and transparent laws and regulations will help minimise risks. Such policies need to be transparent and enforced consistently. There should also be continuity

in policies even if administrations change. The certainty of policies is an important factor for investors. The World Bank Investment Climate Surveys of firms has recently indicated that in developing economies, policy related risks are the main concern of firms, surpassing macroeconomic instability and taxation (World Bank 2005).

Openness/competition

Despite the need to attract investment, particularly from international sources, restrictions are imposed on foreign companies in many APEC economies. As discussed earlier, the oil sector in many oil producing economies, particularly developing member economies, is dominated by state firms. In some economies, the participation of foreign oil companies is not permitted in oil and gas exploration. In other economies, the ownership of oil companies is restricted. The limited openness to foreign investment is often a major disincentive for international oil companies that plan to operate in developing economies (IMF 2005a).

In addition to the direct restrictions, foreign investment laws in many APEC economies are not transparent about the obligations of foreign investors, making such investors uncertain about the application of existing laws (Bora and Graham 1997).

Barriers to competition in the oil sector promote inefficiencies and increases costs. By removing barriers to competition in the oil sector, oil firms will improve their productivity and innovate in their production processes.

Reducing business costs

Estimates by the World Bank (2005) indicate that the costs associated with crime, corruption, regulation, unreliable infrastructure and poor contract enforcement can amount to over 25 per cent of sales or more than three times what is typically paid in taxes. Measures necessary to reduce these costs will contribute to improving the investment climate and in attracting oil firms and other investors, both domestic and foreign.

8

concluding remarks

Diverse range of factors influence oil price rises

The current high oil prices are the culmination of a diverse range of factors. First, global demand for oil has continued to rise. The highest rates of demand have been in the United States, China and other parts of Asia. While growth rates have recently declined to levels closer to historic norms, the absolute amount of oil demanded has increased and will continue to grow. The high levels of demand are strongly linked to the growth in demand for transport fuels, especially gasoline and diesel, as incomes have grown across the APEC region, especially in rapidly growing developing economies. This will place growing pressure on oil producers to increase output, and on national governments to ensure domestic supplies.

The increase in demand leads to the second factor, that production of the oil 'in most demand' (light, low sulfur oil) may have peaked and that downstream facilities lack sufficient capacity to refine enough heavy, high sulfur oil to meet global demand in the near short term. This is reflected in the growing price differential between 'sweet' and 'sour' crude oils on world markets. Until new refineries are built, current capacity is expanded or currently unsuitable facilities are converted to process high sulfur oils, it is likely that this will remain an issue.

The third factor is that the type of oil demanded, particularly in developed economy oil markets, has changed largely in response to environmental regulations, both up and downstream. More stringent regulations on refineries run the risk of rendering even legally permissible development plans prohibitively expensive. The tightening of standards that determine the allowable sulfur content in petrol and diesel fuels has been a major factor in shifting demand for oil toward low sulfur, light oils, particularly in developed economies.

Environmental regulations, however, are not the only barriers faced by would be investors in the oil industry. The fourth factor contributing to high oil prices is investment barriers. These can include restrictions on foreign

(and domestic) ownership, performance requirements, long lead times, and volatile prices. As a result, levels of investment have not increased sufficiently to ensure that supply meets global demand.

Fifth, world oil spare production capacity has declined to its lowest levels since the early 1990s. This has been brought about by both the increasing demand for oil and by the low levels of investment in the oil industry since the mid-1980s. Historically, low levels of spare production capacity have been associated with high oil prices, and high levels of price volatility.

This has been highlighted by the recent disruptions to oil production and processing facilities in Mexico and the United States by Hurricanes Dennis, Emily and Katrina. In addition to the release of some crude oil from emergency reserves by the IEA, federal clean air standards were relaxed by the US Environmental Protection Agency in attempt to increase the fuel supply in the United States and reduce the magnitude of oil price increases (Bailey, Mollard et al. 2005).

Finally, geopolitical and economic tensions in many of the main oil producing regions has raised serious questions about the security of current oil supply chains, as well as exacerbating pressure on demand and spare production capacity. It has led economies that rely heavily on oil imports, as well as major oil consuming economies, to seek to establish more diverse networks of oil supply, processing and transport.

Higher oil prices to undermine APEC economic growth

Oil is a vital input to economies in APEC. Sustained higher oil prices have the potential to cause sizable adverse impacts on many economies, depending on the size and duration of the price increases, the flexibility of domestic energy markets to substitute different fuels and technology, and the oil import dependence of the domestic economy. Based on the economic modeling undertaken, the key impacts of higher sustained oil prices include a reduction in economic output and deterioration in the terms of trade for most APEC economies.

The effect of sustained high oil prices on economic growth in APEC economies is largely influenced by factors such as the oil intensity and oil import dependence of individual economies, and the interplay between the income transfer and output effects associated with the oil price increases. The oil

importing developing economies in the region would generally suffer the most, as some of these economies are more oil intensive and less able to cope with the financial burden brought about by higher oil import costs. These adverse impacts will be accompanied by a deterioration in the terms of trade in these economies.

Depending on the extent of labor market rigidities and the degree to which producers pass on the cost increases associated with high oil prices to consumers, real wages are estimated to fall, particularly in developing, oil importing economies in the APEC region. In practice, in sectors where the skills of the labor force are not easily transferable, the emergence of some unemployment can be expected as a result of sustained high oil prices.

In those APEC economies where oil intensity is low, such as some of the developed economies, the adverse impact of an increase in oil prices on GNP is estimated to be more modest.

Oil exporting economies are estimated to receive windfall revenues as a result of the sustained oil price increase, and hence are estimated to experience an increase in GNP.

The adverse impacts of high oil prices in APEC tend to be concentrated in industries that depend heavily on petroleum inputs. These include the transport industry and the chemicals, rubber and plastics sector. These adverse sectoral impacts are most pronounced in the developing economies of the APEC region that are oil importers.

It is important to recognise that the recent increases in oil prices have been accompanied by increases in the price of other energy commodities, such as gas and coal. Economic modeling undertaken in this study also illustrates that in many APEC economies the projected reduction in economic output is likely to be relatively greater under a sustained increase in overall energy prices than under a sustained increase in oil prices alone.

Emerging technologies could slow the growth in transport fuel demand

The transport sector accounts for the largest share of oil consumption in many APEC economies. Hence the improvement in fuel efficiency on the consumption side, involving emerging technologies as well as those already

available, can play a crucial role in slowing the level of growth of oil consumed in many APEC economies. This is particularly relevant in APEC economies where demand for transport fuels is triggered by continuing income increases in the medium to long term.

There is a range of fuel efficient transport vehicle technologies currently available, including hybrid vehicles and fuel cell vehicles. Although some of these technologies are only just entering into the commercial market, their cost effectiveness, economic viability and market penetration are likely to continue to improve in coming years.

Illustrative quantitative analysis undertaken in this report involving the adoption of emerging transport technologies, shows that sizable fuel cost savings and major energy security benefits could be achieved in the medium to long term by actively encouraging the use of more efficient fuel technologies, for example, fuel efficient hybrid vehicles and diversified energy use in the transport sector. It is estimated in this report that APECwide adoption of fuel efficient hybrid vehicles can potentially lead to fuel consumption in the transport sector growing by 16 per cent between 2006 and 2015, compared with 25 per cent over the same period without the adoption of such technologies. This finding highlights that there may be an important role for government in facilitating research into and also the adoption of energy transport technologies such as hybrid vehicles.

Potential role of technological progress on the supply side

A range of technologies is currently available that have the potential to produce liquid fuels from alternative sources, not requiring crude oil. Unconventional reserves such as tar sands, gas-to-liquids and coal-to-liquids are used by some of these technologies.

In this report, the case of coal-to-liquids was briefly explored in terms of the role that alternative technology could play in order to increase and diversify liquid fuel supply in the future. A key attraction of coal-to-liquids in the APEC region is the sizable coal deposits in a number of economies, including the United States, China, Australia, Canada and Indonesia. Economically viable development and commercialisation of coal-to-liquids technology in the APEC region has the potential to effectively enhance liquid fuel supply and to lower the dependence on crude oil in the region. Active encouragement of the development and commercialisation of such

technologies is another policy response that APEC economies could consider to reduce the oil dependence of the region.

Increasing need for the removal of investment barriers

Many APEC economies still have a range of investment barriers that limit their ability to respond to changes in energy markets, including high oil price increases. These barriers affect three main areas, including: the ability to increase oil production within APEC; the ability to substitute oil with other energy products and to develop and promote less oil intensive technologies; and the ability to develop alternative processes of producing liquid fuels.

In this regard, the acceleration of efforts to remove the various investment barriers discussed in this report can be identified as another key policy response for consideration by APEC economies. This would facilitate timely investment in production, processing, distribution and storage capacity in the energy sector in general and could also encourage investment in more fuel efficient energy technologies that will reduce the overall energy intensity of APEC economies.

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