Energy security in APEC

assessing the costs of energy supply disruptions and the impacts of alternative energy security strategies

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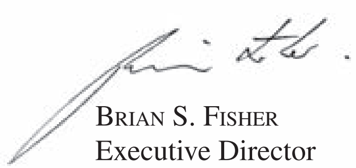
foreword

APEC is an important forum for strengthening economic cooperation in the region. Energy security has become a key issue in the APEC region in recent years as a consequence of increased volatility in the world oil market since 1999 and heightened security concerns following the events of 11 September 2001. The APEC Energy Security Initiative, developed in response to these concerns, includes measures to respond to temporary supply disruptions as well as longer term policy responses that address the broader challenges facing the region's energy supply. Security of energy supply is particularly important given the projected rise in the energy import dependence of APEC economies over the medium to longer term.

The broad objective in this study is to assess the costs of temporary energy supply disruptions to APEC economies and the impacts of alternative energy responses. There are three key components in the economic and modeling analysis of this study:

- a detailed analysis of the economic costs associated with selected temporary energy supply disruption scenarios using ABARE's global trade and environment model
- a broad analysis of the costs and benefits of appropriate response strategies to temporary energy supply disruptions and
- an evaluation of longer term strategies to respond to energy security challenges.

The study was prepared for the APEC Energy Working Group.



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summary

In recent years, global energy security — in particular, security of oil supply — has become a key political and economic issue. Energy security at its simplest means the security of energy supply. Energy security in its economic context refers to the provision of reliable and adequate supply of energy at reasonable prices in order to sustain economic growth.

Increased volatility in the world oil market, and heightened security concerns following the events of 11 September 2001, focused attention on energy security issues and resulted in the development of the APEC Energy Security Initiative. The APEC Energy Security Initiative includes measures to respond to temporary supply disruptions as well as longer term policy responses that address the broader challenges facing the region's energy supply that are practical in a policy context.

The Australian Bureau of Agricultural and Resource Economics (ABARE) and ResourcesLaw International were appointed by the APEC Energy Working Group in 2004 to undertake a study to quantify the costs of selected temporary energy supply disruptions to APEC economies and to analyse the costs and benefits of appropriate response strategies in the short and longer terms.

APEC energy security policy setting

The APEC Energy Security Initiative, which originated in 2000, has been developed to include key recommendations in the following areas:

- joint oil data initiative – the aim of the Joint Oil Data Initiative (JODI) is to improve the quality, timeliness and completeness of world oil market data available to market participants and hence improve market transparency.
- sea lane security – oil and gas transport in the Asian region is almost exclusively by tanker and, of particular concern, the Malacca Strait is very shallow and only 500 metres wide at the narrowest point.

- real time emergency information sharing – the aim of information sharing during oil supply disruptions and other energy emergencies is to enable APEC economies to accurately assess the nature of the emergency and develop appropriate responses.
- energy emergency response – the aim in energy supply response measures is to ensure that governments and industry are aware of their responsibilities in the event of an energy supply emergency. Recommendations relate to energy emergency preparedness plans and oil stockpiling to address short term supply disruptions, including consideration of joint stockpiles.
- longer term responses – energy security issues include energy investment; natural gas trade; nuclear power; energy efficiency; renewable energy; hydrogen, fuel cells and alternative transport fuels; methane hydrates; clean fossil energy; and petroleum infrastructure and crude and refined products (CAIRNS Initiative).

Significant progress has been achieved in implementing key recommendations of the APEC Energy Security Initiative. In addition, two important international agreements that significantly influence energy security policies in the APEC region are the IEA's International Energy Program (IEP) and the ASEAN Petroleum Security Agreement (APSA).

Energy security policies vary widely between APEC economies and are influenced by the specific circumstances of each economy including, most notably, income levels, access to domestic energy resources and participation in international agreements. Emergency fuel stockpiles are held primarily by high income APEC economies that depend on imported oil with Japan, the United States and the Republic of Korea accounting for virtually all of the region's emergency stocks.

APEC energy market setting

Energy consumption

In 2002 the APEC region accounted for 56 per cent of world economic output and 58 per cent of world total primary energy consumption (TPEC; also referred to as total primary energy supply or TPES). In 2002, four economies accounted for 45 per cent of world TPEC (the United States, China, the Russian Federation and Japan), five economies each accounted for between

1.0 and 2.4 per cent, and a further eleven APEC economies each accounted for less than 1.0 per cent (data for Papua New Guinea are unavailable).

The importance of specific fuels in APEC energy consumption in 2002 was:

- APEC total primary energy consumption – 90 per cent was sourced from nonrenewable fuels including oil (crude oil, natural gas liquids and feedstocks, 35 per cent of APEC TPEC in 2002), coal (28 per cent), gas (21 per cent) and nuclear (7 per cent), and 10 per cent from renewable energy, which includes combustible renewables and waste (7 per cent), hydro (1.9 per cent), geothermal energy (0.5 per cent) and solar, wind, tide and wave energy (0.1 per cent).
- APEC electricity generation – 85 per cent was sourced from nonrenewable fuels including coal (46 per cent), gas (18 per cent), nuclear (16 per cent) and oil (6 per cent), with hydroelectricity the most important renewable energy source (13 per cent).
- APEC total final energy consumption – mainly sourced from oil (petroleum products, 45 per cent), electricity (17 per cent), gas (15 per cent), coal (9 per cent) and renewables (9 per cent).

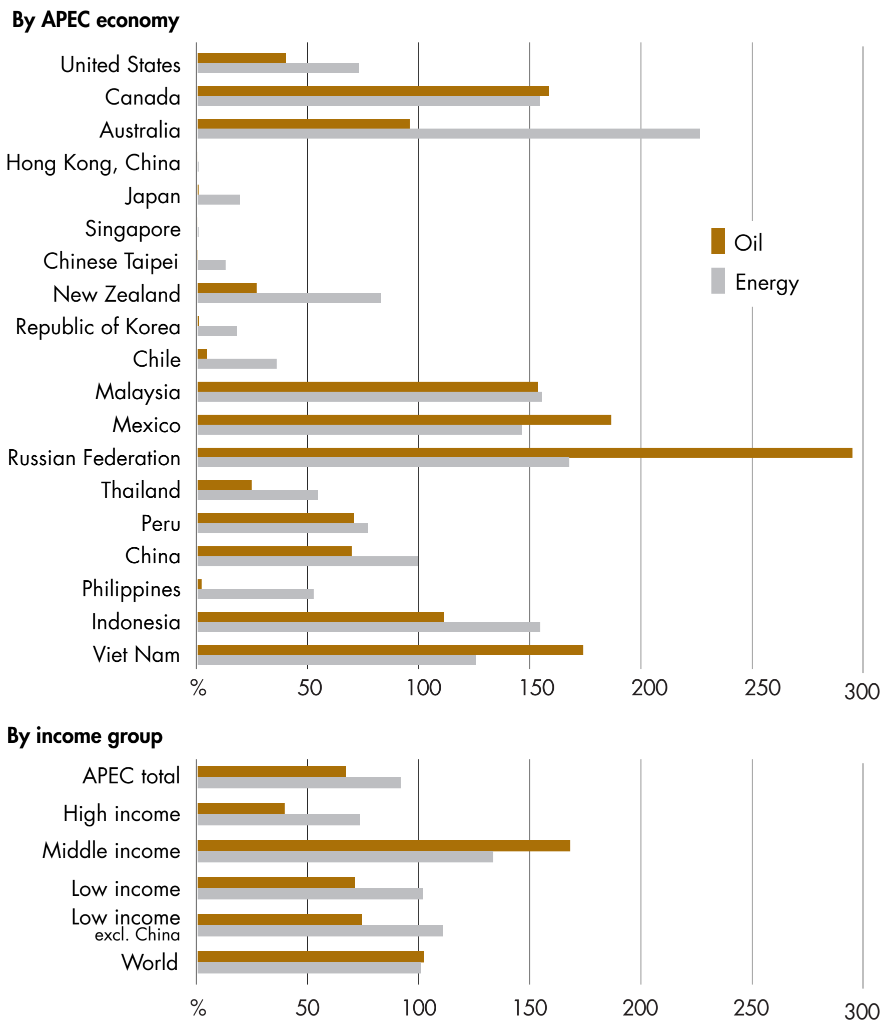
Notably, in the APEC region, nearly all renewable energy, with the exception of combustible renewables and waste, over three quarters of coal and around half of gas resources are used in electricity generation. Final energy is mainly used in the industry, transport and residential sectors and oil, the key focus in energy security assessments, is mainly used in the transport and industry sectors. Transport is the most oil intensive sector in the APEC region, with 94 per cent of energy sourced from oil in 2002. Agriculture is also highly reliant on oil, with an oil share of 68 per cent, although this activity is a relatively small user of oil in absolute terms. Oil accounted for 27 per cent of energy consumption in the industry sector.

Energy production, self sufficiency and trade

In 2002 the APEC region accounted for 53 per cent and 38 per cent of world energy and oil production respectively. Seven APEC economies each accounted for over 1 per cent of world energy production (the United States, China, the Russian Federation, Canada, Australia, Indonesia and Mexico) and six APEC economies each accounted for over 1 per cent of world oil production (the Russian Federation, the United States, Mexico, China, Canada and Indonesia).

APEC energy self sufficiency (energy production as a percentage of energy consumption) was 91 per cent in 2002, indicating that the level of energy production was insufficient to cover the APEC region's total primary energy consumption in the same year (see figure A; note that APEC economies are ranked according to income per person in 2002). Notably, there is considerable variation in self sufficiency by fuel type and income group:

A **Energy and oil self sufficiency in APEC economies, 2002**



- energy self sufficiency, by fuel type – APEC oil self sufficiency was 67 per cent in 2002, accounting for the energy shortfall within the APEC region, compared with APEC coal self sufficiency of 105 per cent and APEC gas self sufficiency of 108 per cent.
- energy self sufficiency, by income group – energy self sufficiency in the high income economies was only 73 per cent in 2002, compared with 133 per cent in the middle income economies and 102 per cent in the low income economies (110 per cent excluding China).

There is also considerable diversity in energy self sufficiency between individual APEC economies:

- energy self sufficiency below 100 per cent – twelve APEC economies recorded an energy self sufficiency below 100 per cent in 2002, of which seven economies were not self sufficient in coal, oil or gas (including Hong Kong, Japan, Singapore, Chinese Taipei, the Republic of Korea, Chile and Thailand).
- energy self sufficiency of 100 per cent or higher – eight APEC economies recorded an energy self sufficiency of at least 100 per cent in 2002, of which four economies were self sufficient in each of the three major fuel types (Canada, the Russian Federation, Indonesia and Viet Nam).

None of the APEC economies with an energy self sufficiency below 100 per cent were self sufficient in oil. In 2002, 10 per cent of APEC TPEC was sourced from net imports.

APEC energy security risks and market volatility

Energy supply disruptions may occur at any point in the energy supply line and originate at a range of geographic locations affecting one or more fuel types. Disruptions may occur in isolation or simultaneously. Temporary energy supply disruptions may be caused by a range of factors, including:

- war, civil unrest, acts of terrorism or piracy on key sea lanes may disrupt energy exploration, production, processing or transport activities, with the potential to have a major impact on world energy markets.
- natural events, such as earthquakes, may cause major energy infrastructure damage, although the damage typically occurs at the local or regional level.

- accidents or technical factors, such as plant breakdown, may disrupt energy supply, although it should be noted that plant shutdown may be anticipated and occurs as part of a regular maintenance program.
- market factors, such as production decisions and instability associated with major producer groups or cartels, may have significant implications for the world energy market (most notably, OPEC decisions in the 1970s).
- policy factors, such as unintended consequences associated with energy market reform, may distort energy production and pricing outcomes to some extent (as occurred in recent years in California).

Any risk assessment of temporary energy supply disruptions in the APEC region requires information on the probability or likelihood of potential energy supply disruptions occurring and the damage or cost of each potential disruption. The benefit of policy intervention to reduce the risks and/or costs of temporary energy supply disruptions is the damage or costs avoided from such disruptions. Before quantifying the economic effects of selected temporary energy supply disruptions, it is useful to examine the historical importance of energy consumption for output growth, the extent and nature of volatility in the energy markets of APEC economies, and key aspects of the energy security risk exposure of APEC economies.

Importance of energy consumption for output growth

Annual growth rates in TPEC and output (measured by real gross domestic product or GDP in domestic currency) were examined in twenty APEC economies over two time periods, 1972–89 and 1990–2002. In each period, there was a relatively strong contemporaneous relationship between output and TPEC growth rates in eleven APEC economies. In a small number of economies, there was a weak or negative contemporaneous relationship.

The average growth rates in both output and TPEC vary considerably between APEC economies and time periods. In the majority of APEC economies, output growth rates tended to be higher on average than TPEC growth rates, indicating that energy intensity has declined in these economies over the period (energy intensity is the ratio of energy consumption to national output). A lower energy intensity indicates an economy is relatively less reliant on energy as an input to production, suggesting that the costs of disruptions to energy users in these economies tend to be lower than in economies that are more energy reliant (all else constant).

However, the number of economies where the average energy consumption growth rate exceeded the average output growth rate increased from five in the period 1972–89, to nine in the period 1990–2002. Notably, in the recent period, six of the nine APEC economies where average energy consumption growth exceeded average output growth were not energy self sufficient in 2002 — these include Japan, Singapore, Chinese Taipei, the Republic of Korea, Thailand and the Philippines.

Extent and nature of volatility in the energy markets of APEC economies

Examining the components of growth in both primary and final energy consumption provides information on the extent and nature of volatility in energy markets but does not imply causation. Realised energy consumption levels are the outcome of both supply and demand conditions — that is, not all periods of slower or negative growth in energy consumption are caused by temporary supply disruptions in the energy sector. A key issue of interest in the current study is the extent to which energy market variability has been associated with the oil market and, for net energy importing economies, with net imports.

Oil consumption has been the major contributing factor to TPEC growth in around half of APEC economies, while coal, gas, nuclear and other energy were each the major sources of TPEC growth in a relatively small number of APEC economies. Four measures are calculated in this study to indicate the extent and nature of volatility in energy markets: including variability in annual growth rates, the strength of the relationship between consumption of a specific fuel type and fluctuations in TPEC over time, and minimum and negative contributions of individual fuel types to annual TPEC growth.

There have been some significant changes in the contribution of oil to TPEC growth in APEC economies between the two time periods, 1972–89 and 1990–2002. Most importantly, while oil remains the major source of variability and downside contributions to TPEC growth, the extent of variability and downside contributions have been modified in the majority of APEC economies in the recent period.

In each APEC economy, domestic energy requirements or TPEC may be sourced from domestic production, net imports and stock drawdown. Net energy imports were the source of the greatest variability in annual TPEC growth in seven of the nine net energy importing economies in the period 1972–89 and in eight of the twelve net energy importing APEC economies in the period 1990–2002.

Overall, from an energy security perspective, oil is the main fuel type that is associated with variability in both primary and final energy consumption in the APEC region. Variability associated with net imports is important in several APEC economies. There is also an important association between variability in energy consumption in the industry sector and variability in final energy consumption.

APEC energy self sufficiency, oil dependence and world resource availability

APEC energy self sufficiency has declined from 96 per cent in 1992 to 91 per cent in 2002 and is projected by ABARE to fall further to 79 per cent in 2030. The APEC region tends to produce slightly more coal and gas, and substantially less oil, than is consumed within the region. Notably, APEC oil self sufficiency has declined from 77 per cent in 1992 to 67 per cent in 2002 and is projected by ABARE to fall to 38 per cent in 2030.

APEC's increasing oil import dependence, or declining oil self sufficiency, is an important energy security risk reflecting both demand side and supply side aspects of the oil market:

- demand side aspects – oil dependence is a feature of APEC economies, particularly in the transport sector, where there are limited substitution possibilities over the short to medium term, but agriculture and energy intensive manufacturing activities are also highly reliant on oil inputs.
- supply side aspects – oil, together with other major fuel types, are nonrenewable resources that need to be discovered before production may proceed, which increases uncertainty in any medium to longer term outlook assessment. In addition, world oil reserves and production are concentrated in relatively high risk regions, with the prospect of increasing market concentration over the medium to longer term.

Proved reserves of coal, oil and gas may be interpreted as estimates of below ground stocks that are assessed to be economic to produce over time under current market conditions. Estimates of proved reserves will vary with economic conditions. For example, a sustained real price rise would result in currently uneconomic resources being reclassified as economic and, as a consequence, aggregate proved reserves for the resource would be revised upward. A sustained real price rise would also encourage exploration activity, with any related resource discoveries potentially adding to proved reserves. Ongoing exploration activity is important in gaining knowledge about new oil and gas fields.

Relative to current production levels, coal resources are relatively more abundant than either oil or gas resources. At the end of 2003, the reserves to production ratio was estimated to be around 41 years for oil, 67 years for gas and 192 years for coal. However, reflecting the impact of exploration activity on the level of proved reserves and despite higher world production levels, the reserves to production ratio for both oil and gas was higher in 2003 than in 1980 — the ratio in 1980 was 29 years for oil and 58 years for gas.

World proved reserves for oil and gas are concentrated in the relatively high risk regions of the Middle East and Africa. At the end of 2003:

- oil – 72 per cent of the world's proved reserves were located in the Middle East/Africa regions (63 per cent in the Middle East and 9 per cent in Africa).
- gas – 49 per cent of the world's proved reserves were located in the Middle East/Africa regions (41 per cent in the Middle East and 8 per cent in Africa).
- coal – 6 per cent of the world's proved reserves were located in the Middle East/Africa regions (data for the separate regions were not available).

In 2003 the share of the Middle East and Africa in world production of oil, gas and coal was 41 per cent (30 per cent, 11 per cent), 15 per cent (10 per cent, 5 per cent) and 6 per cent (0 per cent, 6 per cent) respectively.

Assuming world oil consumption continues to rise over the medium to longer term, the global distribution of oil production will shift toward the distribution for proved reserves — that is, the share of the Middle East will rise — although the timing of this shift will be influenced by new project developments associated with existing reserves, new discoveries made outside the Middle East, and a change in economic conditions that enables currently uneconomic reservoirs or deposits to be reclassified as economic. The development of nonconventional sources, such as tar sands and gas to liquids projects, will also contribute to future oil supply.

The share of the Middle East in world oil production is projected by ABARE to increase to 46 per cent in 2030. However, the share of the Middle East in world gas production is projected to be 10 per cent in 2030, unchanged from 2003 — this outlook reflects the assessment that there are likely to be substantial gas resources outside the Middle East that will be economic to develop over the outlook period.

Future oil exploration is therefore important to discover new reserves as well as to diversify fuel sources to reduce market dependence in high risk areas. Given the level of historical volatility sourced from this region, the concentration of proved reserves and production in the Middle East for oil and, to a lesser extent, gas represents an important energy security risk to the APEC region.

A further important consideration in world energy markets is the role of OPEC. Compared with a peak of 54 per cent in 1973, OPEC's share of world oil production varied within a relatively narrow band of 38–42 per cent between 1990 and 2003, but is projected by ABARE to increase to 61 per cent in 2030. Future oil investment and production decisions by OPEC member economies will have important implications for world oil markets. From an energy security perspective, some consideration needs to be given to the risk of some combination of short term oil supply disruptions associated with political instability in the Middle East and an unexpected change to OPEC oil production targets over a more sustained time period.

Quantifying the economic effects of temporary energy supply disruptions

ABARE's global trade and environment model, GTEM, has been used to quantify the impacts of possible energy supply disruptions on APEC economies. GTEM requires a reference case or a 'business as usual' scenario against which the impacts of the energy supply disruptions can be measured.

In this study, 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 2030 in the absence of changes to key energy, environmental or economic policies.

Reference case projections

Growth in APEC energy consumption is similar to the projected growth in world energy consumption. As a result, APEC's share of world energy consumption in 2030 remains virtually unchanged from 2002.

In the reference case, APEC energy production is projected to grow significantly slower than APEC energy consumption, implying a rapidly growing shortfall in the capacity of the APEC region to satisfy its own energy requirements. Energy consumption in APEC is projected to grow by 2.1 per cent a year between 2002 and 2030, whereas APEC energy production is projected to grow by just 1.5 per cent a year between 2002 and 2030.

The growth in the energy shortfall in APEC is most apparent for oil. Because of resource constraints, APEC oil production is projected to be slow, averaging 0.3 per cent a year from 2002 to 2030. In contrast, APEC oil consumption grows at over 2 per cent a year in the same period. The result is a substantial decline in APEC's capacity to supply its domestic oil requirements and a decline in oil self sufficiency in all APEC income groups.

As a result of slow growth in oil production, the share of APEC in world oil production declines considerably over the projection period from 37 per cent in 2002 to 22 per cent in 2030. Conversely, oil production grows strongly in the Middle East. By 2030 the Middle East produces 46 per cent of world oil supplies, up from 29 per cent in 2002.

Selected temporary energy supply disruptions

The following energy supply disruption scenarios were modeled for 2005 and 2020 to represent the variety of possible threats to APEC energy supplies:

- oil simulations – in each oil simulation, it is assumed that oil production in the Middle East is disrupted for around three months, resulting in a fall in world oil production by around 8 per cent relative to the reference case.

- LNG simulations – in each LNG simulation, it is assumed that LNG production in the Middle East region is disrupted for about six months, resulting in a fall in world LNG production by around 10 per cent relative to the reference case.
- sea lane simulations – in each sea lane simulation, it is assumed that shipping through the Malacca Strait is stopped for five weeks.

Supply disruptions in 2005 are compared with disruptions of a similar magnitude in 2020 in order to depict the implications of projected significant changes within the APEC region, particularly increasing oil import dependence and expanding LNG trade.

Impacts of Middle East oil supply disruptions

A three month disruption to the supply of oil from the Middle East and the associated increase in world energy prices, can be expected to have significant impacts on APEC economies. The extent of these impacts will vary between APEC economies depending on each economy's net oil import position and on each economy's reliance on oil — the results for nineteen APEC economies are indicated in figure B. In particular, the net oil exporting economies of the region are likely to gain from income transfers associated with higher world oil prices, whereas net oil importing economies stand to lose.

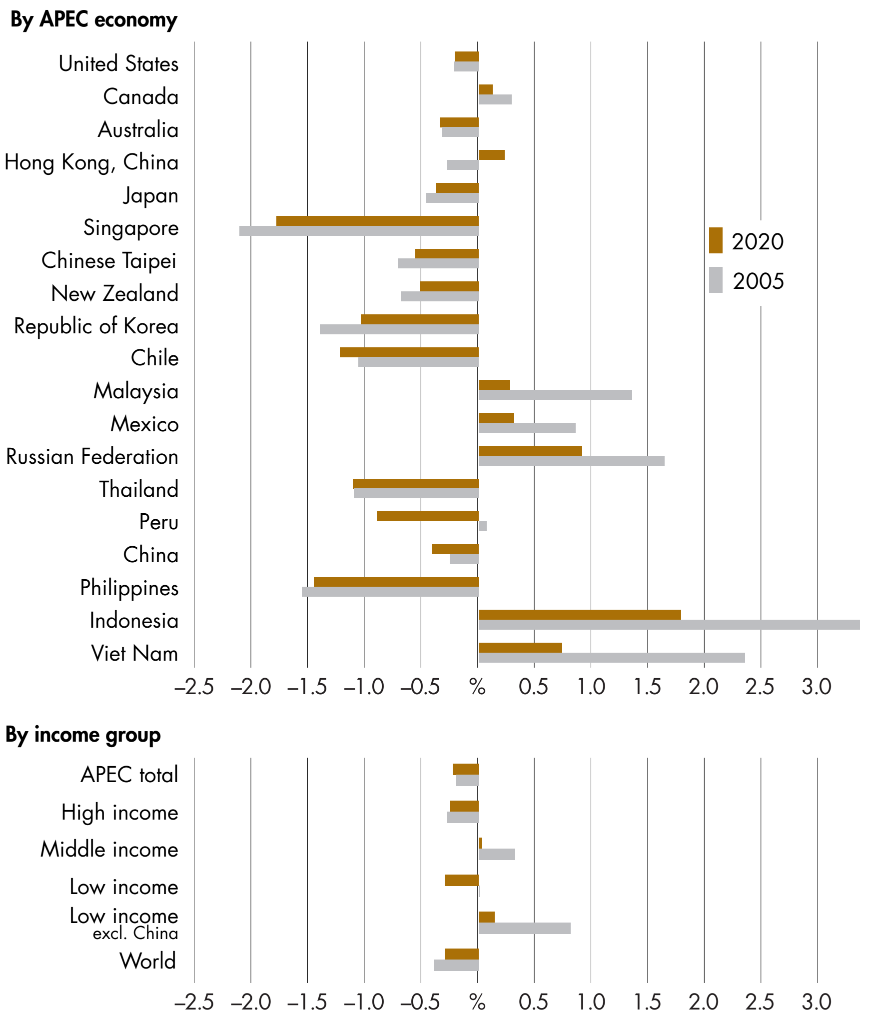
In both the 2005 scenario and the 2020 scenario, the three month disruption to world oil supplies leads to a contraction in APEC gross national product (GNP) of 0.2 per cent relative to the reference case in the year of the disruption. To put these numbers into perspective, the contraction in the 2005 scenario is US$43 billion (in 2002 prices) and is roughly similar to the current size of each of the economies of New Zealand, Peru or Viet Nam. In the 2020 scenario, the contraction in the APEC economy is US$82 billion (in 2002 prices) and is similar to the current size of each of the economies of Malaysia, the Philippines or Singapore.

Aggregate income impacts vary considerably between APEC economies and over time. High income economies experience the greatest losses in APEC as they typically depend heavily on net oil imports. However, the GNP impact in the high income economies relative to the reference case declines from 0.28 per cent in the 2005 scenario to 0.25 per cent in the

2020 scenario because of a substantial decline in the importance of oil for generating output.

In contrast to the results for the high income economies, strong gains are experienced relative to the reference case in the oil exporting economies of Indonesia, Malaysia and the Russian Federation, and to a lesser extent

B GTEM simulation results for the impact of a three month disruption to Middle East oil production on real GNP in APEC economies
relative to the reference case



Mexico. These economies benefit from income transfers associated with higher world oil prices. However, the gains from an oil supply disruption are lower for each of these economies in 2020 than in 2005, reflecting the substantial decline in net oil exports projected for each of these economies over that period.

The negative impact on APEC of the disruption to oil supplies is concentrated in those industries that rely intensively on petroleum inputs, specifically the transport industry and the chemicals, rubber and plastics industry. The higher cost of oil leads to higher prices and lower demand for these oil intensive commodities relative to the reference case.

The aggregate and sectoral output impacts of the oil supply disruptions lead to a substantial decline in APEC oil consumption and imports relative to the reference case in both scenarios. Total APEC oil consumption contracts by 7.3 per cent in 2005 under the 2005 scenario relative to the reference case or by 148 million tonnes. In the 2020 scenario, APEC's crude oil imports decline relative to the reference case by 9 per cent in 2020, or by 243 million tonnes.

Impacts of disruptions to Middle East LNG production

The impacts of the disruption in LNG supplies on APEC as a whole are insignificant, reflecting that LNG supply is only important for a small number of APEC member economies.

Even in the economies that do import LNG from the Middle East, the economywide impacts of a disruption to LNG supplies are marginal. Under the 2005 LNG disruption scenario, for example, aggregate output in 2005 contracts by less than 0.1 per cent in Japan and the Republic of Korea relative to the reference case. Similarly in the 2020 LNG disruption scenario, the contractions in aggregate output in 2020 among all LNG importing economies are less than 0.1 per cent.

The contraction in LNG consumption and in LNG imports relative to the reference case varies between economies according to the degree of dependence on Middle East LNG, and on the opportunities for low cost substitution away from gas. For example, the contraction in LNG imports and LNG consumption is larger in the Republic of Korea than in all other economies, with the exception of Chinese Taipei, because Korea relies heavily on Middle

East LNG. In Chinese Taipei, over three quarters of LNG imports are used to generate electricity, a sector in which there are significant opportunities for fuel substitution. By increasing capacity utilisation of coal fired and nuclear plants, Chinese Taipei is able to reduce its dependence on LNG fired power relative to the reference case. In this way, Chinese Taipei is able to reduce gas consumption and LNG imports relative to the reference case more cheaply than can economies such as Korea, where the residential sector is the primary gas consuming sector.

The fact that it is cheaper for some importers to reduce LNG imports by a given proportion than it is for others reveals that there are opportunities for economies engaged in LNG trade to gain from cooperation, and more generally from enhancing market flexibility.

Impacts of blockages in the Malacca Strait

Trade underpins the strength of APEC economies, and most maritime trade with non-APEC regions flows through the Malacca Strait. Obstruction of the Malacca Strait, APEC's principal maritime trade route with non-APEC economies, raises freight costs for all traded commodities and thereby leads to a contraction in world and APEC trade volumes relative to the reference case. The reduction in demand for traded commodities across the world undermines production and income in the world and in APEC economies.

Again, the impacts on APEC are marginal, particularly when compared with the impacts of the oil supply disruption. For APEC as a whole, the five week blockage costs US$1.7 billion (in 2002 dollars) in gross national product (GNP) in the 2005 scenario, and US$2.8 billion (in 2002 dollars) in the 2020 scenario. In percentage terms, this is less than 0.1 per cent of annual APEC GNP.

The cost would be greater if the blockage were simulated for a longer period. However, five weeks is not an unreasonably short period of time given the experience and state of readiness of the workforces that manage the Strait, particularly in the narrowest length of the channel alongside Singapore. If anything, five weeks may overstate the length of time of any potential blockage. Nonetheless the five week blockage assumed in this study is sufficient to indicate the nature and extent of impacts of a major blockage.

Some economic aspects of energy security policies in the APEC region

Economic rationale for government intervention in energy security

Energy security may be considered within the context of energy policy whereby energy policy makers aim to ensure the provision of energy at least cost over time, given energy technologies and resource availability, and taking into account environmental impacts and economic and other risks in the outlook. The economic rationale for government intervention is based on the presence of market failure (that is, the failure of markets to efficiently provide some goods and services) and the capacity of the government, first, to identify and assess policy options that address the market failure and, second, to implement the policy option judged to result in the highest net economic benefits over time.

Key aspects of market adjustment to major temporary energy supply disruptions were quantified in the GTEM analysis and include demand restraint, surge production and fuel switching. It should be noted, however, that private investment in energy supply reliability is not included explicitly in GTEM. Private companies invest in supply reliability provided there is an economic incentive to do so (ignoring any policy requirements). Private companies may adopt a range of risk sharing and reducing measures designed to offset, at least to some extent, the negative impact of temporary energy supply disruptions on profitability. For example, private companies may manage risks by investing in energy stocks, energy exploration activity, research and development into or adoption of energy conservation and switching technologies, and diversification strategies (such as participation in joint ventures).

Energy markets tend to underinvest in energy supply reliability. This is a result of the public good nature of investment in energy supply reliability (others benefit from private investment in energy supply reliability resulting in free riding), possible external costs of energy supply disruptions (if the energy sector does not incur the full costs of energy supply disruptions, the economic incentive to invest in energy supply reliability is lower than would otherwise be the case) and the inclusion of a risk premium in private investment decision making.

The observation that private investment in energy supply reliability tends to be below the optimal level provides the economic justification for considering government intervention in energy security, either directly through public provision or indirectly to increase private investment in energy supply reliability.

Emergency policy response measures to energy supply disruptions

Energy stocks

Investment in energy stocks is the major approach for smoothing short term fluctuations in both supply and demand where it is feasible to store the fuel type (particularly important for commodities such as oil and LNG). The availability of stocks during a temporary energy supply disruption reduces the costs of the disruption by providing an alternative supply source of the energy commodity.

The policy response to the problem of underinvestment in energy stocks in the private sector is to supplement private storage (for example, through subsidies or tax concessions) or invest in public storage. A major issue with public investment in energy storage is that it reduces the economic incentives for private investment — that is, public storage results in some crowding out of private storage. Public storage reduces the net economic benefits of private storage by moderating price increases during temporary energy supply disruptions. In addition, compared with private sector behavior, there may be greater uncertainty about the nature of public intervention in energy markets through stock drawdown during periods of supply disruption, increasing perceived risks in private investment in stocks and placing further downward pressure on private investment.

A key issue in assessing the net economic benefits of alternative policy options is that information on energy stocks in the world economy is incomplete. The Joint Oil Data Initiative (JODI) is an important undertaking that will improve the quality, timeliness and completeness of world oil market data, although data are not yet available.

Using IEA data on the annual change in energy stocks, it is possible to construct time series on cumulative changes in the stocks of major energy commodities in the APEC region since 1970. Between 1970 and 2002, annual

APEC energy stocks increased by 368 Mtoe (million tonnes of oil equivalent) which is equivalent to around 6 per cent of TPEC in the APEC region in 2002. During this period, increases in oil, gas and coal stocks accounted for 62 per cent, 26 per cent and 12 per cent respectively of the increase in total energy stocks — that is, the focus was on building oil stocks reflecting the relatively higher risks in the world oil market. Nearly two thirds of the overall buildup in energy stocks occurred during the 1970s, a period of considerable oil market volatility.

There has been substantial variation in stockpiling trends since 1970 in the individual APEC economies. Overall, compared with the world economy, there has been greater emphasis in the APEC region on building oil stocks and less emphasis on building gas stocks.

There has been some recent analysis of the potential for joint investment by a number of smaller net oil importing APEC economies in an oil stockpiling facility. For these economies, the economies of scale in a joint facility would reduce the costs that would otherwise be incurred in storing similar quantities of oil in separate facilities in each economy. The costs associated with a range of options for such a joint facility have been examined by APERC. The benefits of additional oil stocks are the reduced costs of any temporary oil supply disruptions. While APERC has provided some indicative estimates of the costs of oil supply disruptions, the modeling analysis in this report provides more comprehensive estimates of the economic impacts of a major global oil supply disruption.

Other emergency response measures

Energy prices have a key role in signalling variations in supply and demand conditions. During an energy supply disruption, higher energy prices are part of the process that allows energy to be rationed to users who place the highest value on the energy source. That is, price rationing is an important part of the normal operation of markets, and the market response to volatility. Price rises encourage demand restraint, fuel switching and surge production in the short term.

Various forms of nonprice rationing mechanisms are adopted by governments during an emergency, mainly to ensure access to energy by high priority users such as emergency services and in response to equity concerns about large energy price rises. Quantity rationing may be achieved through direct allocation (the government allocates energy supplies directly to energy users), demand suppression (the flexibility of energy purchases and consumption is restricted) and queuing (energy supplies are allocated on a first come first served basis). In practice, some combination of these options is used with direct allocation to emergency uses, and demand suppression and queuing mechanisms applied to other energy consumers. To complement quantity rationing, information programs by governments encouraging energy users to adopt more energy conservationist practices, at least for the duration of the shortage, may further restrain demand.

International cooperation is an important aspect of the policy response to a major global energy supply disruption. Governments need information on the nature of the shock, first, to identify and assess policy options to reduce the magnitude and duration of the energy supply disruption (that is, reduce the disruption costs by addressing the source of the shock directly) and, second, to plan and implement the appropriate emergency policy response. The importance of international cooperation and information sharing is well recognised through the APEC Energy Security Initiative.

Longer term policy response measures

Since the probability of a major energy supply disruption occurring is positive, governments need to maintain an emergency response capability. However, there are a range of longer term policy measures that aim to reduce the costs of disruptions in the future that will influence the need for investment in emergency response measures, particularly energy stockpiles. Longer term policy measures aim to reduce the costs of disruptions in the future by reducing the probability of major energy supply disruptions occurring in the future and by reducing the costs when such disruptions actually occur.

Diversification in energy markets

Diversification of fuel types and fuel sources is one of the most important components of the longer term policy response to energy security risks. Key aspects of diversification in energy markets include:

- diversification in energy production – that is, reduce the dependence of economies on higher risk sources of energy by diversifying the geographic location of fuel sources.
- diversification in energy consumption – reduce the dependence of economies on higher risk forms of energy by diversifying the fuel types in energy consumption.

If there is assessed to be an equal probability of disruption across locations and fuel types, diversification would reduce the expected costs of future supply disruptions by spreading the risks across different locations and fuel types. If certain locations and fuel types are assessed to be relatively high risk, private companies and governments need to assess the net economic benefits of diversifying the energy market to reduce dependence in these higher risk areas.

In particular, any economic assessment of the appropriate level of diversification (and other longer term responses) needs to take into account the net economic benefits over time from using relatively abundant energy resources, particularly in low risk geographic locations in the world economy. Coal is the most abundant resource and is located mainly in relatively low risk geographic regions, while oil is the least abundant resource and is located mainly in higher risk geographic regions — gas falls between coal and oil in terms of abundance and location risk.

In this study, diversification indexes are constructed to summarise the fuel mix in TPEC, electricity generation and TFEC in twenty APEC economies in 1980 and 2002 (although data for the Russian Federation are unavailable in 1980). In the APEC region, the fuel mix in TPEC and TFEC was more diverse in 2002 than in 1980, while the fuel mix in electricity generation was more concentrated in the recent period. Between 1980 and 2002, the fuel mix in TPEC became more diversified in all APEC economies except China, which recorded a minor rise.

In 2002, there were nine APEC economies where the oil share in TPEC exceeded 40 per cent and, partly as a consequence, the level of diversification in TPEC was reduced — these economies are Singapore, Mexico, Malaysia, Peru, Hong Kong, Chinese Taipei, the Republic of Korea, Japan and Thailand (of these, only Mexico and Malaysia are energy and oil self sufficient).

R&D and technology adoption in energy markets

Another important component of the longer term policy response is research and development (R&D) into, and adoption of, energy technologies that may reduce the risk and/or cost of disruptions in the future. While energy security may represent only part of the benefits of R&D activity in energy markets, government support for R&D is a key mechanism to achieve a level of energy security that is closer to society's optimal level.

R&D and technology adoption may have major implications for both the supply side and demand side of energy markets:

- new technologies facilitate energy exploration and production for both conventional and nonconventional sources;
- alternative processing technologies (such as gas to liquids plants) increase the flexibility of markets to adapt fuel types to different end uses;
- new technologies may aim to reduce energy consumption in the economy (or increase the efficiency of energy use); and
- new technologies may increase the flexibility of energy markets to adjust to supply disruptions (energy substitution or switching technologies).

R&D activity, and associated adoption of new technologies, is a key mechanism to increase the level of diversification in energy production and consumption. The high level of dependence on oil in transport use in all APEC economies is an area where there has been limited progress in technology adoption to date. Introduction of new technologies to increase the diversity of the fuel mix in transport would significantly reduce energy security risks in this area.

New environmental technologies are important for the upstream industry by allowing energy exploration and production activity to be undertaken in new areas while managing environmental impacts. In addition, R&D is clearly important for the further development of renewable energy sources.

Other longer term policy measures

Other aspects of the longer term policy response may include removal of market impediments in order to increase the efficiency of the energy market to respond to supply disruptions, the provision of energy market information and international policy cooperation. It should be noted that other government policies may have implications for energy security.

The energy policy setting in each economy may have important implications for the economic incentives of the private sector, including investment in energy supply reliability. Policy reform to increase the efficiency of energy markets, including their capacity to respond to supply disruptions, is a significant component of the longer term energy security policy response. For example, an important issue is that economic regulation of natural gas and electricity markets typically limits the extent to which prices may rise in response to an energy supply disruption, increasing the burden of adjustment on other parts of the energy market. This has been one of the issues addressed through the process of energy market reform in many economies in recent years.

Government support for the collection, dissemination and analysis of relevant energy market information is justified, at least to some extent, on energy security and broader economic efficiency grounds. Aspects of international cooperation that are important include, for example, ongoing dialogue between the major oil producers and consumers, progress to ensure reasonable levels of sea lane security, and joint R&D and information projects such as JODI. The APEC Energy Security Initiative is an important example of international cooperation that should significantly enhance energy security in the region.

Prioritising emergency and longer term policies

The energy security policy response in each APEC economy will include a mix of emergency and longer term measures. It should be emphasised that it is beyond the scope of this study to examine in detail the energy security risks and policies of individual APEC economies. The objective has been to present relevant information that may contribute to energy security risk and policy assessments that are undertaken by individual APEC economies and that may further contribute to joint assessments within the APEC forum.

An important issue for individual economies is that energy security policy options need to be prioritised within the framework of the national budget — this includes the total budget available to policy makers as well as the full range of competing priorities in the economy. In middle and low income APEC economies, for example, addressing theft of energy and ensuring physical protection of the workforce and infrastructure may have a higher priority than investment in energy stocks.

In this report, rankings are provided for individual APEC economies based on 2002 data for several key energy security indicators and an indicative aggregate index is constructed. This is a highly simplified approach to indicating various aspects of the relative energy security position of individual APEC economies.

The modeling analysis in this study provides comprehensive estimates of the economic impacts of various temporary energy supply disruptions over the outlook period, including demand restraint, fuel switching and surge production. This information may be used in any assessment of the net economic benefits of investing in supply reliability measures — such as stockpiling, diversification of energy markets and technology adoption — that would reduce these disruption costs. Information provided in recent assessments by APERC and the Energy Modeling Forum (EMF) in the United States on oil security issues is also highly relevant to these assessments. Future energy security policy assessments would be enhanced by undertaking further research using GTEM or a similar framework to examine particular policy options in greater detail.

Concluding comments

This study suggests that oil supply security in particular, as distinct from energy supply security in general, should be the principal focus of concern of policy makers in the APEC region. The study corroborates the widely held belief that there are important energy security risks for net oil importing economies in their increasing dependence on the Middle East as an oil supply source (ABARE projects, given a continuation of current trends, that the share of the Middle East in world oil production will increase from 30 per cent in 2003 to as high as 46 per cent in 2030). A complementary mix of short term and longer term policy response strategies, including exploration for and development of additional oil supply sources outside the Middle East, must therefore be a key priority of policy makers in all current and prospective net oil importing economies in the APEC region.

The importance of an efficient, resilient and open global energy market is also an underlying theme in this study.

In addressing energy security risk, the question that each APEC economy must address is: what makes the economy vulnerable? There are three main causes of economic vulnerability of an individual APEC economy to energy supply disruptions:

- overdependence on either domestic production or imports of a single form of primary energy
- overdependence on any particular supply source of primary energy
- overdependence on a single energy infrastructure facility.

As well as promoting the need for a more open global energy market and supporting the APEC Energy Security Initiative process, for an individual APEC economy, what might be the 'best' response will depend on the combination of particular energy security risks that it faces. There are four main policy responses that individual APEC economies can consider:

- adoption of a diversified portfolio of interchangeable energy forms and energy supply sources – this is a principal response that all economies need to consider; it will entail, 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 timely investment in energy production, transport and storage facilities – these facilities will include pipelines, other transport facilities, power stations and electricity transmission and distribution networks.
- encouragement of investment in more efficient energy technologies – these technologies reduce the energy intensity of economies by, for example, reducing fuel use in transport.

In summary, in addition to the paramount policy of continuing to promote the need for a more open global energy market, the reduction of energy supply vulnerability in APEC economies requires a diversified portfolio approach to energy policy and planning. Each APEC economy must decide for itself what are the most appropriate, cost effective and affordable responses for its particular circumstances. It is hoped that this study will assist them in making the optimal choice.

1

introduction

Since the Asia Pacific Economic Cooperation (APEC) forum was established in 1989, membership has expanded from twelve to twenty-one economies covering a diverse range of economic structures and levels of development. APEC has emerged as a major international organisation and an important forum for strengthening economic cooperation in the region. Based on current membership, APEC's share of world output (gross domestic product based on purchasing power parity) has increased from 52 per cent in 1990 to 56 per cent in 2002 and 2003 (IMF 2004a). In 2002, APEC accounted for 46 per cent of world merchandise exports — exports to other APEC economies represented nearly three quarters of total merchandise exports from APEC economies, with a value of US$2.2 trillion (World Bank 2004).

Why the renewed interest in energy security?

Energy security at its simplest means the security of energy supply. Energy security can be taken as comprising three interrelated elements:

- security of primary energy availability
- security of energy transportation infrastructure and systems and
- security of energy production and conversion facilities.

For the purpose of this study, energy security does *not* include security of energy demand. This is not to deny the legitimate concerns of oil exporting nations to protect their export revenues, concerns that are shared by all nations that export their energy resources.

Energy security is of fundamental and increasing economic importance not only to individual economies but also to future relations between economies. It has become both a political and economic issue.

At the beginning of the previous century, the world commenced a major shift from coal to oil as the primary and most easily affordable energy source. As a generalisation, the economic development of most developed economies during most of the past century was underpinned by the availability of cheap oil. Cheap oil from the Middle East largely financed the post-World War II reconstruction of Europe and of Japan. In 2002, oil accounted for 35 per cent of world primary energy consumption and 95 per cent of world energy consumption in the transport sector (IEA 2004a,b).

In addition to the oil price shocks in the 1970s and subsequent fall in real oil prices in the first half of the 1980s, the global energy economy has undergone two major structural changes, the implications of which may not yet be fully understood. In essence, these changes were:

- a huge increase in competitive trade and investment activity in freely operating global and regional energy markets and
- an unprecedented wave of liberalisation of domestic energy markets.

The efficiency of energy production and transport from increased competitive activity in global and domestic energy markets since 1973 has counterbalanced the supply vulnerabilities of energy importing economies and most of the world has continued to prosper from the availability and affordability of energy. This is a remarkable tribute to the efficient and free operation of energy markets and has been achieved despite the risk that supply disruptions can occur at a variety of upstream and downstream points in both cross border and internal energy transport systems, whether maritime, rail, pipeline or power transport. Disruptions can occur from a variety of factors, including government intervention and events of *force majeure*, such as acts of sabotage and terrorist attacks.

APEC Energy Security Initiative

Energy security has thus become a key issue for APEC in recent years. Energy security in its economic context refers to the reliable and adequate supply of energy at reasonable prices in order to sustain economic growth. Increased volatility in the world oil market, and heightened security concerns following the events of 11 September 2001, focused attention on energy security issues and resulted in the development and subsequent strengthening of the APEC Energy Security Initiative (APERC 2002a, 2003). The APEC Energy Security Initiative was endorsed by APEC Leaders and Ministers in October 2001. At their meeting in June 2004, APEC Energy Ministers highlighted its continuing importance (see box 1).

The APEC Energy Security Initiative includes measures to respond to temporary supply disruptions as well as longer term policy responses that address the broader challenges facing the region's energy supply that are practical in a policy context and acceptable in a political context (APEC 2002). Security of energy supply is particularly important given the projected rise in the energy import dependence of APEC economies over the medium to longer term. The APEC Energy Security Initiative is explained further in chapter 2.

International energy security assessments usually focus on security of supply issues in the world oil market. However, in recent years, security of international shipping lanes and issues associated with security of supply in natural gas and electricity markets, mainly relating to infrastructure, have gained more attention. The focus on oil security issues reflects both demand side and supply side characteristics of the world oil market, particularly the continuing dependence on oil in energy consumption, limited substitution possibilities for oil in the transport sector, and the concentration of oil production and reserves in the Middle East region and OPEC (Organisation

Box 1: Energy Security in APEC

Cooperation for a Sustainable Future – Extract from the APEC Energy Ministers' Declaration in June 2004

The sixth meeting of APEC Energy Ministers was held on 10 June 2004 in Manila, the Philippines. The following is an extract from the APEC Energy Ministers' Declaration (APEC 2004a, pp. 1–2).

Message from APEC Energy Ministers

We, Energy Ministers of the APEC economies, gathered for the 6th time in Manila, the Philippines, on 10 June 2004 under the theme 'Energy Security in APEC: Cooperation for a Sustainable Future'.

We agreed that access to adequate, reliable and affordable energy is fundamental to achieving the region's economic, social and environmental objectives, that energy security challenges faced by the APEC region are constantly evolving, and that our efforts to enhance energy security must be flexible and responsive.

continued

Box 1: Energy Security in APEC

Cooperation for a Sustainable Future – Extract from the APEC Energy Ministers' Declaration in June 2004 *continued*

The importance of these efforts is further highlighted by the recent rise in global oil prices and its potential impact on economic growth and sustainable development within the APEC region. Having concern for the impact of recent high oil prices on our economies, we welcome efforts by oil producers to provide adequate supply to help stabilise the oil market. We recognise, however, that a variety of factors influence global markets, and in that context we commit our own efforts to enhance energy security.

We agreed that common ground exists for strong cooperation on energy security, with regional and global benefits. We agreed that our cooperation must acknowledge the individual circumstances of each member economy, and that our diversity of views is the foundation for meaningful dialogue.

We instruct the Energy Working Group (EWG) to continue its broad-based approach to energy security. We commit to continued development of response mechanisms for short-term disruptions while pursuing longer-term energy security objectives. We agreed that initiatives should be developed and implemented in close cooperation with the business, research and financial communities.

These initiatives include:

- preparing for energy supply disruptions;
- facilitating energy investment;
- using energy more efficiently;
- expanding energy choices; and
- capitalising on technological innovation.

Responding to our energy security challenges

We respond to the direction by APEC Economic Leaders in their 2003 Bangkok Declaration, to 'accelerate the implementation of the Energy Security Initiative by endorsing its Implementation Plan and, as appropriate, a new Action Plan to enhance regional and global energy security.' We also commit to the continued implementation of our Type II Partnership Initiative, 'Energy for Sustainable Development', submitted to the World Summit on Sustainable Development in 2002.

for Petroleum Exporting Countries) member countries. The concentration of natural gas reserves in Middle East OPEC economies also represents an energy security risk to the APEC region.

The Tokyo based Asia Pacific Energy Research Centre (APERC) has released a number of major studies since 2000 on oil security issues in the APEC region. To complement the APEC Energy Security Initiative process, APERC released studies in 2000 and 2002 that examined emergency oil stocks as an option to respond to oil supply disruptions (APERC 2000, 2002a). The APEC energy demand and supply outlook was released in 2002 against a background of increased uncertainty following the events of 11 September 2001 and highlighted energy security concerns associated with the growing oil import dependence of the APEC region over the outlook period to 2020 (APERC 2002b).

In 2003, APERC released another major study on aspects of oil security, with a focus on Asian premium pricing, and export and import dependence issues (APERC 2003). That report also included an overview of energy security developments in some APEC economies, particularly since the events of 11 September 2001.

Study objectives, research method and structure of the report

The objectives in this study are to quantify the costs of selected temporary energy supply disruptions to APEC economies and to analyse the costs and benefits of appropriate response strategies in the short and longer terms. This study was prepared for the APEC Energy Working Group (EWG).

The study has been carried out using ABARE's global trade and environment model (GTEM) to model three selected temporary energy supply disruption scenarios in each of 2005 and 2020, a total of six scenarios.

The six scenarios were selected by ABARE based on its perception of certain current and future areas of risk in world energy markets that are believed to carry the potential to cause major economic costs to the APEC region. Temporary supply disruptions are modeled in world oil and LNG markets, with supply disruptions in each case assumed to be sourced in the Middle East region, and sea lane access to south east Asia through the Strait of Malacca is assumed to be temporarily closed.

- Oil simulations – in each oil simulation, it is assumed that oil production in the Middle East is disrupted for around three months, resulting in a fall in world oil production by around 8 per cent relative to the reference case.
- LNG simulations – in each LNG simulation, it is assumed that LNG production in the Middle East region is disrupted for about six months, resulting in a fall in world LNG production by around 10 per cent relative to the reference case.

- Sea lane simulations – in each sea lane simulation, it is assumed that shipping through the Malacca Strait is stopped for five weeks.

Supply disruptions in 2005 are compared with disruptions of a similar magnitude in 2020 in order to depict the implications of projected significant changes within the APEC region, particularly increasing oil import dependence and expanding LNG trade.

Given an economic framework for assessing alternative policy responses, ABARE's modeling analysis provides the basis against which to assess the net economic benefits of emergency policy response measures and longer term policies that reduce the risks and/or costs of temporary energy supply disruptions. That is, ABARE's model is used to provide an indication of the costs of temporary energy supply disruptions — the benefits of appropriate policy response strategies are a reduction in expected economywide costs, although any costs associated with the adoption of these policies also need to be taken into account.

The risk of major temporary energy supply disruptions may be addressed through a range of possible response strategies:

- short term response strategies – information sharing, emergency stocks, demand restraint, fuel switching and surge production capacity.
- longer term response strategies – diversification in fuel types and fuel sources, technology adoption to enhance substitution possibilities in end use applications, energy conservation and efficiency measures, removal of market impediments (including policies that distort energy market decisions such as the decision to invest in supply reliability, and upstream exploration and production decisions), and information sharing in world energy markets.

In this study, some emphasis is placed on the potential for disruptions in the world oil market and policy measures including oil stocks, diversification and technology adoption that may reduce both the risks and costs of such disruptions.

Chapter 2 provides an overview of APEC energy security policies, including the APEC Energy Security Initiative and agreements through the International Energy Agency (IEA) and Association of South East Asian Nations (ASEAN), two other important international organisations that facilitate international cooperation. The chapter also provides background information on oil stockholding policies in APEC economies and a discussion of energy security policies in selected economies.

In chapters 3 and 4, developments in energy markets in the APEC region are examined, with a focus on aspects that relate to APEC energy security risks and issues. In chapter 3, detailed information on the energy markets of APEC economies in 2002 (the latest year for which comprehensive data are available) is provided, with a focus on sources of dependence in energy consumption. In chapter 4, the historical relationship between output and energy consumption growth is examined for twenty APEC economies, major sources of volatility in energy consumption since the early 1970s are identified for these economies, and information relevant to the assessment of supply side risks in the world energy market is presented.

The modeling analysis of the temporary energy supply disruptions is presented in chapters 5 and 6. Chapter 5 provides background information on ABARE's model (GTEM) and the reference case projections to 2030. Chapter 6 presents the simulations results of the temporary energy supply disruptions, with a focus on the impacts on APEC economies and energy markets.

In chapter 7, economic aspects of the APEC energy security policy response are examined, including the economic rationale for government intervention in energy security, and emergency and longer term policy response measures to actual and potential temporary energy supply disruptions. Issues in prioritising energy security policy response measures are also discussed in this chapter and key directions for future economic research are identified.

Chapter 8 contains some conclusions that can be drawn from this study.

2

APEC energy security policy setting

In recent years, energy security issues have become a high priority for policy makers and other energy market participants in the APEC region. Energy security concerns have been heightened as a consequence of increased oil market volatility since 1999, the events of 11 September 2001 and the release in 2002 of an APERC study that projects, over the period to 2020, an increasing import dependence on Middle East OPEC member economies to meet oil requirements in the APEC region.

In this chapter, background information is provided on APEC member economies and the energy security policy setting, including the APEC Energy Security Initiative developed by the APEC Energy Working Group (EWG), the International Energy Agency and ASEAN commitments relating to energy security, and energy security policies in selected APEC economies.

APEC member economies and income levels

The current membership of APEC is provided in table 1. The APEC economies are ranked according to International Monetary Fund (IMF) data on gross domestic product (GDP) per person in 2002 and divided into three groups: high income (eight economies), medium income (six) and low income (seven). This ranking is used throughout the report to provide an indication of differences in energy market structure and energy security policy choices according to income level.

Table 1 also provides a listing of the membership of APEC economies in two other international organisations that are important from an energy security perspective — the International Energy Agency (IEA) and the Association of South East Asian Nations (ASEAN). There are six APEC economies that are members of the IEA and a further seven that are members of ASEAN. APEC economies that are also members of the IEA tend to be in the high income group, while ASEAN members tend to be in the middle and low income groups.

1 Key economic and energy consumption indicators for APEC member economies and membership of the IEA and ASEAN, 2002

APEC economy, by income category	Gross domestic product per person **a**	Gross domestic product **a**		Total primary energy consumption **b**		IEA, ASEAN members
		Level	Share of world	Level	Share of world	
	US$	US$b	%	Mtoe	%	
High income						
1 United States	35 424	10 206	21.2	2 290	22.4	IEA
2 Canada	30 176	945	2.0	250	2.4	IEA
3 Australia	27 022	532	1.1	113	1.1	IEA
4 Hong Kong, China	26 699	182	0.4	16	0.2	–
5 Japan	26 691	3 399	7.1	517	5.1	IEA
6 Singapore	23 504	98	0.2	25	0.2	ASEAN **c**
7 Chinese Taipei	22 809	516	1.1	94	0.9	–
8 New Zealand	20 403	80	0.2	18	0.2	IEA
Total	–	15 959	33.1	3 323	32.5	–
Middle income						
9 Republic of Korea	16 885	804	1.7	203	2.0	IEA **d**
10 Brunei Darussalam	14 734	5	0.01	2	0.02	ASEAN **c**
11 Chile	9 664	151	0.3	25	0.2	–
12 Malaysia	9 127	224	0.5	52	0.5	ASEAN **c**
13 Mexico	8 941	902	1.9	157	1.5	–
14 Russian Federation	8 315	1 200	2.5	618	6.0	–
Total	–	3 286	6.8	1 057	10.3	–
Low income						
15 Thailand	6 702	426	0.9	83	0.8	ASEAN **c**
16 Peru	4 807	135	0.3	12	0.1	–
17 China	4 534	5 824	12.1	1 229	12.0	–
18 Philippines	4 197	334	0.7	42	0.4	ASEAN **c**
19 Indonesia	3 224	695	1.4	156	1.5	ASEAN **c**
20 Viet Nam	2 201	175	0.4	43	0.4	ASEAN
21 Papua New Guinea	2 165	12	0.02	na	na	–
Total	–	7 601	15.8	1 565	15.3	–
– excluding China	–	1 776	3.7	336	3.3	–
APEC total	–	26 846	55.7	5 945	58.1	–
World	–	48 176	100.0	10 231	100.0	–

a Gross domestic product based on purchasing power parity (PPP); APEC economies are ranked according to GDP per person in 2002. **b** Total primary energy consumption (TPEC) is also referred to as total primary energy supply (TPES). **c** Original signatories in 1986 to the ASEAN Petroleum Security Agreement. **d** Korea joined the IEA in 2001.
Sources: IMF (2004a); IEA (2004a,b).

Based on current membership, the APEC region has increased its share of world output significantly from 48 per cent in 1980 to 56 per cent in 2002 and 2003 (IMF 2004a; based on GDP purchasing power parity).

Within the APEC region there has been significant variation in the economic performance of individual economies. Most notably, China has increased its share of world output from 3 per cent in 1980 to 12 per cent in 2002. Given the current size of its economy, the inclusion of China in the low income group significantly influences aggregate information for this income category. Therefore, information relating to the low income group is typically reported throughout this report in aggregate and excluding China.

In 2002, the high income economies accounted for a third of world output, with the United States (21 per cent of world output) and Japan (7 per cent) together accounting for around half of APEC output. The middle income economies accounted for 7 per cent of world output in 2002 — the largest three economies in this income category are the Russian Federation (2.5 per cent), Mexico (1.9 per cent) and the Republic of Korea (1.7 per cent), which are broadly similar in size to the third largest economy in the high income category, Canada (2.0 per cent). The low income economies accounted for 16 per cent of world output in 2002 or 4 per cent excluding China — the second largest economy in the low income category is Indonesia (1.4 per cent).

Overall, there are eleven economies that each accounted for less than 1 per cent of world output in 2002 including three in both the high and middle income groups and five in the low income group. The smallest APEC economies are Brunei Darussalam (0.01 per cent) in the middle income category and Papua New Guinea (0.02 per cent) in the low income category.

APEC Energy Security Initiative

The APEC Energy Security Initiative includes short term measures to respond to temporary energy supply disruptions as well as longer term policy responses to energy security concerns (APEC 2002). The Energy Security Initiative originated in 2000, was developed at a series of workshops during 2001 and was endorsed by APEC Leaders and Ministers in October 2001. An Implementation Plan and Action Plan to Enhance Energy Security were subsequently developed and endorsed by APEC Leaders in 2003.

In June 2004, Energy Ministers highlighted the continuing importance of the Energy Security Initiative and agreed that initiatives should be developed and implemented in close cooperation with the business, research and financial communities. The EWG Secretariat prepared a report outlining progress in implementing the APEC Energy Security Initiative for the 29th meeting of the EWG, held in Hanoi, Viet Nam, on 16–17 March 2005 (referred to as EWG29; see APEC 2005). Key dates in the development of the Energy Security Initiative are presented in box 2.

At their 5th meeting in Mexico City in July 2002, APEC Energy Ministers endorsed several recommendations in five key areas. The APEC Energy Security Initiative has since been developed further to include more

Box 2: Key dates in the development of the APEC Energy Security Initiative

The following is a list of key events over recent years relating to the development and strengthening of the APEC Energy Security Initiative, including major studies released by the Asia Pacific Energy Research Centre (APERC) on oil security issues.

The information is drawn from the APERC studies and the various papers relating to energy security that are available on the APEC web site (see APERC 2000, 2002a, 2003; www.apecenergy.org.au).

March 2000	APERC released a major study, *Emergency Oil Stocks and Energy Security in the APEC Region* (APERC 2000).
May 2000	In the APEC Energy Ministers' Declaration, San Diego, California, Ministers indicated the time is right to focus on how to implement energy policy and regulatory initiatives that have been endorsed over the past few years and that increase energy security by creating conditions for providing adequate supplies at reasonable prices; '"... rising demand and resulting dependence on oil supplies from outside the region have made energy security a major concern in many of our economies" (Paragraph 4)' (APERC 2002a, p. 5).
Sept. 2000	The Senior Officials Meeting discussed what action APEC could take to respond to oil price volatility and called on the

continued…

Box 2: Key dates in the development of the APEC Energy Security Initiative *continued*

	Energy Working Group (EWG) to analyse the situation and make recommendations on issues of energy security.
Oct. 2000	At the 20th Meeting of the APEC Energy Working Group (EWG20), Peru, an initiative addressing oil supply disruptions was put forward by the United States.
Nov. 2000	Energy security concerns were reaffirmed in the APEC Economic Leaders' Declaration, Brunei Darussalam.
Mar–Sept. 2001	Series of workshops in Tokyo, Houston, Seoul, Bangkok and Port Moresby identified the need to develop a strategic approach to the energy security issue, the outcome of which was the development of an Energy Security Initiative that was endorsed at EWG22 in Port Moresby in September 2001.
Oct. 2001	Meetings of both APEC Leaders and Ministers, held in Shanghai, China, endorsed the APEC Energy Working Group's strategic approach to implementing the APEC Energy Security Initiative.
2002	APERC released a major study, Energy Security Initiative: Emergency Oil Stocks as an Option to Respond to Oil Supply Disruptions (APERC 2002a) — an update of the 2000 APERC study.
2002	APERC released long term projections for the APEC region, Energy Demand and Supply Outlook 2002 (APERC 2002b) — projected a substantial oil import dependence for the APEC region in 2020.
April 2002	APERC organised a Sea Lane Disruption Simulation Exercise in Tokyo involving participants from almost all of the APEC economies.
July 2002	At the 5th Meeting of APEC Energy Ministers (EMM5) in Mexico City, Ministers directed the EWG to further implementation of the Energy Security Initiative (ESI) and endorsed recommendations in five key areas: joint oil data initiative (JODI); sea lane security; real time emergency information sharing; oil supply emergency responses; and nonpetroleum and longer term responses.

continued…

Box 2: Key dates in the development of the APEC Energy Security Initiative *continued*

2003	APERC released a major study, *Energy Security Initiative: Some Aspects of Oil Security* (APERC 2003) — presents an overview of energy security developments in some APEC economies, particularly since the events of 11 September 2001.
Oct. 2003	To advance the implementation of the Energy Security Initiative, in 2003 the EWG developed an Implementation Plan that was endorsed by APEC Senior Officials and Leaders. At their meeting in Bangkok in October 2003, Leaders agreed to 'accelerate the implementation of the ESI by endorsing its Implementation Plan and, as appropriate, a new Action Plan to enhance regional and global energy security'.
Feb. 2004	Trial of the Real Time Emergency Information Sharing System.
Mar. 2004	1st Meeting of the Energy Security Initiative Steering Committee in Beijing.
June 2004	At the 6th Meeting of APEC Energy Ministers in Manila, the Philippines, Ministers agreed that initiatives should be developed and implemented in close cooperation with the business, research and financial communities (see box 1). These initiatives include: preparing for energy supply disruptions; facilitating energy investment; using energy more efficiently; expanding energy choices; and capitalising on technological innovation. Ministers also endorsed the paper, 'Best practice principles on the establishment and management of strategic oil stocks' (APEC 2004c).
Nov. 2004	At the 28th Meeting of the APEC EWG in Port Douglas, Australia, the latest APEC statement on energy security was released, which was endorsed at the 12th APEC Economic Leaders Meeting in Santiago, Chile. The statement is referred to as the CAIRNS Initiative after the title of the paper, *Comprehensive Action Initiative Recognising the Need for Strengthening the APEC Energy Security Initiative – Energy Security, Sustainable Development and Common Prosperity (CAIRNS)* (APEC 2004d).
Mar. 2005	The third report on the implementation of the Energy Security Initiative was prepared by the EWG Secretariat for the 29th Meeting of the APEC EWG in Hanoi, Viet Nam.

measures, particularly under long term policy responses. The five key areas are:

- joint oil data initiative
- sea lane security
- real time emergency information sharing
- energy emergency response
- longer term responses.

The Implementation Plan identifies the key outcomes, and timeframes where appropriate, in each of these key areas (APEC 2003a). The following outline of key areas in the Energy Security Initiative also draws on recent information on progress in implementing the recommendations presented in APEC (2004b; 2005).

Joint oil data initiative

The aim of the Joint Oil Data Initiative (JODI) is to improve the quality, timeliness and completeness of world oil market data available to market participants and hence improve market transparency. JODI commenced in September 2002 and is undertaken jointly by six organisations — APEC, the International Energy Agency (IEA), the European Union (EU), the Latin-American Energy Organisation (OLADE), the Organisation of Petroleum Exporting Countries (OPEC) and the United Nations Statistical Division.

Around 80 economies contribute to JODI, accounting for 93 per cent of world oil production and 95 per cent of world oil consumption. All APEC economies have contributed data to JODI, although there is some variation between economies relating to data quality, timeliness and coverage.

Sea lane security

Oil and gas transport in the Asian region is almost exclusively by tanker and, of particular concern, the Straits of Malacca are very shallow and only 0.5 kilometres wide at the narrowest point (APERC 2002a).

APERC organised a Sea Lane Disruption Simulation Exercise on 18–19 April 2002 to identify necessary actions to better prepare APEC economies for such disruptions (APEC 2002). The exercise used real time scenarios of sea lane disruptions in south east Asia involving accident, piracy and terrorism elements. In addition to establishing a real time emergency information sharing system and strategic oil stockpiles (including refined products) in Asia, recommendations provided at the end of the exercise were to consider upgrading navigational aids in the Straits of Sunda and Lombok as alternative routes to the Straits of Malacca and identify what APEC economies should do to establish appropriate responses.

Work on enhancing maritime security is being undertaken by the International Maritime Organisation (IMO) and the APEC Transportation Working Group. At EWG27 (Beijing, March 2004), members agreed that the EWG should continue to monitor the implications of this work for the transportation of energy by sea.

Real time emergency information sharing

The aim of information sharing during oil supply disruptions and other energy emergencies is to enable APEC economies to accurately assess the nature of the emergency and develop appropriate responses.

The Real Time Emergency Information Sharing System was developed by Japan, was successfully trialed by several APEC economies in February 2004 and has been endorsed for implementation. The permanent system is to be established by the end of 2004. In March 2005, fifteen APEC economies had nominated emergency contacts for the system. At EWG28 (Australia, November 2004), members endorsed a proposal by Australia to develop an operational manual for the Real Time Emergency Information Sharing System.

Energy emergency response

The aim in energy supply response measures is to ensure that governments and industry are aware of their responsibilities in the event of an energy supply emergency. Recommendations relate to energy emergency preparedness plans and oil stockpiling to address short term supply disruptions, including consideration of joint stockpiles.

APERC released studies in 2000 and 2002 that focused on strategic oil stockpiles and a further study in 2003 that focused on the Asian premium pricing, and export and import dependence issues relating to oil security.

Workshops have been held on oil supply emergency response arrangements (United States, May 2003) and joint oil stockpiling (Republic of Korea, December 2003). Presentations by APEC economies on energy emergency arrangements have commenced at EWG meetings (Republic of Korea at EWG26 in December 2003; People's Republic of China at EWG27 in March 2004; and Australia at EWG28 in November 2004).

In December 2003, an ad hoc group was formed to identify best practices for the establishment and management of oil stockpiles (a guide, prepared by the group, on best practices principles is given in APEC 2004c).

Longer term responses

Energy security issues in this category are wide ranging and take into account sustainability and environmental impacts. The APEC Energy Security Initiative includes longer term responses in the following categories:

- energy investment – implement the recommendations of the *Energy Investment Report: Facilitating Energy Investment in the APEC Region*, recognising the important contribution of the private sector and financial community in developing the recommendations; reaffirm our commitment to encourage the implementation of best practices previously endorsed for implementation in the natural gas and electricity sectors.
- natural gas trade – support the creation of a competitive and transparent market for gas trade and encourage member economies to move toward best practice as identified in *Facilitating the Development of LNG Trade in the APEC Region*, recognising the important contribution of the private sector in developing these principles; continue work to improve the security of natural gas supply by identifying vulnerabilities, supporting trade promotion and establishing convenient information links to gas market data available in existing data systems.
- nuclear power – interested member economies are encouraged to cooperate on the nuclear framework as endorsed by the EWG; security, seismic and health concerns, including transborder effects, should be adequately addressed.
- energy efficiency – implement a Pledge and Review Program that includes ways to monitor the implementation of policies and programs; participate in the Energy Standards and Labelling Cooperation Initiative and the web based APEC Standards Notification Procedure aimed

to facilitate trade in efficient energy using equipment used within the region; and encourage broadening the scope of work on energy efficiency to include other energy intensive sectors, and to monitor the development of new technologies that could have significant impacts on, and synergy with, energy efficiency and conservation.

- renewable energy – the EWG to continue its work under the 21st Century Renewable Energy Development Initiative, working closely with the EWG Business Network and the APEC business and research communities.
- hydrogen, fuel cells and alternative transport fuels – implement the recommendations identified in the *Interim Framework Document on Hydrogen and Fuel Cells* that highlights the potential for a hydrogen economy in the APEC region.
- methane hydrates – support research on the potential of methane hydrates as a future energy source, and direct the EWG to communicate research developments within their economies.
- clean fossil energy – EWG to continue its work in the areas of clean fossil energy and carbon dioxide capture and geological sequestration, working closely with the EWG Business Network and the APEC business and research communities.
- petroleum infrastructure and crude and refined products (CAIRNS Initiative) – working closely with the EWG Business Network, identify problems and enhance efficiency in refining, transport and distribution of crude oil and petroleum products.

Progress on implementation of the above directions from Energy Ministers is provided in APEC (2005).

IEA and ASEAN agreements on energy security in APEC economies

In addition to progress on international coordination of energy security policies through the APEC forum, two important international agreements that significantly influence energy security policies in the APEC region are the IEA's International Energy Program and the ASEAN Petroleum Security Agreement.

IEA's International Energy Program (IEP)

The IEA was established in November 1974 within the framework of the OECD to implement the International Energy Program (IEA 2001, 2004a). The IEA was formed by sixteen OECD member economies in response to the economic costs that resulted from the first oil shock in 1973. Currently, twenty-six of the thirty OECD member economies are signatories to the IEP Agreement. The basic aims of the IEA are:

- to maintain and improve systems for coping with oil supply disruptions;
- to promote rational energy policies in a global context through cooperative relations with nonmember countries, industry and international organisations;
- to operate a permanent information system on the international oil market;
- to improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use; and
- to assist in the integration of environmental and energy policies.

Major elements of the IEP are to reduce IEA dependence on imported oil, a commitment to hold minimum levels of emergency reserves and agreement to share available oil supplies in the event of a major disruption (IEA 2001).

The emergency responses include a commitment to hold oil stocks equivalent to 90 days of net oil imports. Oil includes crude oil and other refinery feedstock as well as petroleum products, with the mix depending on the emergency requirements of individual countries. IEA emergency response measures would be activated in a major disruption, whereby supply is reduced by at least 7 per cent, the 'trigger' defined in the IEP — the trigger is based on calculated available supply of IEA countries or a single country as being 93 per cent or less of the annual average supply in the most recent previous four quarters (considered the base period) available from the Monthly Oil Statistics Questionnaire (IEA 2001).

An integrated set of emergency response measures is defined in the IEP, including stock drawdown, demand restraint, fuel switching, surge oil production and sharing of available supplies.

The IEA has a complementary set of measures known as the Coordinated Emergency Response Measures that apply to smaller energy supply disruptions. These measures provide the IEA with a rapid and flexible system of response to actual or imminent oil supply disruptions and, by a decision of the IEA Governing Board, may also be used in a trigger situation. For example, the IEA developed and implemented a Contingency Plan during the 1990-91 Gulf Crisis to supply 2.5 million barrels of oil a day, mainly through stock drawdown. The IEA also developed a Contingency Plan for supply disruptions resulting from possible year 2000 computer problems.

ASEAN Petroleum Security Agreement (APSA)

The ASEAN Petroleum Security Agreement was signed in the Philippines in June 1986 by the six ASEAN member economies at the time, and has been ratified by the additional four countries that have since joined ASEAN.

Under APSA, ASEAN member economies established the ASEAN Emergency Petroleum Sharing Scheme for crude oil and petroleum products that apply both in times of shortage and oversupply (see www.aseansec.org/6568.htm for the agreement). Under the scheme, the oil exporting ASEAN member economies are required to supply a certain quantity of crude oil and/or petroleum products if any other member economies experience critical shortage. Conversely, oil importing member economies are required to purchase exports of crude oil and/or petroleum products from oil exporting ASEAN member economies in distress to increase their level of exports to at least 80 per cent of the normal exports (APERC 2000).

At the 17th ASEAN Ministers on Energy Meeting held in Bangkok during July 1999, it was decided that the ASEAN Council on Petroleum (ASCOPE) should review the provisions of the 1986 APSA. ASCOPE, which comprises the national oil companies, was established in October 1975 by the original five ASEAN member countries to provide an instrument for regional cooperation among member countries (ASCOPE 2004). Currently, there are nine members of ASCOPE (ASEAN member countries excluding Laos). Subsequently, at the 21st ASEAN Ministers on Energy Meeting held in Malaysia on 2 July 2003, the significant progress that ASCOPE had achieved in the review was noted and the Senior Officials Meeting on Energy were requested to expeditiously conclude the new APSA.

Oil stockpiling arrangements and APERC projections of oil import dependence in APEC economies

It is apparent from the development of the APEC Energy Security Initiative that oil is a major source of energy security concerns in the APEC region, although policy makers also recognise that a broad range of factors influence regional energy security over the longer term. Oil security risks and policy responses (both emergency responses that may be potentially implemented in the event of a temporary supply disruption and longer term policy measures) are therefore a key focus in this study.

Emergency response measures aim to reduce the costs of any temporary energy supply disruption. Emergency measures may include stock drawdown, demand restraint, surge production, fuel switching and information sharing.

Longer term policy measures aim to reduce the risk and/or cost of temporary energy supply disruptions. Longer term measures may be designed to achieve increased domestic energy exploration and production, diversification of oil import sources, diversification of the domestic fuel mix through investment in alternative energy sources and technologies, 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.

International coordination of policy actions is well recognised as an important policy option for both short term and longer term energy security.

Oil stockpiling arrangements in APEC economies are described briefly in table 2, based on information presented in APERC (2002a). Given the importance in the timing of the release of the APERC supply and demand outlook for highlighting the growing oil import dependence of the APEC region, information on the oil import dependence of APEC economies in 1999 and 2020 (as presented in APERC 2002b) is also provided in table 2.

APERC estimates oil import dependence as oil consumption minus oil production, calculated as a percentage of oil consumption. In the table, APEC economies are listed in order of oil import dependence in 1999 from the highly dependent net oil importers to net oil exporters.

2 Oil stockpiling arrangements and APERC projections of oil import dependence in APEC economies, 1999 and 2020 [a]

APEC economy, by net oil trade position		Oil import dependence [b] 1999	2020	Change in oil import dependence 1999–2020 [c]
		%	%	
Net oil importers				
4	Hong Kong, China	100.0	100.0	0
6	Singapore	100.0	100.0	0
7	Chinese Taipei	99.9	100.0	+
18	Philippines	99.8	97.0	–
5	Japan	99.7	100.0	+
9	Korea, Rep. of	99.6	99.7	+
11	Chile	96.3	99.5	+
15	Thailand	87.8	95.1	+
8	New Zealand	64.7	80.0	+
1	United States	58.5	70.7	+
3	Australia	30.5	46.1	+
17	China	21.7	69.5	+
16	Peru	16.6	24.3	+
Net oil exporters, projected net oil importers				
19	Indonesia	–50.1	58.0	+
12	Malaysia	–68.0	36.9	+
20	Viet Nam	–103.5	5.3	+
21	Papua New Guinea	–370.2	80.2	+
Net oil exporters				
2	Canada	–36.6	–60.2	–
13	Mexico	–79.6	–74.3	+
14	Russian Federation	–139.5	–91.0	+
10	Brunei Darussalam	–2 169.2	–910.3	+
APEC total		35.9	54.0	+

a Economy numbers are based on the rank given in table 1 based on GDP per person in 2002. **b** Oil import dependence calculated as oil consumption minus oil production, as a percentage of oil consumption. **c** Indicates projected change in oil import dependency between 1999 and 2020: + increased net oil import dependence for net oil importers, or weaker net oil export position (some switching to net oil importers); 0 no change in net oil import dependence; – reduced net oil import dependence for net oil importers, or stronger net oil export position. In total, seventeen APEC economies are expected to increase their net oil import dependence, two will remain roughly the same, while two will reduce theirs.

continued…

2 Oil stockpiling arrangements and APERC projections of oil import dependence in APEC economies, 1999 and 2020 a *continued*

APEC economy	Oil stockpiling arrangements
Net oil importers	
Hong Kong	Voluntary code for commercial stocks of 30 days of retained imports for natural gas and naphtha. Oil supply Contingency Plan has been developed.
Singapore	Fuel oil stockpile for electricity generation only.
Chinese Taipei	Producers of products and importers are required to hold emergency stocks of no less than 60 days of consumption. Petroleum Business Act, November 2001 requires strategic reserves.
Philippines	No requirements since 1998. Energy Contingency Plan being developed.
Japan	Emergency stockpiles; generally exceed IEA requirements.
Korea, Rep. of	Emergency stockpiles; meets IEA requirements.
Chile	Commercial stocks only to meet around 25 days of petroleum product sales.
Thailand	Company stock obligations around 22 days of demand for crude and products. Investigating stockpiling programes.
New Zealand	No emergency stockpiles; commercial stocks meet IEA requirements.
United States	Emergency stockpiles; generally exceed IEA requirements.
Australia	No emergency stockpiles; commercial stocks meet IEA requirements.
China	Plans to establish emergency stocks of up to 3 months of imports by 2010.
Peru	Wholesalers required to hold stocks of 15 days of average dispatch.
Net oil exporters, projected net oil importers	
Indonesia	Maintains emergency stock to secure domestic supplies.
Malaysia	No emergency stockpiling policies. A 'Five Fuels' policy is in place to enhance energy diversity and security.
Viet Nam	No emergency stockpiling policies; generally operational stocks only
Papua New Guinea	No emergency stockpiling policies; generally operational stocks only
Net oil exporters	
Canada	No emergency stockpiling policies; generally operational stocks only; some emergency legislation in Canada
Mexico	No emergency stockpiling policies; generally operational stocks only
Russian Federation	No emergency stockpiling policies; generally operational stocks only
Brunei Darrusalam	No emergency stockpiling policies; generally operational stocks only

Sources: Based on APERC (2002a,b, 2003).

In 1999, thirteen APEC economies were net importers, of which seven are fully or almost fully dependent on oil imports (ranging from 100 to 96 per cent, including Hong Kong, Singapore, Chinese Taipei, the Philippines, Japan, Korea and Chile), a further three rely on oil imports for over half of domestic oil consumption requirements (Thailand, New Zealand and the United States) and the remaining three rely on oil imports for less than a third of domestic needs (Australia, China and Peru). All of these economies are projected to remain highly dependent on oil imports, or to become significantly more reliant on oil imports by 2020.

In the other eight APEC economies, net oil exports in 1999 represented a significant proportion of domestic oil consumption (ranging from 37 to over 2000 per cent). Of these economies, four are projected to become net oil importers by 2020, with significant oil import dependence for three economies (ranging from 37 to 80 per cent, including Papua New Guinea, Indonesia and Malaysia), but low oil import dependence projected for Viet Nam (5 per cent). The remaining four economies are projected to continue to be net oil exporters in 2020 (Canada, Mexico, the Russian Federation and Brunei Darassalam).

Overall, the oil import dependence of the APEC region is projected by APERC to increase from 36 per cent in 1999 to 54 per cent in 2020.

Indonesia is the only net oil exporting economy to maintain emergency oil stocks; these stocks are intended to reduce the risk of oil disruptions along the archipelago. Emergency fuel stockpiles are held primarily by high income APEC economies that depend on imported oil. Japan, the United States and Korea account for virtually all of the region's emergency stocks, with Japan and the United States often exceeding the 90 days of net imports required by the IEA. In contrast, few middle to low income APEC economies hold emergency oil stockpiles. Among those that have announced or are considering oil stocks in the future are the People's Republic of China and Thailand.

Energy security policies in selected APEC economies

While there are considerable differences in detail, energy policy settings across APEC are generally intended to serve policy goals of economic growth and energy security. These objectives have guided energy policy reforms, including market deregulation and the introduction and enhancement of a variety of energy security measures.

Structural adjustments, including energy market deregulation, have been implemented across APEC economies in the pursuit of higher economic productivity. In APEC energy industries, there is an ongoing trend away from public ownership of energy assets to private ownership, from regulated monopolies to regulated competition, and from vertical integration to separation of functions. Generally, high income member economies have moved further along these spectrums of deregulation than have low to middle income economies. Energy sectors in New Zealand, the United States, Australia and Canada, in particular, are generally characterised by private ownership and light handed regulation of competition. With some important exceptions, particularly Chile, most low to middle income economies are still early in the process of opening up their energy sectors to private participation and greater competition. However market reforms are continuing in most economies (see Fairhead et al. 2002 for more detail).

Against this background of energy policy developments, energy security has remained an important concern for APEC member economies. Member economies have responded to energy security concerns with a variety of policy measures, although there are some common themes in policy settings.

Energy security policies vary widely among APEC economies and are influenced by the specific circumstances of the economy including most notably income levels, access to domestic energy resources and participation in international agreements. Current energy policy settings in six selected APEC economies are discussed in appendix A.

Compared with middle to low income member economies, high income APEC economies have made greater progress toward liberalising their energy sectors. Other policy responses to the risk of international supply disruptions include diversification of fuels and of import sources, regional cooperation, and fostering investment in resource developments beyond the border. While these measures are evident among most APEC economies, they are taken further by the high income APEC economies that depend heavily on imported energy. Nuclear power for example is a major source of energy only in Japan, the United States, Korea and Chinese Taipei, the four largest net energy importers in APEC.

In recent years, a number of high profile energy supply disruptions have been associated with design failures in energy market systems. These have occurred in high income APEC economies, where market based regulations are more advanced. In 2001, for example, Californian consumers were faced with rolling blackouts largely because poor regulatory design forced utilities into severe financial difficulties (see Fairhead et al. 2002 for more detail). Failures such as that in California have prompted more careful analysis of the design of energy market regulations to better achieve energy systems that are both efficient and secure (see, for example, Borenstein 2002; Wolak 2003).

In contrast to high income APEC members, most middle to low income member economies are not yet highly dependent on energy imports. In many middle to low income APEC economies, energy supply disruptions caused by inadequate infrastructure are a major constraint on economic growth and social welfare. Attracting private investment in energy infrastructure is therefore a key policy objective in middle to low income economies. In Mexico, for example, policy makers are grappling with a constitutional prohibition on private ownership of energy resources that has prevented Mexico from developing its domestic reserves. As another example, the Russian Federation's pipeline infrastructure is aged, frequently resulting in accidents and supply disruptions. Russia's 'Energy Strategy to 2020' aims to attract foreign investment to Russia's energy export sector on the understanding that investment in export infrastructure would involve renewing and extending Russia's pipeline network.

3

APEC energy market setting

There is considerable diversity in the energy markets of the twenty-one economies that currently comprise APEC, reflecting to a large extent variations in economic size and structure, income levels and proximity to energy resources. In this chapter, background information is provided on the structure of energy markets in APEC economies, with a focus on energy consumption, production and trade in 2002 (the latest year for which comprehensive energy data are available). It should be noted that the IEA energy database, which is the main source of information on APEC energy markets used in this chapter, does not provide information on Papua New Guinea.

Primary energy consumption in APEC economies

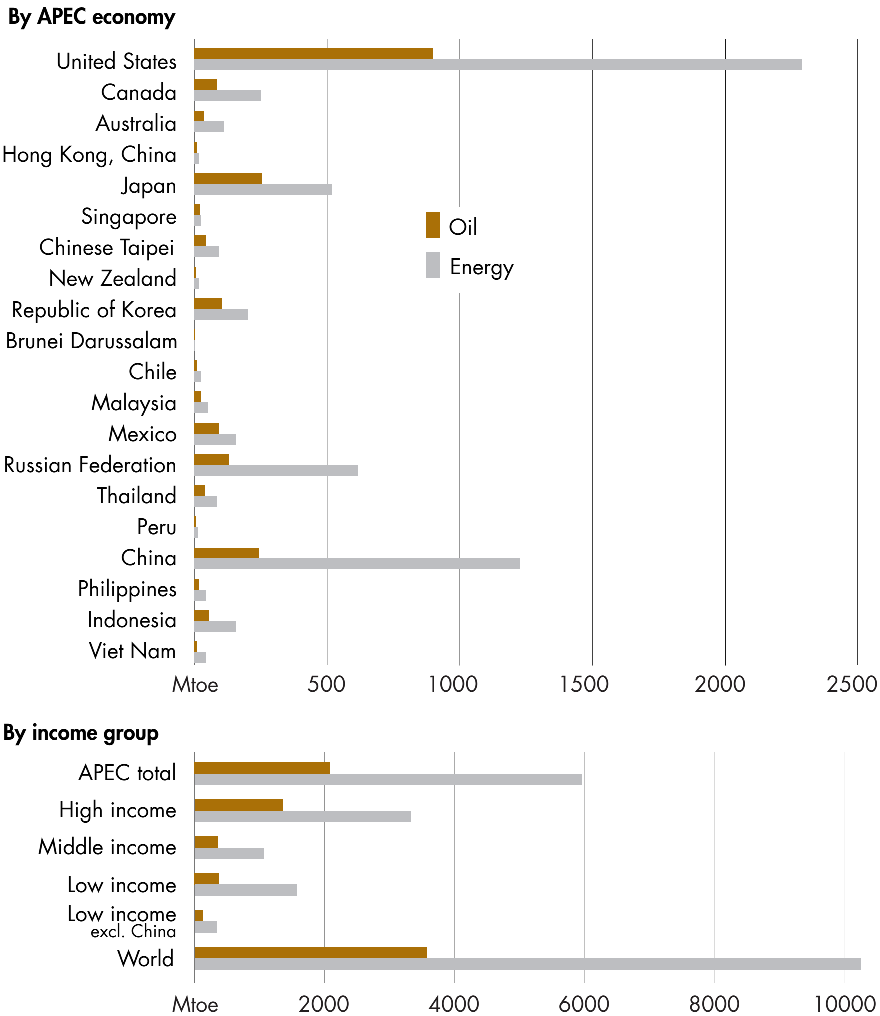
Primary fuels are forms of energy obtained directly from nature and include nonrenewable fuels such as coal, crude oil, natural gas liquids and natural gas, and renewable resources such as hydro, solar and wood.

Total primary energy consumption (TPEC) in the APEC region was 5945 million tonnes of oil equivalent (Mtoe) or 58 per cent of the world level in 2002, slightly higher than the region's share in world output (table 1 and figure 1; note that TPEC is referred to as total primary energy supply or TPES in the IEA energy database).

In 2002 the high income economies accounted for 32 per cent of world primary energy consumption, compared with 10 per cent for middle income economies and 15 per cent for low income economies (or 3 per cent excluding China). Notably, the Russian Federation's share of world primary energy consumption is substantially larger than its output share (6.0 per cent share in primary energy consumption compared with a 2.5 per cent share in output).

Around 90 per cent of primary energy consumption in the APEC region in 2002 was sourced from nonrenewable fuels, comprising oil (35 per cent), coal (28 per cent), gas (21 per cent) and nuclear (approximately 7 per cent) (table 3). Renewable energy is made up predominantly of combustible renewables and waste (7 per cent), hydro (1.9 per cent) and geothermal energy (0.5 per cent). Compared with the world economy, the APEC region uses proportionately more coal and, to a minor extent, geothermal energy, and proportionately less combustible renewables and waste, and to a minor extent hydro (table 3).

1 Total primary consumption of energy and oil in APEC economies, 2002



3 Fuel shares in total primary energy consumption (TPEC), by APEC economy, 2002 a

	Coal	Oil	Gas	Nu-clear	Renewables: Hydro	Renewables: Geo-ther-mal	Renewables: Solar/ wind etc b	Renewables: Com-bustible renew/ waste c	Total
	%	%	%	%	%	%	%	%	%
United States	24	39	23	9.2	0.9	0.4	0.1	3	4
Canada	12	34	30	7.9	12.0	0.0	0.0	5	17
Australia	43	31	18	0.0	1.2	0.0	0.1	6	8
Hong Kong	33	51	12	0.0	0.0	0.0	0.0	0	0
Japan	19	49	13	14.9	1.4	0.6	0.1	1	4
Singapore	0	85	15	0.0	0.0	0.0	0.3	0	0
Chinese Taipei	36	45	7	11.0	0.6	0.0	0.0	0	1
New Zealand	7	35	28	0.0	11.7	11.2	0.4	7	30
Korea, Rep. of	23	50	10	15.3	0.1	0.0	0.0	1	2
Brunei	0	32	67	0.0	0.0	0.0	0.0	1	1
Chile	11	38	25	0.0	8.1	0.0	0.0	17	25
Malaysia	4	49	41	0.0	0.9	0.0	0.0	5	6
Mexico	5	60	24	1.6	1.4	3.0	0.0	5	10
Russian Fed.	17	21	53	6.0	2.3	0.02	0.0	1	3
Thailand	11	45	26	0.0	0.8	0.0	0.0	16	17
Peru	7	57	4	0.0	12.9	0.0	0.5	19	32
China	58	20	3	0.5	2.0	0.0	0.0	18	20
Philippines	12	39	3	0.0	1.4	21.0	0.0	24	46
Indonesia	12	36	21	0.0	0.5	3.4	0.0	27	31
Viet Nam	13	24	5	0.0	3.7	0.0	0.0	54	58
Papua New Guinea	na	na	na	na	na	na	na	na	na
APEC d	28	35	21	6.6	1.9	0.5	0.1	7	10
High income	23	41	22	9.5	1.8	0.4	0.1	3	5
Middle income	16	34	39	6.7	1.8	0.5	0.0	2	5
Low income	48	24	6	0.4	1.9	0.9	0.0	20	23
– excl. China	11	38	18	0.0	1.6	4.2	0.0	27	33
World	23	35	21	6.8	2.2	0.4	0.1	11	14

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 and Hong Kong. **b** Includes solar, wind, tide and wave energy. **c** Combustible renewables and waste. **d** APEC total excludes Papua New Guinea. **na** Not available.
Sources: IEA (2004a,b).

Excluding China where 58 per cent of primary energy consumption is sourced from coal, the share of coal in the primary fuel mix tends to be positively related to income category — that is, the coal share tends to be higher on average for higher income categories. In 2002, the coal share was 23 per cent for high income economies, 16 per cent in middle income economies and 11 per cent in low income economies excluding China (48 per cent including China). There is considerable variation within each income group, however, with low or zero coal fuel shares in several economies in the high and middle income categories (notably, Singapore, New Zealand, Brunei, Malaysia and Mexico).

The share of oil in the primary energy mix ranges from a high of 85 per cent in Singapore (high income) to lows of 21 per cent in the Russian Federation (middle income) and 20 per cent in China (low income). On average, oil is an important source of energy in all income groups with oil shares in 2002 of 41 per cent in high income economies, 34 per cent in middle income economies and 38 per cent in low income economies excluding China (24 per cent including China).

Gas is substantially more important in the primary energy mix, on average, for middle income economies (39 per cent) than for either high income economies (22 per cent) or low income economies (6 per cent, or 18 per cent excluding China). Gas consumption in the middle income economies was 414 Mtoe in 2002, accounting for around a third of total gas consumption in the APEC region. APEC economies with low gas shares are mainly concentrated in the low income category.

Nuclear energy is positively related to income category, with shares in 2002 of 10 per cent in high income economies, 7 per cent in middle income economies and close to zero in low income economies (zero excluding China). Eight APEC economies used nuclear energy in 2002 — four high income economies (Japan, Chinese Taipei, the United States and Canada), three middle income economies (Korea, the Russian Federation and Mexico) and one low income economy (China).

Use of renewable energy is considerably higher in low income economies, mainly reflecting higher consumption of combustible renewables and waste in these economies. Hydro energy is used to some extent in most APEC economies, but the shares are highest in Peru (13 per cent), Canada (12 per cent) and New Zealand (12 per cent). Geothermal energy is used in seven

APEC economies, with the highest shares in the Philippines (21 per cent) and New Zealand (11 per cent).

It should be noted that, because of concerns over data reliability, combustible renewables and waste are often excluded from international energy market assessments where the focus is on economic issues relating to industry and international trade. Combustible renewables and waste are included in this study where possible to highlight the diversity in the energy mix across APEC economies and, in particular, the importance of this energy source for low income economies. In 2002, combustible renewables and waste accounted for 20 per cent of primary energy consumption in low income economies (27 per cent excluding China), compared with 3 per cent and 2 per cent for high and middle income economies, respectively.

The extent to which individual economies tend to specialise in a small number of fuel types or diversify across several fuel types varies widely across all income categories. Summary measures of energy diversification in APEC economies over time are provided in chapter 7 in the context of longer term policy response strategies.

Energy consumption in electricity generation and end use activities

Electricity generation

Electricity is an important source of energy in end use applications. Electricity is produced from a range of primary fuels, with variations between APEC economies reflecting to a significant extent the relative availability of energy resources.

In 2002 the APEC region accounted for 61 per cent of world electricity output (in GWh). Around 85 per cent of APEC electricity output was sourced from nonrenewable fuels comprising coal (46 per cent), gas (18 per cent), nuclear (16 per cent) and oil (6 per cent) (table 4). Hydroelectricity is the most important renewable energy source, accounting for 13 per cent of APEC electricity output. The most notable differences with the fuel mix used in electricity generation in the world economy are in the shares for coal (39 per cent in the world economy) and hydroelectricity (16 per cent). Coal is relatively more important, on average, for electricity generation in the high income economies, with the notable exception of China where

4 Fuel shares in electricity generation, by APEC economy, 2002 a

	Coal	Oil	Gas	Nu-clear	Renewables				Total
					Hydro	Geo-ther-mal	Solar/ wind etc b	Com-bustible renew/ waste c	
	%	%	%	%	%	%	%	%	%
United States	51	2	18	20	6	0.4	0.3	1.8	8
Canada	20	2	6	13	58	0.0	0.1	1.4	60
Australia	78	2	12	0	7	0.0	0.2	1.1	8
Hong Kong	64	0	36	0	0	0.0	0.0	0.0	0
Japan	27	13	22	27	8	0.3	0.0	2.3	10
Singapore	0	40	58	0	0	0.0	2.1	0.0	2
Chinese Taipei	55	12	10	19	3	0.0	0.0	0.0	3
New Zealand	4	0	25	0	61	7.1	1.9	1.1	71
Korea, Rep. of	40	10	13	36	1	0.0	0.0	0.2	1
Brunei	0	1	99	0	0	0.0	0.0	0.0	0
Chile	19	1	25	0	51	0.0	0.0	3.7	55
Malaysia	6	9	78	0	7	0.0	0.0	0.0	7
Mexico	12	37	32	5	12	2.5	0.0	0.2	14
Russian Fed.	19	3	43	16	18	0.0	0.0	0.3	19
Thailand	16	3	72	0	7	0.0	0.0	1.9	9
Peru	2	10	4	0	82	0.0	0.0	0.9	83
China	77	3	0	2	18	0.0	0.0	0.1	18
Philippines	33	13	18	0	15	21.1	0.0	0.0	36
Indonesia	40	23	22	0	9	5.8	0.0	0.0	15
Viet Nam	14	12	23	0	51	0.0	0.0	0.0	51
Papua New Guinea	na	na	na	na	na	na	na	na	na
APEC d	46	6	18	16	13	0.4	0.1	1.2	15
High income	44	5	17	20	11	0.3	0.2	1.7	14
Middle income	22	9	37	17	14	0.4	0.0	0.4	15
Low income	69	5	6	1	18	0.8	0.0	0.2	19
– excl. China	25	13	37	0	19	5.1	0.0	0.7	25
World	39	7	19	17	16	0.3	0.3	1.2	18

a Based on electricity output in GWh. **b** Includes solar, wind, tide and wave energy. **c** Combustible renewables and waste. **d** APEC total excludes Papua New Guinea. **na** Not available.
Sources: IEA (2004a,b).

77 per cent of electricity is generated using this resource. Gas is relatively more important, on average, in middle and low income economies excluding China and these income groups also tend to use slightly more oil in electricity generation.

Final energy consumption

Final energy consumption is the total amount of energy consumed outside the energy conversion sector, which includes most importantly electricity generation and petroleum refineries.

APEC economies accounted for 57 per cent of world final energy consumption in 2002, with the shares attributable to each income category similar to that for primary energy consumption — high income economies accounted for 32 per cent of world final energy consumption, middle income economies for 10 per cent and low income economies for 15 per cent (3 per cent excluding China).

In the APEC region, nearly all renewable energy with the exception of combustible renewables and waste, over three quarters of coal and around half of gas resources are used in electricity generation. The fuel mix in final energy consumption reflects these uses. In 2002, final energy consumption in the APEC region was mainly sourced from oil (mainly refined petroleum products, 45 per cent), electricity (17 per cent), gas (15 per cent), coal (9 per cent) and renewables (9 per cent) (table 5).

In high income economies, 94 per cent of final energy is sourced from oil (54 per cent), electricity (21 per cent) and gas (19 per cent). Within this group, the shares for gas and renewables tend to be significantly higher in four economies, including Canada (28 per cent for gas and 5 per cent for renewables), New Zealand (20 per cent, 10 per cent), the United States (22 per cent, 3 per cent) and Australia (16 per cent, 6 per cent). The share of oil in final energy consumption in Singapore (81 per cent) remains substantially above that of any other APEC economy, while the coal share in Chinese Taipei (12 per cent) is also high relative to most other APEC economies.

Oil, electricity and gas are also important fuel types for middle income economies (together with heat). The gas share for middle income economies is significantly lower in final energy consumption (21 per cent) than in primary energy consumption (39 per cent) because of the importance of

5 Fuel shares in total final energy consumption (TFEC), by APEC economy, 2002

	Coal	Oil	Gas	Renewables: Geo-thermal	Renewables: Solar/ wind etc a	Renewables: Com-bustible renew/ waste b	Renewables: Total	Elec-tricity	Heat
	%	%	%	%	%	%	%	%	%
United States	2	54	22	0.0	0.1	2.6	3	19	0
Canada	2	43	28	0.0	0.0	5.0	5	22	0
Australia	4	51	16	0.0	0.1	6.2	6	23	0
Hong Kong	0	66	5	0.0	0.0	0.5	0	28	0
Japan	6	63	7	0.1	0.2	0.7	1	24	0
Singapore	0	81	1	0.0	0.0	0.0	0	18	0
Chinese Taipei	12	60	3	0.0	0.0	0.0	0	25	0
New Zealand	6	43	20	2.2	0.0	7.5	10	20	0
Korea, Rep. of	6	63	9	0.0	0.0	0.1	0	18	3
Brunei	0	68	0	0.0	0.0	2.7	3	29	0
Chile	4	50	7	0.0	0.0	20.9	21	19	0
Malaysia	3	60	15	0.0	0.0	4.4	4	17	0
Mexico	1	66	10	0.0	0.1	7.8	8	15	0
Russian Fed.	5	22	28	0.0	0.0	0.6	1	13	32
Thailand	9	57	3	0.0	0.0	16.2	16	15	0
Peru	5	60	0	0.0	0.5	19.7	20	15	0
China	30	24	3	0.0	0.0	26.6	27	13	4
Philippines	4	54	0	0.0	0.0	30.6	31	12	0
Indonesia	5	41	11	0.0	0.0	36.1	36	7	0
Viet Nam	11	23	0	0.0	0.0	59.4	59	7	0
Papua New Guinea	na	na	na	na	na	na	na	na	na
APEC c	9	45	15	0.0	0.1	9.2	9	17	4
High income	3	54	19	0.1	0.1	2.6	3	21	0
Middle income	4	39	21	0.0	0.0	2.2	2	15	19
Low income	24	29	3	0.0	0.0	28.3	28	12	3
– excl. China	7	44	6	0.0	0.0	33.8	34	10	0
World	7	43	16	0.0	0.1	14.1	14	16	3

a Includes solar, wind, tide and wave energy. **b** Combustible renewables and waste. **c** APEC total excludes Papua New Guinea. **na** Not available.
Sources: IEA (2004a,b).

gas in electricity generation in this group. Notably, the Russian Federation has a relatively low oil share (22 per cent) and relatively high gas share (28 per cent). Similar to low income economies, Chile has a relatively high share of final energy consumption sourced from combustible renewables and waste (21 per cent).

Excluding China, 78 per cent of final energy requirements in low income economies are obtained on average from oil (44 per cent) and combustible renewables and waste (34 per cent), with the remainder obtained from electricity (10 per cent), coal (7 per cent) and gas (6 per cent). In China, coal accounts for 30 per cent of final energy consumption, the highest coal share in the APEC region, while the oil share (24 per cent) is low relative to that of most other APEC economies.

Energy consumption in end use activities

In APEC economies, as in the world economy, final energy is mainly used in the industry, transport and residential sectors. In 2002, around 84 per cent of final energy in the APEC region was used in these sectors — 33 per cent in industry, 28 per cent in transport and 23 per cent in residential (table 6). Commercial and public services accounted for a further 10 per cent of final energy consumption.

On average, the share of final energy consumption used in industry is slightly higher in middle income economies (37 per cent) compared with other groups, although the share in China is relatively high (40 per cent). The share of final energy consumption in transport, on average, tends to be higher in the high income group (36 per cent), noting that China has the lowest share of all APEC economies in this sector (only 10 per cent).

Energy consumption in the residential sector is negatively related to income category. On average, 38 per cent of final energy in low income economies (39 per cent excluding China) is used in the residential sector, slightly above the share used in industry. This result may partly reflect data inaccuracies, particularly with the estimates of the combustible renewables and waste shares.

Nonenergy uses of energy resources, such as consumption of lubricants and greases, bitumen and solvents, accounted for 3 per cent of total final energy consumption in the APEC region in 2002.

6 Total final energy consumption (TFEC), by end use activity and by APEC economy, 2002

	Industry	Trans-port	Agri-culture	Com-mercial and public services	Resi-dential	Non-specified other energy use	Non-energy use	Total
	%	%	%	%	%	%	%	%
United States	25	40	1.0	13	17	0.0	4	100
Canada	35	28	1.8	15	16	0.0	3	100
Australia	33	40	2.8	8	13	0.0	3	100
Hong Kong, China	11	54	0.0	23	10	0.1	1	100
Japan	38	26	1.9	17	14	0.9	3	100
Singapore	38	36	0.0	7	4	11.2	3	100
Chinese Taipei	55	24	1.7	5	9	2.5	3	100
New Zealand	41	37	2.4	7	10	0.0	2	100
Republic of Korea	45	24	2.8	12	13	1.4	1	100
Brunei Darussalam	11	56	0.0	21	8	2.7	1	100
Chile	37	32	1.1	4	26	0.0	0	100
Malaysia	42	39	0.3	7	10	0.0	2	100
Mexico	31	41	2.8	4	19	0.0	2	100
Russian Federation	35	20	2.6	5	32	2.4	2	100
Thailand	39	33	5.4	5	16	0.1	2	100
Peru	28	28	5.0	3	34	0.0	2	100
China	40	10	4.2	4	38	1.4	3	100
Philippines	30	35	1.8	8	22	2.9	1	100
Indonesia	27	21	1.7	4	46	0.0	1	100
Viet Nam	16	13	1.2	3	66	0.0	0	100
Papua New Guinea	na	na	na	na	na	na	na	na
APEC a	33	28	2.2	10	23	0.8	3	100
High income	29	36	1.3	13	16	0.3	4	100
Middle income	37	25	2.5	6	25	1.7	2	100
Low income	37	13	3.8	4	38	1.2	3	100
– excl. China	29	24	2.6	4	39	0.3	1	100
World	32	26	2.3	8	27	2.1	3	100

a APEC total excludes Papua New Guinea. **na** Not available.
Sources: IEA (2004a,b).

7 Share of petroleum products in total final energy consumption, by end use activity and by APEC economy, 2002

	Industry	Trans-port	Agri-culture	Com-mercial and public services	Resi-dential	Non-specified other energy use	Non-energy use	Total
	%	%	%	%	%	%	%	%
United States	26	97	98	8	12	0	100	54
Canada	24	91	63	24	10	–	97	43
Australia	16	98	93	9	4	–	100	51
Hong Kong, China	69	100	–	13	2	0	100	66
Japan	48	98	96	51	34	100	100	63
Singapore	81	99	0	0	0	100	100	81
Chinese Taipei	52	99	80	21	25	21	95	60
New Zealand	5	99	65	7	3	–	100	43
Republic of Korea	58	99	86	43	25	56	100	63
Brunei Darussalam	66	100	–	0	41	0	100	68
Chile	29	99	73	22	21	–	–	50
Malaysia	35	100	100	32	21	–	100	60
Mexico	34	100	77	49	42	–	100	66
Russian Federation	11	60	40	5	3	75	85	22
Thailand	34	100	99	0	20	0	100	57
Peru	53	100	50	92	29	–	100	60
China	18	91	50	55	5	2	63	24
Philippines	23	99	64	74	21	0	56	54
Indonesia	31	100	100	9	20	–	100	41
Viet Nam	32	99	85	65	2	–	100	23
Papua New Guinea	na	na	na	na	na	na	na	na
APEC a	27	94	68	22	11	44	91	45
High income	31	97	92	18	14	74	100	54
Middle income	27	80	56	25	10	72	90	39
Low income	20	95	57	49	8	2	65	29
– excluding China	32	100	92	29	16	0	95	44
World	27	95	63	20	12	34	94	43

a APEC total excludes Papua New Guinea. **na** Not available.
Sources: IEA (2004a,b).

Oil, the key focus in energy security assessments, is mainly used in the form of petroleum products in the transport and industry sectors. In 2002, 60 per cent and 20 per cent of final consumption of oil in the APEC region was used in the transport and industry sectors respectively.

Transport is the most oil intensive sector in the APEC region, with 94 per cent of energy sourced from oil in 2002 (table 7). By contrast, oil accounted for only 27 per cent of energy consumption in the industry sector. Nonenergy uses and agriculture, however, are also highly reliant on oil, with oil shares of 91 per cent and 68 per cent respectively, although both activities are relatively low users of oil in absolute terms.

Energy production and self sufficiency in APEC economies

From an energy security perspective, it is useful to distinguish between domestic sources of energy that are within the policy jurisdiction of national governments in the APEC region and imported sources of energy.

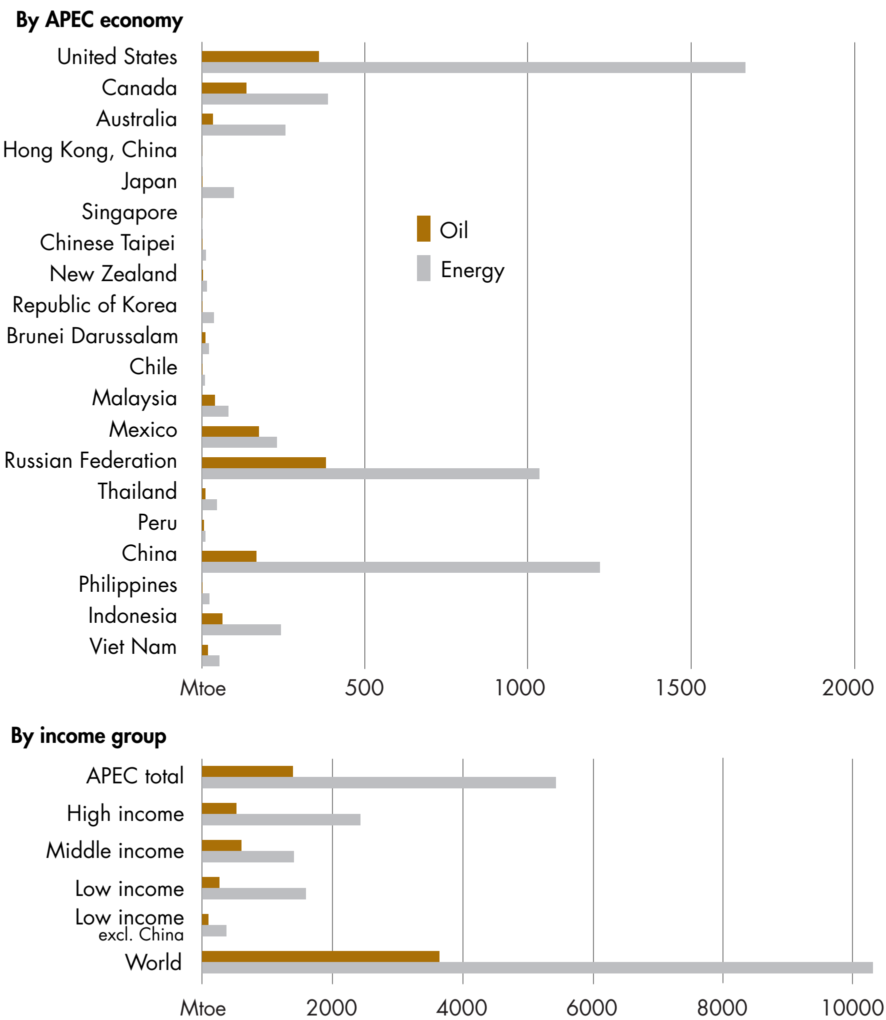
Total primary energy production — including production of coal, oil (crude oil, natural gas liquids and feedstocks), natural gas, nuclear and renewables — in the APEC region was 5433 Mtoe, or 53 per cent of the world level in 2002 (figure 2). High income economies accounted for 24 per cent of world energy production, middle income economies for 14 per cent and low income economies for 15 per cent (4 per cent excluding China).

In 2002 there were seven APEC economies that each accounted for over 1 per cent of world energy production (excluding Papua New Guinea where data are unavailable) — three high income economies and two economies in both the middle and low income groups. The major energy producers in the APEC region include the United States (16.2 per cent of world energy production in 2002), China (11.8 per cent), the Russian Federation (10.0 per cent), Canada (3.7 per cent), Australia (2.5 per cent), Indonesia (2.3 per cent) and Mexico (2.2 per cent).

Japan is the eighth largest energy producer in the APEC region, accounting for 1 per cent of world primary energy production in 2002. It should be noted, however, that 78 per cent of primary energy production in Japan was sourced from nuclear power. To the extent that energy production in the IEA energy database is based on nuclear power generation rather than uranium production, the data should be interpreted with some caution.

In 2002 the APEC region accounted for 64 per cent of world uranium mine production, including Canada (32 per cent of world production), Australia (19 per cent), the Russian Federation (8 per cent), the United States (3 per cent) and China (2 per cent) (World Nuclear Association 2004). Energy

2 Energy and oil production in APEC economies, 2002



production based on uranium production in the APEC region is likely to be slightly higher than indicated in figure 2 since the share of APEC in world nuclear energy is 57 per cent.

Given the strategic importance of oil in energy security risk assessments — strategic in the sense that economies, particularly transport systems, are highly dependent on oil with limited substitution possibilities over the short to medium term — oil production in APEC economies is also indicated in figure 2. In 2002 the APEC region accounted for 38 per cent of world oil production, significantly below the region's share in total energy production. Oil production mainly occurs in the high income economies (15 per cent of world energy production) and middle income economies (17 per cent), with the remaining 7 per cent from low income economies (3 per cent excluding China).

In 2002 there were six major oil producers in the APEC region — two economies from each income group. These included the Russian Federation (10.4 per cent of world energy production in 2002), the United States (9.8 per cent), Mexico (4.8 per cent), China (4.6 per cent), Canada (3.7 per cent) and Indonesia (1.7 per cent).

Energy self sufficiency in APEC economies

The information on total primary energy consumption and energy production in figures 1 and 2, respectively may be used to derive estimates of the energy self sufficiency of each APEC economy. Energy self sufficiency, calculated as energy production divided by energy consumption and presented in percentage terms, provides an indication of the extent to which each APEC economy is able to meet domestic energy requirements from domestic sources.

In 2002, energy self sufficiency in the APEC region was 91 per cent, indicating that the level of energy production was insufficient to cover the APEC region's energy requirements in the corresponding time period (table 8). Notably, there is substantial variation in energy self sufficiency both between income groups and within each group. Energy self sufficiency in the high income economies was only 73 per cent in 2002, compared with 133 per cent in the middle income economies and 102 per cent in the low income economies (110 per cent excluding China).

8 Self sufficiency in energy and specific fuel types, by APEC economy, 2002 a

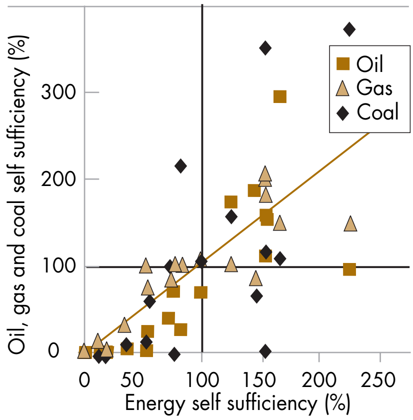
	Coal	Oil	Gas	Nuclear	Renewables	Total b
	%	%	%	%	%	%
United States	102	40	83	100	100	73
Canada	118	158	204	100	100	154
Australia	376	96	143	–	100	226
Hong Kong, China	0	0	0	–	89	0
Japan	0	0	4	100	100	19
Singapore	0	0	0	–	100	0
Chinese Taipei	0	0	10	100	100	12
New Zealand	219	27	100	–	100	83
Republic of Korea	3	1	0	100	100	18
Brunei Darussalam	–	1 522	657	–	100	933
Chile	11	4	29	–	100	36
Malaysia	4	153	179	–	101	155
Mexico	69	186	84	100	100	146
Russian Federation	110	295	147	100	100	167
Thailand	63	24	73	–	100	54
Peru	2	71	100	-	100	77
China	109	69	106	100	100	99
Philippines	16	2	100	–	100	52
Indonesia	354	111	200	–	100	154
Viet Nam	161	174	100	–	100	125
Papua New Guinea	na	na	na	na	na	na
APEC c	105	67	108	100	100	91
High income	102	39	89	100	100	73
Middle income	76	168	136	100	100	133
Low income	114	71	132	100	100	102
– excl. China	207	74	146	–	100	110
World	100	102	100	100	100	101

a Energy production as a percentage of total primary energy consumption (TPEC), based on IEA data. **b** Includes minor adjustments in electricity and heat for Canada and Hong Kong. **c** APEC total excludes Papua New Guinea. **na** Not available.
Sources: Based on IEA (2004a,b).

Importantly, the energy shortfall within the APEC region reflects an oil self sufficiency of 67 per cent in 2002, with regional production slightly exceeding consumption for both coal (self sufficiency of 105 per cent in 2002) and gas (108 per cent).

3 Self sufficiency in energy and specific fuel types, 2002

APEC economies (excluding Brunei)



Oil self sufficiency is particularly low in the high income group (39 per cent) but there is also a substantial shortfall in the low income group (71 per cent, or 74 per cent excluding China). By contrast, the middle income group has substantial oil production in excess of domestic consumption requirements (168 per cent). In 2002, high income economies had a slight shortfall in gas (89 per cent), while middle income economies had a shortfall in coal.

The diversity in the experience of individual APEC economies in self sufficiency for specific major fuel types is indicated in figure 3.

There are twelve APEC economies that recorded an energy self sufficiency below 100 per cent in 2002 — six from the high income group, two from the middle income group and four from the low income group (although China is almost self sufficient). Of these, seven economies were not self sufficient in coal, oil or gas (table 9). Notably, five economies have very low or zero self sufficiency levels for each of these major fuel types — these include Hong Kong, Japan, Singapore, Chinese Taipei and Chile. A further three APEC economies were self sufficient in one specific fuel type, and two economies were self sufficient in two specific fuel types. None of the APEC economies with an energy self sufficiency below 100 per cent were self sufficient in oil.

Energy self sufficiency in the other eight APEC economies for which data are available ranged from 125 per cent in Viet Nam to 933 per cent in Brunei. Of these, one economy was self sufficient in only one fuel type (oil in Mexico), a further three economies were self sufficient in two fuel types and four economies were self sufficient in each of the three major fuel types.

9 Self sufficiency of APEC economies in energy and specific major fuel types (coal, oil and gas), by income category, 2002 a

	Number of specific fuel types in which each economy is self sufficient: coal (c), oil (o) and gas (g)				Total
	0	**1**	**2**	**3**	
	no.	no.	no.	no.	no.
Economies with total energy self sufficiency below 100 per cent					
High income	4	1	1	0	6
	Hong Kong Japan Singapore Chinese Taipei	United States (c)	New Zealand (c,g)		
Middle income	2	0	0	0	2
	Korea Chile				
Low income	1	2	1	0	4
	Thailand	Peru (g) Philippines (g)	China (c,g)		
Total	7	3	2	0	12
Economies with total energy self sufficiency equal to 100 per cent or more					
High income	0	0	1	1	2
			Australia (c,g)	Canada	
Middle income	0	1	2	1	4
		Mexico (o)	Brunei (o,g) Malaysia (o,g)	Russia	
Low income	0	0	0	2	2
				Indonesia Viet Nam	
Total	0	1	3	4	8
APEC economies					
High income	4	1	2	1	8
Middle income	2	1	2	1	6
Low income	1	2	1	2	6
Total	7	4	5	4	20

a Excludes Papua New Guinea due to lack of data.
Sources: Based on IEA (2004a,b).

Seven of the eight economies were self sufficient in oil, ranging from 111 per cent in Indonesia to 1522 per cent in Brunei. The remaining economy, Australia, recorded an oil self sufficiency of 96 per cent in 2002. That is, all APEC economies with an energy self sufficiency that exceeded 100 per cent were self sufficient in, or close to being self sufficient in, oil.

The extent to which the APEC region's self sufficiency position in energy, particularly oil, is projected to change over the longer term is a major issue from an energy security perspective.

APEC energy trade

Energy import dependence in the APEC region is an alternative measure that provides an indication of the extent to which an economy relies on international markets to satisfy domestic energy requirements in a given time period. An energy self sufficiency below 100 per cent indicates that domestic energy consumption exceeds domestic production and requires net energy imports to supply the shortfall and/or a reduction in domestic energy stocks (noting also that petroleum products are also used in international shipping, and are recorded in the energy accounts as international marine bunkers).

Net energy exports of APEC economies in 2002 are presented in absolute terms in figure 4 and as a percentage of total primary energy consumption in figure 5. Net energy imports are indicated by a negative number in the figures, consistent with the balance of payments approach whereby imports are regarded as a cost to the economy while exports provide revenue. Net energy imports in the APEC region were 575 Mtoe in 2002, with net energy imports from high income economies (931 Mtoe) outweighing net energy exports from middle income economies (339 Mtoe) and low income economies (17 Mtoe, or 35 Mtoe excluding China) (table 10).

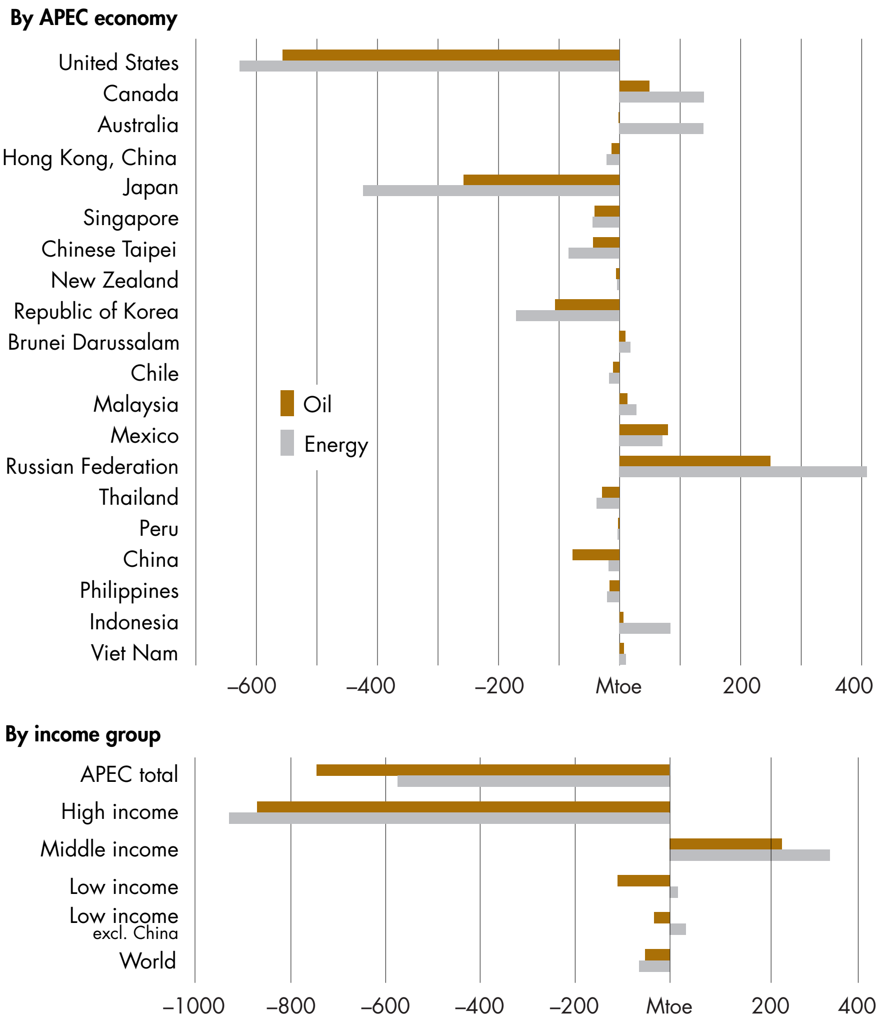
The overall APEC energy trade deficit is mainly driven by the substantial net oil imports in high income economies (872 Mtoe) and, to a much lesser extent, low income economies (110 Mtoe, or 33 Mtoe excluding China). High income economies are also net gas importers (63 Mtoe), while middle income economies are net coal importers (37 Mtoe).

The size of the energy trade position varies widely between APEC economies. In 2002, the three largest net energy importing economies were the

United States (630 Mtoe), Japan (425 Mtoe) and Korea (172 Mtoe) and, in each case, oil was the major contributing factor to the overall net energy trade deficit. The three largest net energy exporting economies were the Russian Federation (410 Mtoe), Canada (139 Mtoe) and Australia (139 Mtoe).

Net energy exports as a percentage of domestic primary energy consumption provides a useful indication of the reliance of the domestic economy on

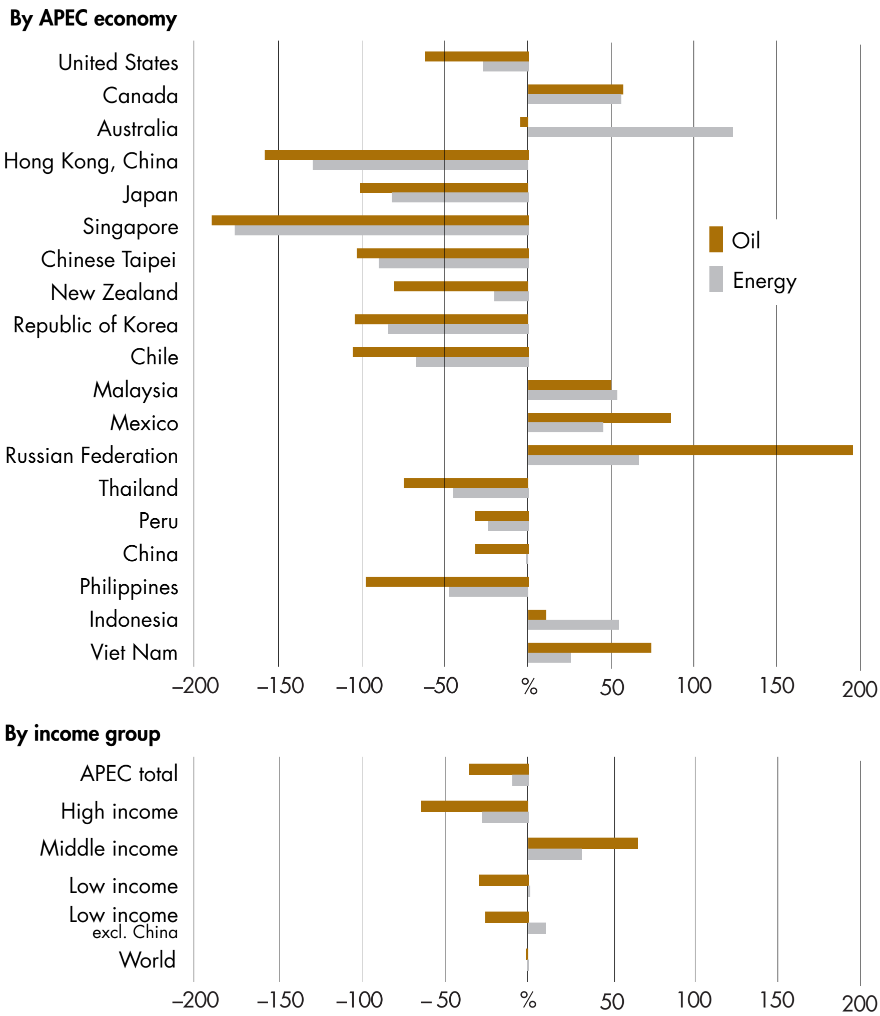
4 Net exports of energy and oil in APEC economies, 2002



imported energy sources in the case of net energy importers, and the size of the export market relative to the domestic market in the case of net energy exporters.

In 2002, 10 per cent of APEC's primary energy consumption was sourced from net imports. Notably, 28 per cent of primary energy consumption in high income economies was sourced from net imports, while net energy

5 Net exports of energy and oil as a percentage of consumption in APEC economies, 2002 excluding Brunei



10 Net energy exports, by fuel type and by APEC economy, 2002 a

	Net exports				Net exports as % of consumption of corresponding fuel type			
	Coal	**Oil**	**Gas**	**Total b**	**Coal**	**Oil**	**Gas**	**Total b**
	Mtoe	Mtoe	Mtoe	Mtoe	%	%	%	%
United States	12	–558	–81	–630	2	–62	–15	–27
Canada	4	49	85	139	12	57	113	56
Australia	131	–2	9	139	269	–5	43	123
Hong Kong, China	–5	–13	–2	–21	–100	–159	–100	–130
Japan	–103	–258	–64	–425	–103	–101	–97	–82
Singapore	0	–41	–4	–45	–100	–191	–100	–177
Chinese Taipei	–34	–44	–6	–84	–103	–103	–90	–90
New Zealand	1	–5	0	–4	109	–81	0	–21
Republic of Korea	–44	–106	–21	–172	–96	–104	–98	–84
Brunei Darussalam	0	10	8	18	–	1 429	556	835
Chile	–2	–10	–4	–17	–82	–106	–71	–67
Malaysia	–2	13	17	28	–94	50	79	53
Mexico	–3	80	–6	71	–43	86	–16	45
Russian Federation	15	250	144	410	14	195	44	66
Thailand	–3	–28	–6	–38	–37	–75	–27	–45
Peru	–1	–2	0	–3	–94	–32	0	–25
China	57	–77	2	–17	8	–32	6	–1
Philippines	–4	–16	0	–20	–85	–98	0	–48
Indonesia	46	6	33	85	254	11	100	54
Viet Nam	3	7	0	11	61	74	0	25
Papua New Guinea	na	na	na	na	na	na	na	na
APEC c	67	–746	103	–575	4	–36	8	–10
High income	6	–872	–63	–931	1	–64	-9	–28
Middle income	–37	237	138	339	–22	66	33	32
Low income	98	–110	29	17	13	–30	32	1
– excl. China	41	–33	27	35	107	–26	46	10
World	–11	–52	–1	–65	0	–1	0	–1

a Net exports (imports) are indicated by a positive (negative) number. **b** Includes small quantities of combustible renewables and waste, and electricity. **c** APEC total excludes Papua New Guinea. **na** Not available.
Sources: IEA (2004a,b).

exports represented 32 and 1 per cent of primary energy consumption in middle and low income economies respectively (or 10 per cent in low income economies excluding China).

The APEC economies that rely on energy imports to meet a large part, or all, of domestic energy requirements are consistent with the economies identified in the previous section with low, or zero, energy self sufficiency (see tables 8 and 9). In some cases, net energy imports exceed domestic energy requirements in the same year, indicating energy stocks have increased during the period (see for example Singapore and Hong Kong). Conversely, APEC economies with net energy exports have levels of self sufficiency above 100 per cent.

4

energy security risks and market volatility in the APEC region

In general terms, energy security refers to the reliable and adequate supply of energy at reasonable prices. From the APEC Energy Security Initiative, potential disruptions to world oil supply remain the major energy security risk in the region. The Middle East and Africa — regions where geopolitical risks are relatively high — are likely to become more important sources of world oil production over the medium to longer term. However, oil is an important energy requirement in all APEC economies and is particularly important for transport where there are limited alternative technologies (or substitution possibilities).

Any risk assessment of temporary energy supply disruptions in the APEC region requires information on:

- the likelihood of potential energy supply disruptions occurring and
- the damage or cost of each potential disruption.

Energy supply disruptions may occur at any point in the energy supply line (upstream, downstream or transport/distribution) and originate at a range of geographic locations affecting one or more fuel types. Disruptions may occur in isolation or simultaneously. Temporary energy supply disruptions may be caused by a range of factors:

- war, civil unrest, acts of terrorism or piracy on key sea lanes, a major focus of energy security concerns in the APEC Energy Security Initiative, may disrupt energy exploration, production, processing or transport activities with the potential to have a major impact on world energy markets. (Disruptions to oil production in the Middle East is the most notable example, although the potential for significant disruptions in world LNG trade is indicated by the experience in Indonesia where gas exploration and LNG production have been disrupted in recent years by security concerns relating to civil unrest in the Aceh province.)
- natural events, such as earthquakes, hurricanes, floods and forest or bush fires, may cause major energy infrastructure damage, although the damage typically occurs at the local or regional level.

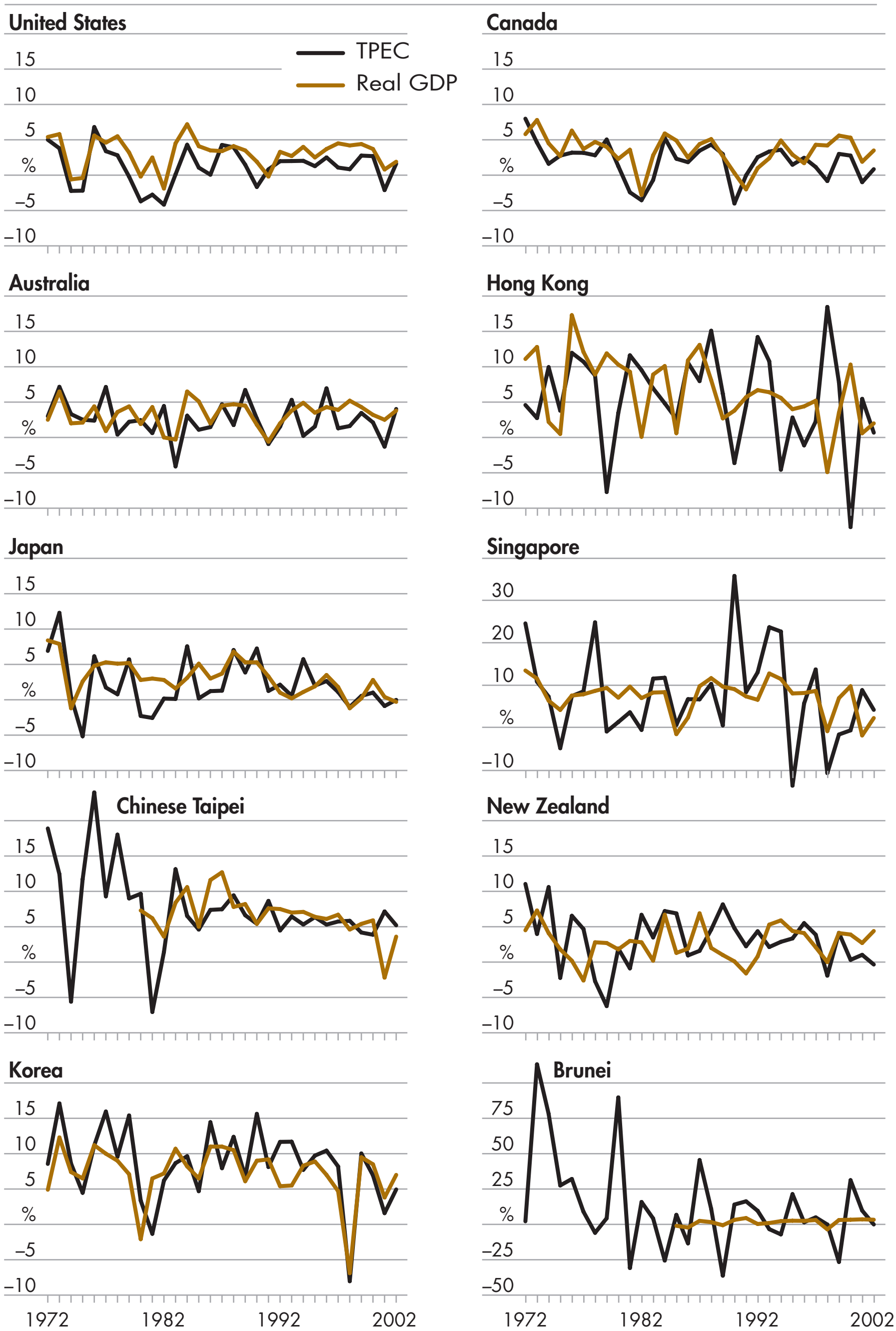
- accidents or technical factors, such as plant breakdown, may disrupt energy supply, although it should be noted that plant shutdown may be anticipated and occurs as part of a regular maintenance program. (An example of unanticipated plant shutdowns is the recent experience in Japan's nuclear power industry where the government has undertaken an assessment of compliance with safety policies to reduce the risk of a future larger disruption in that industry.)
- market factors, such as production decisions and instability associated with major producer groups or cartels, may have significant implications for the world energy market (most notably, OPEC decisions in the 1970s).
- policy factors, such as unintended consequences associated with energy market reform, may distort energy production and pricing outcomes to some extent (as occurred in recent years in California).

If the magnitude and duration of a disruption is significant and unanticipated, there will be consequent direct economic costs for associated conversion and end use activities with flow-on implications for other economic activities. In chapters 5 and 6, ABARE's global trade and environment model (GTEM) is used to quantify the macroeconomic, industry and trade effects of temporary disruptions to oil and LNG production in the Middle East, and a temporary closure to the Strait of Malacca (a critical chokepoint in sea lane access to east Asian markets). Some key policy implications of energy security risks are then examined in chapter 7.

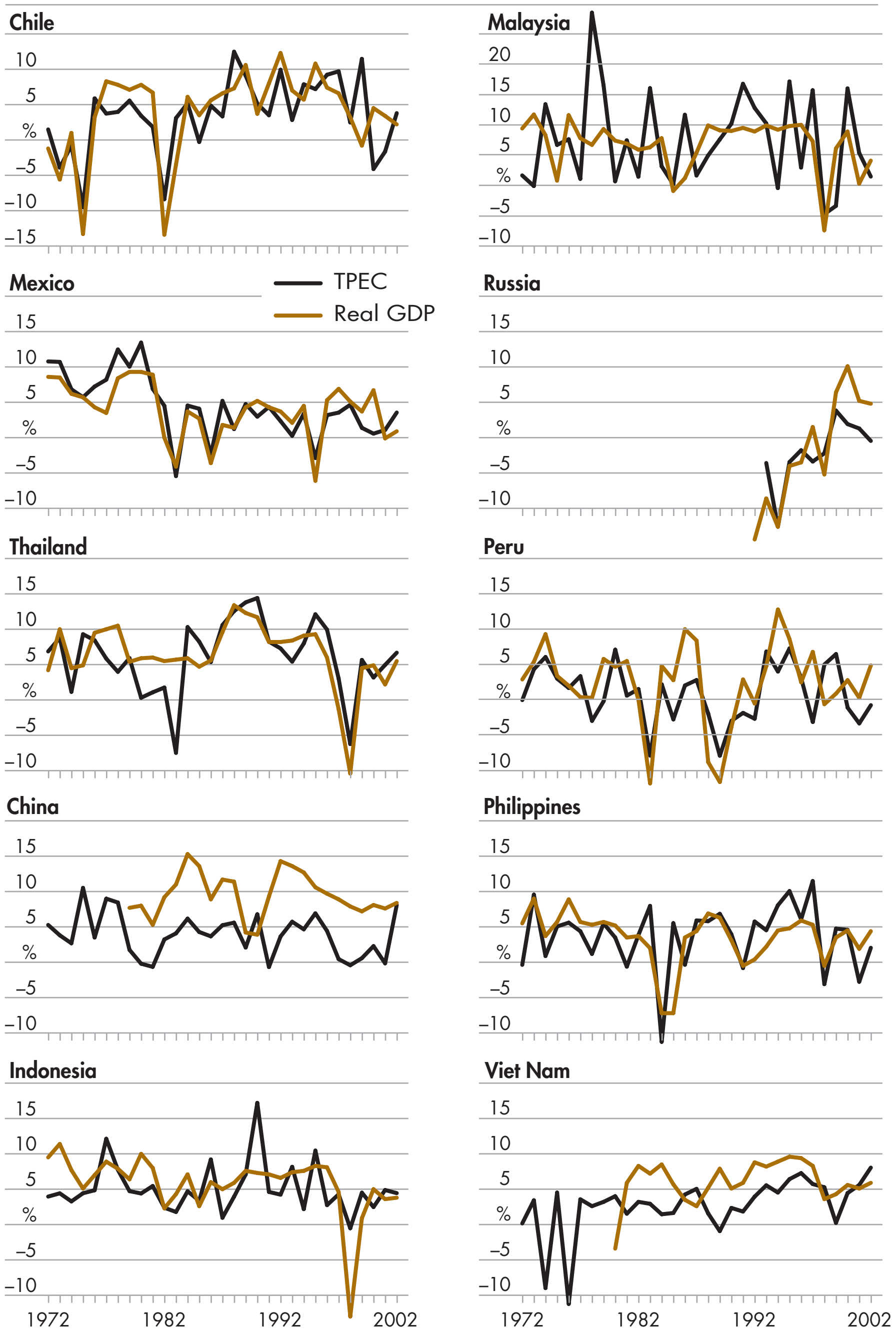
The objective in this chapter is to present relevant information that may contribute to energy security risk assessments that are undertaken by individual APEC economies and that may further contribute to joint assessments within the APEC forum. Information is provided on sources of volatility and downside risks in the energy markets of APEC economies. Based on the historical experience of twenty APEC economies (excludes Papua New Guinea), linkages between output and energy consumption growth are noted (and shown in figure 6 and table 11), and sources of variability in energy markets are examined.

Other aspects relevant to an assessment of energy security risks that are also considered include world energy resource availability and concentration of energy supply in high risk areas. Information on chokepoints in world oil transit and related sea lane security issues is provided in APERC (2002a).

6 Historical growth in output (real GDP) and total primary energy consumption (TPEC) in APEC economies



6 Historical growth in output (real GDP) and total primary energy consumption (TPEC) in APEC economies



Linkages between output and energy consumption growth in APEC economies

Energy is a key input in all sectors of the economy although, as indicated in the previous chapter, there is considerable variation in dependence on specific fuel types. At the national level, the importance of energy use in production is indicated by the relationship between annual growth in output and energy consumption. Annual growth rates in output (measured by real gross domestic product or GDP in domestic currency) and total primary energy consumption (TPEC) since 1972 in twenty APEC economies are presented in figure 6.

Descriptive statistics are provided in table 11 for two time periods — 1972 to 1989, which covers the major world oil price shocks in 1973-74 and 1979-80 and the subsequent downward correction during the 1980s, and 1990 to 2002, which covers the more recent period. The summary information that is provided on the annual percentage change in each variable includes:

- average (or mean) – the simple unweighted sum of the annual percentage change in each variable divided by the number of years.
- standard deviation – a measure of dispersion or variability of the annual percentage changes around the average (a larger standard deviation indicates greater dispersion in annual growth around the average over the time period).
- coefficient of variation – a measure of dispersion that is adjusted for the average growth rate, calculated as the standard deviation divided by the mean (a larger coefficient of variation indicates greater variability in annual growth, relative to the average, over the time period).
- correlation coefficient – a measure of the association between output and energy consumption growth rates (the correlation coefficient ranges from –1.0, indicating fluctuations in growth rates are perfectly negatively related, to 1.0, indicating fluctuations in growth rates are perfectly positively related; a correlation coefficient of 0 indicates that there is no relationship between output and energy consumption growth rates over the time period).

The average growth rates in both output and energy consumption vary considerably between APEC economies and time periods (as noted in the footnotes to table 11, the time period referred to varies in a small number of cases owing to lack of data). In fourteen APEC economies, the average output growth rate for the period 1990–2002 was lower than for the period 1972–89. By contrast, in eight APEC economies, the average growth rate in total primary energy consumption for the period 1990–2002 was lower than for the period 1972–89.

In the majority of APEC economies, output growth rates tended to be higher on average than energy consumption growth rates. However, the number of

11 Descriptive statistics for historical growth in output (real GDP) and total primary energy consumption (TPEC) in APEC economies a

	Average		Standard deviation		Coefficient of variation		Correlation coefficient
	Real GDP	TPEC	Real GDP	TPEC	Real GDP	TPEC	
	%	%	%	%	no.	no.	no.
1972–89							
United States	3.3	1.2	2.5	3.3	0.8	2.7	0.9
Canada	3.8	2.5	2.2	2.7	0.6	1.1	0.7
Australia	3.3	2.8	2.0	2.7	0.6	1.0	0.3
Hong Kong, China	8.3	6.8	5.0	5.1	0.6	0.8	0.0
Japan	4.2	2.5	2.3	4.4	0.6	1.7	0.7
Singapore	7.8	7.2	3.5	8.0	0.5	1.1	0.5
Chinese Taipei **b**	8.1	5.9	2.9	5.5	0.4	0.9	0.4
New Zealand	2.6	3.6	2.5	4.7	1.0	1.3	0.1
Republic of Korea	8.0	9.1	3.3	4.8	0.4	0.5	0.6
Brunei Darussalam **c**	–0.4	2.2	1.9	30.4	–4.4	13.8	0.7
Chile	2.5	2.3	7.2	5.5	2.9	2.4	0.9
Malaysia	6.9	7.2	3.5	7.6	0.5	1.0	0.0
Mexico	4.3	5.9	4.2	4.9	1.0	0.8	0.9
Russian Federation	na	na	na	na	na	na	na
Thailand	7.3	5.8	2.9	5.2	0.4	0.9	0.5
Peru	1.9	0.6	6.5	4.1	3.5	6.6	0.8
China **d**	9.6	3.1	3.4	2.2	0.4	0.7	0.8
Philippines	3.8	3.2	4.4	4.7	1.2	1.5	0.5
Indonesia	6.7	4.8	2.4	2.7	0.4	0.6	0.4
Viet Nam **b**	5.0	2.4	3.6	1.8	0.7	0.7	-0.6

continued

economies where the average energy consumption growth rate exceeded the average output growth rate increased from five in the period 1972–89, to nine in the period 1990–2002 — this would imply an increase in the energy intensity of these economies over the corresponding time period. In the recent period, six of the nine APEC economies where average energy

11 Descriptive statistics for historical growth in output (real GDP) and total primary energy consumption (TPEC) in APEC economies a *continued*

	Average		Standard deviation		Coefficient of variation		Correlation coefficient
	Real GDP	TPEC	Real GDP	TPEC	Real GDP	TPEC	
	%	%	%	%	no.	no.	no.
1990–2002							
United States	2.9	1.2	1.5	1.5	0.5	1.3	0.6
Canada	2.7	1.1	2.2	2.2	0.8	2.0	0.5
Australia	3.3	2.2	1.6	2.3	0.5	1.1	0.4
Hong Kong, China	4.0	3.4	3.6	8.3	0.9	2.5	–0.6
Japan	1.5	1.7	1.8	2.4	1.2	1.4	0.7
Singapore	6.7	8.3	4.4	13.8	0.7	1.7	0.5
Chinese Taipei	5.5	5.7	2.6	1.3	0.5	0.2	–0.2
New Zealand	2.7	2.4	2.3	2.2	0.9	0.9	0.1
Republic of Korea	6.1	7.6	4.3	5.8	0.7	0.8	0.8
Brunei Darussalam	1.8	5.0	2.0	14.4	1.2	2.9	0.2
Chile	5.7	5.2	3.6	4.7	0.6	0.9	0.2
Malaysia	6.6	7.7	5.1	7.9	0.8	1.0	0.6
Mexico	3.1	2.1	3.5	2.1	1.1	1.0	0.7
Russian Federation **e**	–0.7	–2.1	7.3	4.5	–10.6	–2.1	0.9
Thailand	5.0	6.3	5.8	5.0	1.2	0.8	0.9
Peru	3.3	1.3	4.4	4.2	1.3	3.2	0.4
China	9.3	3.2	2.9	3.1	0.3	1.0	0.2
Philippines	2.9	4.1	2.2	4.5	0.7	1.1	0.7
Indonesia	4.3	5.3	5.7	4.5	1.3	0.8	0.5
Viet Nam	6.7	4.6	2.1	2.2	0.3	0.5	0.4

a Average (mean) of the annual percentage change in real gross domestic product (GDP) in domestic currency and total primary energy consumption (TPEC) over the period indicated. Standard deviation is a measure of dispersion around the mean. Coefficient of variation is the standard deviation divided by the mean. Correlation coefficient is a measure of the association between fluctuations in output and energy consumption, and ranges between –1.0 and 1.0. **b** Data for the period 1980–89. **c** Data for the period 1985–89. **d** Data for the period 1979–89. **e** Data for the period 1993–2002. **na** Not available.
Source: Based on IMF (2004a), IEA (2004a,b).

consumption growth exceeded average output growth were not energy self sufficient in 2002 — these include Japan, Singapore, Chinese Taipei, Korea, Thailand and the Philippines (the extent to which these economies are not self sufficient is indicated in tables 8 and 9).

The coefficient of variation is a useful measure of variability that accounts for differences in average growth rates. Based on this measure, in most APEC economies, annual growth in energy consumption was more variable than annual output growth (that is, the coefficient of variation was higher for energy consumption than for output in most APEC economies) — this is consistent with a visual inspection of figure 6. The number of economies where variability in output growth exceeded variability in energy consumption growth increased from two (Chile and Mexico) in the period 1972–89 to four (Chinese Taipei, Mexico, Thailand and Indonesia) in the period 1990–2002.

The correlation coefficient is a useful summary measure of the association between fluctuations in any two time series over a specified time period. In each time period, eleven APEC economies recorded a correlation coefficient of 0.5 or higher, which may be considered to provide an indication of a relatively strong positive association between fluctuations in economic growth rates and fluctuations in energy consumption growth rates. Correlation coefficients of between 0.7 and 0.9 were recorded for several APEC economies in each time period. In a small number of economies, the correlation coefficient was close to zero or negative, indicating a minor or negative contemporaneous relationship between output and energy consumption growth rates.

Energy intensity in APEC economies

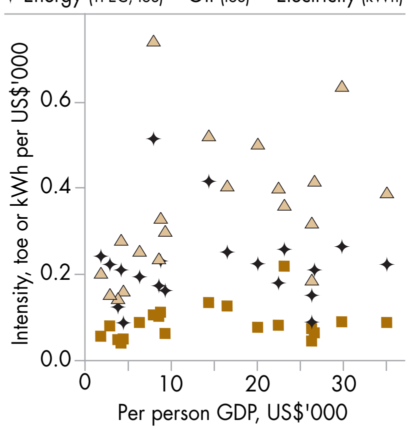
Energy intensity measures provide an indication of the importance of energy consumption in national output. By expressing national output in US dollars, it is possible to compare the energy intensity of individual APEC economies. A higher energy intensity indicates that an economy is relatively more reliant on energy as an input to production, suggesting that the costs of disruptions to energy users in these economies tend to be higher than in economies that are less energy reliant (all else constant).

The intensity of APEC economies with respect to total energy, oil and electricity use in 2002 is presented in figure 7.

These intensity measures are defined as follows:

- energy intensity – total primary energy consumption as a share of per person GDP, expressed in tonnes of oil equivalent per thousand US dollars (where GDP is measured in US dollars on a purchasing power parity basis, consistent with data given in table 1).
- oil intensity – primary consumption of oil (crude oil, natural gas liquids and feedstocks) as a share of per person GDP, expressed in tonnes of oil equivalent per thousand US dollars.
- electricity intensity – electricity generation as a share of per person GDP, expressed in kilowatt hours (kWh) per thousand US dollars.

7 Energy, oil and electricity intensity, by per person GDP in APEC economies, 2002



In 2002, two APEC economies recorded markedly higher primary energy intensity than elsewhere — the Russian Federation (0.51) and Brunei (0.42), both net energy exporting economies in the middle income group. The energy intensity of other APEC economies ranged from 0.09 (Hong Kong and Peru) to 0.26 (Canada and Singapore).

Oil intensity in Singapore (0.22) was substantially higher than elsewhere in the APEC region — Singapore is fully dependent on imports to meet domestic energy requirements. The oil intensity of other APEC economies ranged from 0.04 (China) to 0.14 (Brunei).

Electricity intensity in 2002 was highest in the Russian Federation (0.74) and Canada (0.64), and ranging from 0.15 (the Philippines) to 0.52 (Brunei) in other APEC economies. High income economies, with the exception of Hong Kong (0.19), and middle income economies, with the exception of Mexico (0.24), were more electricity intensive than economies in the low income group.

Sources of variability in the energy markets of APEC economies

It is beyond the scope of this study to undertake a detailed assessment of historical temporary energy supply disruptions and their impact on the APEC region. However, information on the major sources of variability in the energy markets of twenty APEC economies (excluding Papua New Guinea) is provided in this section based on a decomposition of annual growth in total primary energy consumption and total final energy consumption between 1972 and 2002.

This decomposition analysis is described briefly below and descriptive statistics for two time periods, 1972–89 and 1990–2002, are presented. Some emphasis is placed on the most important sources of variability and negative contributions to energy consumption growth. It should be noted, however, that realised energy consumption levels are the outcome of both supply and demand conditions — that is, not all periods of slower or negative growth in energy consumption are caused by temporary supply disruptions in the energy sector.

There are some technical aspects to the statistical analysis presented in this section. As a consequence, readers may prefer to read the nontechnical overview of this in the summary to this report, and skip to the next section.

Decomposition of growth in total primary energy consumption

There are two aspects to the decomposition of annual growth in total primary energy consumption that are of interest in the study:

- decomposition by primary fuel type – the percentage point contribution of primary fuel types to the annual percentage change in total primary energy consumption (for example, the percentage point contribution of oil to TPEC growth is equal to oil consumption in the current year divided by TPEC in the previous year, multiplied by 100).
- decomposition by supply source – the percentage point contribution of supply source to the annual percentage change in total primary energy consumption, where supply source covers domestic production, net imports and stock drawdown (where net imports is imports less exports less international marine bunkers).

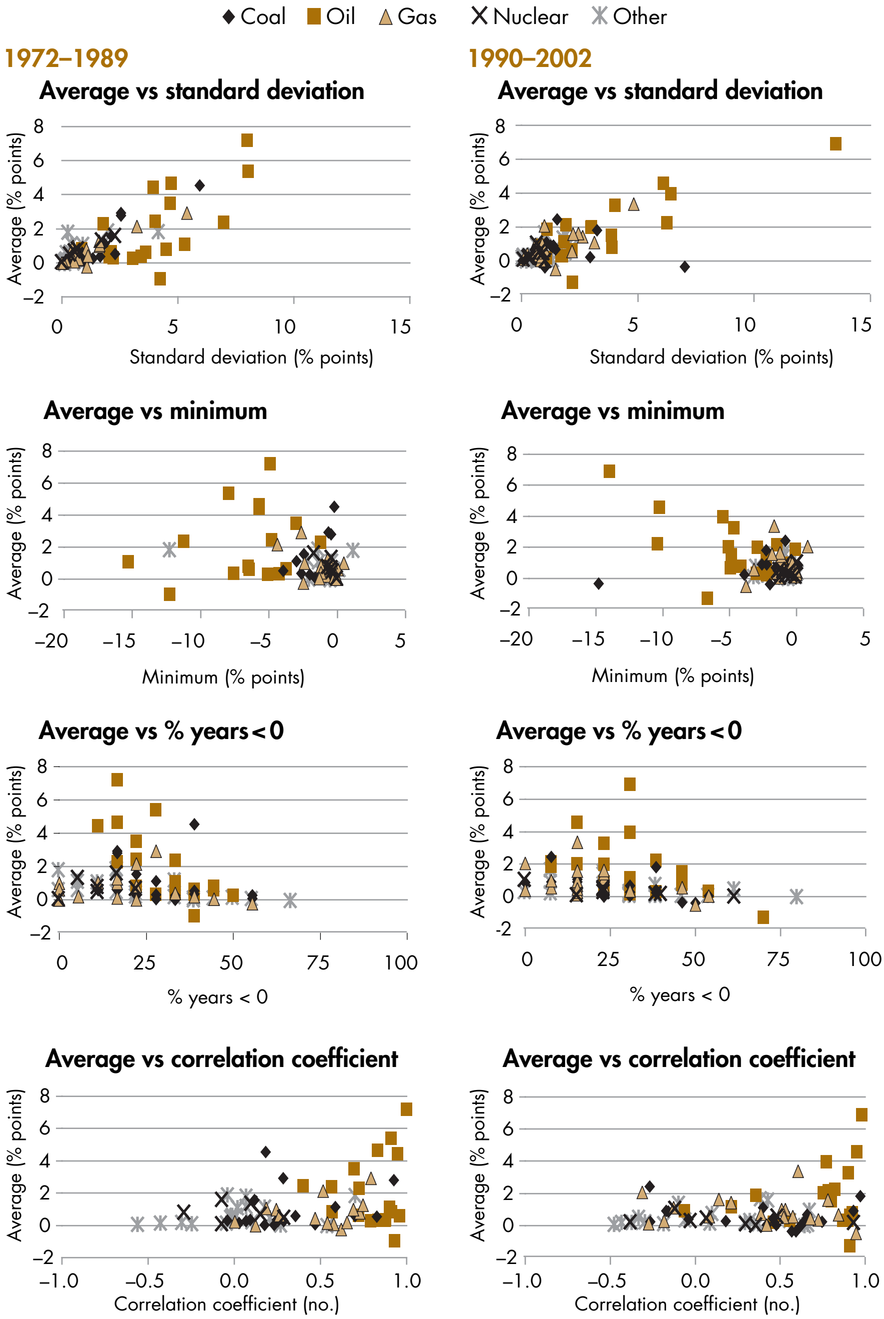
Annual data over the period 1972–2002 for each decomposition of annual growth in total primary energy consumption in twenty APEC economies are provided in appendix B. For example, in Australia, TPEC increased by 4.0 per cent in 2002 due to growth in consumption of coal (contributing 0.6 percentage points to TPEC growth), oil (1.4 percentage points), gas (0.3 percentage points) and other fuel types (1.7 percentage points) — that is, the sum of the percentage point contributions of fuel types (or supply sources) equals TPEC growth (see table 27).

Descriptive statistics are presented to summarise some of the key characteristics in this decomposition analysis and include most importantly:

- average (or mean) – the average annual percentage change or percentage point contribution (that is, the simple unweighted sum of the annual percentage change or percentage point contribution in each variable divided by the number of years).
- standard deviation – a measure of dispersion or variability of the annual percentage change or percentage point contribution of a variable around its average (a larger standard deviation indicates greater dispersion around the average over the time period).
- minimum – the lowest annual percentage change or percentage point contribution of a variable within the specified time period.
- % years < 0 – the percentage of years in the specified time period in which a variable records a negative annual percentage change or percentage point contribution (that is, the number of years in which a variable records a negative annual percentage change or percentage point contribution, calculated as a percentage of the total number of years within the specified time period).
- correlation coefficient – a measure of the association over time between the annual energy consumption growth rate and the percentage point contribution of a variable (as noted previously, the correlation coefficient ranges from –1.0 for a perfect negative association to 1.0 for a perfect positive association).

An overview of the descriptive statistics for the decomposition of TPEC growth by fuel type is provided in figure 8 — in this figure, the average percentage point contribution of each fuel type is graphed against each of the other four descriptive statistics given above for each time period. Descriptive statistics are provided in table 12 for the two subperiods.

8 **Overview of descriptive statistics for the percentage point contributions of fuel types to TPEC growth in APEC economies** excludes Brunei and PNG



12 Decomposition of annual growth in total primary energy consumption, by fuel type and supply source
Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports **a**	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
United States									
1972–89									
Average	0.6	0.3	-0.2	0.4	0.1	1.2	0.6	0.6	0.1
SD **b**	0.8	2.2	1.1	0.4	0.2	3.3	2.3	2.8	2.1
Minimum **c**	-0.9	-4.2	–2.5	–0.3	–0.3	–4.2	–3.6	–5.9	–3.8
% years < 0 **d**	17	39	56	11	22	33	50	39	39
Correlation **e**	0.7	0.9	0.6	0.3	0.1	1.0	0.4	0.7	0.1
1990–2002									
Average	0.3	0.3	0.4	0.2	0.0	1.2	0.2	1.0	0.0
SD **b**	0.4	0.9	0.8	0.4	0.3	1.5	1.4	1.4	2.5
Minimum **c**	–0.3	–1.8	–1.4	–0.6	–0.9	–2.1	–2.3	–1.1	–4.9
% years < 0 **d**	31	31	31	23	54	15	54	31	46
Correlation **e**	0.6	0.6	0.7	0.0	0.7	1.0	–0.3	0.2	0.7
Canada									
1972–89									
Average	0.4	0.3	0.8	0.6	0.4	2.5	3.8	–1.4	0.1
SD **b**	0.6	2.0	1.1	0.6	0.5	2.7	6.3	4.7	2.1
Minimum **c**	–1.0	–4.2	–1.2	–0.4	–1.1	–3.6	–4.0	–8.5	–3.5
% years < 0 **d**	22	28	22	22	22	17	33	56	39
Correlation **e**	0.1	0.8	0.7	0.2	0.2	1.0	0.7	–0.2	–0.3
1990–2002									
Average	0.1	0.2	0.7	0.0	0.2	1.1	3.8	–2.9	0.1
SD **b**	0.7	1.1	1.0	1.1	0.5	2.2	3.3	2.7	2.0
Minimum **c**	–1.5	–2.2	–1.2	–1.2	–0.7	–4.1	–0.6	–8.0	–2.8
% years < 0 **d**	31	31	23	62	31	31	15	92	46
Correlation **e**	0.4	0.5	0.8	0.4	0.3	1.0	0.6	–0.1	0.3
Australia									
1972–89									
Average	1.1	0.6	1.0	0.0	0.1	2.8	7.6	-4.6	–0.2
SD **b**	1.8	2.1	0.5	0.0	0.3	2.7	7.1	6.8	6.6
Minimum **c**	–3.0	–3.7	0.5	0.0	–0.4	–4.1	–9.0	–20.7	–9.7
% years < 0 **d**	28	39	0	0	44	6	11	72	56
Correlation **e**	0.6	0.7	0.2	–	0.0	1.0	0.2	0.3	–0.1
1990–2002									
Average	1.1	0.3	0.6	0.0	0.3	2.2	8.6	–6.3	–0.2
SD **b**	1.1	1.7	0.6	0.0	0.6	2.3	6.3	5.0	3.6
Minimum **c**	–0.5	–3.0	–1.1	0.0	–0.5	–1.3	–1.0	–13.0	–5.2
% years < 0 **d**	15	38	8	0	23	15	15	77	38
Correlation **e**	0.4	0.9	0.1	–	0.6	1.0	–0.4	0.6	0.4

12 Decomposition of annual growth in total primary energy consumption, by fuel type and supply source
Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock draw-down
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
Hong Kong									
1972–1989									
Average	4.5	2.4	0.0	0.0	-0.1	6.8	0.0	6.9	-0.1
SD **b**	5.9	7.0	0.0	0.0	0.2	5.1	0.0	6.5	4.0
Minimum c	–0.2	–11.3	0.0	0.0	–0.5	–7.8	0.0	–4.9	–5.9
% years < 0 **d**	39	33	0	0	67	6	6	11	56
Correlation **e**	0.2	0.6	–	–	0.5	1.0	–0.1	0.8	0.0
1990–2002									
Average	–0.4	2.2	1.1	0.0	0.4	3.4	0.0	3.2	0.2
SD **b**	7.0	6.3	3.1	0.0	1.9	8.3	0.0	8.3	1.7
Minimum **c**	–14.8	–10.4	–1.2	0.0	–1.5	–12.8	0.0	–11.2	–3.0
% years < 0 **d**	46	38	23	0	62	31	0	23	46
Correlation **e**	0.6	0.8	–0.1	–	–0.3	1.0	0.2	1.0	0.1
Japan									
1972–89									
Average	0.3	0.8	0.6	0.7	0.1	2.5	0.5	2.0	0.0
SD **b**	1.3	4.5	0.6	0.7	0.3	4.4	0.9	5.4	1.1
Minimum **c**	–2.0	–6.5	0.0	–0.6	–0.5	–5.2	–1.2	–7.1	–1.3
% years < 0 **d**	56	44	0	11	33	17	28	39	61
Correlation **e**	0.3	0.9	0.3	–0.3	–0.3	1.0	–0.4	1.0	–0.6
1990–2002									
Average	0.4	0.3	0.4	0.5	0.1	1.7	0.5	1.2	0.1
SD **b**	0.6	1.8	0.3	0.8	0.3	2.4	0.9	2.4	0.7
Minimum **c**	–0.9	–1.9	0.0	–1.2	–0.4	–1.0	–1.5	–2.1	–1.5
% years < 0 **d**	15	54	0	23	38	23	23	46	46
Correlation **e**	0.5	0.9	0.7	0.5	0.1	1.0	0.4	0.9	–0.1
Singapore									
1972–89									
Average	0.0	7.2	0.0	0.0	0.0	7.2	0.0	9.6	–2.4
SD **b**	0.0	8.0	0.0	0.0	0.1	8.0	0.0	36.3	36.2
Minimum **c**	–0.1	–4.9	0.0	0.0	–0.1	–4.9	0.0	–42.2	–62.2
% years < 0 **d**	33	17	0	0	56	17	0	56	44
Correlation **e**	0.2	1.0	–	–	–0.6	1.0	–	0.1	0.1
1990–2002									
Average	0.0	6.9	1.4	0.0	0.0	8.3	0.0	7.4	1.0
SD **b**	0.0	13.5	2.6	0.0	0.1	13.8	0.1	14.7	8.8
Minimum **c**	–0.1	–14.0	–1.2	0.0	0.0	–13.7	0.0	–15.2	–11.4
% years < 0 **d**	23	31	23	0	31	31	0	31	54
Correlation **e**	0.6	1.0	0.2	–	–0.2	1.0	–0.1	0.8	0.2

12 Decomposition of annual growth in total primary energy consumption, by fuel type and supply source
Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
Chinese Taipei									
1972–89									
Average	1.6	5.4	0.2	1.5	0.1	8.7	1.3	7.0	0.4
SD **b**	2.1	8.0	0.7	2.3	0.4	7.7	2.3	8.7	5.1
Minimum **c**	–2.4	–7.9	–0.8	–1.6	–0.6	–7.1	–2.0	–7.1	–8.2
% years < 0 **d**	22	28	39	17	50	11	33	17	50
Correlation **e**	0.1	0.9	0.7	–0.1	–0.4	1.0	0.1	0.8	0.1
1990–2002									
Average	2.4	2.1	0.7	0.4	0.0	5.7	0.3	5.7	–0.2
SD **b**	1.5	1.9	0.6	1.0	0.3	1.3	0.9	2.9	4.1
Minimum **c**	–0.8	–1.5	–0.2	–0.9	–0.5	3.9	–0.9	0.2	–7.9
% years < 0 **d**	8	8	15	23	46	0	38	0	62
Correlation **d**	–0.3	0.8	0.4	0.1	–0.5	1.0	–0.2	–0.5	0.7
New Zealand									
1972–89									
Average	0.1	0.3	2.1	0.0	1.1	3.6	4.6	–1.0	0.0
SD **b**	1.0	3.1	3.2	0.0	1.9	4.7	4.5	4.5	2.3
Minimum **c**	–1.6	–5.1	–4.4	0.0	–2.1	–6.3	–7.1	–7.7	–2.9
% years < 0 **d**	56	50	22	0	33	22	17	50	50
Correlation **e**	0.5	0.8	0.5	–	0.1	1.0	0.8	0.4	–0.2
1990–2002									
Average	0.0	1.1	0.6	0.0	0.7	2.4	1.7	0.7	–0.1
SD **b**	0.7	1.8	2.2	0.0	2.2	2.2	3.4	1.9	1.8
Minimum **c**	–1.2	–2.2	–3.2	0.0	–3.0	–2.0	–4.7	–1.3	–3.7
% years < 0 **d**	54	31	46	0	38	15	38	54	62
Correlation **e**	0.5	0.2	0.6	–	0.1	1.0	0.8	–0.4	0.2
Republic of Korea									
1972–89									
Average	2.9	4.6	0.2	1.3	0.0	9.1	2.0	7.0	0.2
SD **b**	2.5	4.7	0.7	1.7	0.1	4.8	2.3	4.4	3.3
Minimum **c**	–0.6	–5.7	–0.1	–0.4	–0.2	–1.3	–2.5	1.7	–4.8
% years < 0 **d**	17	17	6	6	39	6	11	0	56
Correlation **e**	0.3	0.8	0.0	0.1	–0.2	1.0	0.1	0.7	0.4
1990–2002									
Average	0.9	4.6	1.0	1.0	0.1	7.6	0.6	7.0	0.0
SD **b**	1.4	6.1	0.6	0.7	0.1	5.8	1.1	6.6	1.8
Minimum **c**	–2.6	–10.2	–0.5	0.1	0.0	–8.0	–1.7	–10.3	–3.4
% years < 0 **d**	15	15	8	0	8	8	31	15	31
Correlation **e**	–0.2	1.0	0.5	–0.1	–0.3	1.0	–0.4	0.9	0.1

12 Decomposition of annual growth in total primary energy consumption, by fuel type and supply source Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
Brunei Darussalam									
1972–89									
Average	0.0	1.7	16.0	0.0	0.0	17.7	235.3	–239.2	21.5
SD **b**	0.0	14.3	37.5	0.0	0.1	41.0	596.9	642.1	136.7
Minimum **c**	0.0	–44.3	–33.0	0.0	–0.1	–36.8	–191.2	–2060.7	–117.1
% years < 0 **d**	0	39	28	0	11	28	33	44	44
Correlation **e**	–	0.4	0.9	–	0.5	1.0	0.5	–0.3	–0.2
1990–2002									
Average	0.0	1.8	3.2	0.0	0.0	5.0	24.8	–20.0	0.2
SD **b**	0.0	6.9	15.8	0.0	0.0	14.4	38.8	32.9	8.8
Minimum **cc**	0.0	–6.6	–24.8	0.0	–0.1	–27.1	–28.7	–80.9	–15.5
% years < 0 **d**	0	38	46	0	31	38	31	69	54
Correlation **e**	–	0.0	0.9	–	–0.2	1.0	0.4	–0.1	0.1
Chile									
1972–89									
Average	0.5	0.4	0.4	0.0	1.0	2.3	1.2	0.9	0.1
SD **b**	2.3	3.4	1.1	0.0	0.9	5.5	2.7	8.8	4.8
Minimum **c**	–4.0	–7.6	–1.2	0.0	–1.3	–9.5	–3.6	–17.5	–9.3
% years < 0 **d**	39	33	33	0	11	28	17	44	56
Correlation **e**	0.8	0.9	0.5	–	0.0	1.0	0.3	0.8	–0.5
1990–2002									
Average	0.2	2.0	1.6	0.0	1.3	5.2	0.6	4.6	0.0
SD **b**	2.9	3.0	2.5	0.0	1.8	4.7	1.7	4.5	2.8
Minimum **c**	–3.9	–5.1	–1.3	0.0	–0.9	–4.1	–2.6	–4.1	–3.9
% years < 0 **d**	38	15	23	0	23	15	38	15	54
Correlation **e**	0.7	0.8	0.1	–	–0.1	1.0	–0.3	0.8	0.5
Malaysia									
1972–89									
Average	0.3	3.5	2.9	0.0	0.6	7.2	19.8	–12.6	0.1
SD **b**	0.8	4.7	5.4	0.0	0.4	7.6	20.2	16.8	4.3
Minimum **c**	–0.6	–3.0	–2.6	0.0	–0.3	–0.1	–9.9	–44.2	–10.3
% years < 0 **d**	33	22	28	0	6	6	22	78	56
Correlation **e**	0.1	0.7	0.8	–	0.0	1.0	0.6	–0.3	0.2
1990–2002									
Average	0.3	4.0	3.4	0.0	0.1	7.7	7.8	0.0	–0.1
SD **b**	0.8	6.4	4.8	0.0	0.3	7.9	6.4	5.8	2.8
Minimum **c**	–1.2	–5.5	–1.7	0.0	–0.3	–4.7	–4.1	–12.2	–4.8
% years < 0 **d**	23	31	15	0	31	23	8	38	62
Correlation **e**	0.2	0.8	0.6	–	–0.4	1.0	0.7	0.5	0.2

12 Decomposition of annual growth in total primary energy consumption, by fuel type and supply source
Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
Mexico									
1972–89									
Average	0.1	4.4	1.0	0.0	0.4	5.9	10.8	–4.8	–0.1
SD **b**	0.4	3.9	1.6	0.0	0.4	4.9	12.7	9.9	0.8
Minimum **c**	–0.8	–5.7	–2.4	0.0	–0.2	–5.5	–9.5	–25.5	–1.5
% years < 0 **d**	33	11	17	0	17	11	22	61	56
Correlation **e**	0.0	0.9	0.7	–0.1	0.0	1.0	0.7	–0.4	–0.1
1990–2002									
Average	0.2	0.6	1.0	0.1	0.1	2.1	2.2	–0.2	0.1
SD **b**	0.3	2.2	0.9	0.3	0.4	2.1	3.5	3.1	0.9
Minimum **c**	–0.2	–4.9	–0.3	–0.3	–0.8	–3.0	–3.8	–5.0	–1.4
% years < 0 **d**	15	23	15	38	31	8	31	62	54
Correlation **e**	–0.3	0.9	0.5	–0.4	–0.4	1.0	0.5	0.1	–0.1
Russian Federation									
1972–92									
Average	na	na	na	na	na	na	na	na	na
SD **b**	na	na	na	na	na	na	na	na	na
Minimum **c**	na	na	na	na	na	na	na	na	na
% years < 0 **d**	na	na	na	na	na	na	na	na	na
Correlation **e**	na	na	na	na	na	na	na	na	na
1993–2002									
Average	–0.4	–1.3	–0.5	0.1	–0.1	–2.1	–0.9	–1.4	0.1
SD **b**	1.0	2.2	1.5	0.4	0.3	4.5	5.5	3.0	1.4
Minimum **c**	–2.0	–6.7	–3.8	–0.7	–0.6	–12.7	–9.5	–6.9	–2.3
% years < 0 **d**	50	70	50	40	80	70	50	80	40
Correlation **e**	0.6	0.9	0.9	0.9	0.6	1.0	0.8	0.0	0.1
Thailand									
1972–1989									
Average	0.6	2.4	1.1	0.0	1.8	5.8	3.9	2.0	0.0
SD **b**	0.9	4.0	1.6	0.0	4.2	5.2	5.3	4.8	2.0
Minimum **c**	–0.2	–4.8	–0.4	0.0	–12.2	–7.6	–9.7	–5.9	–4.0
% years < 0 **d**	11	22	11	0	17	6	17	22	44
Correlation **e**	0.4	0.4	0.2	–	0.7	1.0	0.7	0.3	0.1
1990–2002									
Average	0.9	3.3	2.1	0.0	0.0	6.3	2.8	3.3	0.2
SD **b**	1.3	4.0	1.0	0.0	1.4	5.0	2.6	4.6	1.1
Minimum **c**	–2.2	–4.6	0.8	0.0	–3.1	–6.3	–1.3	–6.0	–2.6
% years < 0 **d**	8	23	0	0	38	8	23	23	31
Correlation **e**	0.9	0.9	–0.3	–	0.4	1.0	0.5	0.8	–0.1

12 Decomposition of annual growth in total primary energy consumption, by fuel type and supply source Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock draw-down
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
Peru									
1972–89									
Average	0.0	0.6	0.1	0.0	–0.1	0.6	1.9	–1.4	0.1
SD **b**	0.2	3.6	0.5	0.0	1.0	4.1	9.9	10.4	1.7
Minimum **c**	–0.4	–6.5	–1.3	0.0	–2.0	–7.9	–11.8	–33.0	–3.2
% years < 0 **d**	28	44	44	0	39	39	33	50	50
Correlation **e**	0.2	1.0	0.6	–	0.3	1.0	0.2	0.2	–0.1
1990–2002									
Average	0.4	0.8	0.0	0.0	0.1	1.3	–1.1	2.5	–0.1
SD **b**	0.8	3.9	0.8	0.0	1.0	4.2	2.8	5.0	5.0
Minimum **c**	–0.5	–4.2	–1.2	0.0	–2.5	–3.3	–7.7	–5.5	–7.8
% years < 0 **d**	38	46	54	0	38	54	69	38	54
Correlation **e**	0.0	0.9	0.4	–	0.3	1.0	0.5	0.2	0.4
China									
1972–89									
Average	2.8	0.8	0.1	0.0	0.5	4.3	4.7	–0.3	–0.1
SD **b**	2.5	0.9	0.2	0.0	0.2	2.9	3.1	0.6	1.2
Minimum **c**	–0.4	–0.8	–0.2	0.0	0.2	–0.7	–0.5	–1.3	–3.9
% years < 0 **d**	17	22	17	0	0	11	11	72	33
Correlation **e**	0.9	0.6	0.5	–	0.0	1.0	0.9	–0.2	0.2
1990–2002									
Average	1.8	0.9	0.1	0.0	0.3	3.2	2.7	0.3	0.1
SD **b**	3.2	0.8	0.1	0.1	0.1	3.1	2.9	1.2	1.5
Minimum **c**	–2.3	–0.7	0.0	–0.1	0.1	–0.8	–1.7	–2.4	–2.2
% years < 0 **d**	38	23	15	15	0	23	15	31	46
Correlation **e**	1.0	–0.1	–0.3	0.3	–0.1	1.0	0.8	0.2	0.3
Philippines									
1972–89									
Average	0.3	1.1	0.0	0.0	1.8	3.2	2.0	1.0	0.1
SD **b**	0.7	5.3	0.0	0.0	2.0	4.7	2.6	5.0	6.2
Minimum**c**	–1.2	–15.3	0.0	0.0	–1.4	–11.4	–1.9	–13.4	–14.4
% years < 0 **d**	28	33	0	0	17	22	22	17	56
Correlation **e**	0.0	0.9	–	–	0.0	1.0	0.1	0.2	0.6
1990–2002									
Average	0.8	1.5	0.3	0.0	1.5	4.1	1.8	2.3	0.1
SD **b**	1.3	3.9	0.9	0.0	2.0	4.5	1.9	4.2	2.5
Minimum **c**	–1.1	–4.8	0.0	0.0	–2.1	–3.2	–1.9	–4.3	–4.0
% years < 0 **d**	23	46	15	0	23	23	15	31	54
Correlation **e**	0.5	0.8	–0.2	–	0.4	1.0	0.3	0.7	0.3

12 Decomposition of annual growth in total primary energy consumption, by fuel type and supply source
Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports **a**	Stock draw-down
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
Indonesia									
1972–89									
Average	0.3	2.3	1.3	0.0	1.0	4.8	9.3	–4.7	0.3
SD **b**	0.5	1.8	1.6	0.0	0.5	2.7	15.6	13.5	4.4
Minimum **c**	–0.1	–1.2	–0.7	0.0	–0.3	0.9	–22.6	–25.2	–8.7
% years < 0 **d**	22	17	17	0	6	0	22	56	50
Correlation **e**	0.3	0.7	0.7	–	0.2	1.0	0.4	–0.3	–0.1
1990–2002									
Average	0.9	2.0	1.6	0.0	0.9	5.3	6.7	–1.5	0.1
SD**b**	0.9	3.0	2.2	0.0	0.7	4.5	5.7	5.0	1.0
Minimum **c**	0.1	–2.9	–1.9	0.0	0.0	–0.6	–4.7	–10.8	–2.3
% years < 0 **d**	0	23	15	0	8	8	8	69	46
Correlation **e**	–0.2	0.8	0.8	–	0.7	1.0	0.6	0.2	0.2
Viet Nam									
1972–89									
Average	0.4	–1.0	0.0	0.0	1.7	1.1	2.4	–1.3	0.0
SD **b**	1.7	4.3	0.1	0.0	0.3	4.4	2.0	5.0	1.0
Minimum **c**	–2.7	–12.3	–0.1	0.0	1.2	–11.3	–1.9	–14.2	–1.5
% years < 0 **d**	39	39	22	0	0	17	11	56	28
Correlation **e**	0.2	0.9	0.1	–	0.1	1.0	–0.1	0.9	–0.1
1990–2002									
Average	0.7	1.9	0.5	0.0	1.6	4.6	7.6	–3.0	0.0
SD **b**	1.5	1.1	0.8	0.0	1.0	2.2	2.0	2.7	2.1
Minimum **c**	–1.5	–0.1	0.0	0.0	–0.9	0.1	4.5	–7.6	–4.2
% years < 0 **d**	31	8	15	0	8	0	0	77	46
Correlation **e**	0.7	0.4	0.5	–	0.4	1.0	0.5	0.6	–0.2

a Including international marine bunkers. **b** Standard deviation. **c** Minimum observation. **d** Number of years in which a negative observation occurs as a percentage of the total number of years. **e** Correlation coefficient between the percentage change in TPEC and the percentage point contribution of the variable indicated.
Source: Based on IEA energy database; see IEA (2004a, b).

Descriptive statistics for individual years for the full period, 1972–2002, are given in appendix B.

A key issue of interest in the current study is the extent to which energy market variability is associated with the oil market and, for net energy importing economies, with net imports.

Some key observations are made in the following discussion, although it should be emphasised that the descriptive statistics should be interpreted with some caution and are specific to the circumstances of individual APEC economies. For example, data for the Russian Federation, which are available only for 1993–2002, indicate an upward trend in energy consumption growth rates. Hence the measures of dispersion (standard deviation) and downside contributions (minimum and % years < 0) should ideally be interpreted against this background.

Decomposition by primary fuel type

Not all APEC economies consume all primary fuel types. Nuclear power did not contribute to TPEC growth in China in the period 1972–89 or in twelve APEC economies in either time period (including Australia, Hong Kong, Singapore, New Zealand, Brunei, Chile, Malaysia, Thailand, Peru, the Philippines, Indonesia and Viet Nam). In the earlier period, gas was not consumed in three APEC economies (Hong Kong, Singapore and the Philippines) and coal was not consumed in Brunei.

Average

Annual growth in TPEC may be averaged over some specified time period to provide an indication (or summary measure) of the overall strength of TPEC growth during the period. The average percentage point contribution of a fuel type provides an indication (or summary measure) of the extent to which consumption of that fuel type has contributed to average TPEC growth during the period.

For example, in Australia, TPEC increased on average by 2.5 per cent a year over the period 1972–2002 as a result of increased consumption of coal (1.1 percentage points), oil (0.5 percentage points), gas (0.8 percentage points) and other fuel types (0.1 percentage points) (see table 27).

In a small number of cases, the average percentage point contribution of a primary fuel type to TPEC growth was negative — gas in the United States (–0.2 percentage points for the period 1972–89), coal in Hong Kong (–0.4, 1990–2002), all fuel types except nuclear in the Russian Federation (ranging from –1.3 to –0.1, 1993–2002) and oil in Viet Nam (–1.0, 1972–89).

In all other cases, the average percentage point contribution of each primary fuel type to TPEC growth was positive. Oil provided the highest (or equal highest) percentage point contribution, on average, to TPEC growth in eleven APEC economies over the period 1990–2002 (nine APEC economies over the period 1972–89). In some of these APEC economies, the percentage point contribution of oil was substantially higher than that for other fuel types (see, for example, Singapore, Korea and Thailand).

Coal, gas, nuclear and other (mainly renewables) provided the highest (or equal highest) percentage point contribution, on average, to TPEC growth in three, four, two and one APEC economies respectively in the period 1990–2002 (four, three, zero and three economies respectively in the period 1972–89; note the earlier period is based on nineteen APEC economies since the Russian Federation is excluded, while oil and other fuel recorded equal highest percentage point contributions in the Philippines in the latter period).

Measures of variability

Four summary measures of volatility in energy markets are reported, including variability in annual growth rates (standard deviation), minimum and negative contributions of individual fuel types to annual TPEC growth (minimum observation and percentage of years of negative observations respectively) and the strength of the relationship between individual fuel types and TPEC growth (correlation coefficient).

The variability of the percentage point contribution of each fuel type around the average is indicated by the standard deviation. Based on this measure, the percentage point contribution of oil to TPEC growth was more variable than other fuel types in fifteen APEC economies in the period 1990–2002 (fourteen economies in the period 1972–89). By contrast, coal, gas, nuclear and other fuels recorded the largest (or equal largest) standard deviation in only three, two, one and one APEC economies respectively in the period 1990–2002 (one, three, zero and one economies respectively in the period 1972–89).

The minimum percentage point contribution is a measure of the downside contribution of a fuel type to TPEC growth within a given time period. Oil was associated with the lowest minimum percentage point contributions of all fuel types in fifteen APEC economies in the period 1990–2002 (eighteen economies in the period 1972–89). The minimum percentage point contribution for oil ranged from –14.0 percentage points (Singapore) to –0.1 percentage points (Viet Nam) in the period 1990–2002, compared with a range from –44.3 percentage points (Brunei) to –0.8 percentage points (China) in the period 1972–89. Coal and gas were associated with the lowest minimum percentage point contributions to TPEC growth in three and two APEC economies respectively in the latter period (other fuel was the lowest minimum in one APEC economy in the earlier period).

The percentage of years in which there was a negative percentage point contribution to TPEC growth indicates the extent to which there have been downside contributions from a particular fuel type. In each time period, coal, oil and other fuel were associated with the largest number of years of negative percentage point contributions in five, seven and seven APEC economies respectively in the period 1990–2002 (seven, seven and five economies in the period 1972–89).

Oil therefore is the fuel type most often associated with the highest variability in, and lowest minimum, percentage point contributions to TPEC growth with around three quarters or more of APEC economies in each category in each time period (see also figure 8). In addition, oil is the fuel type with the strongest positive association, or correlation coefficient, with TPEC growth in around three quarters of APEC economies in both time periods. However, oil, coal and other fuel are the fuel types most commonly associated with the largest number of years of negative percentage point contributions in each time period.

There have been some notable changes in the percentage point contribution of oil to TPEC growth in APEC economies between the two time periods. In the period 1990–2002, compared with the earlier period 1972–89:

- the average percentage point contribution of oil increased in nine economies, decreased in eight economies and was unchanged (at one decimal place) in two economies;
- the variability in the percentage point contribution of oil to TPEC growth, as measured by the standard deviation, was higher in five economies, lower in thirteen economies and unchanged in one economy;
- the minimum percentage point contribution of oil was higher in fifteen economies and lower in four economies;
- the percentage of years in which oil made a negative percentage point contribution to TPEC growth increased in eleven economies and was reduced in eight economies; and

- the correlation between the percentage point contribution of oil and TPEC growth was higher in six economies, lower in ten economies and unchanged in three economies.

Most importantly, while oil remains the major source of variability and downside contributions to TPEC growth, the extent of variability and minimum percentage point contributions have been modified in the majority of APEC economies in the recent period.

Decomposition by supply source

Net imports have become a more important source of energy for APEC economies over the past three decades. On average, the main source of additional energy for primary energy consumption — that is, the supply source with the largest percentage point contribution to TPEC growth — was domestic production in nine economies, net imports in ten economies and stock drawdown in one economy in the period 1990–2002 (fourteen, six and zero economies respectively in the period 1972–89).

Between the two time periods, there has been a rise in the number of APEC economies that rely on net energy imports, at least to some extent, to meet domestic energy requirements. The average percentage point contribution from net imports was positive in nine economies in the period 1972–89, increasing to twelve economies in the period 1990–2002.

In the context of the current study, it is of interest to examine the major sources of volatility in the net energy importing groups of economies. In the period 1990–2002, for the twelve net energy importing APEC economies:

- net energy imports made the largest percentage point contribution to TPEC growth, on average, in ten economies (six economies in the period 1972–89);
- net energy imports were the source of the greatest variability in the percentage point contribution to TPEC growth, as measured by the standard deviation, in eight economies (seven economies in the period 1972–89);
- net energy imports were the source of the lowest minimum percentage point contributions to TPEC growth in the time period in eight economies (four economies in the period 1972–89); and

- net energy imports were the supply source with the strongest positive association, or correlation coefficient, with fluctuations in TPEC growth in seven economies (also seven economies in the period 1972–89).

However, stock drawdown was the major source of negative percentage point contributions to TPEC growth in ten net energy importing economies in the period 1990–2002 (seven economies in the period 1972–89).

For all APEC economies where data are available, stock drawdown contributed on average to TPEC growth in eleven economies in the period 1990–2002, indicating that energy stocks were reduced over the period in these economies (ten economies in the period 1972–89). Energy stocks were increased (that is, made a negative percentage point contribution to TPEC growth) or were unchanged in five and four economies respectively in the recent period (the same numbers as in the earlier period).

Decomposition of growth in total final energy consumption

As in the previous case, there are two aspects to the decomposition of annual growth in total final energy consumption that are relevant:

- decomposition by final fuel type – the percentage point contribution of fuel types to the annual percentage change in total final energy consumption.
- decomposition by end use sector – the percentage point contribution of end use sectors to the annual percentage change in total final energy consumption where end use sectors include industry, transport and other activities.

Annual data over the period 1972–2002 for each decomposition of annual growth in total final energy consumption in twenty APEC economies are provided in appendix C. Descriptive statistics for this decomposition analysis are provided in table 13 for the two subperiods and in appendix C for the full period.

Decomposition by final fuel type

The final fuel types included in the decomposition are coal, oil, gas, electricity and other fuel (renewables and heat) — see table 5 for fuel shares in 2002. There are a relatively small number of cases where a particular fuel type is excluded from total final energy consumption (TFEC). Coal was not consumed in either time period in two APEC economies (Singapore and Brunei), and gas was not consumed in the Philippines in either time period and in Viet Nam in the earlier period. It may also be noted that consumption of some fuel types occurred at relatively low levels in some economies.

In a number of cases, the average percentage point contribution of a fuel type to TFEC growth was negative — coal and gas in the United States (–0.1 percentage points for coal in both periods and –0.2 percentage points for gas in the period 1972–89), coal in Australia (–0.1, 1972–89 and –0.2, 1990–2002), coal in New Zealand (–0.1, 1990–2002), coal in Korea (–0.4, 1990–2002), coal and gas in Mexico (–0.1 and –0.3, 1990–2002), all fuel types in Russia (ranging from –1.7 to –0.2, 1993–2002), gas and other fuel in Peru (–0.1, 1990–2002 and –0.3, 1972–89), coal in China (–0.6, 1990–2002) and oil in Viet Nam (–2.6, 1972–89).

In all other cases, the average percentage point contribution of each fuel type to TFEC growth was positive. Oil provided the highest (or equal highest) percentage point contribution, on average, to TFEC growth in fifteen APEC economies over the period 1972–89 and in seventeen APEC economies over the period 1990–2002. In several APEC economies, the average percentage point contribution of oil was substantially higher than that for other fuel types.

Coal, gas, electricity and other fuel provided the highest (or equal highest) percentage point contribution, on average, to TPEC growth in one, one, two and two APEC economies, respectively, in the period 1990–2002 (two, three, two and zero economies respectively in the period 1972–89).

Oil is the fuel type most typically associated with the highest variability in, and lowest minimum, percentage point contributions to TFEC growth — oil was the fuel type with the highest (or equal highest) standard deviation and the lowest (or equal lowest) minimum in eighteen and seventeen APEC economies in the periods 1972–89 and 1990–2002, respectively. Oil is also the fuel type with the strongest positive association, or correlation coefficient, with fluctuations in TFEC growth (fifteen and fourteen economies in the periods 1972–89 and 1990–2002, respectively).

Coal is associated with the largest number of years of negative percentage point contributions to TFEC growth in each time period, although this should be interpreted in the context that over three quarters of coal is used in electricity generation with the residual consumed directly in end use activities (twelve and eleven economies in the periods 1972–89 and 1990–2002 respectively). Oil, gas and other fuel recorded the largest number of years of negative contributions in three, two and zero economies respectively in the period 1990–2002 (five, one and five respectively in the period 1972–89).

Decomposition by end use sector

For brevity, industry and transport are identified separately as the main end use sectors in total final energy consumption with residential and other end use activities included in the other end use sector in table 13 — see table 6 for shares of each end use sector in TFEC in 2002.

In a small number of cases, the average percentage point contribution of energy consumption in an end use sector to TFEC growth was negative — industry in the United States (–0.2 percentage points in the period 1972–89), industry in Hong Kong (–0.4, 1990–2002), industry in Mexico (–0.5, 1990–2002), transport and other end use sectors in Russia (–0.6 and –3.0, 1993–2002), and transport and other end use sectors in Viet Nam (–1.4 and –3.3, 1972–89).

Most notably, in the period 1990–2002:

- industry made the largest percentage point contribution to TFEC growth, on average, in eleven economies (seven economies in the period 1972–89);
- industry was the source of the greatest variability in the percentage point contribution to TFEC growth, as measured by the standard deviation, in fourteen economies (sixteen economies in the period 1972–89);
- industry was the source of the lowest minimum percentage point contribution to TFEC growth in twelve economies (eleven economies in the period 1972–89);
- industry was the source of the largest number of negative percentage point contributions to TFEC growth in twelve economies (twelve economies in the period 1972–89); and
- industry was the end use sector with the strongest positive association, or correlation coefficient, with fluctuations in TFEC growth in thirteen economies (fourteen economies in the period 1972–89).

13 Decomposition of annual growth in total final energy consumption, by fuel type and end use sector Percentage point contributions

	By fuel type					Total primary energy consumption	By end use sector		
	Coal	Oil	Gas	Electricity	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
United States									
1972–89									
Average	–0.1	0.4	–0.2	0.4	0.0	0.5	–0.2	0.6	0.2
SD **b**	0.3	2.2	1.2	0.3	0.7	3.5	2.1	0.9	1.1
Minimum **c**	–0.8	–4.1	–2.3	–0.4	–2.5	–4.7	–4.0	–1.5	–2.4
% years < 0 **d**	61	44	50	6	22	44	56	28	50
Correlation **e**	0.5	0.9	0.7	0.9	0.4	1.0	0.9	0.8	0.8
1990–2002									
Average	–0.1	0.6	0.2	0.5	0.1	1.2	0.3	0.6	0.3
SD **b**	0.5	1.0	1.0	0.3	0.6	1.9	1.0	0.6	0.9
Minimum **c**	–1.6	–1.2	–1.6	–0.2	–1.0	–2.5	–2.1	–0.7	–1.9
% years < 0 **d**	62	15	38	8	62	23	23	23	23
Correlation **e**	0.0	0.7	0.8	0.4	0.5	1.0	0.8	0.7	0.7
Canada									
1972–89									
Average	0.0	0.3	0.9	0.8	0.0	2.0	0.8	0.7	0.5
SD **b**	0.2	2.4	1.2	0.5	0.4	3.5	2.1	1.4	1.4
Minimum **c**	–0.3	–5.8	–1.1	–0.3	–1.1	–5.4	–4.1	–3.5	–1.7
% years < 0 **d**	61	33	33	11	44	22	28	17	44
Correlation **e**	0.4	0.9	0.7	0.7	0.3	1.0	0.9	0.8	0.4
1990–2002									
Average	0.0	0.4	0.4	0.3	0.1	1.2	0.4	0.4	0.4
SD **b**	0.2	1.2	1.4	0.3	0.3	2.6	1.2	0.7	1.2
Minimum **c**	–0.6	–2.3	–2.4	–0.1	–0.4	–3.4	–2.1	–0.8	–2.3
% years < 0 **d**	62	31	31	23	46	31	31	31	31
Correlation **e**	0.4	0.8	0.9	0.8	0.5	1.0	1.0	0.6	0.9
Australia									
1972–89									
Average	–0.1	0.9	0.9	0.8	0.0	2.5	0.6	1.3	0.6
SD **b**	0.6	2.0	0.4	0.3	0.5	2.5	1.5	0.8	1.0
Minimum **c**	–1.3	–3.2	0.2	0.1	–1.9	–3.5	–2.4	–0.4	–2.2
% years < 0 **d**	44	28	0	0	33	11	33	6	17
Correlation **e**	0.6	0.9	0.1	0.6	0.1	1.0	0.8	0.9	0.6
1990–2002									
Average	–0.2	0.8	0.3	0.7	0.2	1.8	0.4	0.7	0.6
SD **b**	0.4	1.1	0.6	0.3	0.4	1.9	1.2	0.7	0.4
Minimum **c**	–1.4	–1.3	–1.5	0.2	–0.5	–3.0	–3.1	–0.7	–0.1
% years < 0 **d**	69	23	8	0	46	15	23	15	8
Correlation **e**	0.7	0.9	0.8	–0.2	0.5	1.0	0.9	0.8	0.6

13 Decomposition of annual growth in total final energy consumption, by fuel type and end use sector
Percentage point contributions

	By fuel type					Total primary energy consumption	By end use sector		
	Coal	Oil	Gas	Electricity	Other		Industry	Transport	Other **a**
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
Hong Kong									
1972–89									
Average	0.0	3.6	0.3	1.9	0.0	5.8	1.4	2.5	1.9
SD **b**	0.3	8.1	0.2	1.5	0.1	8.2	6.8	3.2	2.0
Minimum **c**	–0.9	–10.6	0.1	–0.7	–0.2	–8.6	–15.0	–1.8	–2.1
% years < 0 **d**	56	33	0	11	33	28	39	22	22
Correlation **e**	0.0	1.0	0.2	0.1	0.0	1.0	0.9	0.1	0.7
1990–2002									
Average	0.0	3.2	0.2	1.1	0.0	4.5	–0.4	3.4	1.6
SD **b**	0.0	8.9	0.2	0.6	0.0	9.0	3.5	5.9	0.6
Minimum **c**	0.0	–13.4	0.0	0.0	0.0	–12.2	–4.6	–9.3	0.6
% years < 0 **d**	15	46	0	8	46	31	69	31	0
Correlation **e**	0.2	1.0	0.2	0.2	–0.1	1.0	0.8	1.0	0.6
Japan									
1972–89									
Average	0.1	1.0	0.2	0.7	0.1	2.0	0.2	0.8	1.0
SD **b**	0.6	3.7	0.1	0.6	0.2	4.2	2.9	0.7	1.2
Minimum **c**	–0.7	–6.9	0.0	–0.3	–0.1	–6.2	–5.6	–0.5	–1.0
% years < 0 **d**	50	33	11	17	6	28	56	11	17
Correlation **e**	0.0	1.0	0.4	0.8	–0.1	1.0	1.0	0.7	0.8
1990–2002									
Average	0.0	1.0	0.2	0.6	0.0	1.9	0.3	0.6	0.9
SD **b**	0.6	1.3	0.1	0.6	0.1	2.0	1.9	0.7	0.9
Minimum **c**	–1.4	–0.8	0.0	–0.3	–0.1	–2.1	–2.9	–0.3	–0.3
% years < 0 **d**	46	31	8	8	31	23	46	23	8
Correlation **e**	0.6	0.9	0.3	0.7	0.4	1.0	0.7	0.6	0.2
Singapore									
1972–89									
Average	0.0	7.5	0.1	1.5	0.0	9.0	3.0	4.3	1.6
SD **b**	0.0	5.4	0.1	0.7	0.1	5.6	4.6	3.7	3.3
Minimum **c**	0.0	–0.7	–0.1	–0.2	–0.2	0.7	–1.6	–1.5	–5.6
% years < 0 **d**	0	11	6	6	44	0	22	11	22
Correlation **e**	–	1.0	0.1	0.3	–0.3	1.0	0.5	0.4	0.6
1990–2002									
Average	0.0	5.7	0.1	1.4	0.0	7.2	2.8	2.4	2.0
SD **b**	0.0	8.9	0.0	0.5	0.0	9.0	7.4	3.6	4.1
Minimum **c**	0.0	–8.5	0.0	0.4	0.0	–7.2	–6.5	–1.8	–0.5
% years < 0 **d**	0	38	8	0	23	31	38	31	15
Correlation **e**	–	1.0	0.2	0.3	0.4	1.0	0.8	0.2	0.5

13 Decomposition of annual growth in total final energy consumption, by fuel type and end use sector Percentage point contributions

	By fuel type					Total primary energy consumption	By end use sector		
	Coal	Oil	Gas	Electricity	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
Chinese Taipei									
1972–89									
Average	0.3	5.7	0.3	1.6	0.0	7.9	4.4	1.9	1.6
SD **b**	1.9	5.4	0.9	0.7	0.1	6.8	4.4	2.3	1.2
Minimum **c**	–2.5	–3.9	–1.3	–0.2	–0.3	–5.7	–4.1	–4.2	–0.4
% years < 0 **d**	44	17	33	6	72	11	17	6	11
Correlation **e**	0.2	1.0	0.7	0.9	0.3	1.0	0.9	0.8	0.6
1990–2002									
Average	0.5	3.0	0.2	1.6	0.0	5.3	2.9	1.4	1.0
SD **b**	0.5	2.0	0.2	0.5	0.0	1.8	2.3	1.0	0.7
Minimum **c**	–0.6	0.3	–0.2	0.5	0.0	2.8	1.1	–0.2	–0.3
% years < 0 **d**	23	0	23	0	38	0	0	8	8
Correlation **e**	0.3	0.9	0.1	–0.6	–0.1	1.0	0.8	0.2	–0.3
New Zealand									
1972–89									
Average	0.1	0.8	1.0	1.0	0.5	3.3	1.6	1.1	0.6
SD **b**	0.9	2.0	1.5	0.8	1.3	3.7	2.5	1.1	1.0
Minimum **c**	–1.6	–2.3	–0.4	0.1	–0.3	–1.4	–2.0	–0.4	–1.5
% years < 0 **d**	50	33	17	0	22	17	33	6	28
Correlation **e**	0.5	0.8	0.5	0.5	0.5	1.0	0.9	0.7	0.6
1990–2002									
Average	–0.1	1.4	1.1	0.4	0.6	3.5	1.6	1.4	0.5
SD **b**	0.4	1.6	1.3	0.6	1.0	2.2	1.4	1.0	0.8
Minimum c	–0.6	–1.2	–1.0	–0.7	–0.2	–0.7	–1.9	–0.3	–1.1
% years < 0 **d**	46	23	31	15	23	8	8	8	31
Correlation **e**	–0.4	0.8	0.4	0.3	0.4	1.0	0.7	0.8	0.5
Republic of Korea									
1972–89									
Average	1.7	5.4	0.0	1.2	0.0	8.3	3.0	1.9	3.5
SD **b**	2.4	5.0	0.1	0.4	0.0	6.6	3.2	2.5	2.9
Minimum **c**	–2.7	–2.7	0.0	0.4	0.0	–1.5	–2.3	–3.1	–1.0
% years < 0 **d**	17	17	0	0	39	6	17	22	6
Correlation **e**	0.6	1.0	0.0	0.5	0.4	1.0	0.8	0.7	0.7
1990–2002									
Average	–0.4	5.3	0.9	1.4	0.3	7.5	3.8	1.9	1.9
SD **b**	1.1	6.6	0.4	0.7	0.4	6.4	2.6	1.9	2.7
Minimum **c**	–2.5	–9.4	0.4	–0.5	–0.2	–9.9	–0.8	–3.5	–5.6
% years < 0 **d**	62	15	0	8	8	8	8	8	15
Correlation **e**	–0.4	1.0	0.1	0.7	–0.2	1.0	0.8	0.9	0.9

13 Decomposition of annual growth in total final energy consumption, by fuel type and end use sector Percentage point contributions

	By fuel type					Total primary energy consumption	By end use sector		
	Coal	Oil	Gas	Electricity	Other		Industry	Transport	Other **a**
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
Brunei Darussalam									
1972–89									
Average	0.0	7.1	0.0	1.4	0.1	8.6	1.2	5.8	1.5
SD **b**	0.0	12.3	0.0	1.9	0.5	12.8	5.2	7.7	2.4
Minimum **c**	0.0	–6.9	0.0	0.0	–0.4	–4.0	–10.9	–7.1	–1.1
% years < 0 **d**	0	22	0	0	17	22	33	11	17
Correlation **e**	–	1.0	–	0.3	0.0	1.0	0.8	0.9	0.7
1990–2002									
Average	0.0	2.9	0.0	1.6	0.0	4.5	0.3	2.6	1.6
SD **b**	0.0	5.2	0.0	2.1	0.1	6.5	1.5	3.1	2.7
Minimum **c**	0.0	–8.4	0.0	–3.2	–0.2	–7.3	–2.8	–4.3	–3.9
% years < 0 **d**	0	31	0	15	31	23	31	15	31
Correlation **e**	–	1.0	–	0.7	0.0	1.0	1.0	0.9	0.8
Chile									
1972–1989									
Average	0.0	0.9	0.1	0.5	0.8	2.3	1.0	0.6	0.7
SD **b**	1.0	3.2	0.1	0.5	0.7	4.6	2.6	2.0	1.0
Minimum **c**	–2.6	–7.3	–0.1	–0.7	–0.6	–9.8	–5.1	–3.6	–1.1
% years < 0 **d**	50	33	17	17	11	17	28	44	17
Correlation **e**	0.8	0.9	–0.1	0.9	0.4	1.0	0.9	0.9	0.6
1990–2002									
Average	0.1	2.4	0.5	1.2	0.9	5.0	1.9	1.7	1.4
SD **b**	1.2	2.6	0.7	0.5	1.3	3.8	2.7	1.3	0.9
Minimum **c**	–2.3	–1.6	0.0	0.5	–2.0	–1.2	–2.5	–1.2	–0.5
% years < 0 **d**	38	23	0	0	23	8	15	8	8
Correlation **e**	0.7	0.8	0.0	0.5	0.4	1.0	0.9	0.5	0.7
Malaysia									
1972–89									
Average	0.3	3.8	0.6	0.9	0.4	6.1	2.1	2.3	1.7
SD **b**	1.0	4.3	1.4	0.2	0.3	4.4	3.7	1.6	1.1
Minimum **c**	–1.2	–3.9	–0.6	0.7	–0.1	–2.4	–5.5	–1.8	0.3
% years < 0 **d**	33	17	17	0	17	11	33	6	0
Correlation **e**	0.4	0.9	0.1	0.0	–0.1	1.0	0.9	0.5	0.2
1990–2002									
Average	0.1	4.7	1.2	1.5	0.1	7.7	3.3	3.1	1.4
SD **b**	0.6	3.7	1.0	0.7	0.1	3.7	3.2	2.1	1.8
Minimum **c**	–0.6	–4.0	0.0	–0.1	–0.2	–1.6	–1.0	–1.5	–0.9
% years < 0 **d**	31	8	8	8	15	8	23	8	23
Correlation **e**	0.2	0.9	–0.2	0.4	0.4	1.0	0.7	0.5	0.3

13 Decomposition of annual growth in total final energy consumption, by fuel type and end use sector
Percentage point contributions

	By fuel type					Total primary energy consumption	By end use sector		
	Coal	Oil	Gas	Electricity	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
Mexico									
1972–89									
Average	0.1	3.6	0.8	0.6	0.1	5.2	2.2	1.9	1.0
SD **b**	0.3	2.8	1.6	0.2	0.2	4.0	2.2	2.0	0.9
Minimum **c**	–0.5	–3.1	–2.7	0.1	–0.3	–3.5	–2.6	–3.6	–0.9
% years < 0 **d**	44	11	22	0	28	11	17	17	17
Correlation **e**	0.3	0.9	0.7	0.8	0.2	1.0	0.8	0.8	0.7
1990–2002									
Average	–0.1	0.5	–0.3	0.5	0.0	0.7	–0.5	0.8	0.4
SD **b**	0.3	1.8	1.2	0.3	0.3	2.3	1.2	1.2	1.0
Minimum **c**	–0.9	–3.2	–2.0	0.0	–0.5	–2.9	–2.6	–1.4	–1.4
% years < 0 **d**	38	38	62	0	46	46	69	15	31
Correlation **e**	0.4	0.8	0.5	0.1	0.2	1.0	0.5	0.8	0.8
Russian Federation									
1972–92									
Average	na	na	na	na	na	na	na	na	na
SD **b**	na	na	na	na	na	na	na	na	na
Minimum **c**	na	na	na	na	na	na	na	na	na
% years < 0 **d**	na	na	na	na	na	na	na	na	na
Correlation **e**	na	na	na	na	na	na	na	na	na
1993–2002									
Average	–0.2	–0.9	–0.4	–0.2	–1.7	–3.3	0.2	–0.6	–3.0
SD **b**	0.7	2.2	1.3	0.4	2.2	5.5	6.1	1.6	4.9
Minimum **c**	–1.1	–4.8	–3.1	–1.1	–6.4	–14.1	–8.0	–3.0	–15.7
% years < 0 **d**	50	70	50	60	90	70	70	60	70
Correlation **e**	0.7	0.8	0.8	0.9	0.8	1.0	0.5	0.4	0.4
Thailand									
1972–89									
Average	0.3	3.3	0.0	0.8	1.6	6.0	1.5	2.4	2.1
SD **b**	0.4	3.1	0.3	0.4	4.6	5.8	2.5	2.4	4.6
Minimum **c**	–0.1	–2.0	–0.4	0.3	–13.0	–7.4	–3.5	–3.0	–11.2
% years < 0 **d**	17	22	17	0	17	11	22	11	11
Correlation **e**	0.4	0.6	0.1	0.6	0.8	1.0	0.5	0.5	0.7
1990–2002									
Average	0.8	3.5	0.3	1.1	0.1	5.7	2.8	1.9	1.0
SD **b**	1.1	3.5	0.2	0.6	1.4	5.3	3.1	2.7	1.2
Minimum **c**	–1.5	–5.2	–0.1	–0.3	–3.2	–8.5	–4.6	–3.8	–0.8
% years < 0 **d**	23	8	8	8	31	8	15	23	23
Correlation **e**	0.8	1.0	0.7	0.8	0.3	1.0	0.9	0.9	0.1

13 Decomposition of annual growth in total final energy consumption, by fuel type and end use sector
Percentage point contributions

	By fuel type					Total primary energy consumption	By end use sector		
	Coal	Oil	Gas	Electricity	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
Peru									
1972–89									
Average	0.0	0.5	0.0	0.3	–0.3	0.6	0.1	0.4	0.1
SD **b**	0.2	3.8	0.2	0.4	1.1	4.1	1.6	1.8	2.1
Minimum **c**	–0.2	–8.3	–0.4	–0.6	–2.6	–9.0	–3.4	–2.5	–3.3
% years < 0 **d**	39	39	44	17	44	33	33	44	50
Correlation **e**	0.0	0.9	0.4	0.8	0.1	1.0	0.8	0.7	0.7
1990–2002									
Average	0.3	1.3	–0.1	0.6	–0.4	1.6	0.9	0.6	0.1
SD **b**	0.5	3.8	0.1	0.9	0.5	3.7	2.2	2.0	1.3
Minimum **c**	–0.5	–3.8	–0.4	–2.1	–1.1	–3.3	–3.5	–3.1	–2.0
% years < 0 **d**	38	46	62	8	77	54	23	38	46
Correlation **e**	–0.3	1.0	0.2	0.2	0.0	1.0	0.8	0.6	0.7
China									
1972–89									
Average	3.5	1.0	0.2	0.5	0.2	5.4	3.1	0.5	1.8
SD **b**	3.6	1.8	0.2	0.3	0.5	4.4	2.8	0.3	2.2
Minimum **c**	–1.1	–3.4	–0.1	–0.1	0.0	–1.7	–1.7	–0.3	–5.1
% years < 0 **d**	17	17	11	6	17	11	17	6	6
Correlation **e**	0.9	0.6	0.5	0.6	–0.4	1.0	0.9	0.8	0.8
1990–2002									
Average	–0.6	1.3	0.1	0.8	3.3	4.9	1.0	0.4	3.4
SD **b**	2.9	0.5	0.1	0.3	10.7	11.9	3.0	0.5	10.6
Minimum **c**	–7.0	0.0	–0.1	0.3	–0.3	–5.1	–4.9	–0.6	–2.0
% years < 0 **d**	38	0	8	0	8	15	23	15	23
Correlation **e**	0.5	–0.1	0.1	0.5	1.0	1.0	0.6	–0.7	1.0
Philippines									
1972–89									
Average	0.2	0.8	0.0	0.5	0.6	2.0	0.5	0.1	1.5
SD **b**	0.7	4.2	0.0	0.8	1.1	4.2	2.3	1.5	2.2
Minimum **c**	–1.4	–7.0	0.0	–1.4	–0.9	–5.9	–3.5	–2.8	–3.2
% years < 0 **d**	33	39	0	17	33	33	33	44	22
Correlation **e**	0.0	0.9	–	0.5	–0.1	1.0	0.8	0.7	0.6
1990–2002									
Average	0.3	2.9	0.0	0.5	0.8	4.5	1.4	2.6	0.5
SD **b**	0.8	3.4	0.0	0.7	2.0	4.6	4.2	4.5	2.5
Minimum **c**	–0.8	–1.4	0.0	–0.8	–1.3	–1.0	–1.5	–1.4	–4.7
% years < 0 **d**	38	15	0	23	31	15	31	23	46
Correlation **e**	0.4	0.9	–	0.5	0.5	1.0	0.5	0.7	–0.3

13 Decomposition of annual growth in total final energy consumption, by fuel type and end use sector Percentage point contributions

	By fuel type					Total primary energy consumption	By end use sector		
	Coal	Oil	Gas	Electricity	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
Indonesia									
1972–89									
Average	0.1	2.2	0.6	0.2	1.0	4.1	1.3	0.9	1.9
SD **b**	0.1	1.8	0.7	0.1	0.2	1.9	1.2	0.5	0.8
Minimum c	–0.1	–1.6	–0.9	0.0	0.8	0.6	–0.4	–0.5	0.5
% years < 0 **d**	39	11	6	0	0	0	11	6	0
Correlation **e**	0.2	0.9	0.3	–0.1	0.4	1.0	0.8	0.6	0.8
1990–2002									
Average	0.4	2.3	0.7	0.5	0.9	4.7	1.8	1.3	1.7
SD b	0.6	1.5	0.8	0.2	0.8	2.1	1.4	0.9	0.6
Minimum **c**	–0.2	–0.7	–0.7	0.1	0.2	1.1	–0.6	–0.4	0.8
% years < 0 **d**	23	15	15	0	0	0	8	15	0
Correlation **e**	0.2	0.8	0.3	0.7	0.4	1.0	0.8	0.5	0.8
Viet Nam									
1972–89									
Average	0.6	–2.6	0.0	0.5	0.0	–1.5	3.2	–1.4	–3.3
SD **b**	7.0	14.8	0.0	0.5	0.0	15.6	11.5	8.9	15.4
Minimum **c**	–13.0	–45.0	0.0	–0.3	–0.1	–49.7	–10.5	–26.6	–54.8
% years < 0 **d**	50	50	0	17	39	44	39	50	44
Correlation **e**	0.3	0.9	–	0.1	–0.5	1.0	0.2	0.8	0.4
1990–2002									
Average	1.1	4.3	0.0	0.9	25.6	32.0	1.7	2.6	27.7
SD **b**	2.5	5.5	0.1	0.4	89.8	90.8	1.7	4.5	90.3
Minimum **c**	–3.9	–1.7	0.0	0.5	–1.6	0.5	–2.5	–1.8	–0.7
% years < 0 **d**	23	8	46	0	15	0	8	15	8
Correlation **e**	–0.1	0.2	0.0	0.8	1.0	1.0	0.0	0.1	1.0

a Other sectors and nonenergy use. **b** Standard deviation. **c** Minimum observation. **d** Number of years in which a negative observation occurs as a percentage of the total number of years. **e** Correlation coefficient between the percentage change in TFEC and the percentage point contribution of the variable indicated.

Source: Based on IEA energy database; see IEA (2004a,b).

Overall, from an energy security perspective, oil is the main fuel type that is associated with variability in both primary and final energy consumption in the APEC region. Variability associated with net imports is important in several APEC economies. There is also an important association between variability in energy consumption in the industry sector and variability in final energy consumption.

APEC energy self sufficiency, oil dependence and world resource availability

From the previous two sections, it is apparent that variability in energy consumption is closely associated with variability in national output in many APEC economies, and variability in oil consumption is closely associated with variability in energy consumption. In this section, information is presented on key demand side and supply side factors that influence energy security risks in the APEC region, particularly in the oil market.

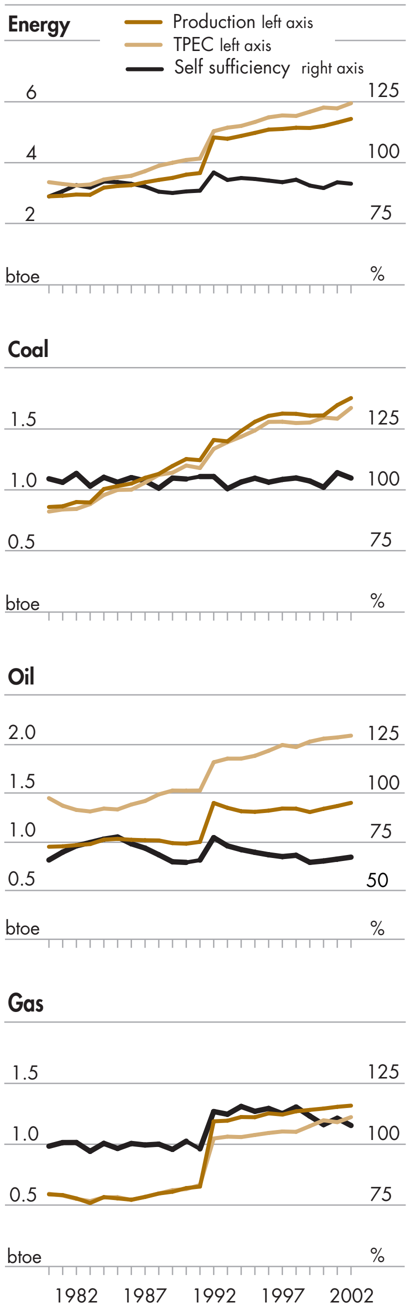
Energy self sufficiency and oil dependence in the APEC region

Primary energy production, consumption and self sufficiency in the APEC region since 1980 both in aggregate and for the three major primary fuel types — coal, oil and gas — are presented in figure 9. The figure is based on data for twenty APEC economies (excludes Papua New Guinea), although it should be noted that data for the Russian Federation are not available prior to 1992.

The APEC region tends to produce slightly more coal and gas, and substantially less oil, than is consumed within the region. Overall, the APEC region is not self sufficient in energy, and the gap between the region's energy production and consumption has widened over the past decade — between 1992 and 2002, annual average growth was 1.2 per cent for energy production and 1.7 per cent for energy consumption. As a consequence, APEC energy self sufficiency — energy production as a percentage of energy consumption — has declined from 96 per cent in 1992 to 91 per cent in 2002, averaging 92 per cent over the period (it was 89 per cent over the period 1980–91).

Annual average growth in consumption has exceeded annual average growth in production over the past decade for each of the three main primary fuel types. For coal, however, the gap between the region's production and consumption growth has been minor (2.2 and 2.3 per cent respectively) and APEC coal self sufficiency was 105 per cent in both 1992 and 2002 (or 105.45 per cent in 1992 and 104.8 per cent in 2002), averaging 104 per cent over the period (also 104 per cent over the period 1980–91).

9 Production, consumption and self sufficiency in APEC
excludes Russia before 1992



Between 1992 and 2002, annual average growth was 1.0 per cent for gas production and 1.6 per cent for gas consumption, resulting in a fall in APEC gas self sufficiency from 113 per cent in 1992 to 108 per cent in 2002. The average gas self sufficiency was 112 per cent over the period 1992–2002, significantly higher than the average of 99 per cent over the period 1980–91.

For oil, however, the gap between production and consumption in the APEC region has widened appreciably over the past decade and oil self sufficiency has declined markedly. Between 1992 and 2002, oil production was unchanged while the annual average growth rate for oil consumption was 1.4 per cent. This resulted in a fall in APEC oil self sufficiency from 77 per cent in 1992 to 67 per cent in 2002, averaging 69 per cent over the past decade (similar to the average of 70 per cent over the period 1980–91).

Any economy or region that participates in international trade will have areas of import dependence. The net economic benefits from international trade are well known. International trade allows economies to specialise to some extent in the production of goods and services in which they have a competitive advantage, exporting production in excess of domestic consumption requirements to earn export revenue. Economies may import goods and services that may be unavailable otherwise or relatively more costly to produce domestically.

APEC's increasing oil import dependence, or declining oil self sufficiency, is an important aspect of the region's energy security risk exposure because of the interaction of key demand side and supply side aspects of the oil market:

- demand side aspects – oil dependence is a feature of APEC economies, particularly in the transport sector where there are limited substitution possibilities over the short to medium term, but agriculture and energy intensive manufacturing activities are also highly reliant on oil inputs.
- supply side aspects – oil together with other major fuel types are non-renewable resources that need to be discovered before production may proceed, which increases uncertainty in any medium to longer term outlook assessment, and world oil reserves and production are concentrated in relatively high risk regions, with the prospect of increasing market concentration over the medium to longer term.

Key areas of dependence in APEC energy consumption were identified in chapter 3 based on 2002 data. Oil dependence in the APEC region may be summarised by the following shares:

- the share of oil in APEC total primary energy consumption was 35 per cent in 2002, ranging from 20 to 85 per cent in individual economies;
- the share of oil in APEC electricity generation was 6 per cent in 2002, ranging from 0 to 40 per cent;
- the share of oil (petroleum products) in APEC total final energy consumption was 45 per cent in 2002, ranging from 22 to 81 per cent; and
- the share of oil (petroleum products) in the energy consumption of the APEC transport sector was 94 per cent in 2002, ranging from 60 to 100 per cent.

The oil dependence of APEC economies accounts for the strategic importance of oil in energy security risk assessments. Linkages between energy consumption and national output were highlighted earlier in this chapter (see figures 6 and 7, and table 11). Supply side aspects of energy markets that are important for energy security risk assessments in the APEC region are discussed below.

World resource availability and market concentration

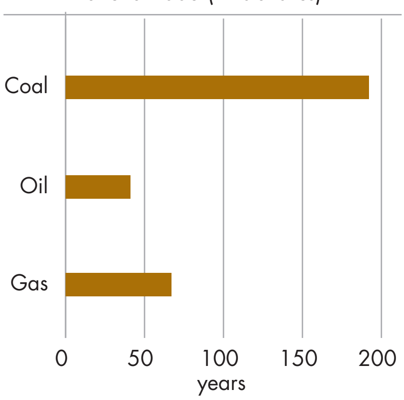
Proved reserves and production of key energy resources in 2003

Proved reserves of coal, oil and gas are generally defined to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs or deposits under existing economic and operating conditions (BP 2004). Proved reserves may be interpreted as estimates of below ground stocks that are assessed to be economic over time under current market conditions.

Importantly, estimates of proved reserves will vary with economic conditions. For example, a sustained real price rise would result in currently uneconomic resources being reclassified as economic and, as a consequence, aggregate proved reserves for the resource would be revised upward (and, conversely, a sustained real price fall would result in a downward revision of proved reserves). A sustained real price rise would also encourage exploration activity, with any related resource discoveries potentially adding to proved reserves.

At the end of 2003, world proved reserves are estimated to have been around 984 billion tonnes for coal, 157 billion tonnes for oil and 176 trillion cubic metres for natural gas (note that one billion is equal to one thousand million in this report) (BP 2004).

10 **World proved reserves/ production ratio**
at end 2003 (BP statistics)



The reserves to production ratio is a commonly used indicator of current resource availability that adjusts for current production levels. The reserves to production ratio may be interpreted as providing an indication of the number of years that proved reserves would maintain production at current levels.

Relative to current production levels, coal resources are relatively more abundant than either oil or gas resources. At the end of 2003, as indicated in figure 10, the reserves to production ratio was estimated to be around 192 years for coal, compared with 41 years for oil and 67 years for gas (BP 2004; production data differ slightly from the IEA).

Reflecting the impact of exploration activity on the level of proved reserves, and despite higher world production levels, the reserves to production ratio for both oil and gas was higher in 2003 than in 1980 — the ratio was 29 years and 58 years respectively for oil and gas in 1980 (world oil and gas production increased at an annual average rate of 0.8 per cent and 2.6 per cent respectively between 1980 and 2003) (BP 2004).

Ongoing exploration activity is important in gaining knowledge about new oil and gas reservoirs. This knowledge is required to at least maintain the level of world proved reserves given that world oil and gas consumption are expected to continue to increase over the period to 2030.

However, the outcome of exploration activity is uncertain — that is, the extent to which exploration can maintain or increase economic reserves of oil and gas in the future is uncertain. This is an aspect of the upstream industry that needs to be taken into account when considering longer term aspects of policy response strategies to energy security risks.

From an APEC perspective, a further important consideration is the location of any exploration activity and associated resource discoveries. The concentration of world proved reserves for oil and gas in the relatively high risk regions of the Middle East and Africa is highlighted in figure 11 (regional definitions are given in BP 2004).

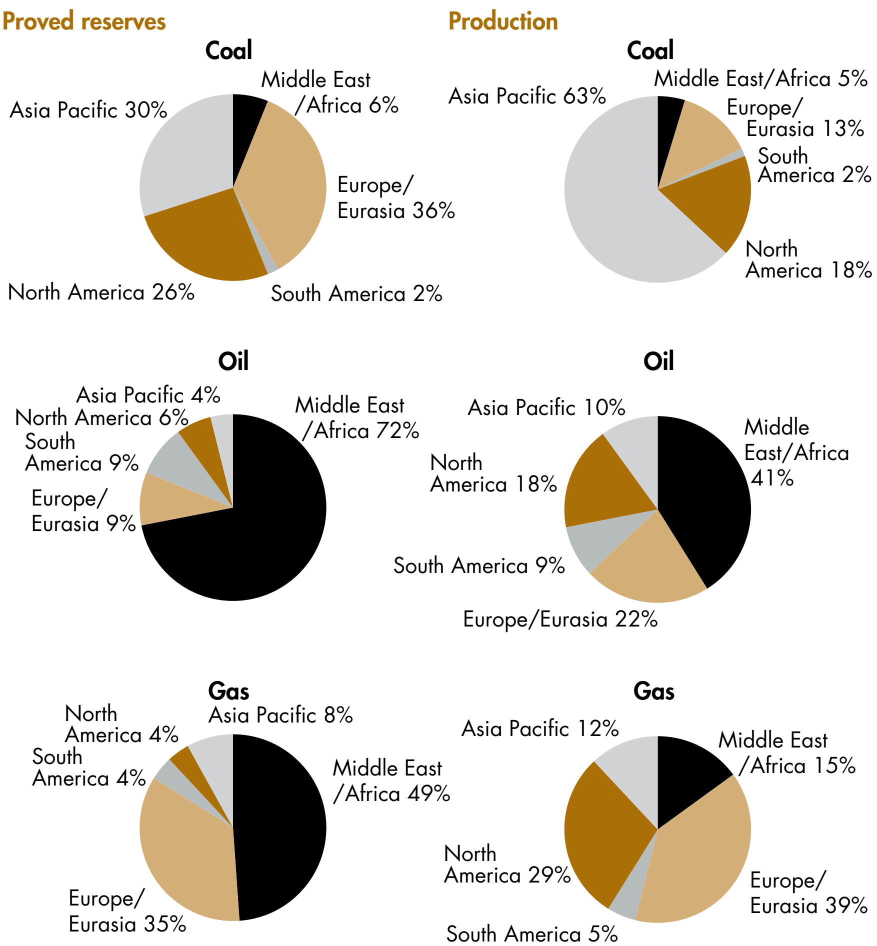
At the end of 2003:

- 72 per cent of the world's proved reserves for oil were located in the Middle East/Africa regions (63 per cent in the Middle East and 9 per cent in Africa);
- 49 per cent of the world's proved reserves for gas were located in the Middle East/Africa regions (41 per cent in the Middle East and 8 per cent in Africa); and
- 6 per cent of the world's proved reserves for coal were located in the Middle East/Africa regions (data for the separate regions are not available in BP 2004).

In 2003, the share of the Middle East and Africa in world production of oil, gas and coal was 41 per cent (30 per cent, 11 per cent), 15 per cent (10 per cent, 5 per cent) and 6 per cent (0 per cent, 6 per cent) respectively.

A major source of instability in world oil supply in recent decades has been the Middle East. APERC (2002a) contains information on significant crude oil supply shocks since 1951 — from a total of eighteen oil supply disruptions,

11 Location of world proved reserves and production
at end 2003 (BP statistics)



five were caused by accidents, a further five to internal struggles and eight to wars, embargoes and/or disputes.

Assuming world oil consumption continues to rise over the medium to longer term, the global distribution of oil production will shift toward the distribution for proved reserves — that is, the share of the Middle East will rise — although the timing of this shift will be influenced by new project developments associated with existing reserves, new discoveries made outside the Middle East, and a change in economic conditions that enables currently uneconomic reservoirs or deposits to be reclassified as economic.

The development of nonconventional sources, such as tar sands and gas to liquids projects, will also contribute to future oil supply.

In the reference case projections used in the GTEM modeling analysis of oil supply disruptions sourced from the Middle East (discussed further in chapter 5), world oil consumption is projected to rise at an annual average rate of 2.2 per cent between 2002 and 2030. The share of the Middle East in world oil production is projected to fall to 28 per cent by 2010, mainly reflecting higher production in Eurasia, but then increases to 37 per cent in 2020 and 46 per cent in 2030 — these are close to the IEA projections of 25 per cent in 2010, 35 per cent in 2020 and 43 per cent in 2030 (see IEA 2004c).

By contrast, in the ABARE reference case projections the share of the Middle East in world gas production is 10 per cent in 2030, unchanged from 2003 — this outlook, which is also similar to the IEA projections, reflects the assessment that there are likely to be substantial gas resources outside the Middle East that will be economic to develop over the outlook period (resource estimates are discussed further in IEA 2004c).

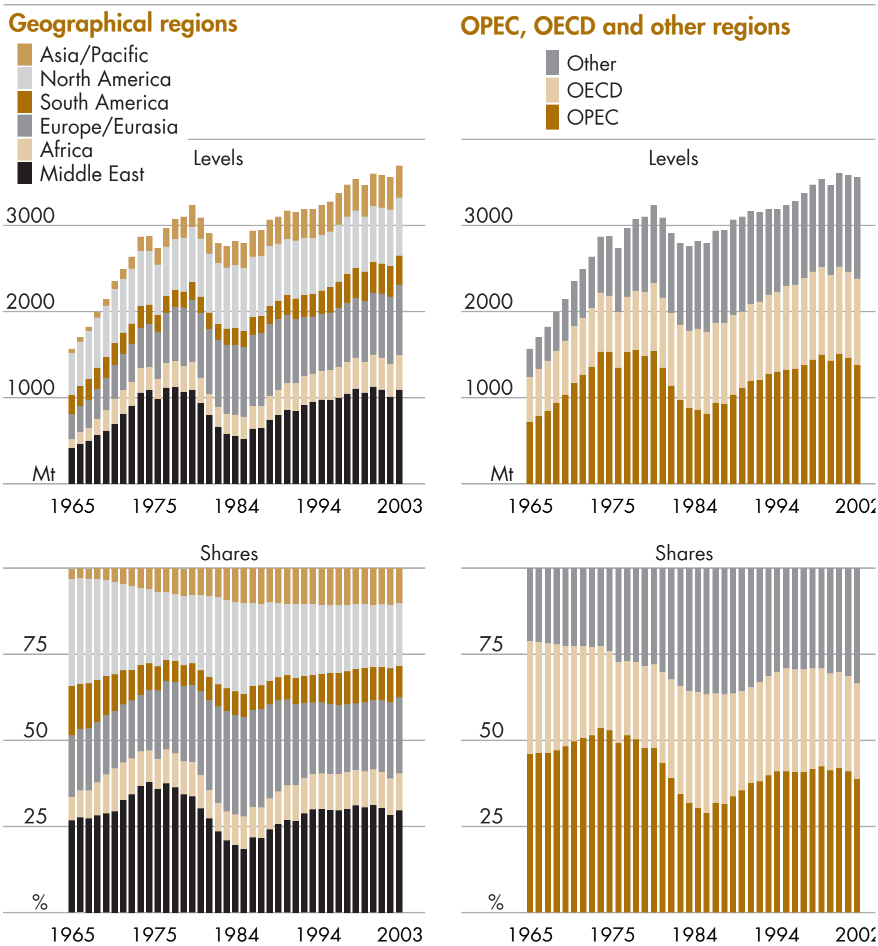
Future oil exploration is therefore important to discover new reserves as well as to diversify fuel sources to reduce market dependence in high risk areas. Given the level of historical volatility sourced from this region, the concentration of proved reserves and production in the Middle East for oil and, to a lesser extent, gas represents an important energy security risk to the APEC region.

World oil production since 1965

A further important consideration in world energy markets is the role of OPEC. The importance of both the Middle East and OPEC in world oil production since 1965 is indicated in figure 12.

In 2003, OPEC accounted for 77 per cent of world proved oil reserves and 40 per cent of world oil production (BP 2004).

12 **World oil production, by region (BP statistics)**



The OPEC producer cartel includes member countries from the Middle East (Iran, Iraq, Kuwait, Qatar, Saudi Arabia and the United Arab Emirates), north Africa (Algeria and Libya), west Africa (Nigeria), Asia Pacific (Indonesia) and south America (Venezuela).

While there have been several short term or temporary oil supply disruptions over the period, one of the most striking features in the world oil market over the past three decades has been the apparent shifts in the medium to longer term production decisions in the OPEC region. That is, oil production decisions by OPEC member countries have significantly influenced world oil prices in recent decades.

To the extent that any cartel (or oligopoly) has market power, industry profits can be increased by restricting production to raise prices above the level that would occur under competitive market conditions. Instability in the cartel arises as there are economic incentives for an individual cartel member to increase production (ignoring production targets) to increase short term profits.

Prior to the first oil shock, world demand for oil had been growing strongly. Between 1965 and 1973, world oil production increased at an annual average rate of 7.8 per cent (table 14). During this period, annual growth in OPEC oil production averaged 9.9 per cent. There had been significant upward pressure on world oil prices in the early 1970s.

OPEC reduced oil production by 0.7 per cent in 1974 and by a further 11.6 per cent in 1975. As a consequence, world oil production increased by only 0.3 per cent in 1974 and fell by 4.9 per cent in 1975. After rising by 26

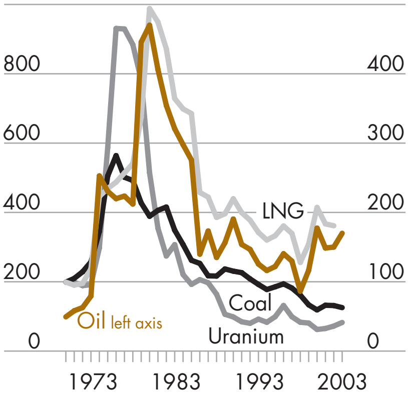
14 Historical annual average growth rates for world oil production, including OPEC, OECD and other regions

	1965–73	1973–79	1979–85	1985–91	1991–97	1997–2003
	%	%	%	%	%	%
OPEC	9.9	0.1	–10.1	6.7	3.1	0.3
OECD	3.6	2.3	3.3	–0.7	1.8	–0.4
Other	8.7	5.8	2.1	0.2	–0.4	3.3
World	7.8	2.0	–2.4	2.1	1.6	1.0

Source: Based on BP (2004).

13 Indicative world real price indexes of energy commodities

US$ per volume unit, 1970=100



per cent in 1973, real world oil prices increased by 217 per cent in 1974 (figure 13).

OPEC oil production increased in 1976 to a level marginally higher than in 1974 and, although there was some variability in subsequent years, was only around 1 per cent higher in 1979 than in 1974 — over this period, real world oil prices fell overall by 16 per cent.

The extent to which the cartel may exploit market power and sustain an increase in prices is limited since a sufficiently large price rise encourages oil conservation and switching to alternative fuel types as well as the exploration for and development of oil fields in other regions. These market responses were most apparent after the second oil shock when real world oil prices increased by 110 per cent in 1979 and by a further 5 per cent in 1980.

Annual growth in world oil production, after slowing substantially between 1973 and 1979, fell significantly between 1979 and 1985. The share of OPEC in world oil production, which had increased from 46 per cent in 1965 to a high of 54 per cent in 1973, fell to 48 per cent in 1979 and a low of 29 per cent in 1985. However, despite reduced OPEC oil production during the first half of the 1980s, real world oil prices fell over the period, with a sharp correction in 1986 — real world oil prices in 1986 were 70 per cent below the level in 1980.

Since that time, world oil production has increased moderately, with slower growth evident in recent years. OPEC increased production to regain market share that has varied within a relatively narrow band of 38–42 per cent since 1990.

The capacity of energy users to switch between fuel types is indicated by the relationship over time between real prices of different energy commodities (figure 13). (In the figure, oil and coal prices are from IMF 2004b, the

LNG price based on the Japanese fiscal year is from IEEJ 2004 and the uranium price is ABARE 2004.)

Future oil investment and production decisions by OPEC member countries will have important implications for world oil market outcomes. From an energy security perspective, some consideration needs to be given to the risk of some combination of short term oil supply disruptions associated with political instability in the Middle East and an unexpected change to OPEC oil production targets over a more sustained time period. For example, there is likely to be some risk attached to the assumption that OPEC economies will be willing to increase production over the longer term commensurate with most long term energy projections.

5

modeling approach

A key objective in this study is to quantify the impacts on APEC economies of possible energy supply disruptions, and to estimate how future energy market developments may affect energy security in the APEC region. The methodology employed in this study is outlined in this chapter, together with an analysis of the reference case, thereby providing the basis for understanding the impacts of energy supply disruption scenarios reported in the following chapter.

This chapter begins with a brief outline of the model and the reference case assumptions. This is followed by a presentation of the reference case outlook for APEC energy markets to 2030 that indicates how factors affecting energy security may evolve in the future. The chapter concludes with a brief comment about how to interpret simulation results.

ABARE's global trade and environment model

The impacts of energy supply disruptions 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 energy market disruptions because it takes into account the interactions between different sectors of the economy and among economies through trade 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 disruptions in energy markets and other external factors that could influence the operation of energy markets.

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 involving 62 production sectors and commodities. In this project, the GTEM database has been aggregated to the 23 regions and 18 sectors that best capture the energy consumption and trade implications of energy supply disruptions in the APEC region (table 15).

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. The aggregation in this study also

15 Regions and sectors in GTEM

	Region		Sector
1	Australia	1	Brown steaming coal
2	Canada	2	Coking coal
3	Chile	3	Black steaming coal
4	People's Republic of China	4	Oil
5	Hong Kong, China	5	Gas
6	Indonesia	6	Refined petroleum products
7	Japan	7	Electricity
8	Republic of Korea	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	Republic of the Philippines	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, Algeria is represented by north Africa and Nigeria by subSaharan Africa. **b** Europe includes Central Asia.

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.

Developing a reference case

As a dynamic general equilibrium model, GTEM requires a reference case or a 'business as usual' scenario against which the impacts of alternative scenarios can be measured. The reference case projections also quantify possible developments in energy security indicators, such as oil import dependence.

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 2030 in the absence of any changes to key energy or economic policies.

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. Table 16 shows the annual average of real GDP growth rates assumed in this study. These assumptions project more rapid economic growth in low income APEC economies, including China, Thailand and Viet Nam, and slower growth in high income APEC economies, including Japan and the United States.

The historical growth rates used in the study are from the International Monetary Fund (IMF 2004a). Long term projections to 2030 are from ABARE and are derived by fitting an ARIMA (autoregressive integrated moving average) forecasting model to the historical GDP data.

16 Real GDP growth rates assumed in the reference case
Average annual

Region	2002–30 %	Region	2002–30 %
Australia	3.3	Republic of the Philippines	3.4
Canada	2.9	Russian Federation	4.8
Chile	4.2	Singapore	4.1
People's Republic of China	6.1	Chinese Taipei	4.1
Hong Kong, China	3.4	Thailand	5.1
Indonesia	4.5	United States	3.2
Japan	1.6	Viet Nam	6.5
Republic of Korea	3.9	Middle East	3.8
Malaysia	5.2	Other OPEC	3.4
Mexico	3.8	Europe	2.3
New Zealand	3.1	Rest of World	4.6
Peru	3.4		

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 17). 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 (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 higher income 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 higher income 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

17 Fuel shares in electricity generation, reference case, 2002 and 2030

	Brown coal		Black coal		Oil		Natural gas		Nuclear		Other	
	2002	2030	2002	2030	2002	2030	2002	2030	2002	2030	2002	2030
	%	%	%	%	%	%	%	%	%	%	%	%
Australia	21.6	15.4	56.1	55.0	1.0	0.6	13.6	22.6	0.0	0.0	7.7	6.4
Canada	11.1	9.3	8.5	7.1	2.4	1.9	5.8	19.8	12.6	13.1	59.7	48.8
Chile	0.0	0.0	19.0	11.8	1.1	0.2	25.3	36.0	0.0	0.0	54.6	52.0
China	0.0	0.0	77.5	70.0	3.0	1.0	0.3	7.3	1.5	6.7	17.7	15.0
Hong Kong, China	0.0	0.0	63.6	65.0	0.4	0.4	35.7	34.3	0.0	0.0	0.3	0.3
Indonesia	0.0	0.0	39.6	55.4	23.2	7.2	22.0	24.8	0.0	0.0	15.2	12.6
Japan	0.0	0.0	26.5	24.3	13.2	7.7	22.3	27.6	26.9	31.6	11.0	8.9
Korea, Rep. of	0.0	0.0	39.7	37.0	9.5	0.5	12.7	13.7	36.2	45.0	1.9	3.8
Malaysia	0.6	0.2	5.4	32.4	9.3	0.2	77.3	58.3	0.0	0.0	7.4	8.9
Mexico	12.1	6.1	0.0	0.0	36.9	12.7	32.1	68.3	4.5	1.9	14.4	11.0
New Zealand	0.0	0.0	4.0	3.5	0.0	0.0	25.1	17.4	0.0	0.0	70.9	79.1
Peru	0.0	0.0	2.3	3.6	10.3	8.0	4.5	25.0	0.0	0.0	83.0	63.4
Philippines	0.0	0.0	33.2	40.5	13.0	4.4	18.0	32.0	0.0	0.0	35.8	23.2
Russian Federation	6.3	4.4	12.8	17.1	3.1	1.6	43.2	48.3	15.9	11.1	18.8	17.4
Singapore	0.0	0.0	0.0	0.0	39.6	13.6	58.3	81.5	0.0	0.0	2.1	4.9
Chinese Taipei	0.0	0.0	55.3	62.0	12.5	4.2	9.9	25.4	19.0	4.4	3.4	4.0
Thailand	15.3	2.0	1.1	16.0	2.6	0.2	72.2	73.8	0.0	0.0	8.7	8.0
United States	2.4	2.0	48.6	52.2	2.5	1.5	17.7	22.7	20.0	13.0	8.8	8.8
Viet Nam	0.0	0.0	13.6	12.9	12.2	1.8	23.2	32.6	0.0	0.0	51.0	52.7

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 lower income APEC economies, where a greater amount of new capacity is expected to be base load.

Oil and gas reserves

The outlook for the production and export of both oil and gas depends very much 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 world oil producers other than the Middle East, the rest of OPEC and Mexico, encounter oil production constraints throughout the projection period, except for Russia which is assumed to approach a natural oil resource constraint toward the end of the projection period. In the gas sector, it is assumed 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. Using this methodology, it is assumed that government initiatives succeed in lifting the constraint on foreign investment midway through the projection period.

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 and Chinese Taipei commences LNG imports from the Middle East toward the end of this decade. In addition, it is assumed that the Russian Federation commences exporting LNG to Japan by 2020 and that, toward the end of the projection period, it begins exporting gas to China and Korea through the Irkutsk pipeline. However, not all prospective projects were modeled. For example, proposals for LNG exports from Peru and a proposal to expand LNG production in Alaska, United States, have been omitted simply because of uncertainties surrounding timing and the size and destination of exports.
- the efficiency of energy use in the electricity and iron and steel sectors improves over time – these assumptions represent 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).
- technology shares for iron and steel reflect recent trends – in particular, the share of steel produced in electric arc furnaces is assumed to increase in most economies, with the notable exceptions of Japan and China. Assumptions 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 2030 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.

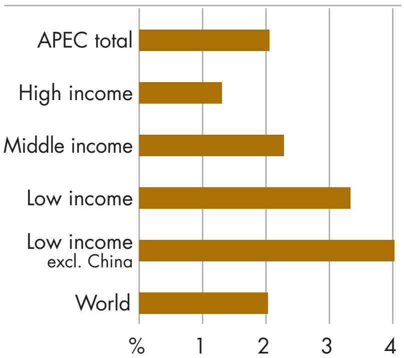
Primary energy consumption in APEC economies

Total primary energy consumption in APEC is projected to grow in the reference case by 2.1 per cent a year between 2002 and 2030, increasing from 5513 million tonnes of oil equivalent (Mtoe) in 2002 to 9751 Mtoe in 2030 (figure 14).

Note that the data for 2002 reported in chapters 5 and 6 differ from that of chapter 3 because the data here excludes combustibles and waste that are not used to generate electricity.

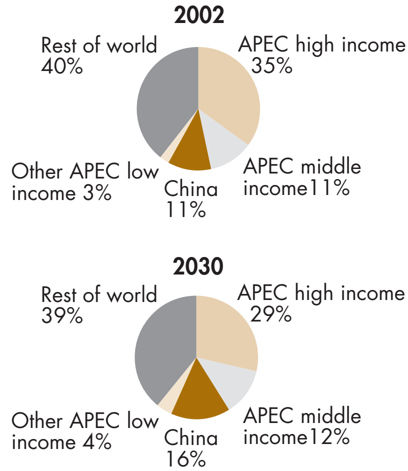
Growth in APEC energy consumption is similar to the projected growth in world energy consumption. As a result, APEC's share of world energy consumption in 2030 remains much the same as in 2002 (figure 15).

14 Average annual growth in TPEC reference case, 2002–30



However, growth in energy consumption varies considerably among APEC economies, with significant consequences for the importance of different APEC income groups in total world energy consumption. Energy consumption is projected to expand most strongly in low income APEC economies as a result of relatively rapid economic growth and increased demand for personal services in these economies. Consequently, the share of world energy consumption consumed by the low income economies is projected to rise considerably, from 14 per cent in 2002 to 20 per cent in 2030. In contrast, slow growth in energy consumption in the high income economies results in a declining share of world energy consumption from 35 per cent in 2002 to 29 per cent in 2030. Energy consumption grows by 2.3 per cent in middle income economies, leading to a slight rise in the share of world energy consumption from 11 per cent in 2002 to 12 per cent in 2030. Growth in middle income economies would be higher but for significant improvements in energy efficiency in the Russian Federation. Slow growth in Russian energy consumption leads to a decline in Russia's share of world energy consumption from 7 per cent to 6 per cent between 2002 and 2030, despite an increase in Russia's share of world economic output from 1 per cent to 1.5 per cent over the same period.

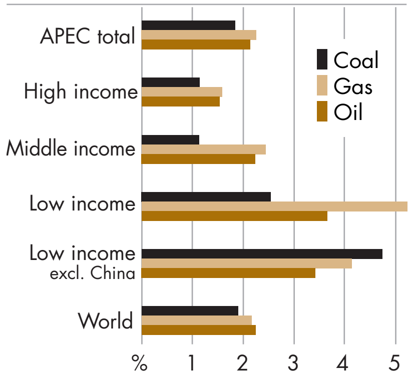
15 Share of world energy consumption reference case



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.

Of significance for energy security, the growth in APEC oil consumption is projected to be faster than all fuels other than natural gas (figure 16). As a result, the share of oil in total primary energy consumption is projected to increase from 38 per cent in 2002 to 39 per cent in 2030.

16 Average annual growth in TPEC reference case, 2002–30



The growth in oil consumption is driven mainly by increased demand from the transport sector, where there are limited substitution possibilities. Growth in oil consumption is strongest in the low and middle income economies, where rapid growth in the transport sector results from rapid economic growth and the sharp rise in private vehicle ownership. However, even in the slower growing high income economies, the consumption of oil grows faster than that of most other fuels.

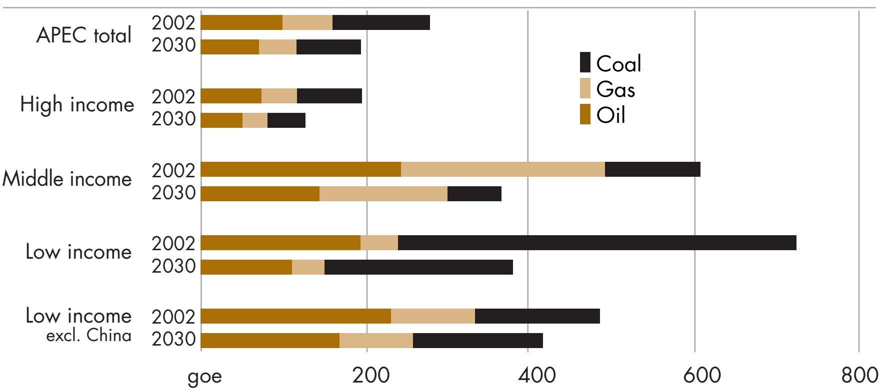
Natural gas is projected to be the fastest growing fuel in APEC energy consumption, particularly because of increased demand for gas for electricity generation in low income economies. Similarly, increased demand for coal in low income economies for electricity generation is the main driver of the growth in APEC coal consumption.

Energy intensity

Energy intensity is the ratio of energy consumption to real GDP. It indicates the importance of a stable supply of energy for an economy. Ignoring other factors, the higher the energy intensity of an economy, the greater would be the likely costs to the economy of a disruption in energy supplies.

In the reference case, APEC's energy intensity is projected to decline by 30 per cent between 2002 and 2030, largely as a result of a structural shift in economies away from energy intensive manufacturing and toward services that are less energy intensive. In absolute terms, the energy required to produce 2002US$1 of output declines from 277 grams of oil equivalent (goe) in 2002 to 192 goe in 2030 (figure 17).

17 **Energy required in APEC to produce 2002US$1 of GDP**
reference case



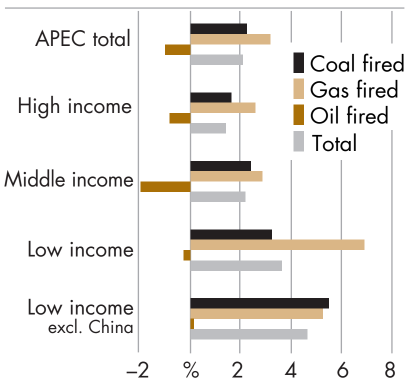
Energy intensity can be expressed in terms of specific fuels, such as oil and gas. By 2030 APEC is expected to require 28 per cent less oil per unit of output and 26 per cent less natural gas per unit of output than in 2002. In absolute terms, the amount of oil required to produce 2002US$1 of output declines from 99 goe to 71 goe between 2002 and 2030. Similarly, to produce the same value of output requires 61 goe of natural gas in 2002, but only 45 goe of natural gas in 2030.

Energy intensity tends to be higher for economies that are less developed. In part this is because economic development is characterised by a shift away from energy intensive production, of base metals for example, toward high technology industries and services which use much less energy. By 2030, the low income economies are more energy intensive than the other income groups, and the high income economies are by far the least energy intensive. However, in both 2002 and 2030, oil intensity is higher in middle income economies than in low income economies excluding China. This is because the middle income economies include the Republic of Korea and the Russian Federation, which are among the world's largest producers and exporters of petroleum products both in 2002 and 2030.

Energy consumption in electricity generation

The changes in the composition of fuel consumption in APEC over the reference case are driven to a large extent by growth in electricity generation across the region. Under the reference case, low income economies are projected to account for around half the growth in electricity generation in the region between 2002 and 2030, despite generating only 20 per cent of the region's electricity in 2002 (figure 18).

18 Average annual growth in APEC electricity generation
reference case, 2002–30



In China, the increase in electricity output over the period is characterised by increasing shares of natural gas and renewable energy sources in the electricity fuel mix. In other low income economies, where most new power generation capacity is expected to be for base load electricity demand, the role of coal in electricity generation is projected to increase, reflecting the continued competitiveness of coal in providing base load power. The cost competitiveness of natural gas turbines for peak load demand is one reason for the increasing share of natural gas in the electricity fuel mix in high income APEC economies, where peak load capacity is projected to account for a larger share of new power generation capacity than in other economies.

In all 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 in order to maintain or raise oil export revenues.

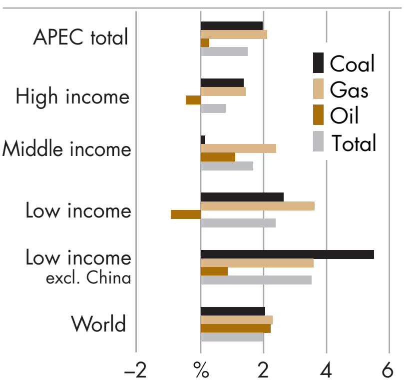
Energy production and self sufficiency in APEC economies

Energy production in the APEC region expands by 54 per cent over the projection period, from 5020 Mtoe in 2002 to 7568 Mtoe in 2030 (figure 19).

Growth in energy production is slower in APEC than in the world as a whole. APEC's share of world energy output therefore declines over the reference case from 54 per cent in 2002 to 48 per cent in 2030.

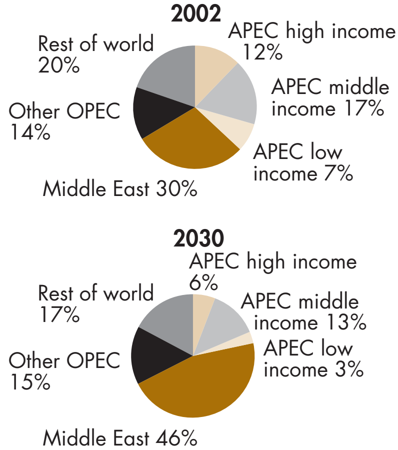
Over the projection period, slow growth in APEC oil production occurs as a result of natural resource constraints that are assumed to develop in most APEC economies, and indeed in most major oil producing economies. As a result of this slow growth, the share of APEC in world oil production declines considerably over the projection period, from 36 per cent in 2002 to 22 per cent in 2030 (figure 20). Conversely, oil production grows strongly in the Middle East and in other OPEC member economies. By 2030, the Middle East produces 46 per cent of world oil supplies, up from 29 per cent in 2002. OPEC as a whole produces 61 per cent of the world's oil in 2030, up from 44 per cent in 2002. Note that in

19 Average annual growth in APEC energy production
reference case, 2002–30



the GTEM database, OPEC members Algeria and Nigeria are represented by north Africa and subSaharan Africa respectively.

20 Share of world oil production
reference case



The increased risk attached to the concentration of oil production in the Middle East would be compounded if the Middle East were also to account for a large or growing share of world gas production. However the Middle East's share of world natural gas output grows to just 10 per cent in 2030, up marginally from 9 per cent in 2002. At the same time, APEC continues to dominate world natural gas production, although by a diminishing degree, supplying 57 per cent of the world's gas in 2030 compared with 60 per cent in 2002.

Energy self sufficiency in APEC economies

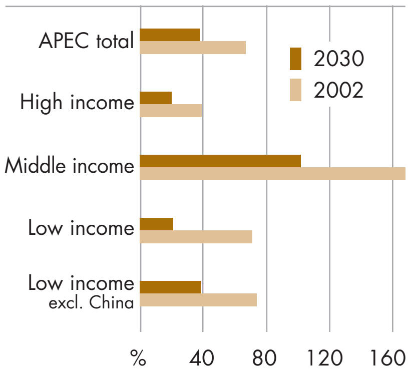
Energy self sufficiency represents an economy's capacity to meet its own energy requirements. It is measured in this study as domestic energy production divided by domestic energy consumption and expressed as a percentage.

Reflecting the slow growth of energy production in the APEC region, energy self sufficiency in APEC declines significantly from 91 per cent in 2002 to 79 per cent in 2030. This indicates a substantial deterioration in the extent to which the APEC region is able to supply its energy requirements.

The principal reason for the decline in energy self sufficiency is a large fall in oil self sufficiency, from 67 per cent in 2002 to 38 per cent by 2030 (figure 21). In contrast, the APEC region's self sufficiency in gas and coal does not change much over the reference case. At 2030, APEC remains self sufficient in gas (104 per cent) and coal (107 per cent).

The most severe decline in oil self sufficiency is experienced by low income economies. Particularly in China, domestic oil production is outpaced by

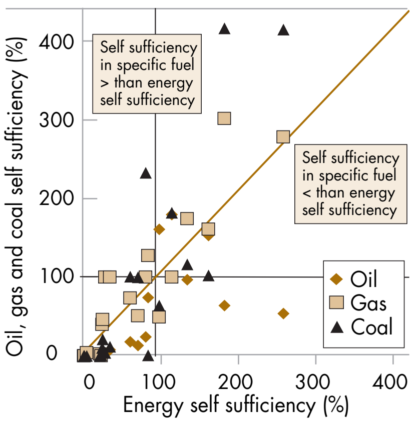
21 APEC oil self sufficiency
reference case



the dramatic growth in oil consumption, resulting in China's self sufficiency in oil falling from 69 per cent in 2002, to just 13 per cent in 2030. At 2030, China's oil self sufficiency is lower even than that of the United States, which is expected to be 18 per cent. Oil self sufficiency also declines strongly in the low income economies other than China, from 74 per cent in 2002 to 39 per cent in 2030. This is being driven by increasing oil reserve constraints in Indonesia, as indicated by the drop in Indonesia's oil self sufficiency from 111 per cent in 2002 to 64 per cent in 2030. By 2030, only the middle income economies retain self sufficiency in oil, at 102 per cent, but this is still significantly lower than in 2002 when oil self sufficiency measured 168 per cent. In the high income economies, oil self sufficiency is already low in 2002 at 39 per cent, but declines further to 20 per cent in 2030.

Despite the decline in oil self sufficiency in most APEC economies, there remains considerable differences in total energy self sufficiency among APEC economies at 2030 (figure 22). Coal and gas reserves are so vast in some economies that they retain self sufficiency greater than 100 per cent in total energy despite waning self sufficiency in oil.

22 Self sufficiency in energy and specific fuel types
reference case, 2030



Of the nineteen APEC economies included in the GTEM analysis, fourteen have an energy self sufficiency below 100 per cent by 2030 (table 18). These economies include six high income economies, three middle income economies (although Mexico is almost self sufficient) and five low income economies. Of these, none are self sufficient in more than one fuel type, other than New Zealand.

18 Self sufficiency of APEC economies in energy and specific major fuel types, reference case 2030

	Number of specific fuel types in which each economy is self sufficient: coal (c), oil (o) and gas (g)				Total
	0	**1**	**2**	**3**	
	no.	no.	no.	no.	no.
Economies with total energy self sufficiency below 100 per cent					
High income	4	1	1	0	6
	Hong Kong Japan Singapore Chinese Taipei	United States (c)	New Zealand (c,g)		
Middle income	2	2	0	0	4
	Korea Chile	Malaysia (g) Mexico (o)			
Low income	1	3	0	0	4
	Thailand	China (c) Peru (g) Philippines (g)			
Total	7	6	1	0	14
Economies with total energy self sufficiency equal to 100 per cent or more					
High income	0	0	2	0	2
			Australia (c,g) Canada (c,g)		
Middle income	0	0	0	1	1
				Russia	
Low income	0	0	1	1	2
			Indonesia (c,g)	Viet Nam	
Total	0	0	3	2	5
APEC economies					
High income	4	1	3	0	8
Middle income	2	2	0	1	5
Low income	1	3	1	1	6
Total	7	6	4	2	19

a GTEM projections do not include Papua New Guinea and Brunei.

Seven economies record low or zero self sufficiency in all major fuel types — specifically Chile, Hong Kong, Japan, Korea, Singapore, Chinese Taipei and Thailand. Only Mexico is self sufficient in oil in 2030 (161 per cent). However, a substantial shortfall in gas at 2030 (49 per cent) contributes to Mexico's total energy self sufficiency being marginally less than 100 per cent (98 per cent).

Five major energy producers in APEC remain self sufficient in both coal and gas at 2030, and consequently remain self sufficient for energy as a whole (table 18). These are Australia, Canada, Indonesia, the Russian Federation and Viet Nam. Energy self sufficiency in these five economies ranges from 258 per cent in Australia down to 114 per cent in Viet Nam. Of these, the Russian Federation and Viet Nam are also self sufficient in oil, and Canada is virtually self sufficient in oil (97 per cent). The remaining two economies, Australia and Indonesia, record oil self sufficiencies of 54 per cent and 64 per cent respectively, representing a substantial shift from being totally self sufficient or nearly so in 2002.

APEC energy trade

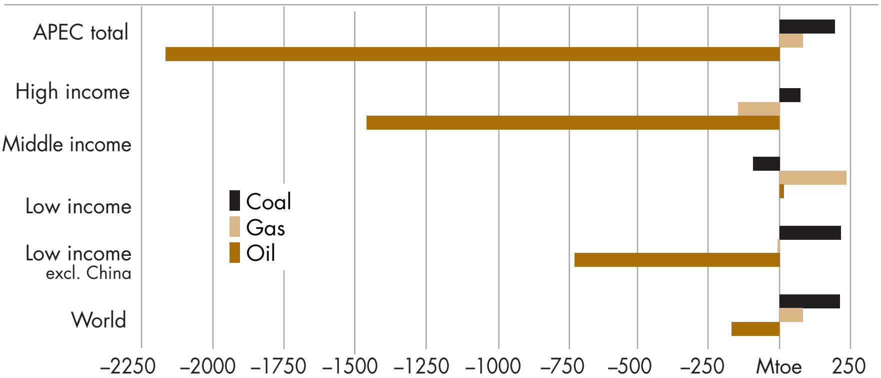
Net energy exports (or imports) are another way of measuring the extent by which domestic energy production exceeds (or falls short of) domestic energy consumption. Net energy exports are simply the volume of exports that exceeds the volume of imports. If this number is negative, then the economy is importing more energy than it exports and is a net energy importer, implying that domestic production is not sufficient to meet its energy requirements.

The APEC region is a net energy importer in 2030 (figure 23). Net energy imports in the APEC region are 2081 Mtoe, a more than a threefold increase in net energy imports from 2002. Most of the change from 2002 is concentrated in China and in the high income economies.

The most significant increase in net energy imports occurs in China, where net energy imports increase almost thirtyfold to 732 Mtoe. This reflects the deterioration in China's oil self sufficiency reported above. China's net oil imports stand at 555 Mtoe in 2030, accounting for 70 per cent of China's energy trade deficit.

23 APEC net energy exports

reference case, 2030



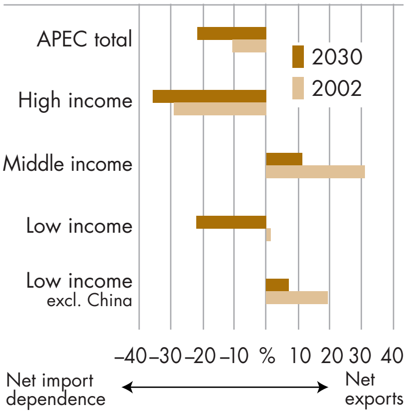
Net energy imports of the high income economies also rise, albeit by a much smaller margin, almost doubling over the projection period to 1617 Mtoe in 2030. As is the case in China, net oil imports constitute most of the energy trade deficit of high income economies, amounting to 1457 Mtoe in 2030. High income economies are also net importers of gas in 2030 (147 Mtoe). However, because of the strong growth in Australian coal exports, high income economies are net coal exporters in 2030 (73.5 Mtoe).

The middle income economies continue to export more energy than it imports, with net exports amounting to 219 Mtoe in 2030. But middle income economies remain net coal importers (94 Mtoe). For the low income economies other than China, energy exports surpass imports by 48 Mtoe in 2030, which is similar in volume to that of 2002.

Most APEC economies are net energy importers by 2030. In 2030 the four largest net energy importing economies represent all income groups and are the United States (1258 Mtoe), China (732 Mtoe), Japan (486 Mtoe) and Korea (315 Mtoe). The volume of net energy imports increases between 2002 and 2030 for all net energy importing economies.

Only five APEC economies are net energy exporters in 2030 — apart from Brunei which is not explicitly modeled in this GTEM analysis. The five net energy exporting economies represent all income groups and are the Russian Federation (615 Mtoe), Australia (307 Mtoe), Indonesia (253 Mtoe), Canada (108 Mtoe) and Viet Nam (11 Mtoe). Notably, the volume

24 APEC net energy import dependence reference case



of net energy exports of the Russian Federation, Australia and Indonesia expand significantly over the projection period. But this expansion is not sufficient to offset the growth in net energy imports in all other APEC economies.

Net energy imports only tell part of the story of how much APEC economies depend on energy imports. A more complete measure is given by expressing net energy imports as a percentage of domestic energy consumption (figure 24). For net energy importers, this indicates the degree of reliance on international markets to supply domestic energy requirements.

The share of APEC's energy consumption that is supplied by net imports doubles over the projection period to 22 per cent of total primary energy consumption in 2030. Much of the change is accounted for by the tenfold increase in the share of net energy imports in China's energy consumption to 30 per cent in 2030. Reliance on net energy imports also grows in high income economies, but by a much slower rate, to 35 per cent in 2030.

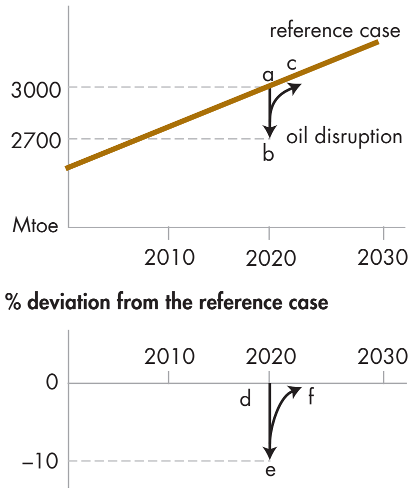
The corresponding indicator for net energy exporters is the percentage share of net energy exports in domestic energy consumption. This measure reveals the extent to which domestic energy requirements are absorbing an increasing share of domestic energy output.

Within APEC, the income groups that export more energy than they import are the middle income economies and the low income economies other than China. Over the reference case, there is a decline in the importance of export markets and a rise in the importance of the domestic market for both income groups. For the middle income economies, net energy exports decline as a share of domestic consumption from 31 per cent in 2002 to 11 per cent in 2030. Similarly, net energy exports as a share of energy consumption in the low income economies other than China declines from 19 per cent in 2002 to 7 per cent in 2030.

Interpreting simulation results

The GTEM reference case provides a benchmark against which the impacts of energy supply disruptions, such as an interruption to Middle East oil supplies, can be measured. For example, the impact of a disruption to Middle East oil exports can be isolated by comparing economic growth, sectoral output and investment, energy consumption and trade, and other variables in the disruption simulation against those in the reference case scenario.

25 Interpreting the deviation from the reference case in a GTEM simulation



To illustrate the point, suppose that oil consumption in a certain economy in the reference case in 2020 was 3000 million tonnes (point a in figure 25). Following an interruption to world oil supplies in 2020, oil consumption at 2020 is projected to be 2700 million tonnes (point *b*), or 300 million tonnes less than in the reference case. Hence the effect of the oil supply disruption in this example would be to reduce oil consumption by 10 per cent relative to the reference case at 2020 (a movement from point *d* to point *e* in the lower diagram).

6

quantifying the economic effects of temporary energy supply disruptions

It is the purpose in this chapter to indicate the likely impacts of three types of energy supply disruptions. These three scenarios are representative of the variety of disruptions that could threaten energy supplies to the APEC region as a whole.

The three scenarios are:

- a temporary disruption to oil production in the Middle East
- a temporary disruption to LNG production in the Middle East
- a temporary blockage of the Malacca Strait.

Each disruption has been simulated both in 2005 and in 2020, in order to assess how structural changes and energy market trends may alter the vulnerability of APEC economies to energy supply disruptions over time.

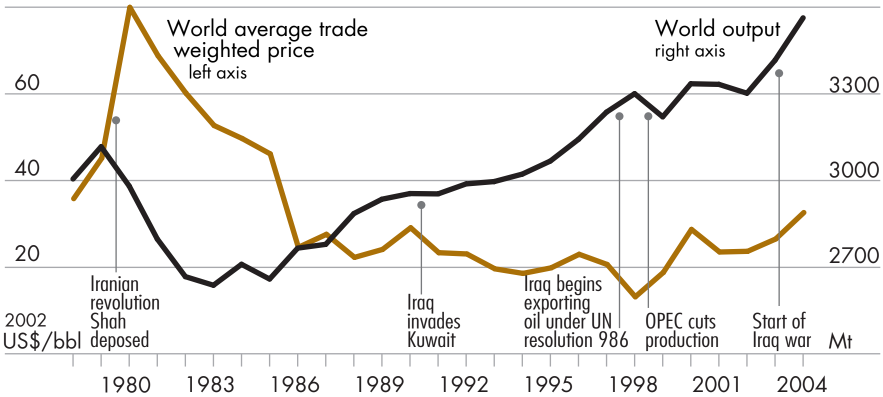
In all scenarios, the disruption is assumed to be temporary, occurring in one year and returning to reference case levels in the subsequent year. It follows that the impacts are only significant in the year of the disruption. Results are therefore only reported for the year of the disruption.

Temporary disruption to Middle East oil supplies

As illustrated in figure 26, the world oil market has experienced a turbulent history of supply disruptions. Much of this instability has had its origins in the Middle East, which is also the location of approximately two thirds of the world's proven oil reserves.

In the light of this history, it is assumed in these scenarios that Middle East oil output declines from the previous year by an amount that is equivalent to 5 per cent of world output. The severity of this disruption is similar in year on year percentage terms to that of 1980 caused by the Iranian

26 World oil market developments



revolution and the subsequent Iran–Iraq war. In both scenarios, the disruption translates to a decline in world oil output relative to the reference case of approximately 8 per cent, or 266 million tonnes of oil equivalent (Mtoe) in the 2005 scenario and 385 Mtoe in the 2020 scenario.

Further assumptions have been made on oil prices and LNG prices to more accurately reflect world markets. Because of the opportunity for arbitrage in the world oil market, oil prices throughout the world move together. To ensure that this occurs in the scenarios modeled here, it is assumed that oil demand is very responsive to changes in the domestic price relative to world 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. 2003a). The link between the oil price and LNG prices has been represented in the oil supply disruption scenarios for Japan, Korea and Chinese Taipei. However, in both scenarios, it is assumed the price of LNG imported by China is not affected by the disruption on the basis that the reference case price is already close to the ceiling price of Chinese contracts. While the detail of price formulas used in LNG contracts are not available to the public, it is possible to infer the relationship based on historical trends, as was done in Fujime (2002).

Summary of the impacts

The scenarios demonstrate that a disruption in the supply of oil will have significant impacts on world energy prices and consequently on APEC's energy sector. 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. In particular, net oil exporting economies are likely to gain from higher world oil prices, whereas net oil importing economies stand to lose. The impacts of the two oil supply disruption scenarios simulated for this study are summarised in table 19.

Energy price impacts

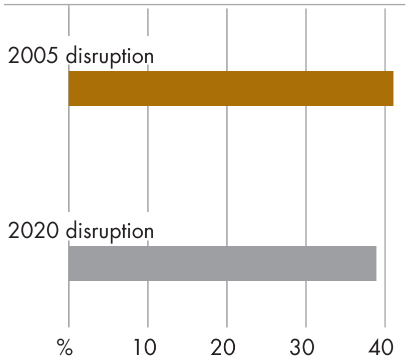
The decline in world crude oil supplies results in a rise in world crude oil prices relative to the reference case by about 40 per cent in both the 2005 and 2020 scenarios, after adjusting for inflation (figure 27). The world average trade weighted oil price, for example, rises to US$52 a barrel (in 2002 dollars) in 2005. Assuming perfectly competitive markets and ignoring policy

19 Impacts of the oil supply disruptions in 2005 and 2020
relative to the reference case

		Energy consumption				Energy imports			Energy exports		
	Real GNP	**Total**	**Oil**	**Gas**	**Coal**	**Oil**	**Gas**	**Coal**	**Oil**	**Gas**	**Coal**
	2002US$b	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe
2005 oil supply disruption scenario											
APEC	–43	–136	–148	–5	15	–136	–5	1	150	1	5
High income	–49	–83	–78	–4	6	–108	–5	0	26	3	2
Middle income	6	–51	–60	–1	–2	–9	0	1	109	–1	2
Low income	0	–2	–10	0	11	–18	0	0	16	–2	1
– excl. China	4	0	–2	0	1	–8	0	0	7	–2	–1
World	–134	–253	–323	11	23	–193	–2	1	–135	–2	7
2020 oil supply disruption scenario											
APEC	–82	–223	–243	–5	20	–211	–6	1	168	2	6
High income	–68	–120	–116	–4	8	–143	–7	0	22	2	3
Middle income	1	–68	–78	–2	–2	–13	1	0	140	0	1
Low income	–16	–35	–49	1	14	–54	1	0	5	0	2
– excl. China	1	–7	–10	0	1	–12	0	0	5	0	0
World	–176	–386	–478	16	32	–308	–3	1	–216	–4	7

responses, higher crude oil prices results in the CPI adjusted price of petroleum products rising by an average 41 per cent and 39 per cent relative to the reference case in the 2005 scenario and 2020 scenario respectively.

27 Change in world crude oil prices following oil supply disruptions relative to the reference case



Not only do oil prices increase, so do the prices for 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 leads to higher LNG prices. For example, the price of LNG rises by just over 20 per cent relative to the reference case in Japan, Korea and Chinese Taipei, in both the 2005 and the 2020 scenarios. In addition, in response to a higher relative price of oil, demand rises for alternative energy sources and this contributes to higher prices for coal and natural gas other than LNG, relative to the reference case.

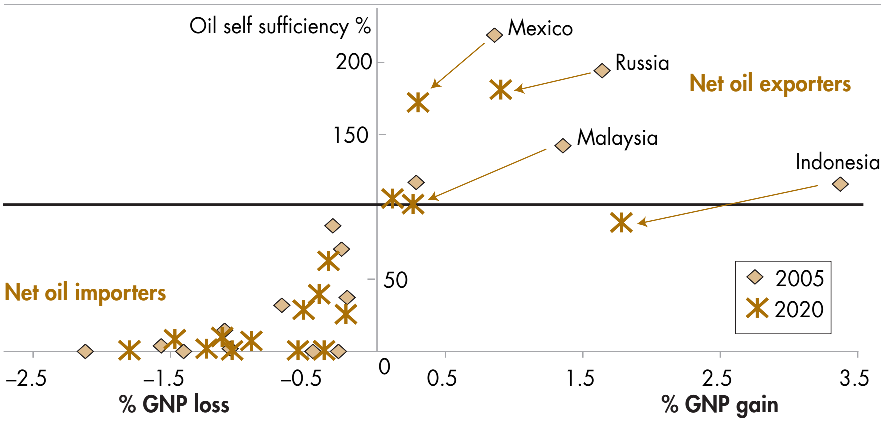
Impacts on economic output

As a result of the rise in world energy prices, and the associated increase in production costs, the level of economic activity across APEC contracts relative to the reference case (table 19).

The impact that higher energy prices have on the level of economic activity may be dissected 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 always negative. The income transfer effect occurs because the rise in real 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 energy intensive industries, because of the increase in the costs of production associated with the shortage in oil supplies.

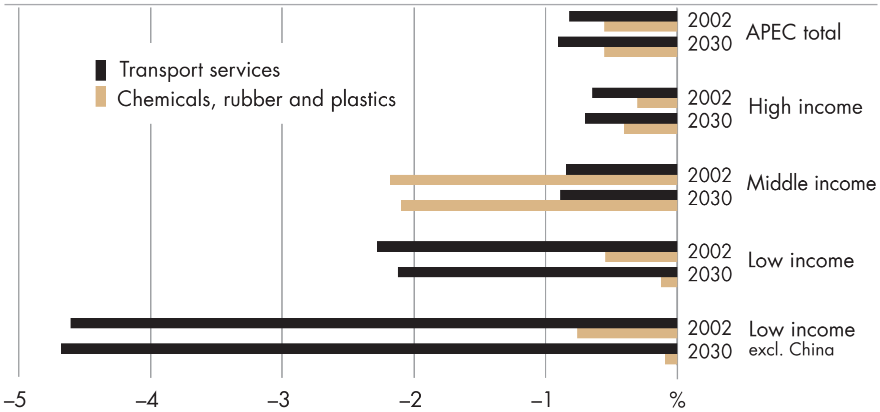
APEC as a whole is a net oil importer, and for this reason, both the output effect and the income transfer effect are negative for the APEC region. APEC's gross national product (GNP) therefore contracts relative to the reference case, by 0.2 per cent, or US$43 billion (in 2002 prices) in the 2005 scenario, and by 0.2 per cent or by US$82 billion (in 2002 prices) in the 2020 scenario. To put these numbers into perspective, the contraction in the 2005 scenario is roughly similar to the current size of each of the economies of New Zealand, Peru or Viet Nam. In the 2020 scenario, the contraction in the APEC economy is similar to the current size of each of the economies of Malaysia, the Philippines or Singapore.

28 Oil self sufficiency and change in output
following oil supply disruptions relative to the reference case



The interplay of the income transfer and output effects explains why aggregate output impacts vary considerably among APEC economies (figure 28). High income economies experience the greatest losses in APEC as they typically depend heavily on net oil imports. Conversely, strong gains are experienced relative to the reference case in the 2005 scenario in the oil exporting economies of Indonesia, Malaysia and Russia, and to a lesser extent Mexico. The gains in Mexico are lower than in other oil exporting economies as investment constraints in Mexico's oil sector assumed in the reference case limit Mexico's oil production capacity. In addition, the gains in Mexico are offset by a decline in Mexico's exports to the United States relative to the reference case.

29 Change in APEC production in selected sectors
following oil supply disruptions relative to the reference case



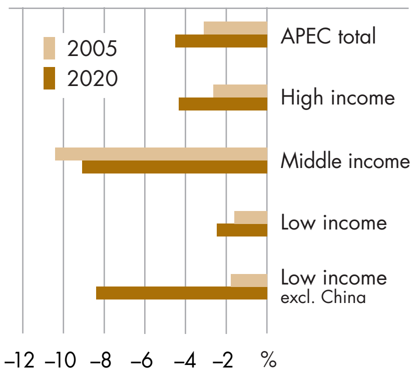
Sectoral impacts

The negative impact on APEC of the disruption to oil supplies is concentrated in those industries that rely intensively on petroleum inputs, specifically the transport industry and the chemicals, rubber and plastics industry (figure 29). The higher cost of oil leads to higher prices and lower demand for these oil intensive commodities relative to the reference case.

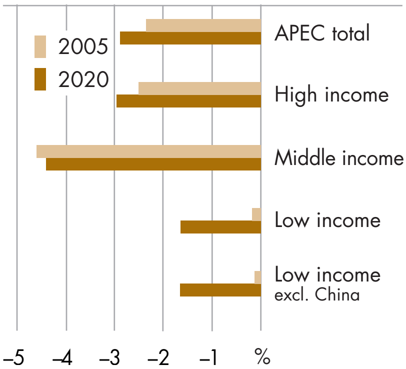
This decline in energy intensive manufacturing is most pronounced for middle income economies, as indicated by the reduction in energy intensity relative to the reference case in figure 30.

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

30 Change in APEC energy intensity
following oil supply disruptions
relative to the reference case



31 **Change in APEC TPEC**
following oil supply disruptions
relative to the reference case

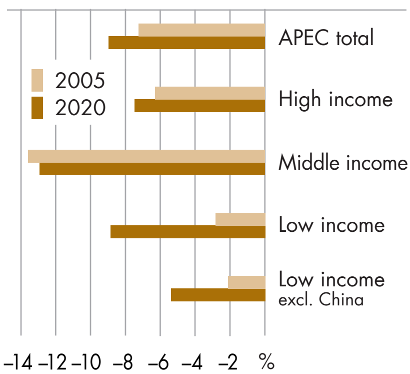


Energy consumption impacts

Together with the reduction in energy intensive production, total primary energy consumption declines relative to the reference case in each scenario (figure 31). Underlying the fall in total primary energy consumption is a sharp drop in oil consumption in response to higher prices. APEC-wide oil consumption declines relative to the reference case by 7.3 per cent in the 2005 scenario and 9 per cent in the 2020 scenario. In contrast, APEC consumption of coal and electricity increase relative to the reference case, as energy users substitute away from oil products in response to higher oil prices. It is worth noting, however, that in Mexico, where oil fired power generates a significant proportion of electricity, the rise in oil costs contributes to a decline in the consumption of electricity relative to the reference case by 2.5 per cent in 2005 and by 1.6 per cent in 2020.

There is some decline in APEC consumption of natural gas relative to the reference case in response to higher LNG prices. However, LNG import volumes are largely determined by contract and hence are not sensitive to price changes, and therefore not too much weight should be put on the estimate that APEC gas consumption declines by 0.3 per cent relative to the reference case in both scenarios.

32 **Change in APEC oil consumption**
following oil supply disruptions
relative to the reference case



Oil consumption impacts vary considerably among APEC income groups (figure 32). Reflecting a greater reduction in energy intensive production, the decline in oil consumption is particularly pronounced for middle income economies in both scenarios.

This is primarily driven by the decline in competitiveness of energy intensive production in Russia.

In the 2005 scenario, low income economies experience the lowest decline in oil consumption among each of the income groups. In contrast, in the 2020 scenario, oil consumption by low income economies declines by more than any other income group — both when China is included and when China is excluded. Behind this marked change in the severity of the impacts on oil consumption lie important developments in the oil sectors of Indonesia and China in particular. Net oil imports in China, for example, grow by over 200 per cent between 2005 and 2020, greatly increasing the negative income transfer effect on China of an oil supply disruption in the latter part of the projection period. Likewise, while currently a net oil exporter, by 2020 Indonesia has become a significant net oil importer in the reference case, relying on net oil imports to supply 12 per cent of oil consumption.

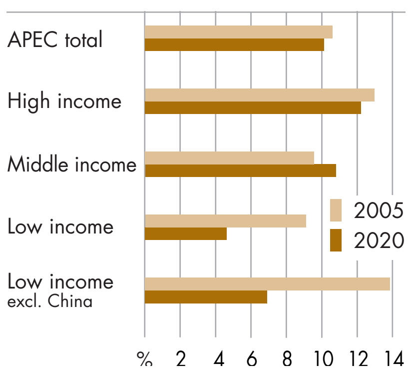
Similarly, the reduction in oil consumed in high income economies relative to the reference case is greater in 2020 than in 2005. This is because the dependence of high income economies on oil imports, and hence the negative income transfer effect, increases over time. Between 2005 and 2020, net oil imports in the United States, for example, grow by 52 per cent relative to the reference case to 790 million tonnes.

Energy production impacts

APEC producers respond to higher oil prices by raising crude oil production to over 10 per cent above the reference case in both the 2005 scenario and the 2020 scenario (figure 33). This is equivalent to an increase in production of about 138 million tonnes in 2005 and 2020 above reference case levels.

Most of this increase in crude oil production is concentrated in middle income economies, particularly APEC's two largest oil exporting economies, the Russian Federation and Mexico,

33 Change in APEC oil production following oil supply disruptions relative to the reference case



together with another significant oil exporter in Malaysia. Oil production in high income economies and in other resource constrained economies such as Thailand also increases in response to higher world oil prices, as high world oil prices make it profitable to operate high marginal cost oil fields. Oil production in high income economies increases relative to the reference case by 56 million tonnes in the 2005 scenario, and by 49 million tonnes in the 2020 scenario. The increase is more subdued in 2020 as a result of the ongoing depletion of oil reserves in the reference case between 2005 and 2020.

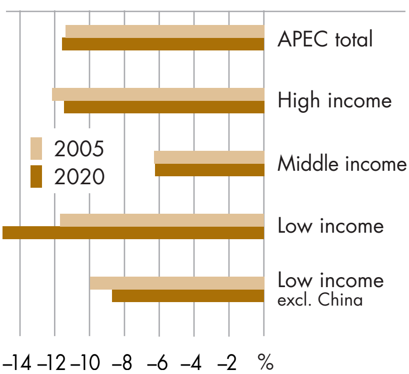
APEC production of coal also rises relative to the reference case in response to the increase in consumption. Coal production rises relative to the reference case by 17 Mtoe in 2005 in the 2005 scenario and by 23 Mtoe in 2020 under the 2020 scenario. In both instances, China accounts for approximately 60 per cent of the increase.

Similarly, world consumption of gas increases relative to the reference case, leading to higher APEC production and export of gas. However, the increase in APEC gas production is not significant, rising above the reference case by just 1.5 Mtoe in 2005 and by 3 Mtoe in 2020.

Energy trade impacts

Changes in energy consumption and energy production determine the impacts of the oil supply disruption scenarios on energy trade. By far the largest trade impacts are experienced in oil markets. Declining demand for oil leads to a fall in oil imports in all economies (figure 34). APEC's demand for crude oil imports contracts by 11 per cent in 2005 under the 2005 scenario relative to the reference case or by 136 million tonnes. In the 2020 scenario, APEC's crude oil imports decline relative to the reference case by 12 per cent in 2020, or by 211 million tonnes.

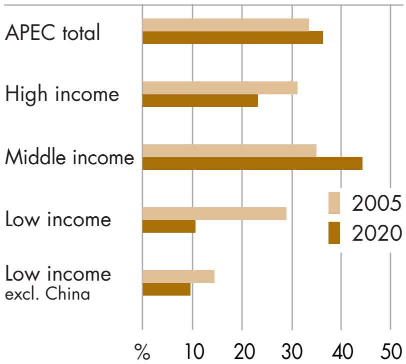
34 Change in APEC oil imports
following oil supply disruptions
relative to the reference case



While crude oil imports contract, crude oil production and exports by

APEC expand in response to higher world oil prices (figure 35). In the 2005 scenario, for example, APEC exports of crude oil rise by 34 per cent in 2005 relative to the reference case, or by 150 million tonnes. The Russian Federation accounts for a large proportion of this expansion, contributing over half in the 2005 scenario and over 70 per cent in the 2020 scenario. Russia's contribution is significantly larger in the 2020 scenario than in the 2005 scenario because its oil reserves remain abundant in contrast to the resource constraints anticipated for APEC generally.

35 **Change in APEC oil exports**
following oil supply disruptions
relative to the reference case



APEC's gas and coal trade grows marginally relative to the reference case, reflecting the increases in gas and coal consumption and production. Furthermore, following a shift toward coal and gas and out of oil consumption in regions other than APEC, APEC increases its position as a net exporter of gas and coal to the rest of the world. APEC's net exports of gas are larger than the reference case by 6 Mtoe and 8 Mtoe in the 2005 scenario and 2020 scenario respectively. Similarly, in both scenarios APEC's net coal exports are 5 Mtoe larger than in the reference case.

Temporary disruption to Middle East LNG production

LNG imports provide almost all of the natural gas requirements of the APEC economies of Japan, Korea and Chinese Taipei. LNG imports will also become significant over time for China, Mexico and the United States. The capital intensive nature of LNG supply and the lack of a mature spot market inhibit the market's capacity to respond to a disruption in supply from a major exporter. As demonstrated by the shutdown of the LNG complex in north Aceh in March 2001, this could leave LNG importers vulnerable to disruptions to LNG supply from their principal suppliers. As gas is an important input to economic activity in LNG importing economies, any interruption to LNG supplies could be costly for LNG importing economies.

Two LNG disruption scenarios are implemented — one in 2005 and one in 2020 — in order to show how developments in the Asia Pacific LNG market may alter the impacts of an LNG supply disruption. In these scenarios it is assumed that the Middle East experiences severe disruptions to the production and export of LNG. For example, security concerns or a technical failure may halt production at one or more important LNG facilities that are dedicated to the Asia Pacific market. Middle East gas exports are assumed to return to reference case levels in the year immediately after the disruption in both scenarios.

In both scenarios, it is assumed the disruption to Middle East gas exports is equivalent to 10 per cent of the world's annual LNG production in the year of the disruption. Based on reference case projections, the volumes of the LNG disruption are estimated to be 15 Mtoe in 2005 and 33 Mtoe in 2020. Relative to the reference case, the LNG disruption interrupts 6 per cent of APEC LNG imports in the 2005 scenario and 7 per cent in the 2020.

The consequences of a disruption to LNG supplies were found to be insignificant for economies that do not trade in LNG. The analysis is therefore confined to those APEC economies that either import or export LNG.

Furthermore, because of the nature of the APEC LNG market, the analysis focuses on the economies that import LNG from the Middle East. Most APEC LNG imports are supplied under long term contracts. These contracts link LNG prices to crude oil prices, but do not typically link LNG prices to interruptions in LNG supply. On the one hand this means that an oil price shock will directly raise the price of most LNG delivered under contract, as was modeled in the preceding oil supply disruption scenarios. On the other hand, LNG imported under a contract will not be affected by a disruption to LNG supply, for example in the Middle East, unless the contract is with the affected supplier. Given the nature of the LNG market, this analysis focuses on economies that source a significant proportion of LNG supplies from the Middle East or on the spot market.

The focus economies in the 2005 LNG disruption scenario are Japan and Korea, as they currently import LNG from the Middle East, and the United States, which relies heavily on the spot market. In the 2020 scenario, the only additional focus economy is that of Chinese Taipei. Chinese Taipei will begin importing LNG from the Middle East under a long term contract toward the end of the decade.

While China and Mexico are expected to commence importing LNG during this decade, it is not clear that these economies will source LNG from the Middle East, and so it is assumed that these economies are not subject to a disruption in LNG supply in either scenario. Other APEC economies are considering introducing LNG imports, specifically New Zealand, the Philippines, Singapore and Thailand (Ball, Schneider, Fairhead and Short 2004). However, the details of these projects have yet to be decided and so LNG imports are not introduced into these economies in the reference case.

There are fewer economies in APEC that export LNG. Current APEC suppliers that are explicitly represented in GTEM include Australia, Indonesia and Malaysia. The Russian Federation is included in the 2020 scenario because it is due to commence exporting LNG to Japan and Mexico later this decade. The United States currently exports small volumes of LNG from Alaska, but is not a major supplier to the APEC region. While there is a proposal to expand LNG production in Alaska, and Peru may commence exporting LNG later this decade, the uncertainties associated with these projects mean that these economies are not treated as exporters in either scenario.

Summary of the impacts

The scenario indicates that a disruption to Middle East exports of LNG to APEC will have marginal impacts on the economies that import LNG from

20 Impacts of the LNG supply disruptions in 2005 and 2020
relative to the reference case

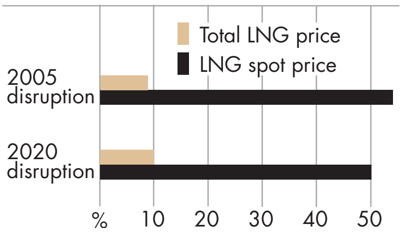
		Energy consumption				Energy imports		
	Real GNP	Total	Oil	Gas	Coal	Oil	Gas	Coal
	2002 US$b	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe
2005 LNG supply disruption scenario								
Japan	–0.59	–1.16	0.16	–2.14	0.01	0.16	–2.19	0.01
United States	0.00	–0.16	0.07	–0.57	0.13	0.15	–0.46	0.00
Korea	–0.32	–0.67	0.12	–1.44	0.13	0.12	–1.44	0.13
2020 LNG supply disruption scenario								
Japan	–0.43	–1.16	0.12	–2.11	0.01	0.12	–2.16	0.01
United States	–0.09	–0.57	0.32	–1.80	0.42	0.46	–2.01	0.00
Korea	–0.53	–1.08	0.16	–2.69	0.23	0.16	–2.69	0.22
Chinese Taipei	–0.17	–1.24	0.08	–0.06	0.09	0.08	–1.81	0.09

the Middle East (table 20). These impacts will arise both directly through energy prices, and indirectly through economywide and sectoral impacts. However, even for economies that are engaged in LNG trade, the impacts are significantly smaller in this set of scenarios than in the oil supply disruption scenarios discussed earlier.

Energy price impacts

While GTEM does not explicitly differentiate LNG supplied under contract and LNG supplied on the spot market, it is possible to infer LNG price impacts on the basis of some reasonable assumptions. The majority of LNG traded in the Asia Pacific is supplied under long term contracts, with prices linked largely to oil prices. In contrast, spot cargoes of LNG currently account for about 2 per cent of the Asia Pacific market. Given that oil prices do not vary significantly in the LNG disruption scenarios, it is reasonable to assume that LNG contract prices do not change for the purpose of this analysis. Based on that assumption, it can be inferred that the disruption to LNG supplies leads to an increase in Asia Pacific LNG spot prices by 54 per cent in the 2005 scenario and by a little over 50 per cent in the 2020 scenario relative to the reference case (figure 36).

36 Change in APEC LNG prices following LNG supply disruptions relative to the reference case

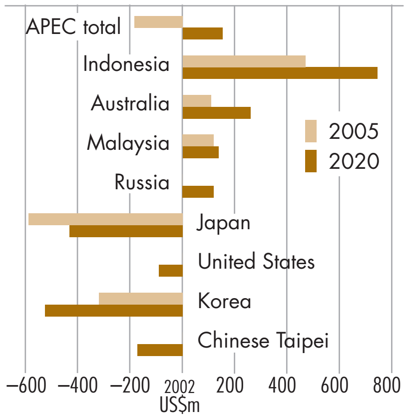


While the impact on the LNG spot price is marginally less in 2020 than in 2005, the impact on the total gas price is marginally greater in 2020 than in 2005. This is because LNG comprises a larger share of the gas market in 2020 than in 2005. For example, it is estimated in the GTEM reference case that the share of LNG in world total gas output is between 6 and 7 per cent in 2005, and increases to almost 10 per cent in 2020.

Impacts on output

The reduction in LNG supplies from the Middle East leads to subdued economic growth in LNG importing economies, while improving economic growth in LNG exporting economies. However, given that LNG constitutes a small part of the total APEC economy, APEC-wide economic activity is only marginally affected by the LNG disruption (figure 37).

37 **Change in GNP** following LNG supply disruptions relative to the reference case



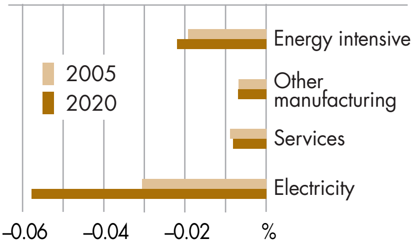
In economies that import LNG from the Middle East, inadequate LNG supplies increase production costs, leading to a contraction in economic activity relative to the reference case. Under the 2005 LNG disruption scenario for example, aggregate output in 2005 contracts by US$590 million (in 2002 prices) in Japan relative to the reference case, and by US$320 million in Korea. Similarly in the 2020 LNG disruption scenario, the contractions in aggregate output in 2020 among LNG importing economies range from US$525 million (in 2002 prices) in Korea down to US$91 million in the United States. The level of economic activity in the United States is not affected in 2005, but declines in 2020 on the basis that the United States' economy becomes more dependent on LNG imports from the Middle East.

For LNG exporting economies such as Indonesia, Malaysia, Australia and, in the second scenario, Russia, higher prices for LNG spot cargoes provide some additional export revenue, which in turn contributes to an expansion in economic activity relative to the reference case. Note that this assumes that all parties agree to redirect LNG cargoes to economies that have lost supply from the Middle East, and away from other LNG importing economies.

Indonesia's economy benefits more than that of other LNG exporters because the LNG sector comprises a large share of the Indonesian economy. In contrast, LNG imports to the Asia Pacific are much less significant to the Russian economy, limiting Russia's economywide gains.

The economic gains are larger in 2020 than in 2005 for LNG exporting economies and hence for APEC as a whole. This reflects the greater capacity of LNG producers to respond to higher prices in 2020 than in 2005.

38 **Change in output of economies importing LNG from the Middle East** following LNG supply disruptions relative to the reference case



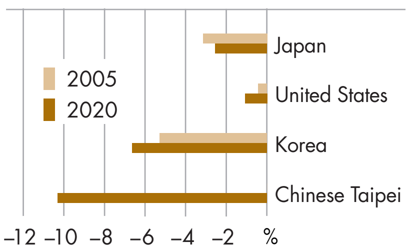
Output changes at the sectoral level are most significant in energy intensive manufacturing and in the energy sector. As gas fired power generates a significant share of electricity in all LNG importing economies considered here, the price of electricity in these economies rises relative to the reference case. As a result, electricity consumption and electricity output are lower than in the reference case for LNG importing economies and for APEC as a whole.

Because the LNG supply disruption raises the price of gas and electricity in LNG importing economies, energy intensive production in these economies loses competitiveness relative to the reference case (figure 38). Production of energy intensive commodities is therefore lower in the LNG disruption scenarios than in the reference case. Production levels in other sectors, including other manufacturing and services, are also below reference case levels to the extent they rely on electricity and gas in their production processes.

Energy and natural gas impacts

A significant decline in gas consumption contributes to a decline in total energy consumption in LNG importing economies relative to the reference case (table 20). Some energy substitution away from gas takes place in these economies, leading to higher levels of consumption of oil and coal than in the reference case.

39 **Change in natural gas imports** following LNG supply disruptions relative to the reference case



In LNG importing economies, the contraction in LNG imports relative to the reference case mirrors the contraction in gas consumption (figure 39). Various factors govern how the extent of contraction in consumption and imports varies among economies. The first is the degree of dependence on Middle East LNG. Korea, for example, relies more on the Middle

East for imported gas supplies than does any other APEC economy in 2005 and in 2020. Hence the LNG disruption impacts more on Korea's gas consumption and imports than for most other economies.

Another key factor underlying the extent to which LNG imports contract is the opportunity for substitution away from gas. In Chinese Taipei, for example, over three quarters of LNG imports are used to generate electricity, a sector in which there are significant opportunities for fuel substitution. By increasing capacity utilisation of coal fired and nuclear plants, Chinese Taipei is able to reduce its dependence on LNG fired power relative to the reference case. In this way, Chinese Taipei is able to reduce gas consumption and LNG imports relative to the reference case much more cheaply than can economies such as Korea, where the residential sector is the primary gas consuming sector.

The fact that it is less expensive for some importers to adjust to a disruption to LNG supplies than it is for others, reveals that there are opportunities for all to gain from cooperation, and more generally from enhancing market flexibility. It is assumed in this set of scenarios that economies take advantage of these opportunities. At the very least, it is assumed that LNG cargoes are redirected, for example, from Chinese Taipei toward Korea, in order to reduce the regionwide cost of the LNG disruption. In addition, spot cargoes are made available by redirecting spot cargoes from economies that rely heavily on the spot market, for example the United States; and by a significant increase in spot LNG cargoes from less traditional suppliers to the Asian region, including for example Trinidad and Nigeria. To the extent any of these factors failed to materialise, the costs that result from the LNG supply disruptions would be greater than reported here.

These factors combine in the 2005 LNG disruption scenario to provide LNG spot cargoes to Japan and Korea approximating 13 Mtoe or 16 per cent of total LNG imports for these two economies in 2005. In the 2020 LNG disruption scenario, LNG spot cargoes supplied to Japan, Korea and Chinese Taipei in 2020 are greater still, approximating 36 Mtoe or 27 per cent of total LNG imports for these three economies. This estimate for 2020, although high, is not unreasonable given the developments that are enhancing market flexibility, including the growth of the spot market (Ball et al. 2004).

Temporary blockage of the Malacca Strait

The Malacca Strait is the principal maritime trade route between the Indian and Pacific Oceans. While small in size, the Malacca Strait carries approximately a quarter of world maritime trade through its channels. Were it to be blocked, ships would need to travel double the length of the Malacca Strait in order to circumvent the Malacca Strait. This has the potential to impose additional costs on economies that rely on trade flows through the Strait of Malacca, including the economies of the Asia Pacific. Two scenarios are implemented in this study to analyse the impacts on APEC energy markets of a blockage of the Malacca Strait — one in 2005, and a second in 2020.

In both scenarios, it is assumed that shipping through the Malacca Strait is stopped for 5 weeks. This is not an unreasonably short period of time given the experience and state of readiness of the workforces that manage the Strait, particularly in the narrowest length of the channel alongside Singapore. If anything, five weeks may overstate the length of time of any potential blockage. Nonetheless the five week blockage assumed in this study is sufficient to indicate the nature and extent of impacts of a major blockage.

The stoppage is simulated by assuming the productivity of shipping decreases by an annualised 5 per cent. The size of this decline in productivity is based on the US Department of Energy's estimate that the size of the fleet required to navigate around the Malacca Strait would double in the event of a blockage (EIA 2004a). For the purposes of the modeling exercise, this is equivalent to assuming that the productivity of shipping through the Strait would be halved during the course of a blockage. A decline in productivity of shipping of 50 per cent over a period of five weeks converts to an annual decline in productivity of almost 5 per cent.

Not all APEC economies depend on the Malacca Strait for trade with non-APEC economies. To reflect this, the productivity of shipping is not shocked for some APEC economies. In particular, the productivity of shipping is not shocked for trade between non-APEC economies and Canada, Mexico, the Russian Federation and, for some commodities, the United States. The remaining volume of trade that is subject to the shock constitutes 25 per cent of world maritime trade in the GTEM database and this proportion is consistent with EIA estimates of the share of world maritime trade currently flowing through the Malacca Strait (EIA 2004a).

Summary of the impacts

Trade underpins the strength of APEC economies, and most maritime trade with non-APEC regions flows through the Malacca Strait. A stoppage of shipping through the Malacca Strait for five weeks, and consequently the decline in productivity of maritime freight relative to the reference case, will lower economic growth and hence energy demand in the APEC region relative to the reference case. Furthermore, the blockage will have an impact on relative energy prices, with some implications for energy intensive production and for energy consumption and trade. However, it has been found that the impacts of a Malacca Strait blockage are not significant, particularly when compared with the impacts of the oil supply disruption scenarios (table 21).

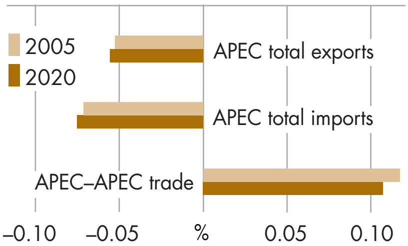
Macroeconomic impacts

The five week blockage of Malacca Strait has some implications for trade and hence for economic welfare in the Asia Pacific region. Under the

21 Impacts of the Malacca Strait blockages in 2005 and 2020
relative to the reference case

		Energy consumption				Energy imports			Energy exports		
	Real GNP	**Total**	**Oil**	**Gas**	**Coal**	**Oil**	**Gas**	**Coal**	**Oil**	**Gas**	**Coal**
	2002US$b	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe
2005 Malacca Strait blockage scenario											
APEC	–1.68	–0.45	–0.68	–0.04	0.17	–0.78	–0.06	0.02	0.58	0.05	–0.23
High income	–0.91	–0.61	–0.96	–0.07	0.08	–0.67	–0.08	0.01	0.83	0.03	–0.09
Middle income	–0.03	0.13	0.36	0.03	0.01	0.08	0.02	0.01	–0.38	–0.01	0.00
Low income	–0.73	0.04	–0.08	0.00	0.09	–0.19	0.00	0.00	0.14	0.03	–0.15
– excl. China	–0.04	0.10	0.03	–0.01	0.06	0.03	0.00	0.00	0.10	0.03	–0.09
World	–2.75	0.18	0.27	–0.03	0.10	–0.64	–0.12	–0.02	–1.04	–0.14	–0.13
2020 Malacca Strait blockage scenario											
APEC	–2.83	–0.83	–1.03	–0.15	0.26	–0.89	–0.18	0.03	0.54	0.06	–0.37
High income	–1.19	–0.63	–1.11	–0.08	0.11	–0.64	–0.11	0.02	0.96	0.04	–0.12
Middle income	–0.07	0.13	0.43	0.06	0.02	0.11	0.04	0.01	–0.48	–0.01	0.00
Low income	–1.56	–0.32	–0.34	–0.12	0.14	–0.37	–0.11	0.00	0.06	0.03	–0.24
– excl. China	–0.10	0.06	–0.02	–0.02	0.09	0.00	–0.01	0.00	0.06	0.03	–0.19
World	–4.54	0.04	0.23	–0.13	0.17	0.04	–0.21	–0.03	–0.69	–0.19	–0.19

40 **Changes in APEC annual trade**
following Malacca Strait blockages
relative to the reference case



additional cost of maritime trade, world and APEC trade volumes contract during the time of the blockage. In the 2005 Malacca Strait blockage scenario, for example, APEC exports contract by 0.05 per cent relative to the reference case, and APEC imports by 0.07 per cent (figure 40). The effects are similar in the 2020 Malacca Strait blockage scenario.

In addition to the downturn in aggregate trade volumes, there is a trade diversion effect. Relative to the reference case, the increase in maritime freight costs confers a competitive advantage on exporters that are close to the import market in question. As a result, the volume of trade within APEC expands relative to the reference case, whereas the volume of trade among APEC and non-APEC regions contracts relative to the reference case.

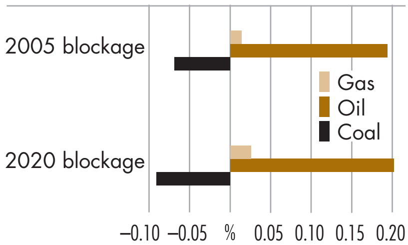
The reduction in demand for traded commodities across the world undermines production and income in the world and in APEC economies. As a result, the Malacca Strait obstruction leads to lower GNP than in the reference case for all APEC income groups (table 21). For APEC as a whole, the five week blockage costs US$1.7 billion (in 2002 dollars) in GNP in the 2005 scenario and US$2.8 billion (in 2002 dollars) in the 2020 scenario. This is far smaller than the contraction in APEC's economic activity experienced in the oil supply disruption scenarios — amounting to US$43 billion (in 2002 dollars) in the 2005 scenario and US$82 billion (in 2002 dollars) in the 2020 scenario.

Energy price impacts

Before analysing the economywide costs at a sectoral level and considering how they flow through to APEC energy markets, there is another key to understanding the energy market implications of the blockage of the Malacca Strait. An additional factor is how energy prices change in response to the additional cost of energy trade between the Indian and Pacific Oceans.

On the one hand the Malacca Strait blockage leads to a higher cost than the reference case for energy that is sourced outside of APEC, particularly crude oil from the Middle East. Further upward pressure is placed on oil prices because additional fuel is required by the maritime transport services sector in order to circumvent the Malacca Strait. Thus following the Malacca Strait blockage, annual crude oil prices in APEC are around 0.2 per cent higher in both scenarios than in the reference case (figure 41).

41 **Change in APEC annual energy prices** following Malacca Strait blockages relative to the reference case



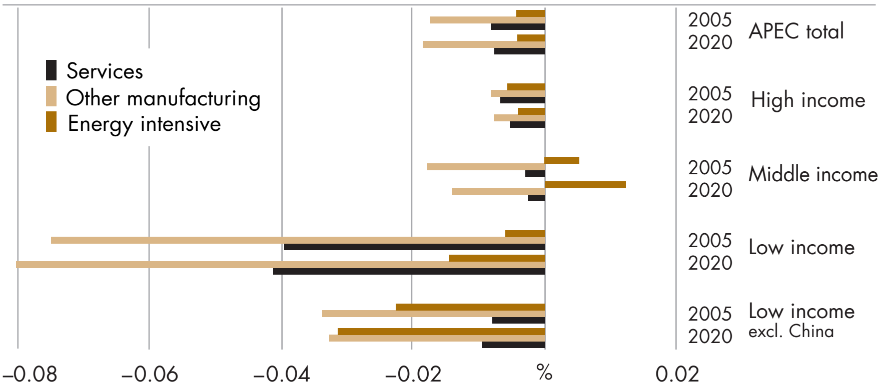
However, crude oil prices are not rising in all regions. Rather, the rise in freight costs effectively drives a wedge between delivered energy prices in APEC and those in other regions. Thus in both Malacca Strait scenarios, crude oil prices in non-APEC regions are lower than in the reference case for the duration of the blockage, because the decline in APEC demand for oil from the Middle East contributes to a decline in global oil demand.

The opposite story applies to coal. As APEC is a substantial net exporter of coal to the rest of the world, higher freight costs increase the cost of seaborne coal from APEC in regions outside of the Asia Pacific. Demand for APEC coal in these regions is therefore lower than in the reference case. Because of the contraction in demand for APEC coal outside of APEC, annual coal prices in the Asia Pacific region are 0.08 per cent lower in both scenarios than in the reference case.

Sectoral impacts

Reflecting the small relative energy price effects, the sectoral changes that flow from the Malacca Strait blockage are insignificant relative to the oil supply disruption scenario (figure 42). The largest contraction relative to the reference case is experienced in the other manufacturing sector. But even in this sector, output contracts by less than 0.1 per cent for all income groups. Energy intensive manufacturing is the least affected sector and, in middle income economies, energy intensive manufacturing expands to some degree relative to the reference case. This very small expansion in energy intensive output reflects the decline in the price of coal in APEC relative to the reference case, as coal is used more than other fuels in energy intensive industries in APEC.

42 Change in APEC annual output of selected sectors following Malacca Strait blockages relative to the reference case

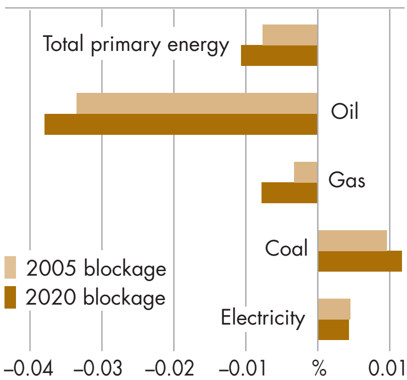


Energy impacts

APEC energy markets are affected by the blockage of the Malacca Strait, through the implications of the blockage for the level of economic activity, energy prices and energy intensive production.

Marginally lower economic activity in the Malacca Strait scenarios than in the reference case, including in the energy intensive sector, leads to marginally lower energy consumption across APEC. The five week obstruction results in total energy consumption being a mere 0.01 per cent or 0.45 Mtoe lower in the 2005 scenario than in the reference case, and 0.011 per cent or 0.83 Mtoe lower under the 2020 scenario (figure 43).

43 Change in total APEC annual energy consumption following Malacca Strait blockages relative to the reference case



However, the implications for APEC energy consumption vary between fuels because of the changes in relative fuel prices. Thus while APEC consumption of oil is lower during the Malacca Strait blockage than in the reference case, gas consumption is hardly affected and consumption of both coal and electricity is marginally greater than in the reference case. Annual oil consumption is lower than in the reference case by 0.03 per cent or 0.68 Mtoe in the 2005 scenario, and by 0.04 per cent or 1.03 Mtoe in the 2020 scenario. In contrast, coal consumption is 0.17 Mtoe and 0.26 Mtoe higher during the same period in the 2005 and 2020 scenarios respectively than in the reference case.

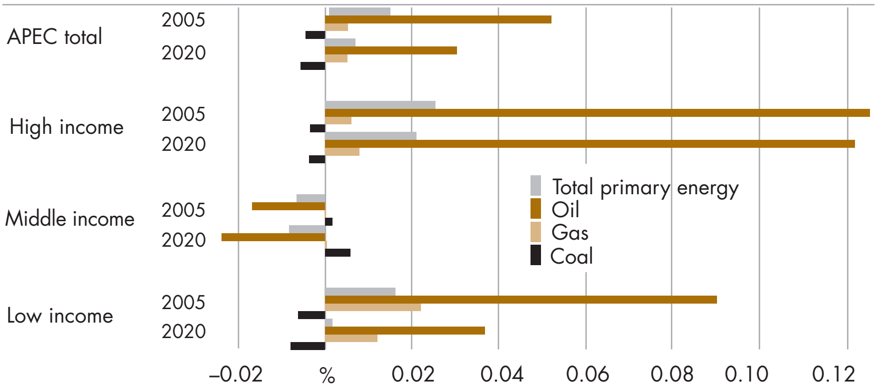
Given that coal fired power is assumed to generate approximately 45 per cent of APEC electricity in both 2005 and 2020, the temporary fall in coal prices within APEC reduces the cost of generating electricity and, on the assumption that cost savings are passed on in lower prices, results in marginally higher electricity consumption than in the reference case. Total APEC electricity generation is estimated to rise by 0.5 terrawatt hours above the reference case during the blockage in the 2005 scenario and by 0.6 terrawatt hours in the 2020 scenario.

There is some variation in energy consumption effects between income groups, depending on energy import dependence and associated changes in the competitiveness of energy intensive manufacturing. The middle income group of economies, which include most of APEC's large oil exporters, is relatively self sufficient in terms of energy and is therefore little affected by the reduction in maritime freight productivity. Therefore, energy intensive production and hence energy consumption in the middle income group of economies rises above the reference case in both scenarios for the duration of the blockage. In contrast, economies with a high degree of dependence on energy imports, for example the high income economies of Japan, Chinese Taipei and Singapore, are more exposed to the adverse impact of higher shipping costs on energy prices. For this reason, energy consumption in high income economies, and particularly oil consumption, is lower in the year of the blockage in both scenarios than in the reference case (see table 21).

In response to changes in consumption and the relative price effects brought about by the Malacca Strait blockage, APEC total energy production is marginally greater than in the reference case (figure 44). This is true of all income groups except for middle income economies.

However, in the Russian Federation, oil and gas producers lack the infrastructure needed to increase exports to the Asia Pacific region. Rather, almost all of Russia's oil and gas export infrastructure serves the European market. In both the 2005 and 2020 Malacca Strait scenarios, Russian

44 **Change in APEC annual energy production**
following Malacca Strait blockages relative to the reference case

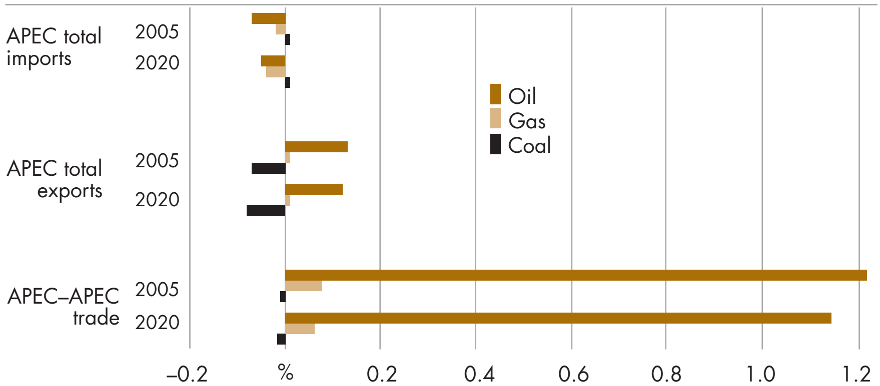


exports of oil and gas lose competitiveness in the European market against the Middle East relative to the reference case, because of the difficulties experienced by the Middle East in transport to Asia. As a result, Europe secures spot supplies from the Middle East and minimises purchases from the Russian Federation, thereby reducing European demand for Russian gas and oil exports. Without the infrastructure to tap into the Asian market, Russian production of gas and oil contracts relative to the reference case. However, the contraction is very small in this set of scenarios — oil production declines by less than 0.05 per cent relative to the reference case in both scenarios and gas production by even less.

Higher freight costs undermine the demand for bulk shipments of commodities such as coal, resulting in lower coal production in the APEC region. On the other hand, domestic coal demand increases in coal producing economies, mainly as a result of substitution away from oil and gas in the electricity sector. However, this increase in domestic demand is only enough to offset the decline in exports in the middle income economies, where almost all coal is consumed domestically.

The effects of the Malacca Strait blockage on energy trade, while small, nonetheless reflect APEC's position as a net importer of oil and as a net exporter of coal (figure 45). APEC relies on long range shipments of oil and gas imports, for example from the Middle East, whereas a significant share of APEC coal exports is shipped to Europe and South Asia. The disruption to shipping through the Malacca Strait increases the cost of oil and

45 Change in APEC energy trade
following Malacca Strait blockages relative to the reference case



gas imports to APEC relative to the reference case and raises slightly the cost of APEC coal delivered in Europe and elsewhere. As a result, APEC imports of gas and oil are lower than in the reference case, as are APEC coal exports.

Intra-APEC energy trade is typically higher in both Malacca Strait blockage scenarios than in the reference case. In response to the regional shortage of oil and gas, APEC economies increase production and exports to other APEC economies. In the coal market, APEC importing economies increase consumption and imports of coal from within APEC relative to the reference case, in response to the regional surplus of coal. This helps to offset the negative, albeit small, impact of the blockage on coal export revenues.

7

some economic aspects of energy security policies in the APEC region

In this chapter, some key economic aspects of energy security risks and policies are discussed, including the economic rationale for government intervention in enhancing energy security, the economic implications of emergency policies to reduce the costs of temporary energy supply disruptions and longer term policy response measures to reduce the risk and/or costs of such disruptions in the future.

It should be emphasised that it is beyond the scope of this study to examine in detail the energy security risks and policies of individual APEC economies. The objective is to present relevant information that may contribute to energy security risk and policy assessments that are undertaken by individual APEC economies and that may further contribute to joint assessments within the APEC forum.

Economic rationale for government intervention in energy security

Energy security has been referred to previously in this report as the reliable and adequate supply of energy at reasonable prices. Energy security may be considered within the context of energy policy whereby energy policy makers aim to ensure the provision of energy at least cost over time given energy technologies and resource availability, and taking into account environmental impacts and economic and other risks in the outlook. Energy policy is part of the broader economic policy framework whereby the government aims to optimise the economic wellbeing of the community over time (in theory, economic wellbeing may be represented by a social welfare function — economic aspects that rely on the subjective judgment of government, such as the importance of equity, may be represented within the social welfare function).

The economic rationale for government intervention is based on the presence of market failure (that is, the failure of markets to efficiently provide some goods and services) and the capacity of the government, first, to identify and assess policy options that address the market failure and, second, to implement the policy option judged to result in the highest net economic benefits over time. The assessment of the net economic benefits of alternative policy options should include any costs of implementation. Any policy option that is not likely to result in positive net economic benefits should not be considered for implementation.

A number of criteria may be used to assess alternative policy options including efficiency, equity, administrative simplicity and flexibility to adapt to changing economic and other circumstances. Notably, not all the costs and benefits of alternative policy options may be quantified.

In practice, energy services are typically provided by both public (state owned) and private companies, although the mix varies among APEC economies. Public companies may have been formed in response to an identified market failure (such as a natural monopoly). For the purposes of the discussion in this section, no distinction is made between public and private companies.

In chapter 6, the economic impacts of three temporary energy supply disruptions in 2005 and 2020 were quantified using GTEM, ABARE's model of the world economy. Temporary supply disruptions were assumed to occur in the world oil and LNG markets, and a temporary closure was assumed to occur in the Strait of Malacca. Consistent with the APEC Energy Security Initiative (chapter 2) and the information on demand and supply side risks to APEC energy markets (chapters 3 and 4), oil supply disruptions represent the main energy security concern in the APEC region. As a consequence, examples presented in this chapter will focus on world oil disruptions and policy responses.

Some key economic effects of a world oil supply disruption are illustrated in box 3. The simple demand–supply framework serves to highlight some of the most important aspects of adjustment in the world oil market — this framework is also useful to indicate the nature of the economic effects of alternative policy options discussed later in this chapter. Some of the most notable aspects of market adjustment to a world oil supply disruption are as follows:

- a fall in world oil production results in a higher world oil price under the assumption of price rationing (that is, prices are allowed to adjust to re-equilibrate world oil demand and supply);

- a higher world oil price provides an economic incentive to increase oil production in locations outside the source of the disruption (surge production);
- a higher world oil price reduces oil consumption by both net oil importers and net oil exporters, but consumption of other fuel types increases to the extent that switching to alternatives is viable in the short term (oil conservation and switching);

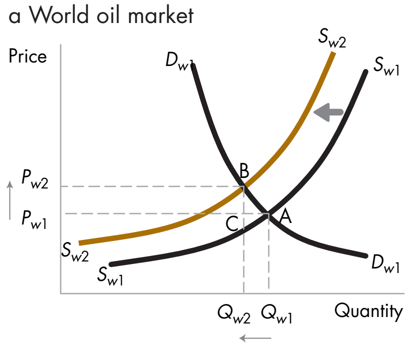
Box 3: Economic effects of an oil supply disruption on the world oil market

In this box, some key aspects of market adjustment to a temporary oil supply disruption are highlighted, based on a simplified representation of the world oil market. Assuming competitive markets, some key economic effects of an oil supply disruption on the world oil market, a net oil importer and a net oil exporter are shown in the following diagrams. It needs to be emphasised that the diagrams should be interpreted as broadly indicative of oil market adjustment.

a. World oil market

Prior to the disruption, the world oil supply (marginal cost) and demand (marginal benefit) curves are given by $S_{w1}S_{w1}$ and $D_{w1}D_{w1}$ respectively (panel a). The world oil market is in equilibrium (that is, marginal cost to the supplier equals marginal benefit to the user) at the intersection of these curves — at this point, A, world oil production of Q_{w1} is sold at a market price of P_{w1}.

a World oil market



The oil disruption reduces the quantity of oil available on the world market — this is represented by a leftward shift in the world supply curve to $S_{w2}S_{w2}$. The world oil market adjusts to the oil disruption by moving to the new equilibrium at point B — world oil production falls to Q_{w2} and the world oil price increases to P_{w2}.

The net economic cost of the oil disruption may be given by the area *ABC* (this is also referred to as the deadweight loss). This area represents the forgone benefits

continued …

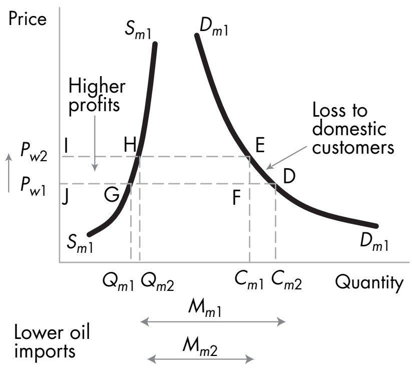
Box 3: Economic effects of an oil supply distruption on the world oil market *continued*

to oil users resulting from the disruption — that is, the lost benefits to oil users who are priced out of the market during the disruption. In practice, the fall in production is often used to indicate net economic cost. At the aggregate level, when the impact of the oil disruption on other economic activities is takeninto account, this corresponds to the change in national output (real GDP or GNP).

b. Net oil importer

Panel b illustrates the situation of a net oil importing economy where domestic oil production satisfies some but not all domestic oil requirements. The oil supply and demand curves of this net oil importer are given by $S_{m1}S_{m1}$ and $D_{m1}D_{m1}$, respectively. When the world oil price increases from P_{w1} to P_{w2} during the oil disruption, domestic oil consumption falls from C_{m1} to C_{m2}, domestic oil production increases from Q_{m1} to Q_{m2}, and oil imports fall from M_{m1} to M_{m2}. The loss to domestic oil consumers is given by the area *DEF*, but the domestic oil industry benefits with higher profits given by the area *GHIJ*.

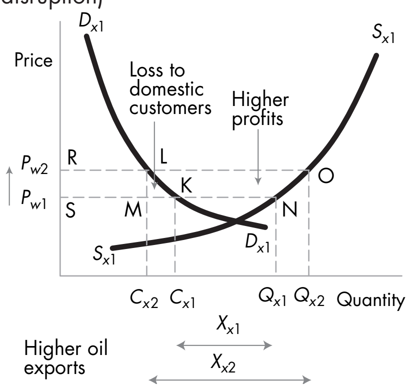
b Net oil importer (outside source of disruption)



c. Net oil exporter

The oil supply and demand curves of a net oil exporter are given by $S_{x1}S_{x1}$ and $D_{x1}D_{x1}$, respectively (panel c). With the world oil price increase, domestic oil consumption falls from C_{x1} to C_{x2}, domestic oil production increases from Q_{x1} to Q_{x2}, and oil exports increase from X_{x1} to X_{x2}. The loss to domestic oil consumers is given by the area *KLM*, but the domestic oil industry benefits with higher profits given by the area *NORS*.

c Net oil exporter (outside source of disruption)



- net oil importers reduce net oil imports; and
- net oil exporters outside the source of the disruption increase net oil exports, benefiting from the temporary increase in the world oil price.

Private companies invest in supply reliability provided there is an economic incentive to do so (ignoring any policy requirements). Private companies may adopt a range of risk sharing and reducing measures designed to offset, at least to some extent, the negative impact of temporary supply disruptions on profitability. Private investment in energy supply reliability is not included explicitly in either GTEM or the demand–supply framework presented in box 3.

Private companies may manage risks, either directly or indirectly, by investing in:

- stocks – the major approach for smoothing fluctuations in both supply and demand where it is feasible to store the fuel type (particularly important for commodities such as oil and LNG).
- excess capacity – particularly an issue for sources of energy that may not be stored, such as electricity.
- long term contracts – particularly important for LNG trade where infrastructure costs are high for both LNG exporters and importers, although LNG trade on the spot market is likely to expand over time, allowing market participants further opportunities to smooth temporary fluctuations in supply and demand.
- futures markets – important for managing price and exchange rate risk in the short term; they also provide an economic incentive for speculators to invest in information that may enable them to participate profitably in the market.
- market information – to provide more accurate assessments of the benefits, costs and risks in the outlook and hence in the net economic benefits of investing in various supply reliability measures.
- exploration – for new energy resource fields or deposits and, more broadly, research and development into, and the adoption of, technologies that facilitate the exploration, development, production and environmental management activities in the upstream energy industry (with implications for the diversity in both the location and mix of energy resources available for production.

- research and development – into, and the adoption of, energy conservation and switching technologies that aim to reduce energy consumption and increase the short and longer term capacity of energy users to switch between alternative fuel types in response to changes in relative prices.
- other diversification strategies – as appropriate to the circumstances of the company (for example, participation in joint ventures).

Consideration of government intervention in energy security is justified if private investment in energy supply reliability is assessed to be lower than some optimal level. Economic arguments relating to government involvement in energy security are discussed in a number of other studies (see, for example, Bohi 1993; Lynch 1997; APERC 2000; Owen 2004).

Several factors are relevant when considering the economic rationale for government intervention in energy security, including:

- external benefits of private investment in energy supply reliability measures
- external costs of energy supply disruptions
- attitudes toward risk by private investors.

In addition, there are other aspects of energy markets that have the capacity to influence energy supply reliability outcomes, including sources of market failure not directly related to energy security and government policies that address those market failures — these aspects are noted later in this chapter.

Public good nature of investment in energy supply reliability

Private investment in energy supply reliability results in benefits to other participants in the energy sector, including those in overseas economies (this is the public good nature of investment in energy supply reliability). Free riding results in levels of investment that are below the optimal level since these additional benefits are not incorporated in the decision making process of individual private companies (that is, at the given market price, the marginal benefit of the investment in energy supply reliability exceeds the marginal cost).

External costs of energy supply disruptions

There are significant macroeconomic costs of energy supply disruptions, reflecting the importance of energy as an input in all sectors of the economy (see table 6), and institutional rigidities that impede efficient adjustment of the economy to the disruption. Equity also becomes a significant issue for governments during severe energy supply disruptions (an aspect of risk assessments that relies on the subjective judgment of governments). If the energy sector does not incur the full costs of energy supply disruptions, the economic incentive to invest in energy supply reliability is lower than would otherwise be the case.

Risk and attitudes toward risk — implications for private investment in energy supply reliability

The presence of risk also represents a form of market failure (in theory, perfectly competitive markets are assumed to operate under conditions of perfect information). In essence, this study is an assessment of the capacity of the private sector to respond to the risk of energy supply disruptions. All markets are characterised by risk, although there is considerable variation between economic activities. The presence of risk in itself is typically not argued to be sufficient cause for government intervention. However, risk is an important consideration in policy formulation where risks are relatively high and the consequences of adverse outcomes are costly.

An important aspect of risk is that private investors are assumed to be risk averse, but efficient resource allocation relies on risk neutral behavior. A risk averse investor is relatively more concerned about the risk of unexpected losses than the prospect of unexpected gains. In the case of the potential for energy supply disruptions, private investors need to assess the trade off between incurring with certainty the costs associated with energy supply reliability measures (such as holding stocks) against any uncertain future benefits of the investment during energy supply disruptions.

It is important for policy makers to note that a risk averse approach by private companies to investment decisions on energy supply reliability measures creates a wedge between optimal and actual levels of private investment in energy supply reliability. If the risks associated with future benefits from investing in supply reliability increase and the expected benefits remain unchanged, private investment in energy supply reliability will fall, increasing the extent to which private investment in energy supply reliability is below the optimal level. (See Hogan 2003a,b for further information on risk aversion and the implications of risk for private investment decisions.)

While a risk averse approach by private investors may not in itself justify government intervention, it is an important consideration in assessing optimal levels of investment in energy supply reliability.

Emergency policy response measures to energy supply disruptions

It was argued in the previous section that private investment in energy supply reliability tends to be below the optimal level — that is, energy markets tend to underinvest in energy supply reliability. This provides the economic justification for considering government intervention in energy security, either directly through public provision or indirectly to increase private investment in energy supply reliability.

In practice, energy supply reliability is influenced by a mix of short term and longer term measures. From a government perspective, it is important to maintain an emergency response strategy to reduce the costs of energy supply disruptions since the probability of these events occurring is positive.

Investment in stocks is the most important mechanism for smoothing short term fluctuations in supply and demand. Other response measures often considered as part of an emergency response include demand restraint through nonprice rationing mechanisms, surge production, fuel switching, information sharing and international cooperation.

Economic role of energy stocks

In general terms, stocks of energy commodities are that part of production held in reserve for future use. In the oil industry, there are three types of stocks:

- primary stocks – associated with the production and refining stages of the industry, which include stocks of crude oil, natural gas liquids and feedstocks as well as stocks of petroleum products. Stocks in this category may be held by companies or governments.

- secondary stocks – associated with the distribution of oil from the large distribution terminals to the small distribution stations including wholesalers, retailers and petrol stations. Note that some petroleum products bypass this stage and are transported directly from the refinery to the end user (for example, aviation turbine oil to airports).
- tertiary stocks – held by consumers, including for example fuel oil at electricity generating plants, automotive diesel oil or gasoline in trucks and motor vehicles, and industrial and commercial stocks.

This categorisation may be applied to other energy commodities, although secondary stocks are not relevant in all cases. For example, black coal is a major energy commodity that is traded internationally and is mainly used in the iron and steel industry (metallurgical or coking coal) and for electricity generation (thermal or steaming coal). However, brown coal may not be transported significant distances or stored due to the risk of spontaneous combustion and, as a consequence, power plants are colocated with brown coal deposits.

The role of stocks is discussed in several papers including, for example, Brennan (1958); Newbery and Stiglitz (1981); Lowry (1988); Williams and Wright (1991); and Rey (1996).

It may be useful to distinguish between nonspeculative and speculative motives for holding stocks, where nonspeculative motives for holding stocks include pure storage, transactions demand and precautionary demand:

- pure storage – includes minimum operating stocks (comprising unavailable inventories and working inventories) and stocks required to smooth production under conditions of day to day fluctuations in demand.
- transactions demand – includes stocks that account for the spatial distribution of users — the convenience of these stocks is less delay and lower costs in moving these products to market.
- precautionary demand – includes stocks that are held to avoid stockout costs, which are the costs incurred when stocks held by the company fall to zero following a surge in demand or disruption in supply. In these circumstances, the options of the company are to make an unplanned drawdown of stocks, an unplanned increase in production, an unplanned purchase of the product on the market or refusal to supply customers.

- speculative demand – includes stocks that are held to take advantage of any profit opportunities through changing market conditions. It has been noted that the role of speculative stocks may be limited since speculators may participate in futures markets.

Overall, the major role of stocks is to smooth fluctuations in production and consumption in the industry — that is, the availability of stocks during a temporary energy supply disruption reduces the costs of the disruption by providing an alternative supply source of the energy commodity (see box 4).

The policy response to the problem of underinvestment in energy stocks in the private sector is to supplement private storage (for example, through subsidies or tax concessions) or invest in public storage. A major issue with public investment in energy storage is that it reduces the economic incentives for private investment — that is, public storage results in some crowding out of private storage.

Public storage reduces the net economic benefits of private storage by moderating price increases during temporary energy supply disruptions. In addition, compared with private sector behavior, there may be greater uncertainty about the nature of public intervention in energy markets through stock drawdown during periods of supply disruption, increasing perceived risks in private investment in stocks and placing further downward pressure on private investment.

Energy stockpiling in the APEC region since 1970

A key issue in assessing the net economic benefits of alternative policy options is that information on energy stocks in the world economy is incomplete. The Joint Oil Data Initiative (JODI) is an important undertaking that will improve the quality, timeliness and completeness of world oil market data, although data are not yet available (see the relevant discussion under the APEC Energy Security Initiative in chapter 2).

Using IEA data on the annual change in energy stocks, it is possible to construct time series on cumulative changes in the stocks of major energy commodities in the APEC region since 1970. This approach enables a comparison of trends in the stockpiling of different energy commodities — including, most importantly, coal, oil and gas — over a period of considerable market volatility. In addition, a comparison may be made in energy stockpiling trends between the APEC region and the world economy, as well as between individual APEC economies.

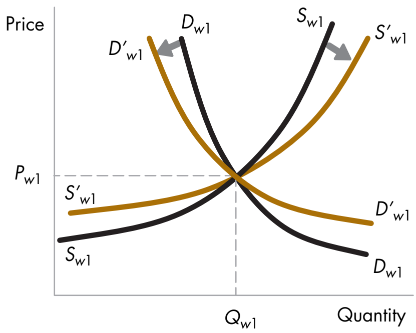
Cumulative changes in stocks for energy, coal, oil and gas since 1970 in the APEC region and world economy are presented in figure 46. Between 1970 and 2002, APEC energy stocks increased by 368 Mtoe mainly through a

Box 4: Some key economic implications of oil stocks for the world oil market

Some key implications of oil stocks for the world oil market are presented in the diagram. In the absence of oil stocks, the world oil supply and demand curves are given by $S_{w1}S_{w1}$ and $D_{w1}D_{w1}$, respectively. Without stockholding capacity, world oil production of Q_{w1} is the same as world oil consumption, and the world oil price is P_{w1}. The impact of a temporary oil supply disruption on the world oil market without stocks was presented in box 3.

To identify the economic incentives for investing in stocks, expectations need to be introduced into the figure. Assume P_{w1} is the expected world oil price. In this simplified framework, if the current price falls below the expected price, producers have an incentive to divert part of their production into stocks and delay sales. These stocks become available for use in years where the actual price is above the expected price (as would occur during a temporary oil supply disruption). The impact of oil stocks is to pivot the world oil supply curve around the expected price, with the new world supply curve given by $S'_{w1}S'_{w1}$.

Illustrative effects of oil stocks on world oil supply and demand



Similar arguments may be made for oil consumers to the extent that they are in a position to hold stocks. The impact of oil stocks is to pivot the world oil demand curve around the expected price, with the new world demand curve given by $D'_{w1}D'_{w1}$ (see Rey 1996 for further discussion).

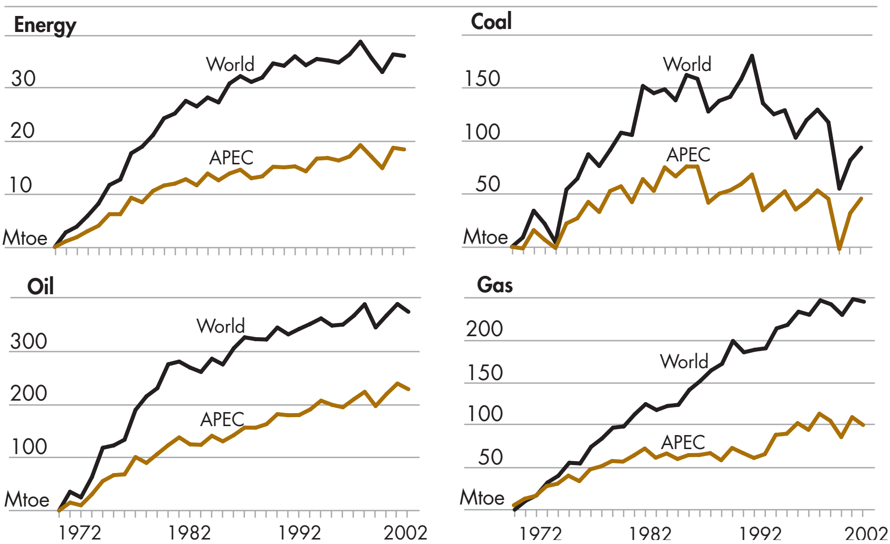
The key role of oil stocks is therefore to smooth fluctuations in supply and demand conditions.

rise in oil stocks (62 per cent: 52 per cent from increased stocks of crude oil, natural gas liquids and feedstocks, and 10 per cent from increased stocks of petroleum products). Increases in gas and coal stocks accounted for 26 per cent and 12 per cent, respectively, of the increase in total energy stocks over the period.

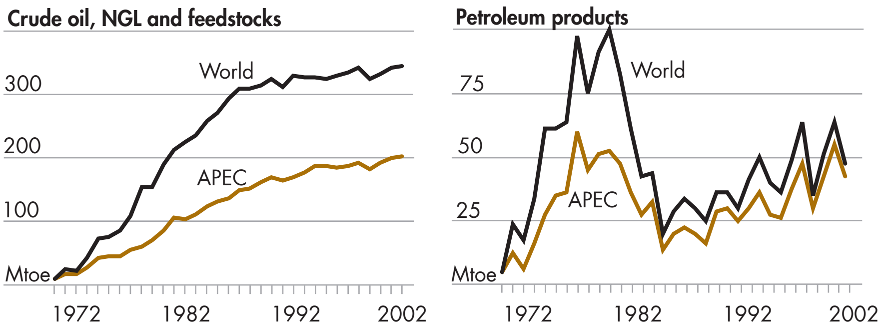
Nearly two thirds of the overall buildup in energy stocks occurred during the 1970s, which would be consistent with the assessment of increased supply side risks following the oil price shocks in the decade (see figure 13 for developments in world energy prices since the early 1970s). Since that time, stockpiling trends have varied between energy commodities — coal stocks have declined since 1986, oil stocks have almost doubled since 1980 but the rate of increase has slowed, and gas stocks have also almost doubled since 1980, with a significant buildup occurring in the mid-1990s (gas stocks were 60 Mtoe higher, on average, between 1981 and 1993 than in 1970, and 93 Mtoe higher between 1994 and 2002).

There have been significant differences in the composition of oil stocks since 1970. This is indicated by shifts in stockpiling trends for crude oil,

46 **Cumulative changes in APEC and world energy stocks since 1970**



47 Cumulative changes in APEC and world stocks of oil and oil products since 1970



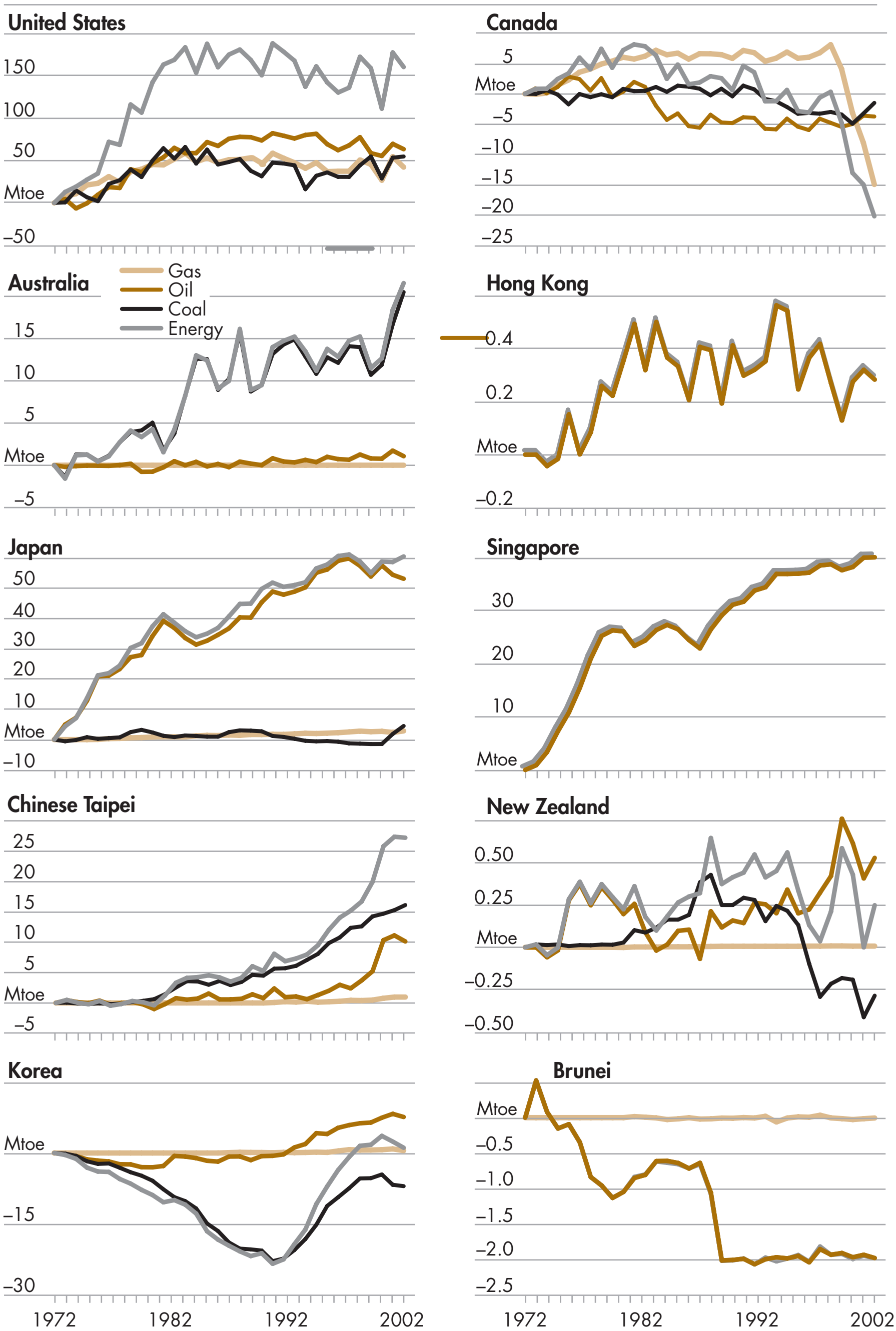
natural gas liquids and feedstocks and for petroleum products, and these shifts are most pronounced for the world economy (figure 47).

Energy stockpiling trends in the APEC region have been broadly similar to those in the world economy. Overall, however, there has been greater emphasis in the APEC region on building oil stocks and less emphasis on building gas stocks. Between 1970 and 2002, world energy stocks increased by 721 Mtoe, with 52 per cent of the increase coming from a buildup in oil stocks, 34 per cent from increased gas stocks and 13 per cent from increased coal stocks.

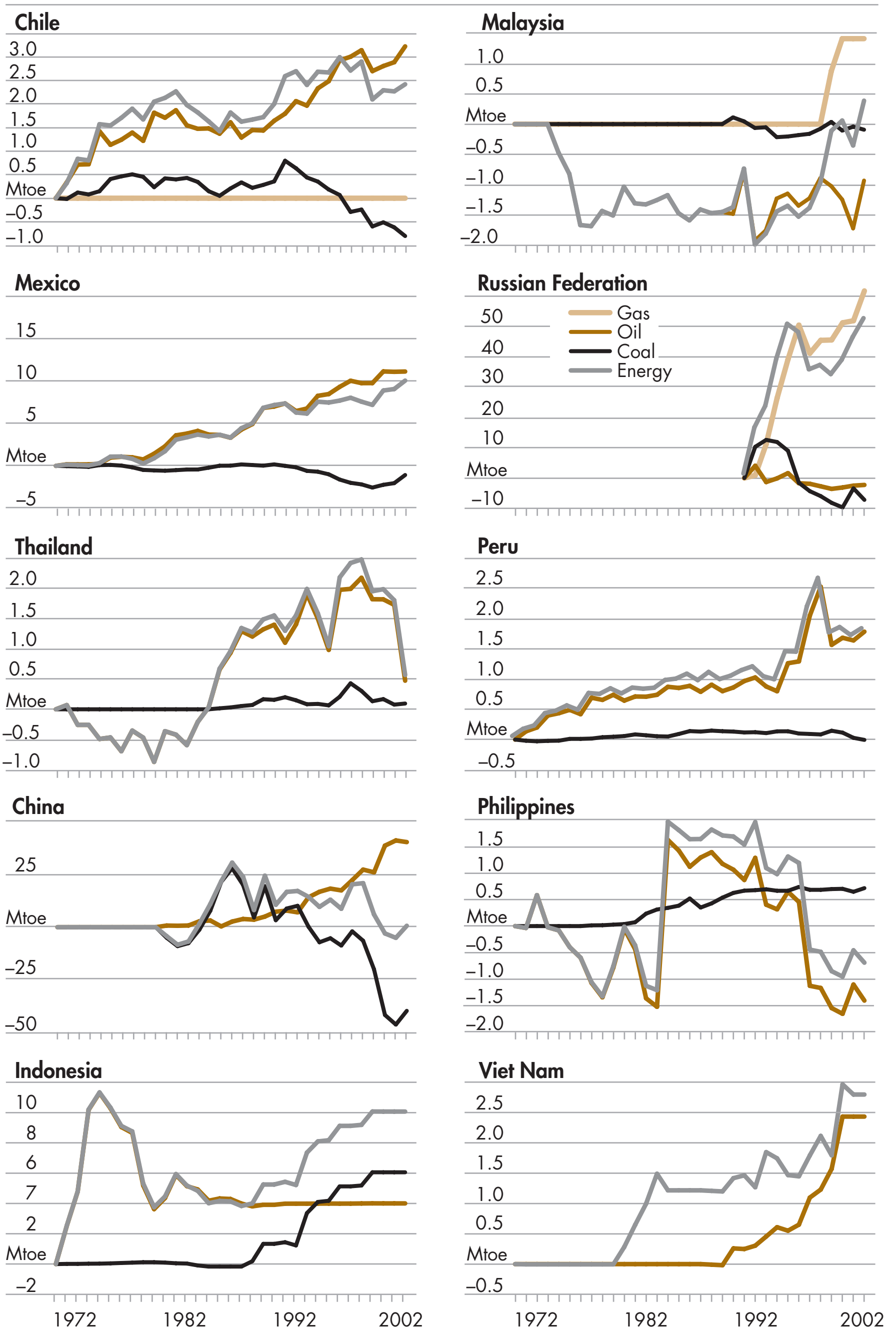
There is considerable variation in stockpiling trends since 1970 in the individual APEC economies (figure 48). As discussed in chapter 2, in recent years, there has been increased concern within the APEC region about heightened energy security risks and the preparedness of economies in the case of a major oil supply disruption. Oil stockholding policies of APEC economies were presented in table 2. The paper 'Best practice principles for the establishment and management of strategic oil stocks' was endorsed by APEC Energy Ministers at their 6th meeting in Manila, the Philippines, in June 2002 (see APEC 2002c).

There has been some recent analysis of the potential for joint investment by a number of smaller net oil importing APEC economies in an oil stockpiling facility. For these economies, the economies of scale in a joint facility would reduce the costs that would otherwise be incurred in storing similar quantities of oil in separate facilities in each economy. The costs associ-

48 Cumulative changes in energy stocks since 1970, by APEC economy



48 Cumulative changes in energy stocks since 1970, by APEC economy



ated with a range of options for such a joint facility have been examined in APERC (2000, 2002a). The benefits of additional oil stocks are the reduced costs of any temporary oil supply disruptions. While APERC provided some indicative estimates of the costs of oil supply disruptions, the modeling analysis in chapter 6 of this report provides more comprehensive estimates of the economic impacts of a major global oil supply disruption and hence the benefits of investing in oil stocks.

The GTEM analysis contributes to a better understanding of the costs of temporary energy supply disruptions, but it should be emphasised that the costs, benefits and risks of investing in emergency oil stockpiling facilities need to be assessed by individual member economies.

Other emergency response measures

Market adjustment to an oil supply disruption was discussed earlier in this chapter (see also box 3). Energy prices have a key role in signaling variations in supply and demand conditions. During an energy supply disruption, higher energy prices is part of the process that allows energy to be rationed to users who place the highest value on the energy source. That is, price rationing is an important part of the normal operation of markets, and the market response to volatility. Price rises encourage demand restraint, fuel switching and surge production in the short term.

There are two particular issues relevant here. Economic regulation of natural gas and electricity markets typically limits the extent to which prices may rise in response to an energy supply disruption, reflecting concern about any price rise being sustained over the longer term (monopoly pricing issues). Rigidities in pricing in the natural gas and electricity markets increase the burden of adjustment on other parts of the energy market. This has been one of the issues addressed through the process of energy market reform in many economies in recent years (energy market reform is discussed further in the next section).

A second issue is that, during a severe oil supply disruption, the price rises associated with price rationing may result in significant concern about the capacity of emergency services and people on lower incomes (including welfare recipients) to maintain access to meet some reasonable level of energy requirements. Emergency services provided by government (such as hospitals and fire stations) usually have annual budgets that are not adjusted contemporaneously with temporary sharp rises in the cost of essential inputs (such as energy). Large energy price rises in the short term have significant adverse consequences for the equity of the adjustment to the disruption — that is, the costs of the disruption are not borne equitably throughout society since people on low incomes will spend proportionately more of their income on energy. Sufficiently large price rises also increase the economic incentives for illegal, or black market, activity in the energy commodity.

Various forms of nonprice rationing mechanisms are adopted by governments during an emergency. Quantity rationing may be achieved through:

- direct allocation – whereby the government allocates energy supplies directly to energy users.
- demand suppression – whereby the flexibility of energy purchases and consumption is restricted — for example, an odds and evens purchasing system (based on the car registration number) restricts access to service stations to every second day.
- queuing – whereby energy supplies are allocated on a first come first served basis.

In practice, some combination of these options is used, with direct allocation to emergency uses, and demand suppression and queuing mechanisms applied to other energy consumers. Some economic implications of alternative rationing systems are discussed in Heyhoe and Levantis (2003).

To complement quantity rationing, information programs by governments encouraging energy users to adopt more energy conservationist practices, at least for the duration of the shortage, may further restrain demand. Information programs aim to change the tastes and preferences of energy consumers (through moral suasion).

International cooperation is an important aspect of the policy response to a major global energy supply disruption. Governments need information on the nature of the shock, first, to identify and assess policy options to reduce the magnitude and duration of the energy supply disruption (that is, reduce the disruption costs by addressing the source of the shock directly) and, second, to plan and implement the appropriate emergency policy response. The importance of international cooperation and information sharing is well recognised through the APEC Energy Security Initiative.

Longer term policy response measures

It was noted in chapter 4 that any risk assessment of temporary energy supply disruptions in the APEC region requires information on the probability or likelihood of potential energy supply disruptions occurring and the damage or cost of each potential disruption. This information is required to assess the net economic benefits of policy intervention in both the short and longer term.

Since the probability of a major energy supply disruption occurring is positive, governments need to maintain an emergency response capability. However, there are various longer term policy measures that aim to reduce the costs of disruptions in the future, which will influence the need for investment in emergency response measures, particularly energy stockpiles.

Longer term policy measures aim to reduce the costs of disruptions in the future by:

- reducing the probability of major energy supply disruptions occurring in the future – that is, changing the risk profile of possible energy supply shocks such that, even if the cost of a particular shock is unchanged, the expected cost of future energy supply disruptions is lowered.
- reducing the costs of any given major energy supply disruption – that is, changing the cost profile of possible energy supply shocks such that, even if the probabilities assigned to future possible disruptions are unchanged, the expected cost of future energy supply disruptions is lowered.

Longer term energy security policies are discussed in a number of studies, including Bohi (1993); Lynch (1997); APERC (2000); Bielecki (2002); Cleveland and Kaufmann (2003).

Diversification of fuel types and fuel sources is one of the most important components of the longer term policy response to the risk of major temporary energy supply disruptions. A second important component of the longer term policy response is research and development (R&D) into, and adoption of, energy technologies that may reduce the risk and/or cost of disruptions, for example, by increasing the flexibility of markets to adjust to supply disruptions.

Other aspects of the longer term policy response may include removal of market impediments in order to increase the efficiency of the energy market to respond to supply disruptions, information collection, analysis and dissemination, and international policy cooperation. It should be noted that other policies may have significant implications for energy security.

Energy resource availability and diversification in energy markets

The areas of diversification in energy markets that are typically identified in any discussion of the longer term policy response to the risk of temporary energy supply disruptions are:

- diversification in energy production – that is, reducing the dependence of economies on higher risk sources of energy by diversifying the geographic location of fuel sources.
- diversification in energy consumption – that is, reducing the dependence of economies on higher risk forms of energy by diversifying the fuel types in energy consumption.

If there is assessed to be an equal probability of disruption across locations and fuel types, diversification would reduce the expected costs of future supply disruptions by spreading the risks across different locations and fuel types. If certain locations and fuel types are assessed to be relatively high risk, private companies and governments need to assess the net economic benefits of diversifying the energy market to reduce dependence in these higher risk areas.

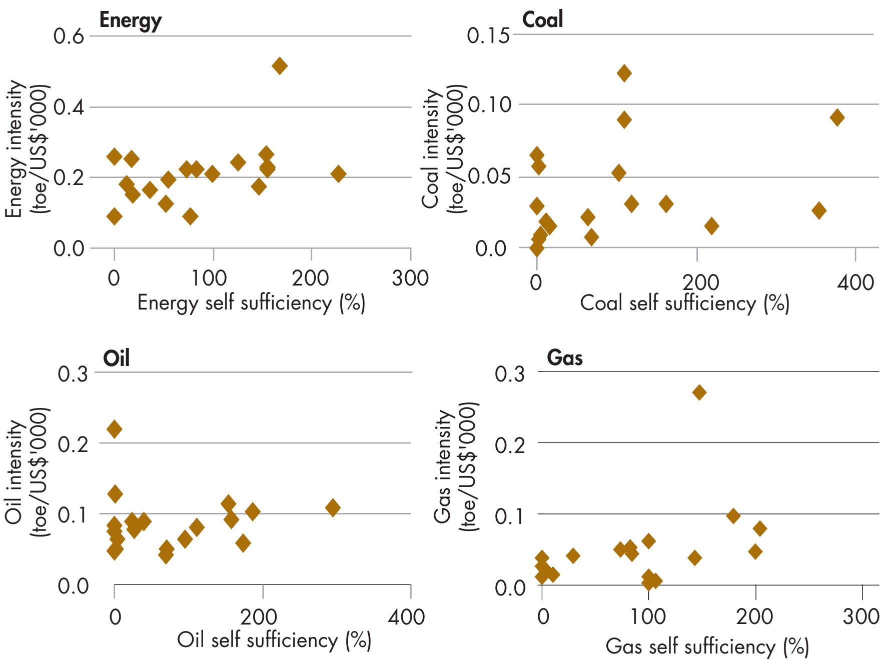
Historically, economies have been developed by utilising available resources such as energy, other natural resources and labor. Economies tend to use more intensively resources that are available domestically. With growing levels of international trade and more efficient transport systems, there has been an increase in the opportunities for less resource rich economies to invest in economic activities that use these resource inputs.

The energy intensity of APEC economies relative to energy self sufficiency in 2002 is presented in figure 49. Energy self sufficiency may be assumed to provide an indication of the domestic availability of the energy resource since economies that are relatively energy resource rich tend to export energy resources.

While energy is a key input in all economies, there is some tendency for energy intensity to increase with energy self sufficiency. In particular, energy intensity tends to be higher for net energy exporters (that is, where energy self sufficiency exceeds 100 per cent). Notably, there are two economies with low energy self sufficiency (less than 50 per cent) and energy intensity levels that are higher than others in this group — the two economies are Singapore and the Republic of Korea.

With the exception of a small number of economies (which may be referred to as outliers), there tends to be a positive relationship between intensity of use and self sufficiency for the individual fuel types — coal, oil and gas — although there is some variation between fuel types (figure 49). For coal, there are two economies with low coal self sufficiency but, compared with other economies in this group, relatively high levels of coal intensity (Chinese Taipei and the Republic of Korea), and a further two economies with coal self sufficiency close to 110 per cent in 2002 and coal intensity levels

49 Energy intensity and self sufficiency in APEC economies, by fuel type, 2002 Excludes Brunei and PNG



among the highest in the APEC region (China and the Russian Federation). For oil, Singapore and the Republic of Korea are the two economies with low oil self sufficiency but relatively high oil intensity. For gas, the Russian Federation is notable for being the most gas intensive economy in APEC, with substantial surplus production relative to domestic requirements (gas self sufficiency was 147 per cent in 2002).

Diversification in energy markets is an important mechanism to reduce the costs of temporary energy supply disruptions. Any economic assessment of the appropriate level of diversification needs to take into account the net economic benefits over time from using relatively abundant energy resources, particularly in low risk geographic locations in the world economy.

Information on world energy resource availability and the geographic distribution of world energy reserves and production was provided in chapter 4 — see, in particular, figures 10 and 11. Coal is the most abundant resource that is mainly located in relatively low risk geographic regions, while oil is the least abundant resource that is mainly located in higher risk geographic regions — gas falls between coal and oil in terms of abundance and location.

In this study, an index is constructed to provide an indicator of the level of diversification in energy consumption in individual APEC economies (table 22). This diversification index has a value between 0 and 1, with a lower number indicating a more diverse (or less concentrated) energy market (it may be noted that this diversification index is based on the Herfindahl–Hirschman index of market concentration and is equal to the sum of squared market shares of each fuel type in energy consumption).

Diversification indexes are constructed to summarise the fuel mix in total primary energy consumption (TPEC), electricity generation and total final energy consumption (TFEC) in twenty APEC economies in both 1980 and 2002 (table 22). It should be noted that the diversification indexes for the region and income categories (APEC and world regions, and the APEC income groups) are based on the fuel shares in the corresponding aggregated energy consumption.

In the APEC region, the fuel mix in total primary energy consumption and total final energy consumption was more diverse in 2002 than in 1980 (that is, the diversification index was lower in 2002 than in 1980), while the fuel mix in electricity generation was more concentrated in the recent period.

22 Diversification index for fuel types in energy consumption, by APEC economy based on the Herfindahl–Hirschman index **a**

	Total primary energy consumption		Electricity generation		Total final energy consumption	
	1980	**2002**	**1980**	**2002**	**1980**	**2002**
	no.	no.	no.	no.	no.	no.
United States	0.31	0.27	0.32	0.34	0.37	0.37
Canada	0.30	0.25	0.49	0.40	0.35	0.32
Australia	0.36	0.32	0.56	0.63	0.38	0.34
Hong Kong, China	0.99	0.38	1.00	0.54	0.57	0.52
Japan	0.50	0.32	0.29	0.22	0.50	0.46
Singapore	1.00	0.75	1.00	0.50	0.71	0.69
Chinese Taipei	0.55	0.35	0.42	0.37	0.47	0.44
New Zealand	0.28	0.24	0.71	0.44	0.36	0.28
Republic of Korea	0.53	0.34	0.63	0.32	0.46	0.44
Brunei Darussalam	0.82	0.55	0.98	0.98	0.69	0.55
Chile	0.36	0.26	0.50	0.36	0.39	0.33
Malaysia	0.52	0.41	0.74	0.62	0.60	0.42
Mexico	0.51	0.42	0.42	0.27	0.43	0.47
Russian Federation	na	0.35	na	0.28	na	0.25
Thailand	0.47	0.31	0.68	0.55	0.44	0.38
Peru	0.45	0.38	0.56	0.69	0.44	0.42
China	0.39	0.40	0.40	0.63	0.53	0.24
Philippines	0.41	0.27	0.51	0.23	0.40	0.40
Indonesia	0.43	0.26	0.60	0.27	0.46	0.32
Viet Nam	0.64	0.37	0.37	0.35	0.44	0.42
Papua New Guinea	na	na	na	na	na	na
APEC d	0.29	0.25	0.25	0.29	0.32	0.27
High income	0.33	0.28	0.25	0.28	0.38	0.38
Middle income	0.47	0.30	0.44	0.24	0.42	0.25
Low income	0.34	0.33	0.36	0.51	0.37	0.24
– excluding China	0.42	0.26	0.46	0.26	0.41	0.33
World	0.28	0.24	0.25	0.25	0.30	0.26

a The Herfindahl–Hirschman index is a measure of market concentration. In this study, the index is referred to as a diversification index, and is equal to the sum of squared market shares — a market share is the share of each fuel type in the energy market. The index has a value between 0 and 1, with a higher number indicating a less diverse (or more concentrated) energy market. **na** Not available.
Source: Based on IEA (2004a,b).

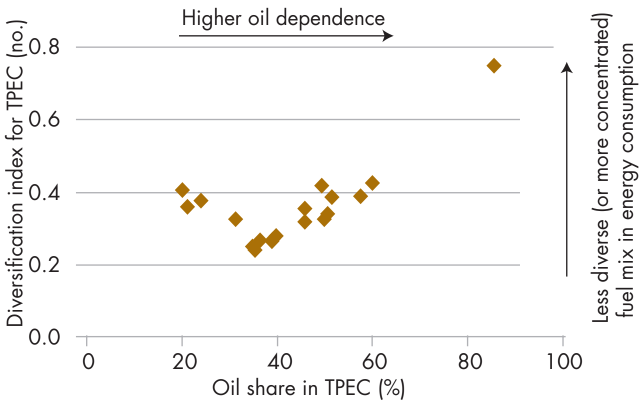
Between 1980 and 2002, the fuel mix in total primary energy consumption became more diversified in all APEC economies except China, which recorded a minor rise. In 2002 the diversification index ranged from 0.24 for New Zealand (most diversified) to 0.75 for Singapore (least diversified).

From an energy security perspective, it may be useful to identify those economies where the fuel mix in energy consumption is less diverse (or more concentrated) than in other economies and where oil dependence is higher. The relationship between the diversification index for total primary energy consumption and the share of oil in total primary energy consumption in 2002 for individual APEC economies is provided in figure 50.

Singapore is notable given its high oil dependence (the share of oil in total primary energy consumption was 85 per cent in 2002) and associated high level of market concentration (the diversification index for total primary energy consumption was 0.75). There are eight other APEC economies where the oil share in energy consumption exceeds 40 per cent and, partly as a consequence, the level of diversification in energy consumption is reduced — these economies are Mexico, Malaysia, Peru, Hong Kong, Chinese Taipei, the Republic of Korea, Japan and Thailand.

An important mechanism for government involvement in achieving higher levels of diversification in energy markets, on both the supply side and

50 Diversification in energy consumption (TPEC) and oil dependence in APEC economies, 2002
Excludes Brunei and PNG



demand side, is research and development (R&D) into, and adoption of, technologies. Some key economic aspects of the role of information in energy markets are noted in the next section.

R&D and technology adoption in energy markets

Research and development activity is an important mechanism to enhance future energy security in the APEC region. ABS (2004a,b) provides the following definitions of research and development (R&D) activity and its major categories. R&D activity is defined as the systematic investigation or experimentation involving innovation or technical risk, the outcome of which is new knowledge, with or without a specific practical application, or new or improved products, processes, materials, devices or services — R&D activity extends to modifications to existing products/processes and ceases when work is no longer experimental.

Research and experimental development activity includes basic research, applied research and experimental development:

- basic research – experimental and theoretical work undertaken primarily to acquire new knowledge without a specific application in view — basic research may be pure basic research or strategic basic research.
- pure basic research – carried out without looking for long term benefits other than the advancement of knowledge.
- strategic basic research – directed into specified broad areas in the expectation of useful discoveries — strategic basic research provides the broad base of knowledge for the solution of recognised practical problems.
- applied research – original work undertaken in order to acquire new knowledge with a specific application in view — it is undertaken either to determine possible uses for the findings of basic research or to determine new methods or ways of achieving some specific and predetermined objectives.
- experimental development – systematic work, using existing knowledge gained from research or practical experience, for the purpose of creating new or improved products/processes.

In Australia, for example, government and industry investment expenditure in research and experimental development work varies widely between economic activities. However, government tends to focus on basic and applied research, particularly where there may be broader industry benefits — that is, in areas where the private sector may not participate if there is the assessment that they would not capture adequate benefits, for example, through a patent or by maintaining secrecy about the knowledge. Industry investment in R&D tends to be mainly focused on applied research and experimental development work where the commercial applications are more apparent — that is, in areas that are substantially less risky in terms of capturing the benefits from their investment.

The economic argument for governments to supplement private research and development (R&D) activity is well recognised. Private investment in R&D tends to be lower than would be optimal from society's perspective since private companies do not capture all the benefits from their investment. The government response typically includes protection of intellectual property rights through the patent system, taxation concessions for private R&D expenditure and direct public provision of, or support for, research facilities.

This justification for government intervention in R&D does not rely on any arguments relating to energy security. The economic rationale for government intervention to increase the level of energy security in an economy, or group of economies, by supplementing private investment in energy supply reliability was discussed earlier in this chapter. Government support for R&D is a key mechanism to achieve a level of energy security that is closer to society's optimal level. The distinction becomes important since energy security may represent only part of the benefits of R&D activity in energy markets.

R&D activity, and associated adoption of new technologies, is a key mechanism to increase the level of diversification in energy production and consumption. An important aspect of diversification is to reduce dependence, or market concentration, in high risk areas (geographic locations and fuel types).

R&D and technology adoption may have major implications for both the supply side and demand side of energy markets. In particular:

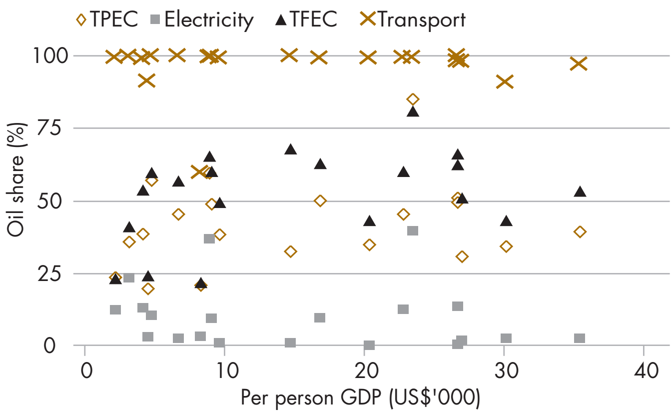
- new technologies facilitate energy exploration and production for both conventional and nonconventional sources;

- alternative processing technologies (such as gas to liquids plants) increase the flexibility of markets to adapt fuel types to different end uses;
- new technologies may aim to reduce energy consumption in the economy (or increase the efficiency of energy use); and
- new technologies may increase the flexibility of energy markets to adjust to supply disruptions (energy substitution or switching technologies).

It may be noted that any energy saving or conservation measures may be represented in the simple demand-supply framework given in box 3 — energy saving may be represented as a leftward shift in the demand curve, such that a lower quantity of energy is consumed at any given market price. Similarly, any energy substitution or switching measures that increase substitution possibilities in end use activity may be represented in the diagrams in box 3 — increased energy substitution possibilities may be represented by a flattening of the demand curve, such that consumption of the specified fuel type is reduced, particularly at higher prices that provide the economic incentive to switch to the alternative fuel.

As noted previously, oil is the key area of dependence in energy markets. The share of oil in total primary energy consumption, electricity generation, total final energy consumption and energy consumption in the transport sector is summarised in figure 51 for individual APEC economies in 2002

51 Oil shares in energy consumption and per person GDP in APEC economies, 2002



(note the definition of oil — crude oil, natural gas liquids and feedstocks, and petroleum products — is appropriate to the energy consumption measure).

The high level of dependence on oil in transport use in all APEC economies is an area where there has been limited progress in technology adoption. Introduction of new technologies to increase the diversity of the fuel mix would significantly reduce energy security risks in this area. Some energy market analysts have argued for the introduction of the electrification of the transport sector to allow greater utilisation of relatively abundant resources in each economy while also complementing the current distribution system — electrification is compatible with the current infrastructure, unlike alternative hydrogen technologies that would require investment in separate distribution facilities to the end user (see the web site for the Institute for the Analysis of Global Security (www.iags.org/es).

New environmental technologies are important for the upstream industry as they allow energy exploration and production activity to be undertaken in new areas while managing environmental impacts. In addition, R&D is clearly important for the further development of renewable energy sources.

Other longer term policy measures

There are a number of other policy measures that may be considered for implementation over the longer term to reduce the risks and costs of temporary energy supply disruptions. It should be noted that there may be reasons in addition to energy security goals that provide an economic justification for considering policy intervention in the following broad areas.

Removal of market impediments

The energy policy setting in each economy may have important implications for the economic incentives of the private sector, including investment in energy supply reliability. Policy reform to increase the efficiency of energy markets to respond to supply disruptions is a significant component of the longer term energy security policy response.

Trade and investment liberalisation in the APEC region was examined in Schneider et al. (2000) and energy market reform in the APEC region was examined by Fairhead et al. (2002). In the latter report, some security of supply implications of market deregulation are noted — in Britain, for example, privatisation and deregulation have provided economic incentives to electricity generators to diversify their sources of fuel supply and it has been argued that system security has increased (see Fairhead et al. 2002, p. 36).

The efficiency of policy arrangements in energy exploration and production varies widely among APEC economies. Policies underpinning the allocation of exploration and production rights, and the collection of resource royalties may significantly impede industry exploration and production activity in some economies.

On a related point, some commentators such as Heyhoe and Levantis (2003) have suggested that, during a major oil supply disruption, the oil industry should be subject to an additional tax so that the community may share in the benefits of higher world oil prices (see box 3 for a discussion of some key economic effects of an oil disruption). However, under an efficient policy regime, higher oil prices should translate into higher resource royalty payments to governments for community use (see Hogan 2003a). Additional taxation would also reduce the economic incentives for surge production — that is, for the domestic oil industry to increase production during the disruption.

Provision of energy market information and international cooperation

Government support for the collection, dissemination and analysis of relevant energy market information is justified, at least to some extent, on energy security and broader economic efficiency grounds. Information may be used by both governments and the private sector as an input to commercial and policy decisions. The nature of the information varies widely and may include the public provision of basic geoscientific data as an input to exploration activity (see Hogan 2003b), information collection as required to meet international obligations (such as through membership of the IEA), and economic analysis of energy markets and policies (including quantitative assessments).

Dissemination of reliable information on future developments in energy markets, over different time frames, would assist energy users in making more informed choices when considering alternative energy related investments or consumer durable purchases.

The Joint Oil Data Initiative (JODI) is an example of a joint international project that should contribute substantially to the information available for international oil market analysis. Other aspects of international cooperation that are important include, for example, ongoing dialogue between the major oil producers and consumers, progress to ensure reasonable levels of sea lane security and joint R&D projects. The APEC Energy Security Initiative is an important example of international cooperation that should significantly enhance energy security in the region.

Prioritising emergency and longer term policies

The energy security policy response in each APEC economy will include a mix of emergency and longer term measures. It is important that each APEC economy undertake its own energy security policy assessment by applying the available information to their economy's specific circumstances.

To prioritise policy options, each economy needs to make an assessment of the expected net economic benefits of each policy option. There are several elements of any energy security policy assessment that require subjective judgment by policy makers within the relevant economy. It is not possible to assign objective probabilities to future possible outcomes — assessing the likelihood of future energy supply disruptions requires subjective judgment (in a formal analytical framework, subjective probabilities may be assigned to future events). Governments need to make subjective judgments about the relative importance of equity and other issues relating to social welfare during a major energy supply disruption.

An important issue for individual economies is that energy security policy options need to be prioritised within the framework of the national budget — this includes the total budget available to policy makers as well as the full range of competing priorities in the economy, although this judgment may be based on an objective assessment of the issues. In middle and low income APEC economies, for example, theft of energy and physical protection of the workforce and infrastructure are major energy security issues that have a higher priority than investment in energy stocks.

In table 23, rankings are provided for individual APEC economies based on 2002 data for several key energy security indicators, including energy intensity, energy and oil self sufficiency, the oil share in energy consumption (TPEC) and the diversification index for energy consumption (TPEC).

An indicative aggregate index is constructed by summing the rankings of each individual indicator. The ranking of this indicative aggregate index is provided in the final column of table 23. In each case, a ranking that is closer to 1 is associated with higher energy risks and/or costs based on the information content of the indicator. This is a highly simplified approach to

23 Rankings for APEC economies, by key energy security indicator in 2002 a

	Ranking for individual energy indicators					Indicative aggregate index	
	Energy intensity (TPEC/GDP)	Self sufficiency Oil	Self sufficiency Energy	Oil share in TPEC	Diversi-fication index for TPEC	Sum of indi-vidual rankings	Rank-ing
	no.	no.	no.	no.	no.	no.	no.
United States	10	10	9	10	15	54	10
Canada	3	16	15	15	19	68	18
Australia	11	13	19	17	13	73	20
Hong Kong	19	1	2	4	7	33	3
Japan	17	4	5	6	12	44	5
Singapore	4	1	1	1	1	8	1
Chinese Taipei	14	3	3	9	10	39	4
New Zealand	8	9	11	14	20	62	15
Korea, Rep. of	5	5	4	5	11	30	2
Brunei	2	20	20	16	2	60	13
Chile	16	7	6	12	18	59	12
Malaysia	7	15	17	7	4	50	6
Mexico	15	18	14	2	3	52	9
Russian Fed.	1	19	18	19	9	66	17
Thailand	13	8	8	8	14	51	7
Peru	20	12	10	3	6	51	7
China	12	11	12	20	5	60	13
Philippines	18	6	7	11	16	58	11
Indonesia	9	14	16	13	17	69	19
Viet Nam	6	17	13	18	8	62	15
Papua New Guinea	na	na	na	na	na	na	na

a A higher ranking (that is, a number closer to 1) is associated with higher energy risks and/or costs based on the information content of the indicator. Rankings exclude Papua New Guinea due to lack of data. **na** Not available
Source: Based on IEA (2004a,b).

indicating various aspects of the relative energy security position of individual economies in the APEC region.

The modeling analysis in this study used ABARE's model of the world economy, GTEM, to quantify the economic impacts of various energy supply disruptions over the outlook period (see chapters 5 and 6). The GTEM analysis captures key aspects of the short run adjustment in markets including demand restraint, fuel switching and surge production. This information may be used in energy security policy assessments since the economic benefits of short term and longer term policy response measures — such as stockpiling, diversification of energy markets, R&D activity and technology adoption — includes the reduction in future energy supply disruption costs.

This study is complementary to the studies undertaken in recent years by APERC — see, in particular, the analysis of joint stockpiling options and associated costs (see APERC 2000, 2002a,b; 2003). See also papers associated with a major project that is currently being undertaken through the Energy Modeling Forum (EMF) in the United States on oil security issues (see www.stanford.edu; earlier work in this area is given in EIA 1990).

Future energy security policy assessments would be enhanced by undertaking further research using GTEM or a similar framework to examine particular policy options in greater detail. For example, inclusion of energy stocks in GTEM would provide useful results on the costs and benefits of future stockpiling policy options in the APEC region. The relative economic costs and benefits of diversification, technology adoption and other longer term policy options may also be quantified in future research.

8

conclusion

This study suggests that oil supply security in particular, as distinct from energy supply security in general, should be the principal focus of concern of policy makers in the APEC region. The study corroborates the widely-held belief that there are important energy security risks for net oil importing economies in their increasing dependence on the Middle East as an oil supply source (ABARE projects, given a continuation of current trends, that the share of the Middle East in world oil production will increase from 30 per cent in 2003 to as high as 46 per cent in 2030). A complementary mix of short term and longer term policy response strategies, including exploration for and development of additional oil supply sources outside the Middle East, must therefore be a key priority of policy makers in all current and prospective net oil importing economies in the APEC region.

The importance of an efficient, resilient and open global energy market is also an underlying theme of this study.

Causes of economic vulnerability

In addressing energy security risk, the question that each APEC economy must address is: what makes the economy vulnerable?

There are three main causes of economic vulnerability of an individual APEC economy to energy supply disruptions. The first, and most important, is overdependence on either domestic production or imports of a single form of primary energy — this applies whether the energy form is oil, gas, coal, uranium, hydro or any of the new forms of renewable energy.

The second cause of economic vulnerability of an individual APEC economy is overdependence on any particular supply source of primary energy — this could apply, for example, where it is the supply of oil from the Middle East, the supply of coal from Australia or the supply of LNG from Indonesia.

The third cause of vulnerability is overdependence on a single energy infrastructure facility — this could apply, for example, where the economy depends on a single oil or gas pipeline, a single oil or gas storage facility or a single electricity transmission grid.

Policy responses by APEC economies

Irrespective of the range of energy supply risks that affect all or any APEC economies, it is suggested that continued promotion of an open global energy market should be considered as one of the overarching policy responses. Despite a doubling of global energy demand over the past 25 years, increased competition in global and domestic energy markets in the same period has counterbalanced the supply vulnerabilities of energy importing economies, and most of the world has continued to prosper from available and affordable energy supplies.

As well as promoting the need for a more open global energy market, all APEC economies will be well served by participating in the APEC Energy Security Initiative process which covers both short term and longer term measures to enhance energy security in the region. The broad areas covered by the APEC Energy Security Initiative include: contributing monthly data to the global Joint Oil Data Initiative (JODI); taking measures to enhance sea lane security; participating in the APEC real time emergency information sharing system; developing an energy emergency response; and developing a range of longer term responses.

Additionally, for an individual APEC economy, what might be the 'best' response will depend on the combination of particular energy security risks that it faces. Emergency stockpiling systems have an important balancing role to play, albeit only as a temporary response to shortages. There are four main policy responses that individual APEC economies can consider:

- adoption of a diversified portfolio of interchangeable energy forms and energy supply sources – this is a principal response that all economies need to consider; it will entail, for example, increased investment in domestic exploration for oil and other energy forms, investment in fuel switching systems and, in many economies, increased utilisation of natural gas.
- interconnection of energy systems – interconnection reduces vulnerability to system failure.

- encouragement of timely investment in energy production, transport and storage facilities – these facilities will include pipelines, other transport facilities, power stations and electricity transmission and distribution networks.
- encouragement of investment in more efficient energy technologies – these technologies will reduce the energy intensity of economies by, for example, reducing fuel use in transport.

Table 24 sets out a list of energy supply risks and a choice of risk reduction strategies that are open to any economy.

In summary, in addition to the paramount policy of continuing to promote the need for a more open global energy market, the reduction of energy supply vulnerability in APEC economies requires a diversified portfolio approach to energy policy and planning. Each APEC economy must decide for itself what are the most appropriate, cost effective and affordable responses for its particular circumstances. It is hoped that this study will assist them in making the optimal choice.

24 Main energy security risks and basic reduction strategies

Security risk	Risk reduction strategies
1 Heavy dependence on oil	■ Diversify the energy mix (increase share of natural gas, coal and 'old' and 'new' renewables) ■ Utilise fuel switching systems
2 Heavy dependence on natural gas	■ Diversify the energy mix (increase share of oil, coal, nuclear and 'old' and 'new' renewables) ■ Utilise new conversion technologies such as gas to liquids (GTL), if viable ■ Utilise fuel switching systems
3 Heavy dependence on coal	■ Diversify the energy mix (increase share of oil, natural gas, nuclear and 'old' and 'new' renewables) ■ Utilise liquefaction and gasification technologies, if viable ■ Utilise fuel switching systems

continued…

24 Main energy security risks and basic reduction strategies *continued*

Security risk	Risk reduction strategies
4 Heavy dependence on hydro-electricity	■ Diversify energy mix (increase share of oil, natural gas, coal, nuclear and 'new' renew-ables) ■ Utilise fuel switching systems
5 Heavy dependence on imports	■ Diversify external sources of supply ■ Increase domestic oil and gas exploration ■ Build stockpiling capacity ■ Strengthen alliances with reliable suppliers
6 Inadequate stockpiling capacity	■ Participate in regional and international oil stockpiling schemes for the common good ■ Increase domestic oil stockpiling capacity ■ Increase domestic gas storage above and below ground ■ Increase domestic coal stockpiling
7 Inadequate transport capacity	■ Increase cross border and domestic pipeline capacity ■ Build and expand LNG receiving terminals
8 Poor utilisation of primary energy	■ Utilise new vehicle technologies ■ Utilise new and more efficient generation technologies ■ Maintain high reserve generating plant mar-gins ■ Increase fuel switching capacity
9 Poor efficiency of gas and electricity industries	■ Maintain high system security ■ Utilise private capital and competitive markets ■ Reduce energy intensity ■ Utilise demand management systems ■ Compel demand restraint ■ Ration supplies if unavoidable
10 Poor utilisation of electricity transmission and distribution networks	■ Decentralise generation ■ Upgrade and augment networks ■ Interconnect with other power systems by cross border transmission ■ Extend grid service to unserviced areas

current energy policy settings in selected APEC economies

In this appendix, information is provided on the energy policies in each of the study's six focus economies — China, Japan, the Republic of Korea, Mexico, Thailand and the United States. These focus economies are selected to be representative of the economic and geographic diversity of economies within the APEC forum and, based on IMF data, include two high income economies (the United States and Japan), three middle income economies (the Republic of Korea, Mexico and Thailand) and one low income economy (China).

China

China's 10th Five-Year Plan 2001 establishes China's energy policy framework (People's Republic of China 2001). China recognises that its rapid economic development can only be sustained if it can maintain access to adequate supplies of reliable energy at a reasonable cost. To achieve this, China promotes demand restraint, encouraging the adoption of petroleum substitutes and efficiency improvements in energy use. China is also looking to stabilise energy supplies by improving the reliability of energy imports, effectively exploiting domestic energy resources, and opening up energy markets to private investment.

To raise the security of its oil and gas imports, China is diversifying import sources. China, together with the Russian Federation and the Republic of Korea, have been considering the option of a pipeline to export natural gas from Irkutsk in southern Russia to China and Korea. However Russian exports from Irkutsk are not likely to commence before 2010 (FACTS Inc. 2003b). Meanwhile China is building LNG receiving terminals in Fujian and Guangdong, with the prospect of LNG imports from Australia and Indonesia beginning around 2007.

China is also looking to enhance its influence over energy resources outside of China by investing in foreign fields. For instance, China National Offshore Oil Corporation (CNOOC) became Indonesia's largest offshore oil producer in January 2002. Also in 2002, CNOOC secured a 12.5 per cent stake in Indonesia's Tangguh field, which is to supply LNG to China's Fugian province for 25 years, commencing around the end of this decade. Similarly CNOOC has become a minor partner in Australia's North West Shelf, which will supply Guangdong province with LNG from 2007.

To guarantee reliable energy supplies, China is aiming to exploit indigenous primary energy resources as much as is economically feasible (People's Republic of China 2001). For this reason, China intends to continue to rely on Chinese coal as its most important source of energy. This will involve opening new large scale coal mines in the coal rich western provinces. This coal will be used to generate electricity in mine-mouth power stations, which will then be transmitted to the high energy consuming areas in the east.

To achieve this, an enormous West–East Power Transmission scheme which will transmit both coal fired and hydro power from the west to the centres of rapid growth in China's coastal provinces, is under construction. By 2020, this west–east network may be carrying over 100 GW (FACTS Inc. 2003b). This is roughly equivalent to Canada's entire current generating capacity (IEA 2003).

While continuing to rely heavily on coal and hydro, China is also looking to expand gas production. China aims to intensify exploration and exploitation of gas reserves, located mainly in the western provinces of Sichuan, Xinjiang and Shaanxi. At the same time, China is expanding its west–east gas pipeline network to bring Chinese gas to Beijing, Shanghai and the neighboring provinces. By 2007, 12 billion cubic metres are expected to be flowing along the west–east pipeline to Shanghai (FACTS Inc. 2003b). Pipelines to Beijing and surrounding cities will have a similar capacity.

China is implementing significant energy market reforms in order to attract the private investment that China's energy sector needs to achieve rapid growth in domestic energy output. As a result of reforms, independent power producers generate over half of total electricity, and while they are currently obliged to sell to state owned utilities, in the future they will compete with state owned utilities to supply a single wholesaler (Fairhead et al. 2002). Foreign participation in the oil and gas sectors is less well advanced. Upstream activities in these sectors are dominated by state owned enterprises, with foreign involvement limited to minority shares in production sharing arrangements. It is likely that foreign investment opportunities will improve as China seeks to expand its exploration and production activities.

Japan

In the 1980s, Japanese policy makers were particularly concerned to alleviate Japan's vulnerability to oil price shocks and other energy supply disruptions. This motivated Japan's shift out of oil fired power, the rapid rise in efficiency of energy use, the growth of nuclear, and the policy of diversifying both fuel types and fuel suppliers.

Oil stockpiles are fundamental for Japan's capacity to respond to an emergency energy supply disruption. As of 1 July 2002, oil stockpiles were equivalent to 119 days worth of imports, which is larger than the IEA requirement of 90 days import equivalent (JNOC 2003). The private sector is required to maintain 70 days worth of stocks, and the government maintains the rest through the Japan National Oil Corporation.

Japan is now also expanding its Liquid Petroleum Gas stockpiles, targeting public stockpiles equivalent to 30 days of imports by 2010, in addition to the 50 days worth that the private sector is already obliged to hold under the Petroleum Stockpiling Law (JNOC 2003).

Japan pursues a policy of cooperation with major oil and gas producing countries, in order to improve the security of energy import supplies. Apart from investment and joint ventures in oil and gas exploration and production activities, Japan supports development in oil and gas producing countries outside of the energy sector, in accordance with the needs and priorities of the recipient countries (ANRE 2002b). Japan's objective is to strengthen its ties with major oil and gas exporting countries to improve Japan's access to oil and gas supplies.

In the 1990s, economic stagnation turned the focus of energy policy in Japan to the efficiency of energy supply industries. Japan began along a path of substantial market reform that continues today. Oil refining industries were deregulated in the mid-1990s, resulting in consolidation of the refining industry, which continues today. Liberalisation of the electricity and gas sectors has proceeded at a slower pace, but significant progress has been made. Privately owned utilities that once operated as regional monopolists, now compete with each other and with independent power producers (IPPs) to supply large users. Furthermore, in the electricity sector by 2009, all new thermal power stations will be subject to competitive bidding.

Public resistance to new nuclear plants has led to the government scaling down its nuclear power target. Only four new nuclear reactors are expected by 2010, and these are already under construction. An additional six nuclear plants are planned by 2030 (Facts Inc 2004).

Republic of Korea

The framework for Korea's energy policies is provided by Korea's 2nd National Energy Plan 2002–2011 (MOCIE 2002). In the light of Korea's heavy dependence on energy imports, this plan places considerable emphasis on energy security initiatives, and takes a broad view of the measures that can contribute to stabilising Korea's energy supply.

Under Korea's National Energy Plan, it is the government's role to guarantee a stable energy system, and to maintain Korea's capacity to respond to energy crises. Various measures have been implemented to secure Korea's energy supplies.

Strategic stocks of oil and gas are key energy security initiatives. Through the state owned Korea National Oil Corporation (KNOC), Korea maintains a stockpile of petroleum to cushion its economy against supply disruptions. Strategic stocks are equivalent to 90 days of petroleum imports (EIA 2003). In 2001, stocks were expanded from the equivalent of 60 days imports to enable Korea to join the IEA.

Gas storage is regarded as important to stabilise gas demand and shipments of LNG, particularly in the event of a short term supply disruption. Korea is therefore expanding its gas storage capacity from 27 tanks in 2002 to 78 tanks by 2015 (EIA 2003).

In the interests of Korea's long term energy security, KNOC is investing in exploration and production projects around the world, as well as in domestic offshore blocks. KNOC aims to supply 10 per cent of Korea's oil requirements by 2010 (EIA 2003). KNOC is presently involved in 18 gas and oil projects across 13 countries. However in the future, KNOC will select and focus activities in target regions such as in the Caspian Sea and

Central Asia, while also expanding domestic continental shelf exploration and drilling (MOCIE 2002).

Korea places a high emphasis on international cooperation in order to enhance its energy security (MOCIE 2002). In recent developments, Korea became a member of the IEA in 2001, and an observer to the Energy Charter Treaty of Europe in 2002. The Energy Charter Treaty provides a framework of rules for energy cooperation including trade and investment. Korea is also seeking to enhance its relationships with OPEC and other oil exporting economies.

To diversify and improve energy import supplies, Korea is considering the possibility of pipeline gas from Irkutsk in the Russian Federation. However, this pipeline is not likely to come on line until after 2010 (FACTS Inc. 2003b). In the meantime, Korea is seeking to improve the conditions of its LNG import contracts by alleviating the take or pay principle and by developing a mix of both short and long term contracts (MOCIE 2002).

Korea is proactively promoting cooperation in the energy sector with North Korea and other north east Asian neighbors so as to foster closer ties, thereby improving stability and economic prosperity for the region (MOCIE 2002). For example, Korea and North Korea are jointly evaluating a natural gas pipeline route from China through North Korea to Korea (EIA 2003).

Apart from policies related to energy security, Korean energy policy developments are focused on reforming energy markets. Korea is a net exporter of refined petroleum products. Deregulation of the petroleum refinery industry in 1998 opened up the industry to foreign investment and substantial consolidation, improving the competitiveness of the industry.

Substantial market reforms have also been implemented in the electricity supply sector. The government intends to separate and partially privatise KEPCO's generation, transmission and distribution arms, and ultimately establish a capacity credit market system to coordinate power supply and demand (MOCIE 2002). Some initial steps were taken in 2001 when the generation capacity of Korea Electric Power Company was split into six subsidiaries. Five of these subsidiaries are to be privatised. The sixth is KEPCO's nuclear generating capacity and will remain government owned.

Much less progress has been made toward reforming the gas sector. Legislation has yet to be passed to allow the monopoly LNG importer, Kogas to be privatised. In recent developments, corporations can now apply to import LNG directly, including for distribution to third parties, ending Kogas' monopoly power over the import of LNG (Energy Economist 2004).

Mexico

While Mexico is a major net oil and gas exporter, inadequate investment in Mexico's energy sector is creating energy shortages. Mexico's 2001–06 National Energy Plan aims to remove the constraints on investment in energy. However, efforts to reform constitutional impediments to private investment and to otherwise attract investment to the energy sector have been slow because of resistance from congress.

State owned monopolists dominate Mexico's energy sectors. These enterprises tend to be inadequately resourced. Efforts to open up the sectors to competition and private investment have been seriously hampered by Mexico's Constitution, which prohibits any private ownership of Mexico's energy reserves or of Mexico's power sector (EIA 2004c).

Petroleos Mexicanos (Pemex), the state owned oil and gas company, has exclusive rights to oil and gas exploration and production in Mexico (EIA 2004c). The company's financial capacity to invest in exploration and production has been severely curtailed by 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.

It is the current administration's policy to increase gas and oil output (EIA 2004c). However, this requires the participation of private investors. In 2002, the government extended the coverage of 'multiple service contracts' in an effort to open up the oil and gas sectors to private investment within the confines of the Constitution. Under multiple service contracts, private companies undertake oil or gas industry activities on behalf of Pemex, but have no rights to any of the oil or gas. Instead companies are paid fees for services. Nine multiple service contracts have been awarded to date to develop Mexico's gas resources. These developments will not be sufficient to supply Mexico's domestic gas and oil requirements, with Mexico already planning to import LNG. Pemex anticipates that Mexico will also commence importing oil in the next decade unless substantial investment is undertaken in exploration.

In the electricity sector, the Federal Electricity Commission (CFE) has a monopoly over all stages, with the exception of generation which was opened up to independent power producers (IPPs) in 1992. In addition, IPPs close to the border have the option of exporting power to the United States, providing a check on the monopoly power retained by CFE over the downstream sector. As of May 2004, IPPs accounted for 14.3 per cent of generation capacity, CFE for 74 per cent and the rest is generated by other state enterprises, self suppliers or cogeneration (EIA 2004c).

As in the oil and gas sectors, there is a need for private investment to help expand Mexico's electricity supply capacity. There have been serious power outages in recent years because of inadequate capacity in the transmission system and because of a heavy reliance on hydro power during consecutive years of drought. Without private investment, power shortages can be expected to increase as demand continues to expand rapidly to keep pace with expected relatively strong economic growth and a rise in Mexico's electrification rate, which is currently 95 per cent.

Developments that could help to ease power supply constraints are the construction of power plants by US firms to serve markets in both the United States and Mexico.

Thailand

Thailand's energy strategy has the twin aims of enhancing energy security and improving economic competitiveness. There are four plans in the strategy — a plan to raise energy efficiency, a plan to increase the role of commercial renewable energy, a plan to enhance energy security directly, and a plan to develop Thailand into a regional energy hub (Energy Policy and Planning Office 2003). There are measures in each of these plans that would contribute to greater energy security.

Measures that raise energy efficiency will reduce Thailand's dependence on energy, and potentially reduce the cost of energy intensive activities. To increase efficiency in the transport sector, Thailand is seeking to achieve greater use of rail instead of personal motor vehicles, more careful planning of transport networks, and is introducing tax measures to encourage conservation. To achieve an improvement in efficiency in the industry sector, Thailand is relying on tax measures that reward energy conservation, the introduction of energy efficient technologies such as cogeneration and the operation of a system of minimum efficiency standards and labeling.

Diversifying fuel sources is another aspect to Thailand energy policy that will reinforce Thailand's energy security. Thailand plans to increase the role of commercial renewables in electricity generation from 0.5 per cent to 8 per cent by 2011. Various measures have this objective, including the requirement that 4 per cent of all new generating capacity be renewables, combined with the introduction of incentives to purchase power generated by renewable sources.

To directly enhance the security of Thailand's power supplies, a fund has been established to help gain the support of local communities for the construction of new power plants. Siting of new plants has been a problem in the past because of local resistance.

To strengthen its access to fossil fuel resources, Thailand is increasing domestic exploration for fossil fuels, while also assisting Thai companies to invest in projects outside of Thailand. In addition, Thailand is seeking to cooperate more closely with its neighboring countries in the development of joint energy resources. At a regional level, Thailand is looking to foster greater regional cooperation, including speeding up the trans-ASEAN gas pipeline project.

Thailand envisages itself as a major hub of energy trade for its region. To achieve this, Thailand is introducing tax measures that encourage energy trade, including tax free zones in two coastal regions, and the removal of trade barriers on energy. In terms of infrastructure, Thailand is looking to connect the oil pipeline network in the north with that of the north east, and to connect its energy networks with those of southern China.

On a bolder level, Thailand proposes a 'Strategic Energy Landbridge' — a system of pipelines and road transport that will run from its west coast to its east coast, together with a substantial stockpile depot system. This would provide Thailand with greater control over energy resources while reducing the wider region's dependence on the Malacca Strait. Thailand is trying to foster interest and funding from other major importers such as Japan, the Republic of Korea, China and India.

United States

Generally, energy policy initiatives in the United States have been concentrated on managing the liberalisation of energy sectors, and managing energy transformation and consumption. But energy security is gaining prominence as an important policy objective because the United States is facing growing resource constraints. Compounding energy security concerns in the United States, the traditional sources of US energy imports — Canada and Mexico — are also facing constraints, forcing the United States to look elsewhere to satisfy its growing demand for fuels.

Despite decades of reform initiatives, the regulation of energy sectors varies considerably across the United States (Fairhead et al. 2002). In the natural gas sector, the United States has implemented considerable reforms to enhance the degree of competition between utilities. In particular, there is open access to interstate pipelines, and utilities may negotiate directly with large users. Some states have also introduced retail competition. The oil industry is characterised by private ownership and a high degree of vertical integration. The Department of Energy controls the strategic level of petroleum reserves. Similarly the US coal sector is lightly regulated.

Electricity market regulations vary widely. Some states have implemented a market based system for the generation and supply of power, including competitive wholesale markets such as the Pennsylvania – New Jersey – Maryland market. However, the electricity system in many other states is characterised by vertical integration and disparate ownership of the grid.

In the longer term, the focus of the United States on developing new energy technologies is also designed to enhance energy security by facilitating the use of domestic and internationally abundant coal reserves (EIA 2005).

Short term response measures to an energy supply disruption are also key elements of energy security policy in the United States. The US Strategic Petroleum Reserve is the largest emergency oil stockpile in the world. In October 2004 the reserve contained 670 million barrels. By Presidential decree in November 2001, the reserve is due to be filled to its maximum capacity of 700 million barrels by 2005 (EIA 2005). However, this timeframe may be revised given that drawdown of the reserve was initiated in late 2004 in response to the extensive damage done by Hurricane Ivan to the oil supply infrastructure in the Gulf of Mexico.

Drawdown of the Strategic Petroleum Reserve is initiated by a Presidential decision that it is required by a severe energy disruption or by international obligations — for example, under the International Energy Agency (EIA 2005). Oil from the stockpile begins to arrive on the market around fifteen days after the President's decision and is distributed mainly by competitive sale to the highest bidders.

decomposition of annual growth in total primary energy consumption in twenty APEC economies

Descriptive statistics relating to sources of APEC energy market volatility since 1972, given in table 12 in chapter 4, are based on information presented in this appendix. The detailed decomposition analysis of annual growth in total primary energy consumption (TPEC) in twenty APEC economies is given in tables 25–44 (in order of the ranking of economies used throughout this report; see table 1) .

TPEC in an economy may be defined by fuel type or by supply source. By fuel type, TPEC is equal to the sum of the consumption of individual primary fuel types (where some minor adjustments in the IEA energy accounts, noted in table 3, are included in renewables energy consumption). By supply source, TPEC is equal to domestic production plus net imports (defined as imports less exports less international marine bunkers) plus stock drawdown. These definitions may be expressed as follows:

by fuel type: TPEC = coal consumption + oil consumption
+ natural gas consumption + nuclear power consumption
+ renewables energy consumption

by supply source: TPEC = production + imports – exports
– international marine bunkers – change in stocks
= production + net imports + stock drawdown

The decomposition analysis is based on the observation that the annual percentage change in TPEC in each APEC economy may be decomposed into the percentage point contributions of individual primary fuel types or supply sources. The percentage point contribution accounts for both the annual percentage change in consumption of an individual fuel type or supply source as well as the share of the component in TPEC.

Footnotes to tables 25–44

a Including international marine bunkers. **b** Maximum observation minus the minimum observation. **c** Number of years in which a negative observation occurs as a percentage of the total number of years. **d** Correlation coefficient between percentage change in TPEC and the variable indicated.
Source: Based on IEA energy database; see IEA (2004a,b).

25 Decomposition of annual growth in TPEC by fuel type and supply source
United States Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock draw-down
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.6	3.6	0.3	0.3	0.2	5.0	1.8	2.8	0.4
1973	1.3	2.4	–0.4	0.5	0.1	3.8	–0.5	4.4	–0.1
1974	0.1	–2.1	–0.9	0.5	0.2	–2.2	–1.6	–0.7	0.1
1975	–0.3	–0.3	–2.5	1.0	–0.1	–2.2	–1.2	0.8	–1.8
1976	2.1	3.4	0.7	0.3	0.3	6.8	0.6	3.7	2.5
1977	0.1	3.4	–0.9	0.9	–0.1	3.4	1.5	4.8	–2.9
1978	0.8	0.7	0.4	0.4	0.5	2.8	1.2	–1.5	3.1
1979	0.5	–1.6	0.9	–0.3	0.2	–0.2	3.2	–1.0	–2.4
1980	0.5	–4.2	0.0	–0.1	0.1	–3.7	1.5	–5.9	0.8
1981	0.6	–2.9	–0.8	0.3	0.0	–2.8	–0.3	–3.3	0.8
1982	–0.9	–1.8	–1.9	0.2	0.2	–4.2	–1.0	–2.6	–0.5
1983	1.0	–0.2	–1.3	0.2	0.4	0.1	–3.6	1.1	2.6
1984	1.3	1.2	0.8	0.6	0.5	4.3	7.1	1.0	–3.8
1985	0.9	0.0	–0.6	0.9	–0.2	1.1	–1.1	–1.4	3.5
1986	–0.7	1.5	–1.3	0.5	0.2	0.1	–0.6	3.1	–2.4
1987	1.4	0.9	1.2	0.6	0.2	4.3	1.9	1.9	0.5
1988	0.9	1.3	0.9	1.1	–0.3	3.9	1.5	1.5	1.0
1989	0.3	0.1	1.0	0.0	0.1	1.5	–0.1	1.3	0.3
1990	0.0	–1.8	–0.2	0.7	–0.2	–1.7	1.7	–0.6	–2.8
1991	–0.3	–0.8	1.0	0.5	0.3	0.8	–0.5	–1.1	2.5
1992	0.3	0.8	0.5	0.1	0.3	2.0	0.2	1.7	0.0
1993	0.8	0.8	0.7	–0.1	–0.2	2.0	–2.3	3.3	1.0
1994	0.3	0.8	0.5	0.4	0.1	2.0	3.1	1.6	–2.7
1995	–0.1	0.0	0.8	0.4	0.2	1.3	0.0	–0.8	2.1
1996	1.1	1.3	–0.2	0.0	0.3	2.5	1.2	1.7	–0.3
1997	0.7	1.0	0.2	–0.6	–0.2	1.1	–0.1	2.0	–0.8
1998	0.1	0.6	–0.4	0.6	–0.1	0.8	0.6	1.7	–1.4
1999	0.2	0.7	1.2	0.7	0.0	2.8	–0.8	1.2	2.3
2000	0.9	0.5	1.0	0.3	0.0	2.7	–0.3	1.4	1.5
2001	–0.3	0.5	–1.4	–0.1	–0.9	–2.1	0.8	2.0	–4.9
2002	0.3	–0.2	1.0	0.1	0.4	1.6	–1.2	–0.9	3.7
Descriptive statistics: 1972–2002									
Average	0.5	0.3	0.0	0.3	0.1	1.2	0.4	0.7	0.1
Std deviation	0.6	1.8	1.0	0.4	0.3	2.7	1.9	2.3	2.2
Range **b**	3.0	7.8	3.7	1.7	1.4	11.0	10.7	10.7	8.6
– maximum	2.1	3.6	1.2	1.1	0.5	6.8	7.1	4.8	3.7
– minimum	–0.9	–4.2	–2.5	–0.6	–0.9	–4.2	–3.6	–5.9	–4.9
% years < 0 **c**	23	35	45	16	35	26	52	35	42
Correlation **d**	0.7	0.8	0.6	0.2	0.2	1.0	0.3	0.7	0.2

26 Decomposition of annual growth in TPEC by fuel type and supply source

Canada Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock draw-down
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.4	3.4	2.7	0.5	0.8	7.9	14.8	–7.4	0.6
1973	–0.8	1.8	1.5	1.4	0.6	4.5	14.0	–8.5	–1.0
1974	–0.3	1.1	–0.2	0.0	0.9	1.5	–4.0	5.1	0.4
1975	0.7	2.6	0.7	–0.4	–1.1	2.7	–2.7	6.4	–1.0
1976	0.4	1.1	0.2	0.8	0.5	3.1	–3.2	3.6	2.7
1977	0.5	0.3	1.0	1.3	0.0	3.1	4.5	1.6	–3.1
1978	0.2	0.4	0.3	0.9	0.9	2.7	0.7	–1.7	3.7
1979	1.0	1.6	1.6	0.7	0.0	4.9	10.5	–2.2	–3.3
1980	0.7	–1.6	1.0	0.3	0.7	1.2	–1.4	1.6	1.0
1981	0.3	–2.3	–1.2	0.4	0.2	–2.5	–3.5	0.3	0.6
1982	0.6	–4.2	0.4	–0.1	–0.3	–3.6	1.1	–5.3	0.6
1983	0.7	–3.2	–0.3	1.4	0.6	–0.8	2.5	–4.6	1.3
1984	1.4	0.7	1.7	0.5	0.8	5.2	12.0	–3.3	–3.5
1985	–0.5	–1.0	1.7	1.0	1.0	2.2	6.6	–7.4	3.0
1986	–1.0	1.4	–1.0	1.5	0.8	1.7	–0.8	4.4	–1.8
1987	0.9	1.4	0.4	0.8	–0.1	3.4	6.6	–2.9	–0.4
1988	0.9	0.1	2.4	0.5	0.3	4.2	9.9	–6.3	0.7
1989	0.1	2.0	1.2	–0.3	–0.1	2.9	0.6	1.5	0.8
1990	–1.5	–1.4	–0.7	–0.9	0.4	–4.1	–0.1	–1.2	–2.8
1991	0.5	–2.2	0.3	1.5	–0.3	–0.1	5.5	–8.0	2.4
1992	0.5	1.1	1.4	–0.6	0.1	2.5	4.3	–3.6	1.8
1993	–1.0	0.9	1.7	1.6	0.2	3.3	10.1	–4.6	–2.3
1994	0.3	0.0	1.4	1.6	0.2	3.5	10.2	–5.9	–0.8
1995	0.2	0.7	1.0	–1.2	0.6	1.4	4.7	–5.7	2.3
1996	0.2	0.6	1.5	–0.6	0.7	2.4	4.1	–0.3	–1.4
1997	0.7	1.4	0.2	–1.1	–0.1	1.1	2.7	–0.5	–1.1
1998	0.5	1.2	–1.2	–1.2	–0.2	–0.9	1.5	–3.0	0.6
1999	0.0	0.6	1.2	0.2	0.9	2.9	–0.6	1.0	2.5
2000	0.9	0.4	1.3	–0.1	0.2	2.7	3.2	–1.8	1.3
2001	–0.1	0.3	–0.9	0.4	–0.7	–1.1	1.8	–0.3	–2.5
2002	–0.5	–1.0	1.4	–0.1	1.1	0.8	2.5	–3.1	1.3
Descriptive statistics: 1972–2002									
Average	0.2	0.3	0.7	0.4	0.3	1.9	3.8	–2.0	0.1
Std deviation	0.7	1.7	1.0	0.9	0.5	2.6	5.2	4.0	2.0
Range **b**	2.9	7.6	3.9	2.8	2.1	12.0	18.7	14.8	7.1
– maximum	1.4	3.4	2.7	1.6	1.1	7.9	14.8	6.4	3.7
– minimum	–1.5	–4.2	–1.2	–1.2	–1.1	–4.1	–4.0	–8.5	–3.5
% years < 0 **c**	26	29	23	39	26	23	26	71	42
Correlation **d**	0.3	0.7	0.8	0.3	0.3	1.0	0.6	–0.1	–0.1

27 Decomposition of annual growth in TPEC by fuel type and supply source

Australia Percentage point contributions

	By fuel type					Total	By supply source		
	Coal	Oil	Gas	Nuclear	Other	Total primary energy consumption	Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	1.8	–0.4	1.5	0.0	0.1	3.0	16.4	–5.2	–8.3
1973	1.0	4.9	1.5	0.0	–0.2	7.2	10.3	–8.1	5.0
1974	–0.7	2.6	0.9	0.0	0.5	3.3	–0.8	2.6	1.5
1975	2.8	–1.1	0.5	0.0	0.2	2.5	12.5	–7.6	–2.4
1976	–0.1	1.9	0.5	0.0	0.1	2.4	0.5	3.6	–1.7
1977	3.3	2.3	1.9	0.0	–0.3	7.1	11.2	–4.5	0.5
1978	–3.0	2.6	0.7	0.0	0.0	0.4	0.7	–3.5	3.2
1979	1.3	–0.3	1.2	0.0	0.0	2.2	3.9	0.8	–2.5
1980	3.8	–1.9	0.8	0.0	–0.2	2.4	1.1	–4.0	5.3
1981	0.4	–2.0	1.8	0.0	0.5	0.6	12.9	–4.6	–7.6
1982	1.4	1.6	1.3	0.0	0.2	4.4	5.9	0.5	–1.9
1983	–0.7	–3.7	0.6	0.0	–0.2	–4.1	6.1	–9.1	–1.0
1984	1.8	0.8	0.7	0.0	–0.1	3.1	11.7	–16.2	7.5
1985	1.2	–1.5	1.0	0.0	0.3	1.1	18.0	–20.7	3.7
1986	–0.8	1.3	1.4	0.0	–0.4	1.5	13.4	–6.2	–5.7
1987	3.0	1.2	0.5	0.0	0.0	4.7	13.4	–1.8	–7.0
1988	0.1	0.9	0.6	0.0	0.2	1.8	–9.0	–6.2	16.9
1989	3.8	2.2	0.5	0.0	0.2	6.7	8.7	7.7	–9.7
1990	0.0	1.1	1.5	0.0	0.1	2.7	14.7	–7.5	–4.6
1991	1.6	–1.6	–1.1	0.0	0.1	–0.9	6.3	–11.5	4.3
1992	0.6	0.9	0.6	0.0	–0.5	1.5	8.3	–7.1	0.3
1993	0.8	3.0	0.7	0.0	0.9	5.3	4.0	–1.2	2.5
1994	–0.5	0.1	0.7	0.0	–0.1	0.2	–0.5	0.1	0.6
1995	0.4	–0.3	1.2	0.0	0.2	1.6	14.5	–7.7	–5.2
1996	3.4	2.9	0.1	0.0	0.6	7.0	3.1	0.2	3.7
1997	2.4	–1.6	0.1	0.0	0.3	1.3	10.0	–5.9	–2.8
1998	1.6	–0.4	0.7	0.0	–0.2	1.6	13.2	–13.0	1.4
1999	2.2	0.5	0.7	0.0	0.1	3.5	–1.0	0.4	4.0
2000	0.4	0.8	0.9	0.0	0.1	2.1	18.5	–11.9	–4.5
2001	0.7	–3.0	0.9	0.0	0.0	–1.3	15.3	–12.4	–4.2
2002	0.6	1.4	0.3	0.0	1.7	4.0	5.7	–4.0	2.4
Descriptive statistics: 1972–2002									
Average	1.1	0.5	0.8	0.0	0.1	2.5	8.0	–5.3	–0.2
Std deviation	1.5	1.9	0.6	0.0	0.4	2.5	6.7	6.1	5.5
Range **b**	6.8	8.6	2.9	0.0	2.3	11.3	27.5	28.4	26.7
– maximum	3.8	4.9	1.9	0.0	1.7	7.2	18.5	7.7	16.9
– minimum	–3.0	–3.7	–1.1	0.0	–0.5	–4.1	–9.0	–20.7	–9.7
% years < 0 **c**	23	39	3	0	35	10	13	74	48
Correlation **d**	0.5	0.8	0.2	–	0.2	1.0	0.0	0.4	0.0

28 Decomposition of annual growth in TPEC by fuel type and supply source

Hong Kong Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock draw-down
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–0.2	4.8	0.0	0.0	–0.1	4.5	0.1	3.2	1.2
1973	–0.2	2.8	0.0	0.0	0.0	2.6	0.0	4.5	–1.9
1974	0.0	9.9	0.0	0.0	–0.1	9.8	0.0	13.6	–3.8
1975	0.0	3.9	0.0	0.0	–0.1	3.7	0.0	–4.1	7.8
1976	0.1	11.7	0.0	0.0	0.1	11.9	0.0	17.4	–5.5
1977	–0.1	10.7	0.0	0.0	0.0	10.6	0.0	12.6	–1.9
1978	0.0	8.6	0.0	0.0	0.1	8.7	0.0	4.6	4.0
1979	0.0	–7.5	0.0	0.0	–0.3	–7.8	0.0	–4.9	–3.0
1980	0.0	3.5	0.0	0.0	–0.1	3.4	0.0	3.4	–0.1
1981	0.6	10.8	0.0	0.0	0.1	11.5	0.0	5.8	5.7
1982	14.2	–4.7	0.0	0.0	0.0	9.4	0.0	15.3	–5.9
1983	18.2	–11.3	0.0	0.0	–0.1	6.8	0.0	2.1	4.7
1984	9.0	–3.8	0.0	0.0	–0.5	4.7	0.0	6.1	–1.4
1985	8.8	–5.9	0.0	0.0	–0.4	2.5	0.0	1.3	1.3
1986	7.0	3.7	0.0	0.0	–0.2	10.5	0.0	14.8	–4.3
1987	11.8	–3.8	0.0	0.0	–0.1	7.9	0.0	5.3	2.5
1988	8.5	6.6	0.0	0.0	–0.1	15.0	0.0	12.9	2.1
1989	3.9	2.5	0.0	0.0	–0.3	6.1	0.0	10.1	–4.0
1990	–5.5	1.9	0.0	0.0	0.0	–3.7	0.0	–6.7	3.0
1991	4.1	1.4	0.0	0.0	–1.0	4.4	0.0	5.7	–1.3
1992	3.3	12.3	0.0	0.0	–1.5	14.1	0.0	14.2	–0.1
1993	7.8	2.3	0.0	0.0	0.6	10.7	0.0	12.1	–1.4
1994	–14.8	3.7	0.0	0.0	6.4	–4.7	0.0	–6.3	1.6
1995	3.0	–0.2	0.2	0.0	–0.3	2.7	0.0	0.6	2.1
1996	–10.5	–1.3	9.8	0.0	0.7	–1.2	0.0	1.8	–3.0
1997	–4.8	1.2	5.7	0.0	0.0	2.2	0.0	1.7	0.5
1998	6.2	13.3	–1.0	0.0	–0.1	18.4	0.0	16.9	1.4
1999	–2.7	8.1	1.3	0.0	1.0	7.7	0.0	7.7	0.0
2000	–1.2	–10.4	–1.2	0.0	0.0	–12.8	0.0	–11.2	–1.6
2001	7.9	–2.5	0.1	0.0	–0.1	5.4	0.0	4.7	0.7
2002	2.6	–1.0	–0.6	0.0	–0.4	0.6	0.0	0.1	0.5
Descriptive statistics: 1972–2002									
Average	2.5	2.3	0.5	0.0	0.1	5.3	0.0	5.3	0.0
Std deviation	6.8	6.6	2.1	0.0	1.3	6.7	0.0	7.4	3.2
Range **b**	33.0	24.5	11.0	0.0	7.9	31.1	0.1	28.5	13.6
– maximum	18.2	13.3	9.8	0.0	6.4	18.4	0.1	17.4	7.8
– minimum	–14.8	–11.3	–1.2	0.0	–1.5	–12.8	0.0	–11.2	–5.9
% years < 0 **c**	42	35	10	0	65	16	3	16	52
Correlation **d**	0.5	0.6	-0.2	-	-0.3	1.0	0.0	0.9	0.0

29 Decomposition of annual growth in TPEC by fuel type and supply source

Japan Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–0.5	7.2	0.0	0.1	0.0	6.9	–1.2	7.4	0.6
1973	1.1	11.1	0.6	0.0	–0.5	12.3	–1.1	14.7	–1.3
1974	1.1	–2.4	0.5	0.8	0.4	0.4	0.4	0.4	–0.3
1975	–1.4	–4.6	0.3	0.4	0.0	–5.2	–0.2	–7.1	2.1
1976	–0.2	5.1	0.4	0.8	0.0	6.2	1.0	5.7	–0.6
1977	–1.0	2.5	0.6	–0.2	–0.3	1.7	–0.3	3.1	–1.0
1978	–2.0	–0.8	1.4	2.2	0.0	0.8	1.3	–1.8	1.3
1979	1.4	2.2	0.9	0.9	0.4	5.7	1.0	6.0	–1.2
1980	2.4	–6.5	0.8	0.9	0.2	–2.3	1.1	–3.8	0.4
1981	1.6	–4.7	0.2	0.4	0.0	–2.6	0.4	–4.9	2.0
1982	–0.4	–1.8	0.2	1.1	1.1	0.2	2.1	–2.0	0.0
1983	–0.8	–0.5	0.4	0.9	0.2	0.1	0.9	–0.5	–0.2
1984	2.3	1.4	2.5	1.5	–0.2	7.6	1.2	7.3	–0.9
1985	0.9	–3.5	0.7	1.8	0.3	0.2	2.1	–1.7	–0.2
1986	–1.1	1.6	0.1	0.6	–0.1	1.2	0.5	1.2	–0.5
1987	–0.5	0.3	0.2	1.4	–0.1	1.3	0.8	0.6	–0.1
1988	2.0	4.8	0.4	–0.6	0.4	7.0	–0.5	6.5	1.1
1989	–0.1	2.8	0.8	0.3	0.1	3.9	0.2	4.8	–1.2
1990	1.1	3.6	0.9	1.2	0.4	7.3	1.4	5.2	0.7
1991	0.3	–0.5	0.6	0.7	0.2	1.2	0.9	–0.4	0.8
1992	–0.4	2.2	0.1	0.6	–0.3	2.1	0.2	2.3	–0.4
1993	0.1	–1.5	0.2	1.5	0.2	0.6	1.6	–1.0	–0.1
1994	1.2	3.2	0.7	1.1	–0.4	5.7	0.6	5.9	–0.8
1995	0.5	–0.4	0.2	1.2	0.5	2.0	1.6	–0.3	0.7
1996	0.2	1.1	0.7	0.6	0.1	2.6	0.6	2.3	–0.3
1997	0.7	–1.0	0.3	0.9	0.3	1.1	0.9	–0.2	0.4
1998	–0.9	–1.1	0.4	0.7	0.0	–1.0	0.6	–2.1	0.5
1999	0.2	0.6	0.6	–0.8	–0.1	0.5	–0.9	1.1	0.3
2000	0.9	–0.6	0.5	0.3	0.0	1.0	0.3	2.2	–1.5
2001	1.1	–1.9	0.1	–0.1	–0.1	–0.9	–0.2	–1.4	0.8
2002	0.6	0.6	0.0	–1.2	0.0	0.0	–1.5	1.9	–0.4
Descriptive statistics: 1972–2002									
Average	0.3	0.6	0.5	0.6	0.1	2.2	0.5	1.7	0.0
Std deviation	1.1	3.6	0.5	0.7	0.3	3.6	0.9	4.4	0.9
Range **b**	4.4	17.6	2.5	3.4	1.5	17.5	3.6	21.8	3.6
– maximum	2.4	11.1	2.5	2.2	1.1	12.3	2.1	14.7	2.1
– minimum	–2.0	–6.5	0.0	–1.2	–0.5	–5.2	–1.5	–7.1	–1.5
% years < 0 **c**	39	48	0	16	35	19	26	42	55
Correlation **d**	0.3	0.9	0.3	0.0	–0.2	1.0	–0.2	1.0	–0.5

30 Decomposition of annual growth in TPEC by fuel type and supply source

Singapore Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock draw-down
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.0	24.6	0.0	0.0	–0.1	24.5	0.0	79.5	–55.0
1973	0.0	10.8	0.0	0.0	–0.1	10.8	0.0	49.1	–38.3
1974	0.0	7.3	0.0	0.0	0.0	7.3	0.0	–2.4	9.6
1975	–0.1	–4.9	0.0	0.0	0.1	–4.9	0.0	20.8	–25.7
1976	0.0	7.3	0.0	0.0	0.0	7.4	0.0	27.4	–20.0
1977	0.0	8.4	0.0	0.0	0.1	8.5	0.0	–18.0	26.4
1978	0.0	24.9	0.0	0.0	–0.1	24.8	0.0	–42.2	67.0
1979	0.0	–0.9	0.0	0.0	–0.1	–1.0	0.0	–21.8	20.8
1980	0.0	1.3	0.0	0.0	–0.1	1.3	0.0	–41.0	42.3
1981	0.0	3.5	0.0	0.0	0.0	3.6	0.0	65.7	–62.2
1982	0.0	–0.6	0.0	0.0	0.0	–0.6	0.0	14.1	–14.7
1983	0.0	11.5	0.0	0.0	0.0	11.5	0.0	–4.2	15.7
1984	0.0	11.7	0.0	0.0	0.0	11.7	0.0	–14.4	26.1
1985	0.1	0.6	0.0	0.0	0.0	0.6	0.0	–14.7	15.3
1986	0.0	6.6	0.0	0.0	0.1	6.6	0.0	12.6	–5.9
1987	0.0	6.6	0.0	0.0	0.0	6.6	0.0	68.5	–61.9
1988	0.0	10.2	0.0	0.0	0.0	10.3	0.0	–0.3	10.5
1989	0.0	0.5	0.0	0.0	0.0	0.5	0.0	–6.4	6.8
1990	0.1	35.6	0.0	0.0	0.0	35.7	0.0	21.4	14.3
1991	–0.1	8.4	0.0	0.0	0.0	8.3	0.0	19.7	–11.4
1992	0.0	10.2	2.8	0.0	0.0	13.0	0.0	2.9	10.1
1993	0.0	18.8	4.8	0.0	0.0	23.6	0.0	35.1	–11.4
1994	0.0	21.5	1.1	0.0	0.0	22.6	0.0	10.2	12.4
1995	–0.1	–14.0	0.2	0.0	0.0	–13.7	0.0	–13.5	–0.2
1996	–0.1	6.2	–0.7	0.0	0.3	5.6	0.3	6.0	–0.6
1997	0.0	13.7	–0.1	0.0	0.0	13.6	0.0	18.8	–5.2
1998	0.0	–11.3	0.5	0.0	0.0	–10.8	0.0	–15.2	4.4
1999	0.0	–0.5	–1.2	0.0	0.0	–1.7	0.0	–7.6	5.9
2000	0.0	–0.8	0.1	0.0	0.0	–0.7	0.0	7.1	–7.8
2001	0.0	0.6	8.2	0.0	0.0	8.8	0.0	13.9	–5.1
2002	0.0	1.3	2.8	0.0	0.0	4.1	0.0	–2.9	7.0
Descriptive statistics: 1972–2002									
Average	0.0	7.1	0.6	0.0	0.0	7.7	0.0	8.6	–1.0
Std deviation	0.0	10.5	1.8	0.0	0.1	10.6	0.0	28.9	27.8
Range **b**	0.2	49.6	9.3	0.0	0.4	49.4	0.3	121.8	129.2
– maximum	0.1	35.6	8.2	0.0	0.3	35.7	0.3	79.5	67.0
– minimum	–0.1	–14.0	–1.2	0.0	–0.1	–13.7	0.0	–42.2	–62.2
% years < 0 **c**	29	23	10	0	45	23	0	45	48
Correlation **d**	0.4	1.0	0.2	–	–0.3	1.0	0.0	0.3	0.1

31 Decomposition of annual growth in TPEC by fuel type and supply source

Chinese Taipei Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.4	16.5	1.4	0.0	0.6	18.9	1.1	8.9	8.9
1973	–2.4	13.7	1.3	0.0	–0.2	12.4	–1.7	15.6	–1.5
1974	–1.1	–5.7	0.5	0.0	0.7	–5.6	–0.3	0.3	–5.6
1975	0.2	11.4	–0.1	0.0	0.2	11.7	1.1	0.8	9.8
1976	–0.2	23.1	1.7	0.0	–0.6	24.0	1.7	29.4	–7.1
1977	0.2	8.7	0.5	0.1	–0.2	9.3	–0.6	10.9	–1.1
1978	1.8	12.6	–0.1	3.3	0.3	18.0	3.3	11.3	3.4
1979	2.6	2.8	–0.2	4.0	–0.1	9.0	3.1	4.7	1.2
1980	2.8	5.3	0.2	1.9	–0.5	9.7	1.2	16.6	–8.2
1981	–1.1	–7.9	–0.8	2.3	0.6	–7.1	1.6	–7.1	–1.6
1982	2.1	–2.3	–0.8	2.4	0.0	1.4	1.2	–4.6	4.9
1983	5.7	1.6	0.2	5.6	0.1	13.1	5.5	5.1	2.5
1984	3.4	–1.6	0.0	4.9	–0.2	6.5	4.3	2.8	–0.6
1985	1.3	–0.3	–0.4	3.3	0.7	4.6	3.2	–0.6	2.0
1986	4.8	4.1	–0.3	–1.4	0.1	7.4	–1.8	8.2	1.0
1987	2.3	0.8	0.0	4.4	–0.1	7.5	4.1	7.0	–3.6
1988	3.7	7.3	0.4	–1.6	–0.2	9.4	–2.0	14.7	–3.3
1989	1.4	6.6	0.0	–1.4	0.1	6.6	–2.0	2.3	6.3
1990	–0.8	2.0	1.3	2.6	0.3	5.4	2.4	10.9	–7.9
1991	2.1	4.1	1.6	1.3	–0.5	8.7	0.0	0.2	8.4
1992	4.0	0.4	0.3	–0.7	0.5	4.5	–0.6	8.3	–3.2
1993	2.8	3.8	–0.2	0.2	–0.3	6.4	–0.1	6.9	–0.4
1994	1.5	1.7	1.5	0.2	0.3	5.3	0.6	6.2	–1.5
1995	0.8	5.1	0.3	0.2	0.0	6.4	0.2	7.8	–1.7
1996	3.6	0.6	0.1	1.0	0.0	5.3	0.9	3.6	0.8
1997	3.9	1.5	0.8	–0.6	0.1	5.7	–0.6	5.1	1.2
1998	2.6	1.5	1.4	0.2	0.1	5.8	0.3	6.0	–0.5
1999	1.6	2.2	0.0	0.5	–0.2	4.2	0.3	6.1	–2.3
2000	5.1	–1.5	0.3	0.0	0.0	3.9	–0.1	7.3	–3.3
2001	2.4	5.0	0.7	–0.9	0.0	7.2	–0.9	2.9	5.2
2002	2.1	1.1	1.0	1.2	–0.3	5.2	1.0	2.3	1.9
Descriptive statistics: 1972–2002									
Average	1.9	4.0	0.4	1.1	0.0	7.4	0.9	6.4	0.1
Std deviation	1.9	6.4	0.7	1.9	0.3	6.0	1.9	6.8	4.6
Range **b**	8.1	31.1	2.5	7.3	1.3	31.1	7.5	36.6	18.0
– maximum	5.7	23.1	1.7	5.6	0.7	24.0	5.5	29.4	9.8
– minimum	–2.4	–7.9	–0.8	–1.6	–0.6	–7.1	–2.0	–7.1	–8.2
% years < 0 **c**	16	19	29	19	48	6	35	10	55
Correlation **d**	0.0	0.9	0.4	0.0	–0.4	1.0	0.2	0.7	0.2

32 Decomposition of annual growth in TPEC by fuel type and supply source

New Zealand Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock draw-down
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.4	7.2	1.9	0.0	1.4	11.0	5.9	4.0	1.1
1973	1.8	1.6	0.5	0.0	–0.1	3.9	2.7	2.6	–1.4
1974	1.0	3.8	0.4	0.0	5.4	10.5	6.5	6.9	–2.9
1975	–1.0	–4.5	0.4	0.0	2.9	–2.3	2.5	–6.8	2.0
1976	0.4	3.0	5.2	0.0	–2.1	6.5	7.2	–3.3	2.5
1977	–0.6	–0.2	5.9	0.0	–0.5	4.6	7.0	0.0	–2.5
1978	–1.1	–2.5	–0.8	0.0	1.7	–2.8	–1.4	–3.2	1.9
1979	–1.6	–1.2	–4.4	0.0	1.0	–6.3	–7.1	0.8	0.0
1980	0.7	0.2	–0.7	0.0	1.6	1.8	2.1	2.0	–2.3
1981	–0.1	–2.8	1.9	0.0	0.0	–1.0	3.3	–7.7	3.4
1982	0.0	–0.3	8.2	0.0	–1.3	6.6	10.0	–2.3	–1.1
1983	0.8	–1.1	1.5	0.0	2.2	3.4	4.8	0.3	–1.7
1984	–0.2	1.1	5.1	0.0	1.1	7.1	8.7	–1.6	0.0
1985	–0.6	2.3	6.2	0.0	–1.1	6.8	9.1	–2.7	0.4
1986	–1.2	–5.1	5.3	0.0	1.8	0.8	8.1	–7.4	0.1
1987	1.4	0.8	–1.2	0.0	0.5	1.5	–1.7	5.8	–2.6
1988	1.4	–0.8	2.5	0.0	1.4	4.5	6.3	–6.8	5.1
1989	–0.2	3.3	0.9	0.0	4.1	8.1	8.5	2.1	–2.5
1990	–0.3	–0.2	–0.1	0.0	5.3	4.7	4.7	–0.1	0.1
1991	–0.6	–0.2	2.4	0.0	0.5	2.1	4.1	–1.3	–0.6
1992	1.3	2.2	1.8	0.0	–1.0	4.3	1.4	1.2	1.7
1993	–0.7	1.3	–0.7	0.0	2.3	2.0	3.4	–0.2	–1.2
1994	–0.1	4.4	–2.0	0.0	0.5	2.8	–1.3	4.6	–0.5
1995	0.5	3.6	–1.4	0.0	0.5	3.2	–0.6	1.7	2.1
1996	0.4	2.4	3.4	0.0	–0.8	5.4	6.9	–1.3	–0.1
1997	0.2	1.8	1.9	0.0	–0.1	3.8	4.8	–0.4	–0.6
1998	–1.2	0.2	–3.2	0.0	2.2	–2.0	–4.7	4.2	–1.5
1999	0.2	–2.2	3.8	0.0	2.3	4.0	4.5	0.7	–1.2
2000	0.0	1.9	1.4	0.0	–3.0	0.2	–2.2	–0.5	3.0
2001	1.1	0.3	1.5	0.0	–1.9	0.9	0.0	–0.6	1.5
2002	–0.2	–0.6	–1.5	0.0	1.8	–0.4	1.5	1.8	–3.7
Descriptive statistics: 1972–2002									
Average	0.1	0.6	1.5	0.0	0.9	3.1	3.4	–0.3	0.0
Std deviation	0.9	2.6	2.9	0.0	2.0	3.8	4.2	3.7	2.1
Range **b**	3.4	12.3	12.6	0.0	8.4	17.3	17.1	14.6	8.8
Maximum	1.8	7.2	8.2	0.0	5.4	11.0	10.0	6.9	5.1
Minimum	–1.6	–5.1	–4.4	0.0	–3.0	–6.3	–7.1	–7.7	–3.7
% years < 0 **c**	55	42	32	0	35	19	26	52	55
Correlation **d**	0.5	0.7	0.5	-	0.1	1.0	0.8	0.3	-0.1

33 Decomposition of annual growth in TPEC by fuel type and supply source

Republic of Korea Percentage point contributions

	By fuel type					Total	By supply source		
	Coal	Oil	Gas	Nuclear	Other	primary energy consumption	Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	1.5	7.0	0.0	0.0	0.0	8.6	–1.1	7.2	2.4
1973	8.6	8.5	0.0	0.0	0.0	17.1	3.1	8.5	5.6
1974	2.3	6.0	0.0	0.0	0.2	8.6	4.1	9.3	–4.7
1975	0.6	3.9	0.0	0.0	–0.1	4.5	3.3	4.4	–3.2
1976	3.6	7.5	0.0	0.0	0.0	11.2	–2.5	7.9	5.7
1977	2.8	13.3	0.0	0.1	–0.1	16.0	1.3	16.6	–1.9
1978	–0.6	8.2	0.0	1.9	0.1	9.6	1.8	6.8	1.1
1979	5.4	9.2	0.0	0.6	0.1	15.4	0.9	15.1	–0.7
1980	3.5	–0.2	0.0	0.2	–0.1	3.4	0.6	1.7	1.1
1981	4.6	–5.7	0.0	–0.4	0.2	–1.3	1.1	2.4	–4.8
1982	1.1	4.7	0.0	0.6	–0.1	6.2	0.7	2.0	3.5
1983	3.1	2.3	0.0	3.1	0.1	8.7	3.0	3.5	2.1
1984	7.7	0.5	1.6	–0.1	9.6	2.9	2.8	4.0	
1985	4.1	–2.1	0.0	2.5	0.2	4.7	3.7	4.9	–3.9
1986	2.0	6.7	0.0	5.6	0.1	14.5	7.0	8.3	–0.9
1987	–0.1	0.3	0.1	4.6	0.2	7.9	4.8	3.2	–0.1
1988	2.5	9.0	3.0	0.3	–0.2	12.4	0.1	12.6	–0.3
1989	–0.1	4.3	0.8	2.5	0.1	6.7	0.6	8.2	–2.1
1990	0.1	13.1	–0.1	1.8	0.2	15.6	0.0	12.1	3.5
1991	–0.5	7.1	0.4	1.0	0.1	8.1	0.0	11.5	–3.4
1992	–2.6	13.2	0.5	0.1	0.1	11.7	–1.7	15.7	–2.3
1993	1.8	8.4	0.9	0.4	0.2	11.7	–0.2	11.8	0.2
1994	0.7	5.6	1.0	0.1	0.0	7.7	–0.5	10.1	–1.9
1995	0.8	6.1	1.4	1.6	0.1	9.7	1.3	7.2	1.2
1996	2.5	4.8	1.1	1.2	0.2	10.4	1.2	9.1	0.2
1997	1.4	4.7	1.8	0.5	0.2	8.2	0.9	6.9	0.4
1998	0.6	–10.2	1.5	1.9	0.2	–8.0	2.0	–10.3	0.2
1999	0.9	5.1	–0.5	2.1	0.1	10.0	2.2	6.4	1.3
2000	2.6	2.3	1.7	0.9	0.2	6.9	1.1	6.7	–0.9
2001	1.9	–1.7	1.0	0.4	0.1	1.6	0.4	–0.5	1.6
2002	1.6	0.9	0.9	0.9	0.2	4.9	1.0	3.9	0.1
Descriptive statistics: 1972–2002									
Average	2.1	4.6	0.5	1.2	0.1	8.5	1.4	7.0	0.1
Std deviation	2.3	5.3	0.5	1.4	0.1	5.2	2.0	5.3	2.7
Range **b**	11.2	23.5	0.8	5.9	0.5	25.1	9.5	26.8	10.6
– maximum	8.6	13.3	3.4	5.6	0.2	17.1	7.0	16.6	5.7
– minimum	–2.6	–10.2	3.0	–0.4	–0.2	–8.0	–2.5	–10.3	–4.8
% years < 0 **c**	16	16	–0.5	3	26	6	19	6	45
Correlation **d**	0.2	0.9	6	0.1	–0.3	1.0	0.0	0.8	0.3

34 Decomposition of annual growth in TPEC by fuel type and supply source

Brunei Darussalam Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	**Oil**	**Gas**	**Nuclear**	**Other**		**Production**	**Net imports a**	**Stock draw-down**
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.0	–2.2	3.9	0.0	0.0	1.7	1 516.3	–2060.7	544.9
1973	0.0	5.5	106.6	0.0	0.6	112.7	2 122.1	–1891.7	–117.1
1974	0.0	3.4	74.3	0.0	0.0	77.7	127.0	26.8	–76.1
1975	0.0	1.0	25.9	0.0	0.1	27.0	102.0	–121.1	46.2
1976	0.0	1.2	30.5	0.0	0.0	31.6	395.7	–391.3	27.0
1977	0.0	–0.3	8.8	0.0	0.0	8.5	107.5	–66.7	–32.4
1978	0.0	0.6	–7.1	0.0	0.1	–6.4	2.1	–12.9	4.4
1979	0.0	1.6	2.3	0.0	0.0	3.9	122.2	–96.0	–22.4
1980	0.0	6.7	82.6	0.0	0.0	89.3	20.7	79.0	–10.5
1981	0.0	–0.8	–30.4	0.0	0.0	–31.3	–191.2	152.2	7.8
1982	0.0	1.7	13.6	0.0	0.0	15.4	16.3	8.5	–9.5
1983	0.0	–2.7	6.4	0.0	0.0	3.7	12.0	–19.5	11.2
1984	0.0	7.0	–33.0	0.0	0.0	–26.1	–41.4	15.3	0.1
1985	0.0	–0.1	6.4	0.0	–0.1	6.3	–24.2	27.6	2.9
1986	0.0	–0.3	–13.7	0.0	0.1	–13.9	–28.0	22.1	–8.1
1987	0.0	27.1	17.9	0.0	0.0	45.0	–9.6	16.9	37.8
1988	0.0	25.8	–15.4	0.0	0.0	10.4	–20.7	2.6	28.6
1989	0.0	–44.3	7.5	0.0	0.0	–36.8	6.4	3.7	–46.9
1990	0.0	–6.6	20.2	0.0	0.0	13.5	27.2	–12.1	–1.6
1991	0.0	0.1	15.8	0.0	–0.1	15.8	48.7	–40.4	7.5
1992	0.0	8.4	0.7	0.0	0.1	9.1	68.3	–48.6	–10.6
1993	0.0	–1.9	–2.0	0.0	0.0	–3.9	–18.9	6.9	8.1
1994	0.0	2.8	–10.3	0.0	–0.1	–7.6	24.4	–26.7	–5.2
1995	0.0	5.8	15.1	0.0	0.0	20.9	35.9	–14.3	–0.7
1996	0.0	1.2	–0.2	0.0	0.1	1.0	–28.7	22.3	7.3
1997	0.0	4.0	0.5	0.0	0.0	4.5	–6.1	26.1	–15.5
1998	0.0	–3.1	2.5	0.0	0.0	–0.6	–27.2	10.7	15.9
1999	0.0	–2.3	–24.8	0.0	0.0	–27.1	46.8	–67.5	–6.4
2000	0.0	–6.4	37.2	0.0	–0.1	30.8	105.9	–80.9	5.9
2001	0.0	19.5	–10.3	0.0	0.1	9.3	25.9	–10.5	–6.1
2002	0.0	2.0	–2.6	0.0	0.0	–0.6	20.4	–24.8	3.8
Descriptive statistics: 1972–2002									
Average	0.0	1.8	10.6	0.0	0.0	12.4	147.0	–147.3	12.6
Std deviation	0.0	11.6	30.6	0.0	0.1	32.8	462.2	496.1	103.6
Range **b**	0.0	71.4	139.7	0.0	0.6	149.5	2 313.3	2 212.9	662.1
– maximum	0.0	27.1	106.6	0.0	0.6	112.7	2 122.1	152.2	544.9
– minimum	0.0	–44.3	–33.0	0.0	–0.1	–36.8	–191.2	–2 060.7	–117.1
% years < 0 **c**	0	39	35	0	19	32	32	55	48
Correlation **d**	–	0.4	0.9	–	0.5	1.0	0.5	–0.4	–0.2

35 Decomposition of annual growth in TPEC by fuel type and supply source

Chile Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock draw-down
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–2.3	3.4	–0.1	0.0	0.5	1.5	0.7	2.9	–2.2
1973	0.9	–3.1	–1.2	0.0	–0.5	–3.9	–3.6	–6.4	6.1
1974	–0.5	–2.1	0.2	0.0	1.6	–0.8	0.2	8.3	–9.3
1975	–2.8	–7.6	0.7	0.0	0.2	–9.5	–1.3	–17.5	9.3
1976	0.3	4.0	0.5	0.0	1.2	5.9	2.6	5.8	–2.5
1977	0.6	1.6	0.3	0.0	1.2	3.7	1.1	3.0	–0.4
1978	0.2	2.5	–0.4	0.0	1.6	4.0	0.5	–1.5	5.0
1979	1.0	2.9	0.9	0.0	0.8	5.6	–3.4	15.8	–6.8
1980	1.3	0.7	0.1	0.0	1.3	3.4	8.4	–8.1	3.2
1981	–0.2	1.7	0.0	0.0	0.4	1.9	4.3	–1.8	–0.6
1982	–4.0	–5.9	0.2	0.0	1.3	–8.4	1.4	–14.2	4.3
1983	2.1	–2.3	0.5	0.0	2.8	3.1	1.5	3.1	–1.5
1984	3.2	0.2	0.0	0.0	1.8	5.2	2.8	2.0	0.4
1985	–0.5	–1.3	0.2	0.0	1.3	–0.3	0.6	–1.0	0.2
1986	0.5	3.4	–0.7	0.0	1.6	4.9	2.1	8.9	–6.2
1987	–0.2	1.8	–0.1	0.0	1.9	3.3	0.6	–3.0	5.8
1988	4.9	4.7	2.3	0.0	0.6	12.5	1.6	13.1	–2.2
1989	4.7	1.8	3.9	0.0	–1.3	9.1	1.6	7.5	–0.1
1990	1.7	2.0	0.5	0.0	0.9	5.1	1.5	5.4	–1.8
1991	–3.7	3.4	–1.3	0.0	5.0	3.5	3.1	2.6	–2.3
1992	–1.5	5.5	1.3	0.0	4.7	9.9	2.4	4.1	3.4
1993	0.0	4.1	–0.4	0.0	–0.9	2.8	–2.6	2.9	2.6
1994	2.2	4.7	0.3	0.0	0.7	7.9	0.7	10.8	–3.6
1995	1.0	4.7	–0.3	0.0	1.8	7.2	0.1	5.4	1.7
1996	4.8	3.5	0.0	0.0	0.8	9.2	–0.3	11.4	–1.8
1997	4.7	1.7	3.5	0.0	–0.2	9.7	–0.1	6.8	3.0
1998	–2.2	0.3	4.4	0.0	0.0	2.5	–1.1	5.7	–2.1
1999	2.2	1.9	7.6	0.0	–0.3	11.5	–0.8	7.9	4.4
2000	–3.9	–5.1	2.3	0.0	2.6	–4.1	2.7	–2.9	–3.9
2001	–2.9	–2.6	3.0	0.0	0.9	–1.6	1.5	–4.1	0.9
2002	0.7	2.1	0.2	0.0	0.9	3.8	0.5	4.1	–0.7
Descriptive statistics: 1972–2002									
Average	0.4	1.1	0.9	0.0	1.1	3.5	0.9	2.5	0.1
Std deviation	2.5	3.3	1.9	0.0	1.4	5.3	2.3	7.4	4.1
Range **b**	8.8	13.0	8.8	0.0	6.3	22.0	12.0	33.3	18.6
– maximum	4.9	5.5	7.6	0.0	5.0	12.5	8.4	15.8	9.3
– minimum	–4.0	–7.6	–1.3	0.0	–1.3	–9.5	–3.6	–17.5	–9.3
% years < 0 **c**	39	26	29	0	16	23	26	32	55
Correlation **d**	0.7	0.8	0.3	-	0.0	1.0	0.1	0.8	–0.2

36 Decomposition of annual growth in TPEC by fuel type and supply source

Malaysia Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–0.1	0.3	0.5	0.0	1.0	1.7	20.7	–19.0	0.0
1973	0.1	–0.9	0.0	0.0	0.7	–0.1	–0.9	0.8	0.0
1974	0.1	10.9	1.8	0.0	0.7	13.4	–5.4	11.2	7.6
1975	0.0	5.0	0.6	0.0	1.1	6.7	15.0	–6.6	–1.6
1976	0.1	6.9	0.6	0.0	0.0	7.6	45.2	–44.2	6.6
1977	0.0	1.2	–0.3	0.0	0.2	1.1	12.1	–0.7	–10.3
1978	0.1	8.4	19.1	0.0	0.8	28.5	49.3	–17.4	–3.3
1979	0.1	11.9	4.3	0.0	0.3	16.6	37.1	–23.7	3.1
1980	0.2	2.1	–2.1	0.0	0.5	0.7	–5.1	10.3	–4.5
1981	0.4	9.2	–2.6	0.0	0.5	7.4	–9.9	11.2	6.2
1982	0.0	–2.2	3.4	0.0	0.3	1.4	21.7	–18.3	–2.0
1983	1.2	8.0	6.4	0.0	0.5	16.1	55.1	–38.4	–0.7
1984	0.1	–3.0	4.6	0.0	1.4	3.2	40.4	–37.2	–0.1
1985	0.6	0.1	–0.8	0.0	0.3	0.2	5.3	–7.5	2.4
1986	–0.6	–0.5	12.4	0.0	0.4	11.7	37.8	–25.0	–1.1
1987	0.3	0.5	–0.1	0.0	0.9	1.6	4.9	–1.5	–1.7
1988	–0.6	4.3	0.6	0.0	0.6	5.0	15.7	–12.1	1.3
1989	3.0	0.5	4.3	0.0	–0.3	7.6	16.9	–8.9	–0.4
1990	0.3	11.4	–1.7	0.0	0.1	10.2	8.0	2.5	–0.3
1991	0.4	2.9	13.3	0.0	0.3	16.8	17.8	1.5	–2.5
1992	0.2	10.1	2.4	0.0	0.2	12.8	5.5	0.1	7.2
1993	0.1	9.7	0.1	0.0	0.3	10.2	7.5	7.6	–4.8
1994	–0.1	–1.3	0.4	0.0	0.6	–0.4	5.8	–5.7	–0.6
1995	0.1	13.2	3.9	0.0	0.0	17.2	19.1	–2.8	0.8
1996	1.2	–1.9	3.8	0.0	–0.1	3.0	14.4	–12.2	0.7
1997	–1.1	9.7	7.5	0.0	–0.3	15.7	9.2	7.3	–0.8
1998	0.1	–5.5	0.5	0.0	0.2	–4.7	2.0	–6.2	–0.6
1999	–1.2	–4.9	2.0	0.0	0.7	–3.4	–4.1	1.8	–1.0
2000	2.0	1.7	12.3	0.0	0.0	16.0	7.8	6.6	1.6
2001	0.6	6.0	–1.0	0.0	–0.2	5.4	1.8	2.3	1.2
2002	0.8	0.4	0.4	0.0	–0.1	1.5	6.6	–2.9	–2.3
Descriptive statistics: 1972–2002									
Average	0.3	3.7	3.1	0.0	0.4	7.4	14.8	–7.3	0.0
Std deviation	0.8	5.4	5.1	0.0	0.4	7.6	16.8	14.6	3.7
Range **b**	4.2	18.7	21.8	0.0	1.6	33.2	65.0	55.5	18.0
– maximum	3.0	13.2	19.1	0.0	1.4	28.5	55.1	11.2	7.6
– minimum	–1.2	–5.5	–2.6	0.0	–0.3	–4.7	–9.9	–44.2	–10.3
% years < 0 **c**	29	26	23	0	16	13	16	61	58
Correlation **d**	0.1	0.7	0.7	–	–0.1	1.0	0.5	–0.1	0.2

37 Decomposition of annual growth in TPEC by fuel type and supply source

Mexico Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.5	8.5	1.5	0.0	0.3	10.7	3.9	6.3	0.5
1973	0.3	7.2	2.2	0.0	0.9	10.6	4.6	6.0	0.0
1974	0.3	4.7	0.9	0.0	0.8	6.7	14.9	–7.6	–0.6
1975	0.4	4.9	0.5	0.0	–0.2	5.6	13.7	–7.2	–0.9
1976	–0.8	8.0	–0.4	0.0	0.4	7.1	8.1	–2.3	1.2
1977	1.2	5.6	0.9	0.0	0.4	8.1	17.5	–9.8	0.4
1978	0.1	7.8	4.4	0.0	0.1	12.4	23.5	–11.5	0.4
1979	–0.1	5.1	4.1	0.0	0.9	9.9	23.9	–12.5	–1.5
1980	0.0	12.0	1.5	0.0	–0.2	13.3	39.1	–25.5	–0.2
1981	–0.2	4.8	1.6	0.0	0.6	6.8	25.0	–17.7	–0.5
1982	0.3	2.0	1.9	0.0	0.2	4.4	23.3	–20.0	1.0
1983	0.2	–5.7	0.0	0.0	–0.1	–5.5	–2.0	–3.5	0.0
1984	0.0	3.7	0.2	0.0	0.5	4.4	1.9	2.0	0.5
1985	0.2	2.5	0.9	0.0	0.4	4.0	–2.0	6.4	–0.4
1986	0.2	–1.2	–2.4	0.0	0.9	–2.5	–9.5	6.5	0.5
1987	–0.1	4.0	0.3	0.0	0.9	5.1	8.1	–1.7	–1.3
1988	–0.2	1.0	0.2	0.0	0.2	1.1	–0.7	1.3	0.5
1989	0.3	4.5	–0.6	0.1	0.3	4.6	0.5	5.3	–1.1
1990	–0.1	0.4	1.7	0.6	0.2	2.9	2.1	–0.5	1.2
1991	–0.2	3.0	0.8	0.3	0.4	4.2	6.0	–1.9	0.1
1992	0.4	1.3	0.1	–0.1	0.5	2.2	–0.2	1.5	1.0
1993	0.4	–1.0	0.3	0.2	0.2	0.2	2.3	–1.4	–0.7
1994	0.6	3.1	0.5	–0.1	–0.8	3.3	0.3	4.1	–1.2
1995	0.5	–4.9	–0.1	0.8	0.8	–3.0	–2.1	–2.0	1.1
1996	0.7	0.3	1.8	–0.1	0.4	3.1	8.3	–5.0	–0.2
1997	0.1	2.3	0.8	0.5	–0.2	3.4	7.2	–3.7	–0.1
1998	0.1	2.7	1.9	–0.2	0.1	4.6	3.8	0.2	0.6
1999	0.1	1.1	–0.3	0.1	0.3	1.3	–3.8	5.1	–0.1
2000	0.1	–1.2	1.7	–0.3	0.2	0.5	2.1	–0.3	–1.4
2001	0.1	0.5	0.7	0.1	–0.4	1.0	2.6	–2.7	1.0
2002	0.2	0.7	2.6	0.2	–0.3	3.5	–0.1	4.1	–0.5
Descriptive statistics: 1972–2002									
Average	0.2	2.8	1.0	0.1	0.3	4.3	7.2	–2.8	0.0
Std deviation	0.3	3.8	1.3	0.2	0.4	4.3	10.7	8.0	0.8
Range **b**	2.0	17.7	6.8	1.1	1.7	18.9	48.6	32.1	2.8
– maximum	1.2	12.0	4.4	0.8	0.9	13.3	39.1	6.5	1.2
– minimum	–0.8	–5.7	–2.4	–0.3	–0.8	–5.5	–9.5	–25.5	–1.5
% years < 0 **c**	26	16	16	16	23	10	26	61	55
Correlation d	–0.1	1.0	0.6	–0.3	0.1	1.0	0.7	–0.4	–0.1

38 Decomposition of annual growth in TPEC by fuel type and supply source

Russian Federation Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–	–	–	–	–	–	–	–	–
1973	–	–	–	–	–	–	–	–	–
1974	–	–	–	–	–	–	–	–	–
1975	–	–	–	–	–	–	–	–	–
1976	–	–	–	–	–	–	–	–	–
1977	–	–	–	–	–	–	–	–	–
1978	–	–	–	–	–	–	–	–	–
1979	–	–	–	–	–	–	–	–	–
1980	–	–	–	–	–	–	–	–	–
1981	–	–	–	–	–	–	–	–	–
1982	–	–	–	–	–	–	–	–	–
1983	–	–	–	–	–	–	–	–	–
1984	–	–	–	–	–	–	–	–	–
1985	–	–	–	–	–	–	–	–	–
1986	–	–	–	–	–	–	–	–	–
1987	–	–	–	–	–	–	–	–	–
1988	–	–	–	–	–	–	–	–	–
1989	–	–	–	–	–	–	–	–	–
1990	–	–	–	–	–	–	–	–	–
1991	–	–	–	–	–	–	–	–	–
1992	–	–	–	–	–	–	–	–	–
1993	0.2	–2.7	–1.1	0.0	–0.1	–3.7	–9.5	4.7	1.0
1994	–1.1	–6.7	–3.8	–0.7	–0.4	–12.7	–8.8	–2.8	–1.1
1995	–1.3	–0.6	–1.7	0.1	0.0	–3.5	–4.0	–0.1	0.6
1996	0.4	–2.3	0.3	0.4	–0.6	–1.9	–1.1	–3.1	2.3
1997	–2.0	–0.4	–1.1	0.0	0.0	–3.5	–4.2	–0.9	1.6
1998	–1.0	–1.0	–0.1	–0.1	–0.1	–2.3	1.1	–1.1	–2.3
1999	1.4	0.5	0.6	0.7	0.4	3.7	3.8	–0.9	0.8
2000	0.3	0.5	0.7	0.4	0.0	1.8	2.6	0.5	–1.3
2001	–0.7	0.5	1.0	0.3	0.1	1.2	4.8	–3.2	–0.4
2002	0.0	–0.7	0.1	0.2	–0.1	–0.6	6.2	–6.9	0.2
Descriptive statistics: 1993-2002									
Average	–0.4	–1.3	–0.5	0.1	–0.1	–2.1	–0.9	–1.4	0.1
Std deviation	1.0	2.2	1.5	0.4	0.3	4.5	5.5	3.0	1.4
Range **b**	3.4	7.2	4.8	1.5	0.9	16.4	15.6	11.7	4.6
– maximum	1.4	0.5	1.0	0.7	0.4	3.7	6.2	4.7	2.3
– minimum	–2.0	–6.7	–3.8	–0.7	–0.6	–12.7	–9.5	–6.9	–2.3
% years < 0 **c**	50	70	50	40	80	70	50	80	40
Correlation **d**	0.6	0.9	0.9	0.9	0.6	1.0	0.8	0.0	0.1

39 Decomposition of annual growth in TPEC by fuel type and supply source

Thailand Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock draw-down
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–0.2	6.1	0.0	0.0	0.9	6.8	0.5	3.4	2.8
1973	0.0	7.4	0.0	0.0	1.3	8.7	1.3	9.5	–2.2
1974	0.3	–2.7	0.0	0.0	3.5	1.0	3.7	–4.1	1.4
1975	0.0	1.1	0.0	0.0	8.1	9.2	8.1	2.7	–1.6
1976	0.1	5.6	0.0	0.0	2.6	8.3	2.7	4.2	1.4
1977	0.1	3.7	0.0	0.0	2.0	5.7	2.1	6.5	–2.9
1978	0.2	4.9	0.0	0.0	–1.2	3.9	–1.1	2.8	2.2
1979	1.0	1.3	0.0	0.0	3.6	5.8	4.3	0.2	1.3
1980	0.2	2.5	0.0	0.0	–2.5	0.2	–2.4	6.5	–4.0
1981	0.2	–2.9	1.1	0.0	2.7	1.0	4.3	–5.7	2.5
1982	0.9	–4.8	3.5	0.0	2.1	1.7	7.0	–5.9	0.5
1983	–0.1	3.8	0.9	0.0	–12.2	–7.6	–9.7	4.5	–2.4
1984	0.7	2.7	2.9	0.0	3.8	10.2	9.3	0.2	0.7
1985	3.4	–4.7	4.3	0.0	5.1	8.1	15.4	–5.6	–1.7
1986	0.2	1.5	–0.4	0.0	3.9	5.3	3.7	0.2	1.4
1987	1.6	3.0	4.2	0.0	1.7	10.5	7.1	3.7	–0.3
1988	0.6	7.6	2.4	0.0	1.8	12.5	7.3	3.7	1.5
1989	1.4	7.8	0.0	0.0	4.6	13.7	5.7	8.8	–0.8
1990	2.7	9.4	1.1	0.0	1.2	14.3	6.0	7.9	0.4
1991	1.7	2.0	2.8	0.0	1.7	8.1	7.0	0.4	0.7
1992	0.6	5.3	0.9	0.0	0.4	7.2	2.5	5.7	–1.1
1993	0.8	6.1	1.6	0.0	–3.1	5.3	–1.3	7.0	–0.4
1994	1.3	5.8	1.5	0.0	–0.7	7.9	2.7	3.6	1.6
1995	1.7	8.5	0.8	0.0	1.0	12.0	2.3	9.4	0.2
1996	2.6	5.1	2.3	0.0	–0.2	9.9	5.1	7.3	–2.6
1997	0.1	–0.5	3.2	0.0	0.2	2.9	4.8	–3.2	1.3
1998	–2.2	–4.6	1.6	0.0	–1.0	–6.3	–0.5	–6.0	0.2
1999	0.5	2.6	1.8	0.0	0.6	5.6	2.1	2.6	0.8
2000	0.3	–1.6	3.4	0.0	1.0	3.1	3.9	–0.1	–0.8
2001	1.5	1.3	3.9	0.0	–1.8	4.9	–1.0	5.6	0.3
2002	0.5	3.1	1.9	0.0	1.1	6.6	3.2	2.0	1.3
Descriptive statistics: 1972–2002									
Average	0.7	2.8	1.5	0.0	1.0	6.0	3.4	2.5	0.1
Std deviation	1.0	4.0	1.5	0.0	3.4	5.0	4.4	4.7	1.7
Range **b**	5.7	14.2	4.7	0.0	20.3	21.9	25.1	15.6	6.8
– maximum	3.4	9.4	4.3	0.0	8.1	14.3	15.4	9.5	2.8
– minimum	–2.2	–4.8	–0.4	0.0	–12.2	–7.6	–9.7	–6.0	–4.0
% years < 0 **c**	10	23	6	0	26	6	19	23	39
Correlation **d**	0.6	0.6	0.1	–	0.6	1.0	0.6	0.5	0.1

40 Decomposition of annual growth in TPEC by fuel type and supply source

Peru Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.1	–0.5	–0.1	0.0	0.4	0.0	1.8	–2.5	0.7
1973	0.2	3.5	0.0	0.0	0.7	4.3	3.8	2.2	–1.6
1974	0.1	5.0	0.1	0.0	0.9	6.1	4.4	0.0	1.7
1975	0.1	2.8	0.9	0.0	–0.7	3.0	–2.4	5.8	–0.4
1976	–0.4	1.2	0.4	0.0	0.4	1.7	2.9	–2.7	1.5
1977	0.2	3.0	–0.3	0.0	0.5	3.4	8.1	–1.5	–3.2
1978	–0.2	–3.1	0.2	0.0	0.2	–3.0	27.5	–33.0	2.6
1979	0.1	–0.1	–0.3	0.0	0.2	–0.2	17.6	–16.8	–1.0
1980	0.1	6.9	0.4	0.0	–0.3	7.1	2.5	2.9	1.6
1981	0.0	–1.1	0.7	0.0	1.0	0.6	0.9	1.3	–1.6
1982	0.2	–0.4	0.3	0.0	1.4	1.5	3.2	–2.7	1.0
1983	–0.2	–6.5	–1.3	0.0	0.1	–7.9	–11.5	4.0	–0.3
1984	–0.3	0.8	0.9	0.0	0.8	2.2	9.6	–6.3	–1.0
1985	0.1	–2.1	0.1	0.0	–0.8	–2.8	0.4	–4.1	0.9
1986	0.5	3.2	0.0	0.0	–1.7	2.1	–6.7	9.3	–0.5
1987	0.1	4.2	–0.3	0.0	–1.2	2.8	–9.4	10.5	1.7
1988	0.0	0.3	–0.2	0.0	–2.0	–1.9	–11.8	12.0	–2.1
1989	0.2	–6.5	–0.5	0.0	–1.1	–7.9	–6.9	–3.2	2.3
1990	–0.5	–1.5	–0.1	0.0	–0.8	–3.0	–1.9	0.6	–1.7
1991	1.4	–2.9	–0.2	0.0	–0.1	–1.8	–7.7	6.3	–0.4
1992	–0.1	0.4	–0.5	0.0	–2.5	–2.7	–2.4	–0.6	0.3
1993	1.2	6.0	–1.2	0.0	0.9	6.8	5.0	–0.5	2.4
1994	–0.3	4.4	–0.5	0.0	0.4	4.0	0.4	4.8	–1.1
1995	0.2	5.3	2.0	0.0	–0.1	7.3	–0.8	13.0	–4.8
1996	0.2	2.6	0.3	0.0	0.0	3.1	–0.5	–0.5	4.1
1997	0.1	–2.3	–0.9	0.0	–0.1	–3.1	–1.8	5.2	–6.5
1998	0.3	3.7	0.5	0.0	0.4	5.0	0.4	2.2	2.5
1999	–0.3	5.5	1.0	0.0	0.4	6.5	–2.2	–2.8	11.5
2000	1.8	–3.7	–0.3	0.0	1.2	–1.1	–1.7	8.4	–7.8
2001	–0.5	–4.2	0.1	0.0	1.2	–3.3	0.4	–5.5	1.7
2002	1.7	–3.2	0.4	0.0	0.4	–0.7	–1.1	2.3	–2.0
Descriptive statistics: 1972–2002									
Average	0.2	0.7	0.1	0.0	0.0	0.9	0.6	0.3	0.0
Std deviation	0.6	3.7	0.7	0.0	1.0	4.1	7.8	8.6	3.4
Range **b**	2.3	13.3	3.3	0.0	3.9	15.2	39.3	46.0	19.3
– maximum	1.8	6.9	2.0	0.0	1.4	7.3	27.5	13.0	11.5
– minimum	–0.5	–6.5	–1.3	0.0	–2.5	–7.9	–11.8	–33.0	–7.8
% years < 0 **c**	32	45	48	0	39	45	48	45	52
Correlation **d**	0.0	0.9	0.5	–	0.3	1.0	0.2	0.2	0.2

41 Decomposition of annual growth in TPEC by fuel type and supply source

China Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock draw-down
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	2.3	1.5	0.2	0.0	1.1	5.2	5.2	–0.1	0.0
1973	0.9	1.6	0.2	0.0	1.0	3.7	4.0	–0.3	0.0
1974	–0.4	1.8	0.3	0.0	0.9	2.6	3.4	–0.9	0.0
1975	7.8	1.6	0.3	0.0	0.7	10.4	11.7	–1.2	0.0
1976	0.3	2.4	0.2	0.0	0.6	3.4	3.0	0.4	0.0
1977	6.9	1.2	0.3	0.0	0.5	8.9	8.9	0.0	0.0
1978	6.2	1.5	0.2	0.0	0.4	8.3	8.8	–0.5	0.0
1979	1.3	–0.2	0.1	0.0	0.5	1.7	2.4	–0.8	0.0
1980	–0.3	–0.5	0.0	0.0	0.5	–0.3	–0.5	–0.5	0.7
1981	–0.2	–0.8	–0.2	0.0	0.5	–0.7	–0.5	–0.2	0.0
1982	2.9	–0.1	–0.1	0.0	0.5	3.1	4.3	–0.2	–0.9
1983	3.2	0.3	0.0	0.0	0.5	4.0	5.1	0.0	–1.1
1984	5.5	0.3	0.1	0.0	0.2	6.1	7.5	–1.3	–0.2
1985	2.7	0.8	0.4	0.0	0.3	4.2	5.7	–1.3	–0.2
1986	2.4	0.8	0.1	0.0	0.3	3.6	2.8	0.5	0.3
1987	3.9	0.9	0.0	0.0	0.4	5.1	3.1	–0.1	2.1
1988	4.2	0.9	0.0	0.0	0.4	5.5	4.3	0.1	1.2
1989	0.8	0.6	0.1	0.0	0.4	2.0	5.2	0.7	–3.9
1990	7.0	–0.7	0.0	0.0	0.4	6.7	3.6	–0.5	3.6
1991	–2.3	1.2	0.1	0.0	0.2	–0.8	1.0	0.5	–2.2
1992	2.1	1.3	0.0	0.0	0.2	3.5	2.2	0.7	0.6
1993	3.6	1.6	0.1	0.0	0.3	5.6	3.0	2.2	0.4
1994	4.0	–0.1	0.1	0.4	0.2	4.6	5.5	–1.1	0.2
1995	5.4	1.2	0.0	–0.1	0.2	6.8	7.5	0.1	–0.8
1996	2.7	1.4	0.1	0.0	0.1	4.3	3.6	0.0	0.7
1997	–1.5	1.7	0.0	0.0	0.1	0.3	0.1	1.6	–1.4
1998	–0.6	–0.3	0.2	0.0	0.2	–0.5	–1.3	–0.2	1.0
1999	–1.5	1.5	0.2	0.0	0.3	0.5	–1.7	0.8	1.4
2000	0.1	1.5	0.2	0.0	0.3	2.2	1.5	1.2	–0.5
2001	–1.6	0.5	0.3	0.0	0.5	–0.2	2.7	–2.4	–0.6
2002	6.1	1.2	0.2	0.2	0.2	8.0	7.2	1.5	–0.7
Descriptive statistics: 1972–2002									
Average	2.4	0.9	0.1	0.0	0.4	3.8	3.9	0.0	0.0
Std deviation	2.8	0.8	0.1	0.1	0.2	3.0	3.1	1.0	1.3
Range **b**	10.1	3.2	0.6	0.4	1.0	11.2	13.3	4.6	7.6
– maximum	7.8	2.4	0.4	0.4	1.1	10.4	11.7	2.2	3.6
– minimum	–2.3	–0.8	–0.2	–0.1	0.1	–0.8	–1.7	–2.4	–3.9
% years < 0 **c**	26	23	16	6	0	16	13	55	39
Correlation **d**	0.9	0.3	0.3	0.1	0.1	1.0	0.9	0.0	0.2

42 Decomposition of annual growth in TPEC by fuel type and supply source
Phillipines Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.0	–0.8	0.0	0.0	0.4	–0.5	0.0	3.9	–4.5
1973	0.0	9.4	0.0	0.0	0.1	9.5	0.0	1.1	8.4
1974	0.1	–1.8	0.0	0.0	2.5	0.8	2.5	1.7	–3.4
1975	0.1	5.2	0.0	0.0	–0.3	5.0	–0.2	3.6	1.6
1976	0.1	3.5	0.0	0.0	1.9	5.5	2.0	4.2	–0.7
1977	0.9	3.0	0.0	0.0	0.4	4.3	0.8	2.0	1.5
1978	0.3	0.0	0.0	0.0	0.8	1.1	0.7	1.4	–1.0
1979	0.0	2.4	0.0	0.0	3.0	5.4	9.0	0.9	–4.5
1980	0.4	–4.0	0.0	0.0	7.0	3.4	4.1	0.2	–0.9
1981	–0.4	–3.0	0.0	0.0	2.7	–0.7	1.5	–7.6	5.4
1982	0.4	–0.3	0.0	0.0	3.6	3.8	5.4	–3.6	2.0
1983	1.4	3.2	0.0	0.0	3.3	7.9	5.2	5.9	–3.2
1984	1.3	–15.3	0.0	0.0	2.6	–11.4	2.4	0.6	–14.4
1985	1.4	1.0	0.0	0.0	3.0	5.4	2.3	–13.4	16.6
1986	–1.2	2.1	0.0	0.0	–1.4	–0.4	–1.1	0.6	0.1
1987	0.5	6.2	0.0	0.0	–1.0	5.8	–1.9	8.6	–0.8
1988	0.9	3.7	0.0	0.0	1.1	5.7	1.6	4.9	–0.8
1989	–0.8	4.9	0.0	0.0	2.6	6.8	2.4	3.1	1.2
1990	0.7	2.3	0.0	0.0	0.8	3.9	0.5	3.7	–0.4
1991	0.2	–1.6	0.0	0.0	0.5	–0.9	0.2	–1.6	0.5
1992	–0.5	6.7	0.0	0.0	–0.5	5.7	1.2	6.7	–2.2
1993	0.1	4.9	0.0	0.0	–0.6	4.4	–0.3	0.1	4.7
1994	1.0	4.5	0.0	0.0	2.4	8.0	1.3	9.2	–2.6
1995	1.0	4.9	0.0	0.0	4.0	10.0	3.2	8.2	–1.5
1996	1.5	1.8	0.0	0.0	2.6	6.0	2.3	2.3	1.3
1997	2.5	7.0	0.0	0.0	1.9	11.4	1.7	5.5	4.2
1998	–1.1	–4.8	0.0	0.0	2.7	–3.2	2.7	–1.9	–4.0
1999	2.2	–2.3	0.0	0.0	4.8	4.7	4.8	–1.0	0.8
2000	3.4	–1.6	0.0	0.0	2.6	4.5	3.1	2.1	–0.6
2001	0.5	–1.6	0.2	0.0	–2.1	–2.9	–1.9	0.5	–1.4
2002	–0.8	–0.7	3.2	0.0	0.2	1.9	4.4	–4.3	1.8
Descriptive statistics: 1972–2002									
Average	0.5	1.3	0.1	0.0	1.7	3.6	1.9	1.5	0.1
Std deviation	1.0	4.7	0.6	0.0	2.0	4.5	2.3	4.7	5.0
Range **b**	4.6	24.7	3.2	0.0	9.1	22.7	10.9	22.7	31.0
– maximum	3.4	9.4	3.2	0.0	7.0	11.4	9.0	9.2	16.6
– minimum	–1.2	–15.3	0.0	0.0	–2.1	–11.4	–1.9	–13.4	–14.4
% years < 0 **c**	26	39	6	0	19	23	19	23	55
Correlation **d**	0.3	0.9	–0.1	–	0.1	1.0	0.2	0.4	0.5

43 Decomposition of annual growth in TPEC by fuel type and supply source

Indonesia Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.0	3.3	0.1	0.0	0.5	3.9	28.3	–25.2	0.8
1973	–0.1	3.7	0.2	0.0	0.6	4.3	36.2	–23.2	–8.7
1974	0.1	2.9	0.5	0.0	–0.3	3.2	5.1	–13.3	11.3
1975	0.1	2.2	0.2	0.0	1.8	4.3	–6.8	5.6	5.5
1976	–0.1	1.8	1.8	0.0	1.2	4.8	28.0	–23.7	0.5
1977	0.0	5.2	5.4	0.0	1.4	12.0	30.1	–16.1	–2.0
1978	0.0	3.6	2.6	0.0	1.5	7.6	3.9	–2.7	6.4
1979	0.0	2.9	0.6	0.0	1.0	4.6	3.2	5.0	–3.6
1980	0.0	3.9	–0.5	0.0	0.9	4.3	7.0	1.6	–4.2
1981	0.0	3.3	0.7	0.0	1.3	5.4	4.3	2.4	–1.4
1982	0.0	1.1	–0.1	0.0	1.2	2.3	–22.6	21.0	3.8
1983	0.0	–1.2	1.7	0.0	1.3	1.7	4.7	–2.4	–0.7
1984	0.1	–0.4	3.9	0.0	1.1	4.6	28.2	–24.4	0.8
1985	0.6	1.4	0.4	0.0	0.9	3.3	–9.3	14.1	–1.5
1986	1.8	4.4	2.1	0.0	0.9	9.1	11.3	–2.5	0.3
1987	0.7	–0.2	–0.7	0.0	1.1	0.9	–2.2	2.7	0.4
1988	0.5	0.3	1.5	0.0	1.5	3.8	4.3	0.2	–0.6
1989	0.9	2.6	2.5	0.0	1.0	7.0	12.8	–4.4	–1.4
1990	0.7	6.3	7.2	0.0	2.9	17.1	17.6	–2.1	1.5
1991	0.1	0.4	3.2	0.0	0.8	4.5	15.3	–10.6	–0.2
1992	0.3	2.0	1.0	0.0	0.8	4.1	4.3	–0.5	0.4
1993	0.5	6.1	0.9	0.0	0.5	8.1	7.3	3.0	–2.3
1994	1.2	–2.9	2.9	0.0	0.9	2.1	11.7	–10.8	1.2
1995	0.1	7.1	2.4	0.0	0.8	10.4	6.1	3.7	0.6
1996	1.1	0.1	1.1	0.0	0.3	2.6	7.1	–3.7	–0.7
1997	0.5	1.9	1.4	0.0	0.4	4.2	3.6	–0.2	0.7
1998	0.7	–1.1	–1.2	0.0	1.0	–0.6	1.9	–2.5	0.0
1999	1.1	1.3	2.1	0.0	0.0	4.4	7.3	–2.3	–0.6
2000	0.7	2.7	–1.9	0.0	0.7	2.4	–4.7	6.4	0.6
2001	3.5	–0.3	0.5	0.0	1.2	4.8	4.0	0.8	0.0
2002	0.8	2.0	0.7	0.0	0.9	4.3	5.6	–1.2	0.0
Descriptive statistics: 1972–2002									
Average	0.5	2.1	1.4	0.0	1.0	5.0	8.2	–3.4	0.2
Std deviation	0.7	2.3	1.9	0.0	0.6	3.5	12.4	10.8	3.4
Range **b**	3.6	10.0	9.1	0.0	3.2	17.7	58.8	46.3	20.0
– maximum	3.5	7.1	7.2	0.0	2.9	17.1	36.2	21.0	11.3
– minimum	–0.1	–2.9	–1.9	0.0	–0.3	–0.6	–22.6	–25.2	–8.7
% years < 0 **c**	13	19	16	0	6	3	16	61	48
Correlation **d**	0.0	0.8	0.8	–	0.5	1.0	0.4	–0.1	0.0

44 Decomposition of annual growth in TPEC by fuel type and supply source
Viet Nam Percentage point contributions

	By fuel type					Total primary energy consumption	By supply source		
	Coal	Oil	Gas	Nuclear	Other		Production	Net imports a	Stock drawdown
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–1.8	0.4	0.0	0.0	1.4	0.1	–1.4	1.5	0.0
1973	2.4	–0.6	0.0	0.0	1.5	3.3	4.3	–1.0	0.0
1974	1.5	–12.1	0.0	0.0	1.5	–9.1	4.3	–13.4	0.0
1975	3.9	–1.2	0.0	0.0	1.7	4.4	5.4	–0.9	0.0
1976	–0.7	–12.3	0.0	0.0	1.7	–11.3	2.8	–14.2	0.0
1977	1.4	0.2	0.0	0.0	1.9	3.5	3.9	–0.4	0.0
1978	–0.5	1.1	0.0	0.0	1.9	2.5	1.3	1.2	0.0
1979	0.5	0.8	0.0	0.0	1.9	3.1	0.3	2.8	0.0
1980	–2.1	4.1	0.0	0.0	1.9	3.9	1.0	4.4	–1.5
1981	1.1	–1.2	0.0	0.0	1.5	1.4	3.8	–2.0	–0.4
1982	1.6	0.1	0.0	0.0	1.4	3.1	2.2	0.8	0.1
1983	0.1	1.3	0.2	0.0	1.2	2.8	1.5	2.1	–0.7
1984	0.0	–0.2	0.0	0.0	1.6	1.4	–1.9	–0.4	3.6
1985	–0.1	0.2	–0.1	0.0	1.5	1.5	3.0	–0.2	–1.3
1986	1.3	1.0	0.0	0.0	1.8	4.2	3.2	1.0	0.0
1987	1.6	1.5	0.0	0.0	1.9	4.9	2.4	2.5	0.0
1988	–0.9	0.5	0.0	0.0	2.0	1.5	4.2	–2.8	0.0
1989	–2.7	–0.8	–0.1	0.0	2.5	–1.0	3.7	–4.8	0.0
1990	–1.5	1.5	0.0	0.0	2.3	2.3	6.3	–3.1	–1.0
1991	–0.3	–0.1	0.1	0.0	2.1	1.7	8.6	–7.6	0.7
1992	0.0	1.9	0.0	0.0	2.0	3.9	7.9	–5.1	1.0
1993	–0.3	3.9	0.0	0.0	1.9	5.5	7.0	1.5	–3.0
1994	0.8	1.7	0.0	0.0	1.9	4.4	4.5	–2.6	2.5
1995	3.6	0.3	0.6	0.0	1.8	6.3	9.6	–3.9	0.6
1996	0.8	2.4	0.3	0.0	3.7	7.2	10.6	–2.6	–0.8
1997	3.0	0.7	0.7	0.0	1.3	5.6	8.8	–2.0	–1.1
1998	0.1	2.8	1.0	0.0	1.3	5.2	10.0	–4.9	0.1
1999	–1.0	1.7	0.3	0.0	–0.9	0.1	4.6	–6.3	1.8
2000	0.4	2.5	0.5	0.0	1.0	4.4	7.7	0.8	–4.2
2001	1.7	2.1	0.0	0.0	1.6	5.5	5.2	–3.3	3.6
2002	1.2	2.9	3.0	0.0	0.7	8.0	7.9	0.5	–0.4
Descriptive statistics: 1972–2002									
Average	0.5	0.2	0.2	0.0	1.7	2.6	4.6	–2.0	0.0
Std deviation	1.6	3.6	0.6	0.0	0.7	4.0	3.2	4.2	1.5
Range **b**	6.5	16.3	3.1	0.0	4.6	19.3	12.6	18.6	7.8
– maximum	3.9	4.1	3.0	0.0	3.7	8.0	10.6	4.4	3.6
– minimum	–2.7	–12.3	–0.1	0.0	–0.9	–11.3	–1.9	–14.2	–4.2
% years < 0 **c**	35	26	19	0	3	10	6	65	35
Correlation **d**	0.3	0.9	0.4	–	0.1	1.0	0.4	0.7	–0.1

C appendix

decomposition of annual growth in total final energy consumption in twenty APEC economies

Descriptive statistics relating to sources of APEC energy market volatility since 1972, given in table 13 in chapter 4, are based on information presented in this appendix. The detailed decomposition analysis of annual growth in total final energy consumption (TFEC) in twenty APEC economies is given in tables 45–64 (in order of the ranking of economies used throughout this report; see table 1) .

TFEC in an economy may be defined by fuel type or by end use sector. By fuel type, TFEC is equal to the sum of the consumption of individual final fuel types (where renewables and heat are included in a single category of other energy consumption; see table 5). By end use sector, TPEC is equal to the sum of energy consumption in end use activities, including nonenergy use (for brevity, only industry, transport and other end use sectors are included in the decomposition; see table 6). These definitions may be expressed as follows:

by fuel type: TFEC = coal consumption + oil consumption + gas consumption + electricity output + other energy consumption

by end use sector: TFEC = industry energy consumption + transport energy consumption + energy consumption in other end use sectors

The decomposition analysis is based on the observation that the annual percentage change in TFEC in each APEC economy may be decomposed into the percentage point contributions of individual final fuel types or end use sectors. The percentage point contribution accounts for both the annual percentage change in consumption, by final fuel type or end use sector, as well as the share of the component in TFEC.

Footnotes to tables 45–64

a Other sectors and non-energy use. **b** Maximum observation minus the minimum observation. **c** Number of years in which a negative observation occurs as a percentage of the total number of years. **d** Correlation coefficient between percentage change in TFEC and the variable indicated.
Source: Based on IEA energy database; see IEA (2004a,b).

45 Decomposition of annual growth in TFEC by fuel type and end use sector

United States Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricity	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–0.2	3.1	0.4	0.8	0.1	4.2	1.1	1.9	1.2
1973	–0.2	1.8	0.3	0.7	0.0	2.7	1.5	1.4	–0.2
1974	–0.1	–2.3	–1.0	0.0	0.0	–3.3	–1.5	–0.8	–1.1
1975	–0.5	–0.7	–2.3	0.2	–0.1	–3.4	–3.6	0.4	–0.2
1976	–0.3	4.1	0.5	0.7	0.4	5.4	1.8	1.4	2.1
1977	0.0	3.4	–0.9	0.6	0.2	3.3	2.1	1.1	0.0
1978	0.1	0.6	0.3	0.4	0.4	1.8	–0.7	1.2	1.4
1979	0.2	–0.8	0.8	0.3	0.2	0.6	1.8	–0.7	–0.5
1980	–0.8	–4.1	0.3	0.2	0.1	–4.3	–0.4	–1.5	–2.4
1981	0.3	–2.0	–0.5	0.3	0.0	–1.8	–0.4	–0.1	–1.2
1982	–0.7	–1.5	–2.0	–0.4	0.1	–4.7	–4.0	–0.2	–0.5
1983	0.3	–1.1	–1.3	0.4	0.4	–1.2	–1.5	0.4	–0.1
1984	0.3	2.2	1.7	0.9	0.6	5.7	3.1	1.1	1.6
1985	–0.2	0.0	–1.0	0.3	–0.1	–1.0	–1.4	0.3	0.1
1986	–0.2	1.2	–1.1	0.1	0.1	0.2	–0.6	0.9	–0.1
1987	–0.1	1.5	0.8	0.7	0.5	3.4	1.2	1.2	1.0
1988	0.2	1.5	2.0	0.8	–0.1	4.4	1.2	1.7	1.5
1989	–0.2	–0.4	–0.4	0.5	–2.5	–3.1	–4.0	0.3	0.6
1990	0.2	–1.2	–0.8	0.4	–1.0	–2.5	–0.4	–0.1	–1.9
1991	–0.1	–1.1	–0.2	0.9	0.5	0.1	0.1	–0.7	0.7
1992	–1.6	1.4	0.3	0.0	0.5	0.6	–0.3	0.8	0.1
1993	–0.2	0.7	1.1	0.6	–0.4	1.8	0.1	0.8	0.9
1994	0.0	1.8	0.1	0.5	0.0	2.4	0.7	1.4	0.3
1995	–0.1	0.4	0.5	0.5	0.3	1.6	0.2	0.9	0.6
1996	0.0	1.8	1.0	0.5	–0.1	3.2	0.5	0.9	1.7
1997	0.1	0.5	0.6	0.3	–0.1	1.4	1.0	0.7	–0.4
1998	0.0	0.4	–1.3	0.6	0.2	–0.1	0.0	0.9	–1.0
1999	0.1	1.7	–0.1	0.5	1.5	3.7	1.4	1.2	1.1
2000	0.0	1.0	2.0	0.7	0.0	3.7	2.2	0.7	0.8
2001	0.0	0.6	–1.6	–0.2	–0.5	–1.8	–2.1	0.0	0.4
2002	–0.2	0.5	0.6	0.3	–0.1	1.2	0.0	0.8	0.3
Descriptive statistics: 1972–2002									
Average	–0.1	0.5	0.0	0.4	0.0	0.8	0.0	0.6	0.2
Std deviation	0.4	1.7	1.1	0.3	0.6	2.9	1.7	0.8	1.1
Range **b**	1.9	8.1	4.3	1.4	4.0	10.4	7.0	3.4	4.5
– maximum	0.3	4.1	2.0	0.9	1.5	5.7	3.1	1.9	2.1
– minimum	–1.6	–4.1	–2.3	–0.4	–2.5	–4.7	–4.0	–1.5	–2.4
% years < 0 **c**	61	32	45	6	39	35	42	26	39
Correlation **d**	0.3	0.9	0.7	0.7	0.4	1.0	0.8	0.8	0.8

46 Decomposition of annual growth in TFEC by fuel type and end use sector

Canada Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–0.2	3.7	2.1	1.2	0.0	6.8	1.7	1.8	3.3
1973	0.3	3.7	0.3	0.8	0.2	5.4	4.7	2.3	–1.7
1974	–0.3	1.9	2.3	1.2	0.0	5.1	1.7	1.2	2.3
1975	–0.3	–2.6	–0.3	–0.3	–1.1	–4.5	–4.1	0.5	–1.0
1976	0.0	1.1	2.7	1.1	0.1	5.1	2.1	1.2	1.8
1977	–0.3	1.1	1.8	1.2	0.0	3.8	2.3	0.4	1.1
1978	0.1	1.1	–0.6	0.7	0.6	1.8	0.6	1.2	–0.1
1979	0.2	1.4	2.1	0.4	0.6	4.6	2.2	2.7	–0.3
1980	–0.1	–0.9	1.1	0.8	0.3	1.3	1.3	0.4	–0.4
1981	–0.3	–2.6	–0.3	0.5	–0.3	–3.0	–1.8	–0.3	–0.9
1982	–0.2	–5.8	0.5	–0.1	0.2	–5.4	–3.2	–3.5	1.3
1983	0.0	–2.2	–0.2	0.9	0.3	–1.2	0.5	–1.0	–0.7
1984	0.3	0.4	2.0	1.5	–0.1	4.0	3.1	1.0	0.0
1985	0.1	–0.1	1.7	0.9	0.2	2.9	1.6	0.5	0.9
1986	–0.1	0.3	–1.1	1.0	0.2	0.2	–0.1	0.0	0.3
1987	0.0	1.3	0.0	0.4	0.0	1.6	1.6	1.2	–1.1
1988	0.1	1.8	1.9	1.1	–0.3	4.6	0.8	1.9	1.9
1989	–0.1	1.1	1.0	0.5	–0.2	2.2	–0.4	0.5	2.0
1990	–0.6	–1.0	–0.5	0.0	–0.3	–2.4	–1.0	–0.7	–0.7
1991	0.2	–2.3	0.5	0.2	0.1	–1.3	–0.2	–0.8	–0.3
1992	0.0	0.9	1.1	0.0	–0.1	1.9	0.2	1.1	0.6
1993	–0.1	1.2	1.2	0.5	–0.2	2.6	0.8	0.4	1.4
1994	–0.1	1.3	1.0	0.3	0.8	3.3	1.5	1.3	0.5
1995	0.1	0.9	0.7	0.5	0.2	2.4	1.1	0.8	0.5
1996	0.0	1.6	1.8	0.3	0.0	3.7	1.1	0.7	1.8
1997	0.0	1.5	–0.3	0.3	–0.1	1.4	0.4	0.8	0.1
1998	0.0	–0.8	–2.0	–0.1	0.2	–2.7	–1.0	0.6	–2.3
1999	0.0	2.0	0.9	0.5	0.5	3.9	1.9	0.7	1.3
2000	0.1	0.4	1.1	0.7	0.0	2.3	0.5	–0.3	2.1
2001	–0.2	–0.4	–2.4	0.0	–0.4	–3.4	–2.1	–0.4	–0.9
2002	–0.1	0.5	2.1	0.4	0.4	3.3	1.4	0.4	1.6
Descriptive statistics: 1972–2002									
Average	0.0	0.3	0.7	0.6	0.1	1.6	0.6	0.5	0.5
Std deviation	0.2	1.9	1.3	0.5	0.4	3.2	1.8	1.1	1.3
Range **b**	0.8	9.6	5.2	1.8	1.9	12.2	8.8	6.2	5.7
– maximum	0.3	3.7	2.7	1.5	0.8	6.8	4.7	2.7	3.3
– minimum	–0.6	–5.8	–2.4	–0.3	–1.1	–5.4	–4.1	–3.5	–2.3
% years < 0 **c**	61	32	32	16	45	26	29	23	39
Correlation **d**	0.4	0.9	0.7	0.7	0.4	1.0	0.9	0.8	0.6

47 Decomposition of annual growth in TFEC by fuel type and end use sector
Australia Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Elec- tricty	Other		In- dustry	Trans port	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–0.7	–0.3	1.9	0.6	0.2	1.7	–0.3	1.1	0.9
1973	0.5	5.5	1.1	1.1	–0.3	8.0	2.1	3.3	2.5
1974	–0.9	–0.1	1.2	1.2	0.1	1.6	2.6	1.2	–2.2
1975	0.5	0.6	0.7	0.7	0.0	2.5	0.3	1.3	0.8
1976	–0.5	0.7	0.6	0.5	0.1	1.3	0.1	1.1	0.1
1977	–0.2	3.5	1.1	1.0	0.1	5.3	1.7	2.3	1.4
1978	–1.3	1.5	0.9	0.6	–0.1	1.5	–0.9	2.0	0.4
1979	0.4	0.8	1.0	0.8	–0.3	2.7	0.9	0.9	0.9
1980	0.2	0.0	1.5	0.7	0.2	2.6	1.3	1.0	0.3
1981	–0.5	–2.1	0.9	0.8	0.5	–0.5	–0.9	0.5	–0.1
1982	0.3	–0.1	0.4	0.6	0.2	1.4	–0.7	1.1	0.9
1983	–0.9	–3.2	0.5	0.1	0.0	–3.5	–2.4	–0.4	–0.6
1984	0.3	2.4	0.4	1.1	–0.2	4.0	1.5	1.6	1.0
1985	1.2	0.6	1.6	0.8	0.2	4.4	2.8	1.3	0.3
1986	–0.6	0.8	0.9	1.1	–1.9	0.3	–1.7	1.0	0.9
1987	0.2	0.4	0.8	0.8	0.1	2.4	1.1	0.8	0.5
1988	0.0	3.1	0.2	1.1	0.1	4.5	1.6	1.7	1.2
1989	0.1	2.2	0.5	1.1	0.3	4.2	1.9	1.5	0.8
1990	0.1	1.2	0.8	1.0	0.2	3.3	1.3	0.8	1.2
1991	0.1	–1.2	0.1	0.4	0.0	–0.7	–0.5	–0.7	0.5
1992	0.0	1.1	0.3	0.2	–0.5	1.0	–0.4	1.1	0.3
1993	0.1	1.6	0.4	0.6	1.1	3.8	1.5	0.9	1.4
1994	–0.1	1.3	0.7	0.5	–0.2	2.3	1.3	1.1	–0.1
1995	–0.1	2.1	0.8	0.6	0.3	3.7	0.9	1.8	1.0
1996	–0.2	2.0	0.1	0.5	0.8	3.3	0.7	1.6	1.0
1997	0.3	0.7	0.2	0.6	0.3	2.2	0.7	0.8	0.7
1998	–0.1	0.6	0.5	1.2	–0.2	1.9	0.8	0.4	0.7
1999	–0.1	0.7	0.3	0.7	0.0	1.5	0.5	0.7	0.3
2000	–0.3	1.6	0.7	0.5	0.1	2.7	0.8	1.1	0.8
2001	–0.3	–0.1	0.9	0.9	0.0	1.3	0.9	0.1	0.3
2002	–1.4	–1.3	–1.5	1.1	0.1	–3.0	–3.1	–0.1	0.2
Descriptive statistics: 1972–2002									
Average	–0.1	0.9	0.7	0.8	0.0	2.2	0.5	1.1	0.6
Std deviation	0.5	1.7	0.6	0.3	0.5	2.2	1.4	0.8	0.8
Range **b**	2.6	8.7	3.3	1.1	3.0	11.4	5.9	4.0	4.7
– maximum	1.2	5.5	1.9	1.2	1.1	8.0	2.8	3.3	2.5
– minimum	–1.4	–3.2	–1.5	0.1	–1.9	–3.5	–3.1	–0.7	–2.2
% years < 0 **c**	55	26	3	0	39	13	29	10	13
Correlation **d**	0.6	0.9	0.4	0.4	0.2	1.0	0.8	0.8	0.6

48 Decomposition of annual growth in TFEC by fuel type and end use sector

Hong Kong Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–0.3	0.8	0.1	0.5	0.0	1.1	–1.5	3.4	–0.8
1973	–0.2	–2.0	0.1	2.0	0.0	–0.1	–2.8	2.8	–0.1
1974	0.0	21.0	0.2	–0.3	–0.1	20.8	16.8	–0.2	4.1
1975	0.0	–6.2	0.1	1.4	–0.2	–4.9	–5.2	1.1	–0.9
1976	0.1	14.7	0.2	2.5	0.2	17.6	10.1	5.0	2.6
1977	–0.1	9.6	0.1	2.4	0.0	12.1	7.4	–0.2	4.8
1978	–0.1	1.2	0.2	1.8	0.0	3.2	1.2	1.7	0.4
1979	0.0	–10.6	0.3	1.6	0.1	–8.6	–15.0	8.4	–2.1
1980	–0.1	–3.0	0.3	2.4	0.0	–0.3	–3.1	–0.8	3.5
1981	0.9	5.9	0.3	1.5	0.0	8.6	1.9	3.5	3.1
1982	–0.9	9.0	0.4	1.9	0.1	10.5	4.2	2.2	4.2
1983	0.0	–2.2	0.5	3.1	0.0	1.4	0.8	0.3	0.3
1984	0.0	3.5	0.5	1.9	0.0	5.8	3.6	0.3	1.9
1985	0.0	–5.1	0.5	1.6	0.0	–3.0	–3.0	–1.8	1.7
1986	0.0	11.2	0.5	3.2	0.0	14.9	3.6	8.1	3.2
1987	0.0	1.5	0.6	6.1	0.0	8.2	5.1	0.1	3.1
1988	0.0	12.0	0.6	2.2	0.0	14.8	4.3	8.6	1.9
1989	0.0	2.6	0.5	–0.7	0.0	2.4	–2.5	2.6	2.3
1990	0.0	3.4	0.4	1.8	0.0	5.6	–4.6	7.9	2.3
1991	0.0	–2.5	0.3	1.8	0.0	–0.3	–3.4	1.6	1.6
1992	0.0	18.3	0.6	1.0	0.0	19.9	6.5	11.1	2.3
1993	0.0	3.5	0.3	1.6	0.0	5.3	–2.9	6.5	1.8
1994	0.0	8.2	0.4	1.4	0.0	9.9	0.6	6.8	2.5
1995	0.0	–0.6	0.3	0.6	0.0	0.3	–1.5	0.9	0.9
1996	0.0	–1.5	0.2	1.5	0.0	0.2	–1.0	–0.4	1.6
1997	0.0	1.9	0.2	0.5	0.0	2.6	–0.4	2.3	0.6
1998	0.0	17.9	0.0	2.2	0.0	20.1	5.5	12.3	2.2
1999	0.0	10.9	0.1	0.0	0.0	11.0	3.6	6.5	0.9
2000	0.0	–13.4	0.2	0.9	0.0	–12.2	–3.7	–9.3	0.7
2001	0.0	–3.5	0.1	0.7	0.0	–2.7	–1.6	–2.6	1.5
2002	0.0	–1.6	0.0	0.6	0.0	–0.9	–2.4	0.0	1.6
Descriptive statistics: 1972–2002									
Average	0.0	3.4	0.3	1.6	0.0	5.3	0.7	2.9	1.7
Std deviation	0.2	8.3	0.2	1.2	0.1	8.4	5.6	4.5	1.5
Range **b**	1.7	34.4	0.6	6.8	0.3	33.0	31.8	21.6	6.9
– maximum	0.9	21.0	0.6	6.1	0.2	20.8	16.8	12.3	4.8
– minimum	–0.9	–13.4	0.0	–0.7	–0.2	–12.2	–15.0	–9.3	–2.1
% years < 0 **c**	39	39	0	10	39	29	52	26	13
Correlation **d**	0.0	1.0	0.2	0.1	0.0	1.0	0.8	0.6	0.6

49 Decomposition of annual growth in TFEC by fuel type and end use sector

Japan Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Trans port	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	1.0	4.1	0.1	1.6	0.0	6.8	3.8	0.9	2.2
1973	–0.5	9.0	0.3	1.5	0.0	10.3	4.8	1.9	3.5
1974	0.3	–2.3	0.2	–0.2	0.0	–2.0	–1.4	0.0	–0.6
1975	–0.1	–5.0	0.1	0.5	0.0	–4.6	–5.6	0.9	0.1
1976	–0.3	4.5	0.2	1.2	0.0	5.7	3.1	1.1	1.5
1977	–0.3	0.8	0.2	0.7	0.0	1.4	–0.6	0.9	1.0
1978	–0.7	2.1	0.0	0.9	0.0	2.4	–0.6	1.4	1.6
1979	0.8	1.4	0.3	0.9	0.0	3.3	2.0	0.9	0.4
1980	0.8	–6.9	0.1	–0.3	0.0	–6.2	–5.5	0.3	–1.0
1981	0.7	–3.4	0.2	0.1	0.0	–2.4	–2.9	–0.4	0.9
1982	–0.6	–0.4	0.0	–0.1	1.0	–0.1	–0.2	–0.5	0.5
1983	–0.7	1.3	0.2	1.2	0.0	1.9	–0.5	0.8	1.7
1984	0.9	3.5	0.5	1.0	0.1	6.0	3.1	0.8	2.2
1985	0.3	–1.0	0.1	0.7	0.0	0.0	–0.1	0.3	–0.2
1986	–0.5	1.8	0.2	0.1	–0.1	1.6	–0.6	0.9	1.3
1987	–0.6	2.2	0.1	1.3	0.0	2.9	0.9	1.0	1.0
1988	0.7	3.7	0.4	1.1	0.0	6.0	2.1	1.4	2.5
1989	0.2	2.1	0.2	1.3	0.0	3.8	1.9	1.8	0.1
1990	–0.5	1.3	0.3	1.8	0.5	3.4	–2.3	2.1	3.6
1991	–0.8	1.5	0.4	0.7	0.0	1.7	–0.4	1.2	1.0
1992	0.0	2.2	0.2	0.2	0.0	2.6	1.0	0.9	0.7
1993	–0.2	–0.4	0.4	0.2	–0.1	–0.2	–1.4	0.2	1.0
1994	0.5	3.0	0.1	1.5	0.0	5.1	3.4	1.1	0.6
1995	–0.2	1.5	0.4	0.6	0.0	2.3	–0.1	1.1	1.4
1996	0.5	2.7	0.2	0.5	0.0	4.0	2.6	1.0	0.4
1997	0.6	0.5	0.2	0.6	0.0	2.0	1.4	0.4	0.2
1998	–1.4	–0.8	0.0	0.2	–0.1	–2.1	–2.9	–0.2	1.1
1999	0.3	1.9	0.3	0.6	0.0	3.0	2.2	0.2	0.7
2000	0.4	0.0	0.3	0.6	0.1	1.4	0.8	0.0	0.7
2001	–0.2	–0.7	0.0	–0.3	–0.1	–1.3	–1.2	0.1	–0.3
2002	0.3	1.0	0.4	0.4	0.0	2.2	1.1	–0.3	1.3
Descriptive statistics: 1972–2002									
Average	0.0	1.0	0.2	0.7	0.1	2.0	0.3	0.7	1.0
Std deviation	0.6	2.9	0.1	0.6	0.2	3.4	2.5	0.7	1.0
Range **b**	2.4	15.8	0.5	2.1	1.1	16.5	10.4	2.6	4.6
– maximum	1.0	9.0	0.5	1.8	1.0	10.3	4.8	2.1	3.6
– minimum	–1.4	–6.9	0.0	–0.3	–0.1	–6.2	–5.6	–0.5	–1.0
% years < 0 **c**	48	32	10	13	16	26	52	16	13
Correlation **d**	0.1	1.0	0.4	0.8	0.0	1.0	0.9	0.6	0.7

50 Decomposition of annual growth in TFEC by fuel type and end use sector

Singapore Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.0	13.7	0.2	3.2	–0.2	16.9	0.2	8.2	8.4
1973	0.0	12.6	0.1	2.1	–0.1	14.6	4.1	5.6	4.9
1974	0.0	10.7	0.2	–0.2	–0.1	10.7	3.1	1.4	6.2
1975	0.0	–0.4	0.2	1.5	0.1	1.3	1.1	6.0	–5.6
1976	0.0	12.2	0.3	1.6	0.1	14.1	4.1	10.0	–0.1
1977	0.0	14.3	0.1	1.6	0.2	16.2	–0.3	13.3	3.0
1978	0.0	9.2	0.2	2.3	–0.1	11.5	4.2	5.5	1.8
1979	0.0	5.7	0.1	1.1	0.0	7.0	0.6	6.7	–0.2
1980	0.0	–0.7	0.1	1.4	–0.1	0.7	0.0	–0.5	1.2
1981	0.0	3.4	0.0	1.1	0.0	4.5	1.0	1.4	2.1
1982	0.0	6.6	0.0	0.8	0.0	7.4	–1.0	5.1	3.3
1983	0.0	4.6	0.0	1.4	0.0	6.1	0.7	3.8	1.6
1984	0.0	8.0	0.0	1.6	0.0	9.6	11.7	1.9	–3.9
1985	0.0	17.7	–0.1	1.1	–0.1	18.6	16.2	–1.5	3.9
1986	0.0	1.4	0.0	1.0	0.0	2.4	–1.6	3.3	0.7
1987	0.0	9.1	0.0	2.0	0.0	11.1	7.2	2.6	1.3
1988	0.0	0.6	0.1	1.7	0.0	2.5	1.0	1.2	0.2
1989	0.0	6.2	0.1	1.0	0.0	7.3	2.6	4.1	0.5
1990	0.0	14.6	0.1	1.8	0.0	16.5	4.1	8.3	4.2
1991	0.0	–3.1	0.1	0.8	0.0	–2.3	–2.4	–0.4	0.6
1992	0.0	–3.8	0.1	1.4	0.0	–2.3	–2.9	1.0	–0.5
1993	0.0	8.4	0.1	1.5	0.0	10.0	2.8	7.4	–0.1
1994	0.0	9.2	0.1	2.0	0.0	11.2	0.9	8.7	1.6
1995	0.0	5.8	0.0	1.3	0.0	7.1	5.0	1.4	0.7
1996	0.0	4.1	0.1	1.5	0.0	5.7	3.8	1.8	0.1
1997	0.0	19.5	0.1	2.3	0.0	21.9	21.9	–1.8	1.9
1998	0.0	–8.5	0.0	1.2	0.0	–7.2	–6.5	–1.4	0.6
1999	0.0	–0.2	0.0	1.2	0.0	1.0	–1.7	2.5	0.2
2000	0.0	–1.8	0.0	1.7	0.0	–0.1	–3.9	2.8	1.1
2001	0.0	18.7	0.0	0.4	0.0	19.1	4.1	–0.1	15.1
2002	0.0	11.7	0.0	1.0	0.0	12.7	10.8	0.7	1.2
Descriptive statistics: 1972–2002									
Average	0.0	6.8	0.1	1.4	0.0	8.2	2.9	3.5	1.8
Std deviation	0.0	7.0	0.1	0.6	0.1	7.2	5.8	3.7	3.6
Range **b**	0.0	28.1	0.3	3.4	0.4	29.2	28.4	15.2	20.7
– maximum	0.0	19.5	0.3	3.2	0.2	21.9	21.9	13.3	15.1
– minimum	0.0	–8.5	–0.1	–0.2	–0.2	–7.2	–6.5	–1.8	–5.6
% years < 0 **c**	0	23	6	3	35	13	29	19	19
Correlation **d**	–	1.0	0.1	0.3	–0.2	1.0	0.7	0.3	0.5

51 Decomposition of annual growth in TFEC by fuel type and end use sector

Chinese Taipei Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.1	16.0	1.7	2.4	0.3	20.5	10.2	8.3	1.9
1973	–1.8	8.5	1.7	1.6	0.0	10.0	3.8	2.2	4.0
1974	–2.5	–3.9	0.1	0.8	–0.2	–5.7	–1.1	–4.2	–0.3
1975	–1.9	11.2	0.6	2.0	–0.3	11.6	5.4	3.7	2.4
1976	0.9	14.3	1.7	2.7	0.0	19.5	12.6	3.5	3.3
1977	–0.9	8.6	1.3	1.9	–0.2	10.7	8.2	3.0	–0.4
1978	2.8	10.0	0.6	2.5	–0.1	15.8	11.5	1.3	3.0
1979	–0.5	7.1	–0.6	1.7	0.0	7.7	5.8	1.2	0.7
1980	1.3	3.0	0.0	1.2	0.0	5.5	2.9	1.0	1.5
1981	0.3	–3.1	–0.8	–0.2	0.0	–3.9	–4.1	0.1	0.1
1982	3.9	–1.5	–1.3	0.7	0.0	1.8	–0.2	0.7	1.2
1983	2.3	4.0	0.1	1.9	0.0	8.3	4.5	1.9	1.9
1984	–1.1	5.0	0.1	1.4	0.0	5.3	2.4	1.6	1.3
1985	–1.2	4.2	–0.5	0.8	0.0	3.3	1.3	0.9	1.1
1986	1.0	6.2	–0.3	2.2	0.0	9.1	6.1	1.8	1.2
1987	0.6	4.8	0.1	1.9	0.0	7.5	3.3	2.5	1.8
1988	3.4	4.2	0.2	2.2	0.0	10.2	5.7	2.8	1.7
1989	–0.5	4.1	0.0	1.8	0.0	5.2	0.4	2.6	2.3
1990	0.0	3.4	0.1	1.5	0.0	5.0	1.8	2.1	1.1
1991	0.5	1.1	0.6	2.1	0.0	4.3	1.6	1.4	1.2
1992	1.0	4.1	0.4	1.5	0.0	6.9	2.7	3.9	0.3
1993	0.9	2.8	0.1	2.0	0.0	5.8	2.4	1.8	1.5
1994	0.5	5.3	0.2	1.7	0.0	7.7	4.3	2.1	1.2
1995	–0.2	1.8	0.4	1.8	0.0	3.8	1.7	1.6	0.5
1996	0.3	2.9	0.2	1.5	0.0	4.9	1.7	1.1	2.1
1997	0.5	0.5	0.1	1.7	0.0	2.8	2.0	0.6	0.1
1998	1.3	1.6	0.0	1.4	0.0	4.3	1.2	1.4	1.7
1999	–0.6	3.2	–0.2	1.8	0.0	4.3	1.1	1.4	1.9
2000	1.0	0.3	–0.1	2.6	0.0	3.9	2.1	0.3	1.4
2001	0.8	7.5	0.0	0.5	0.0	8.7	9.2	–0.2	–0.3
2002	0.6	4.7	0.4	1.4	0.0	7.1	5.2	1.1	0.8
Descriptive statistics: 1972–2002									
Average	0.4	4.6	0.2	1.6	0.0	6.8	3.7	1.7	1.4
Std deviation	1.4	4.4	0.7	0.6	0.1	5.4	3.7	1.9	1.0
Range **b**	6.4	20.0	3.0	2.9	0.5	26.1	16.8	12.5	4.5
– maximum	3.9	16.0	1.7	2.7	0.3	20.5	12.6	8.3	4.0
– minimum	–2.5	–3.9	–1.3	–0.2	–0.3	–5.7	–4.1	–4.2	–0.4
% years < 0 **c**	35	10	29	3	58	6	10	6	10
Correlation **d**	0.2	1.0	0.7	0.7	0.2	1.0	0.9	0.8	0.5

52 Decomposition of annual growth in TFEC by fuel type and end use sector

New Zealand Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.3	7.0	0.8	3.1	0.0	11.2	5.0	3.7	2.6
1973	0.6	0.3	0.3	1.3	0.0	2.5	1.9	0.2	0.4
1974	0.6	1.7	1.0	0.5	5.6	9.3	5.7	1.9	1.7
1975	–0.8	0.0	0.3	1.8	0.3	1.5	–2.0	1.4	2.1
1976	0.4	0.4	0.9	1.3	0.2	3.2	1.9	0.3	1.0
1977	0.0	0.7	0.0	0.2	0.6	1.6	1.2	0.2	0.2
1978	–1.6	–0.3	0.3	0.1	0.1	–1.4	–1.7	1.0	–0.6
1979	–0.2	–0.7	–0.4	0.1	–0.2	–1.4	–0.3	0.4	–1.5
1980	0.8	0.4	1.3	0.6	0.7	3.8	2.7	0.1	1.0
1981	–0.1	–2.3	0.8	0.7	0.0	–1.0	–0.4	–0.4	–0.2
1982	–0.1	0.0	1.7	1.5	–0.3	2.9	0.9	0.4	1.5
1983	–0.4	–1.6	2.4	2.0	0.0	2.4	1.8	0.3	0.3
1984	0.2	1.8	6.3	1.1	0.7	10.0	7.5	2.2	0.4
1985	–0.4	–0.7	1.7	0.3	0.0	0.8	0.7	0.6	–0.5
1986	–0.3	1.4	–0.1	1.1	0.0	2.0	–0.3	1.8	0.5
1987	1.3	1.9	0.1	0.5	0.3	4.0	1.9	2.2	–0.1
1988	2.5	2.0	0.0	0.9	0.3	5.7	3.6	1.9	0.2
1989	–0.5	2.2	–0.1	0.6	0.1	2.3	–0.7	1.9	1.1
1990	0.1	2.0	–0.1	0.5	3.4	5.8	2.7	1.5	1.6
1991	–0.6	–1.2	2.5	0.7	–0.1	1.2	1.9	–0.3	–0.4
1992	0.6	2.9	–0.7	–0.7	0.7	2.9	1.4	1.6	–0.1
1993	0.0	0.0	1.1	1.6	0.1	2.8	1.1	0.9	0.8
1994	0.0	4.0	1.7	0.6	–0.2	6.0	2.0	2.5	1.5
1995	–0.4	2.3	2.2	0.1	0.3	4.6	2.2	2.4	–0.1
1996	–0.4	0.4	3.1	0.7	0.0	3.8	3.1	0.7	0.0
1997	–0.5	1.1	0.8	0.1	0.6	2.1	0.3	1.3	0.5
1998	0.0	–0.1	–0.5	0.7	0.9	1.1	0.5	0.5	0.1
1999	–0.5	1.8	2.2	0.7	1.9	6.1	2.8	1.6	1.7
2000	0.0	1.1	1.8	0.1	0.1	3.1	3.2	1.0	–1.1
2001	0.9	–0.1	–1.0	–0.4	0.0	–0.7	–1.9	0.5	0.7
2002	–0.2	3.9	1.3	1.1	0.2	6.3	1.9	3.4	1.0
Descriptive statistics: 1972–2002									
Average	0.0	1.0	1.0	0.8	0.5	3.4	1.6	1.2	0.5
Std deviation	0.7	1.8	1.4	0.8	1.2	3.1	2.1	1.0	0.9
Range **b**	4.0	9.3	7.3	3.8	5.9	12.6	9.5	4.1	4.0
– maximum	2.5	7.0	6.3	3.1	5.6	11.2	7.5	3.7	2.6
– minimum	–1.6	–2.3	–1.0	–0.7	–0.3	–1.4	–2.0	–0.4	–1.5
% years < 0 **c**	48	29	23	6	23	13	23	6	29
Correlation **d**	0.3	0.8	0.4	0.4	0.4	1.0	0.9	0.7	0.6

53 Decomposition of annual growth in TFEC by fuel type and end use sector

Republic of Korea Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Elec-tricty	Other		In-dustry	Trans port	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.7	0.2	0.0	1.1	0.0	2.0	–0.3	–1.1	3.4
1973	8.9	16.8	0.0	1.2	0.0	26.9	11.1	4.5	11.2
1974	2.3	0.2	0.0	1.1	0.0	3.6	3.1	–0.9	1.4
1975	0.4	3.2	0.0	0.8	0.0	4.3	2.3	0.4	1.6
1976	2.5	7.9	0.0	1.4	0.0	11.8	6.4	1.4	3.9
1977	3.5	11.6	0.0	1.3	0.0	16.5	1.2	6.3	8.9
1978	0.6	8.5	0.0	1.6	0.0	10.7	6.1	2.9	1.7
1979	2.3	9.1	0.0	1.2	0.0	12.6	6.2	4.0	2.4
1980	2.6	–0.3	0.0	0.4	0.0	2.8	0.4	–2.6	5.0
1981	2.4	–2.7	0.0	0.7	0.0	0.5	–1.0	–3.1	4.6
1982	–1.0	–1.2	0.0	0.7	0.0	–1.5	–2.3	1.7	–1.0
1983	2.3	4.6	0.0	1.3	0.0	8.2	2.5	4.0	1.7
1984	3.0	4.9	0.0	1.1	0.0	9.0	2.1	1.7	5.2
1985	2.3	2.7	0.0	0.9	0.0	5.9	1.1	1.6	3.1
1986	1.4	6.6	0.0	1.2	0.0	9.2	3.0	3.0	3.2
1987	–0.3	7.1	0.0	1.6	0.0	8.5	3.8	3.6	1.2
1988	0.1	8.8	0.2	1.9	0.0	11.1	4.8	3.2	3.1
1989	–2.7	8.6	0.3	1.3	0.0	7.6	2.7	3.3	1.6
1990	–0.7	15.0	0.4	1.9	0.0	16.6	7.9	3.8	5.0
1991	–2.5	11.5	0.5	1.3	0.4	11.3	7.0	2.9	1.4
1992	–2.5	14.3	0.6	1.3	0.2	13.9	8.2	2.7	3.0
1993	–1.0	8.5	0.6	1.3	0.1	9.8	4.1	3.0	2.7
1994	–0.7	7.2	0.9	1.8	0.4	9.6	3.7	3.1	2.8
1995	–0.2	5.9	0.8	1.5	0.2	8.6	1.7	3.2	3.7
1996	0.2	4.4	1.2	1.6	0.3	7.7	2.9	2.2	2.7
1997	–0.2	3.8	1.3	1.4	0.2	6.3	4.0	0.3	2.1
1998	–0.6	–9.4	1.2	–0.5	0.1	–9.9	–0.8	–3.5	–5.6
1999	0.2	6.5	0.4	1.6	0.3	10.3	3.0	2.1	5.2
2000	0.8	0.7	1.8	1.4	0.3	4.6	2.8	1.9	–0.1
2001	0.4	–0.7	1.4	1.1	1.6	3.0	1.8	0.8	0.4
2002	1.1	1.2	0.5	2.9	–0.2	6.2	3.2	1.6	1.4
Descriptive statistics: 1972–2002									
Average	0.8	5.3	0.4	1.3	0.1	8.0	3.3	1.9	2.8
Std deviation	2.2	5.6	0.4	0.6	0.3	6.4	2.9	2.2	2.9
Range **b**	11.6	26.1	0.5	3.4	1.8	36.8	13.4	9.8	16.8
– maximum	8.9	16.8	1.8	2.9	1.6	26.9	11.1	6.3	11.2
– minimum	–2.7	–9.4	1.8	–0.5	–0.2	–9.9	–2.3	–3.5	–5.6
% years < 0 **c**	35	16	0.0	3	26	6	13	16	10
Correlation **d**	0.4	0.9	0	0.5	–0.1	1.0	0.8	0.8	0.8

54 Decomposition of annual growth in TFEC by fuel type and end use sector

Brunei Darussalam Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Elec-tricty	Other		In-dustry	Trans port	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.0	–4.0	0.0	0.0	0.0	–4.0	1.0	–7.1	2.0
1973	0.0	11.6	0.0	0.0	0.0	11.6	–1.1	13.7	–1.1
1974	0.0	10.4	0.0	0.0	1.9	12.3	4.7	8.5	0.0
1975	0.0	6.7	0.0	0.0	0.0	6.7	–0.8	7.6	0.0
1976	0.0	7.9	0.0	0.0	0.0	7.9	0.8	7.9	–0.8
1977	0.0	–2.9	0.0	0.0	0.7	–2.2	–10.9	8.0	0.0
1978	0.0	5.2	0.0	0.0	0.0	5.2	3.7	1.5	0.0
1979	0.0	12.8	0.0	0.0	0.0	12.8	6.4	7.1	0.0
1980	0.0	50.9	0.0	3.8	0.0	54.7	15.1	30.8	8.2
1981	0.0	–6.9	0.0	4.1	–0.4	–3.3	–4.9	–0.8	2.8
1982	0.0	10.5	0.0	2.9	0.0	13.4	2.9	5.9	4.2
1983	0.0	6.7	0.0	3.3	0.0	10.0	3.3	3.3	3.3
1984	0.0	–3.0	0.0	1.7	0.0	–1.3	–3.4	1.3	0.3
1985	0.0	4.8	0.0	0.3	0.3	5.5	1.4	3.1	1.4
1986	0.0	2.3	0.0	0.3	–0.3	2.3	–1.3	4.5	–0.6
1987	0.0	4.1	0.0	6.0	0.3	10.4	1.6	3.8	4.7
1988	0.0	7.4	0.0	1.4	–0.3	8.6	2.0	4.9	2.0
1989	0.0	2.6	0.0	0.5	0.3	3.4	1.1	0.5	1.3
1990	0.0	2.8	0.0	0.8	0.0	3.6	0.8	3.1	–0.3
1991	0.0	4.7	0.0	0.5	–0.2	4.9	0.5	4.9	0.0
1992	0.0	11.7	0.0	2.1	0.2	14.1	2.8	6.3	4.7
1993	0.0	5.1	0.0	3.9	–0.2	8.8	1.0	3.1	4.7
1994	0.0	4.5	0.0	2.6	0.0	7.2	0.9	3.8	2.5
1995	0.0	6.3	0.0	3.5	0.2	10.1	1.1	4.6	4.4
1996	0.0	6.6	0.0	3.2	0.0	9.8	1.3	5.0	3.5
1997	0.0	5.5	0.0	4.2	–0.1	9.6	1.5	4.1	4.2
1998	0.0	–8.4	0.0	1.1	0.0	–7.3	–2.8	–4.3	–0.4
1999	0.0	–4.0	0.0	–0.9	0.0	–4.9	–1.4	–2.6	–0.9
2000	0.0	–1.1	0.0	1.4	0.0	0.3	–1.1	0.0	1.4
2001	0.0	–0.3	0.0	–3.2	0.2	–3.3	–1.5	2.1	–3.9
2002	0.0	4.4	0.0	1.2	–0.2	5.5	0.8	3.9	0.8
Descriptive statistics: 1972–2002									
Average	0.0	5.3	0.0	1.5	0.1	6.8	0.8	4.5	1.6
Std deviation	0.0	10.1	0.0	1.9	0.4	10.7	4.1	6.3	2.5
Range b	0.0	59.3	0.0	9.2	2.3	62.0	26.0	37.9	12.1
– maximum	0.0	50.9	0.0	6.0	1.9	54.7	15.1	30.8	8.2
– minimum	0.0	–8.4	0.0	–3.2	–0.4	–7.3	–10.9	–7.1	–3.9
% years < 0 c	0	26	0	6	23	23	32	13	23
Correlation d	–	1.0	–	0.4	0.1	1.0	0.8	0.9	0.6

55 Decomposition of annual growth in TFEC by fuel type and end use sector

Chile Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–0.8	2.2	0.3	0.5	–0.6	1.6	0.9	–0.7	1.4
1973	–0.1	–1.8	0.3	–0.2	–0.4	–2.1	–0.4	–2.1	0.4
1974	–0.1	–1.3	0.4	0.7	1.1	0.8	2.9	–1.5	–0.7
1975	–2.1	–7.3	0.1	–0.7	0.2	–9.8	–5.1	–3.6	–1.1
1976	0.0	2.1	0.2	0.7	1.0	4.0	2.3	0.6	1.1
1977	0.4	3.2	0.0	0.6	1.1	5.3	2.5	1.5	1.2
1978	–0.4	3.6	0.1	0.7	1.6	5.6	2.4	3.3	0.0
1979	–0.4	1.5	0.1	0.7	0.7	2.7	0.5	1.9	0.2
1980	0.7	2.0	–0.1	0.5	1.1	4.2	1.8	2.2	0.2
1981	0.2	1.2	0.0	0.4	0.1	1.9	–1.1	2.1	0.9
1982	–2.6	–4.1	0.1	–0.2	0.7	–6.1	–4.6	–1.8	0.3
1983	1.2	–0.2	0.2	0.4	2.2	3.8	4.3	–0.2	–0.3
1984	1.4	0.6	0.1	1.0	1.8	4.8	3.6	0.0	1.3
1985	0.5	–1.2	–0.1	0.5	0.5	0.2	–0.1	–0.4	0.7
1986	0.9	3.3	0.1	0.8	0.8	5.9	1.8	1.3	2.8
1987	–0.4	2.2	–0.1	0.5	1.3	3.5	0.8	2.0	0.8
1988	0.8	6.1	0.1	1.1	0.8	8.9	3.1	3.7	2.1
1989	0.2	4.9	0.0	1.0	0.2	6.3	2.1	2.2	2.0
1990	0.6	2.2	0.1	0.5	1.7	4.9	0.9	1.3	2.8
1991	0.5	2.9	0.1	1.3	3.0	7.7	3.1	2.1	2.5
1992	1.3	5.1	0.1	1.8	2.3	10.6	5.8	2.1	2.7
1993	–0.5	4.9	0.0	0.7	–2.0	3.1	–1.1	2.8	1.5
1994	–0.7	3.7	0.1	0.7	1.0	4.9	0.0	3.2	1.7
1995	0.0	5.1	0.1	1.7	1.4	8.2	3.9	2.9	1.3
1996	0.7	4.1	0.1	1.5	1.2	7.6	2.9	3.0	1.6
1997	2.4	5.4	1.7	1.5	–0.2	10.9	7.0	2.1	1.7
1998	–2.3	–0.8	0.1	0.7	1.0	–1.2	–2.5	1.8	–0.5
1999	0.0	–0.6	0.4	1.9	1.1	2.8	1.1	0.6	1.2
2000	–1.0	0.3	2.3	0.9	1.4	3.9	2.7	0.3	1.0
2001	0.9	–1.6	0.8	1.3	–0.9	0.5	0.7	–1.2	1.0
2002	–0.8	0.2	0.5	0.7	0.7	1.3	0.0	1.1	0.2
Descriptive statistics: 1972–2002									
Average	0.0	1.5	0.3	0.8	0.8	3.4	1.4	1.1	1.0
Std deviation	1.1	3.0	0.5	0.6	1.0	4.4	2.6	1.8	1.0
Range **b**	5.0	13.4	2.3	2.6	5.0	20.6	12.1	7.3	3.9
– maximum	2.4	6.1	2.3	1.9	3.0	10.9	7.0	3.7	2.8
– minimum	–2.6	–7.3	–0.1	–0.7	–2.0	–9.8	–5.1	–3.6	–1.1
% years < 0 **c**	45	29	10	10	16	13	23	29	13
Correlation **d**	0.7	0.9	0.1	0.8	0.4	1.0	0.9	0.8	0.7

56 Decomposition of annual growth in TFEC by fuel type and end use sector

Malaysia Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–0.2	–3.9	0.1	0.8	0.9	–2.4	–5.5	1.1	2.0
1973	0.1	1.1	0.0	0.7	0.8	2.8	–2.4	4.2	1.0
1974	0.1	12.1	0.2	0.7	0.8	13.9	8.6	2.0	3.4
1975	0.0	3.3	0.1	0.7	1.2	5.3	0.2	2.8	2.3
1976	0.1	2.8	0.1	0.9	–0.1	3.7	2.4	1.0	0.3
1977	0.0	–3.9	–0.1	1.4	0.3	–2.3	–2.2	–1.8	1.8
1978	0.2	6.9	0.1	0.9	0.7	8.8	3.1	0.7	5.0
1979	0.2	9.5	0.0	1.3	–0.1	10.9	5.1	3.4	2.4
1980	0.3	7.8	0.0	0.9	0.3	9.3	4.1	3.9	1.3
1981	0.6	6.8	0.1	0.7	0.4	8.7	4.9	2.6	1.2
1982	–0.1	2.4	0.1	0.8	0.4	3.6	–0.6	2.6	1.6
1983	1.9	4.7	0.0	0.8	0.3	7.7	1.7	4.6	1.5
1984	0.2	–0.1	0.9	0.9	0.5	2.5	–0.1	1.5	1.0
1985	1.0	0.5	3.7	0.7	0.0	5.8	3.9	0.8	1.1
1986	–1.0	2.4	5.0	0.9	0.2	7.5	2.5	3.7	1.3
1987	0.6	3.8	0.7	0.8	0.7	6.5	3.6	1.9	0.9
1988	–1.2	5.0	–0.6	1.3	0.3	4.6	–0.2	3.2	1.6
1989	3.5	7.3	0.1	1.3	0.3	12.5	8.6	3.5	0.4
1990	–0.6	9.3	0.2	1.3	0.3	10.4	4.2	5.5	0.7
1991	0.6	7.6	0.2	1.4	0.0	9.8	3.6	2.9	3.3
1992	0.5	6.5	1.4	1.8	0.2	10.3	4.3	2.7	3.3
1993	0.2	5.3	1.8	1.3	0.2	8.8	8.1	1.2	–0.5
1994	–0.6	4.3	0.7	2.5	0.1	7.0	–1.0	3.7	4.3
1995	0.6	10.5	0.3	2.2	0.1	13.7	9.2	2.7	1.7
1996	0.1	4.9	2.1	1.7	0.1	9.0	0.3	4.8	3.8
1997	0.0	5.4	0.0	2.8	0.0	8.3	4.3	4.9	–0.9
1998	0.1	–4.0	0.9	1.4	0.0	–1.6	–0.2	–1.5	0.1
1999	–0.6	4.8	1.0	–0.1	0.1	5.2	–0.2	5.9	–0.5
2000	1.3	2.8	2.7	1.5	0.1	8.4	5.1	2.4	0.9
2001	0.0	2.4	2.2	1.1	–0.2	5.5	1.6	3.5	0.4
2002	0.3	1.0	2.8	1.0	0.2	5.3	3.2	0.9	1.2
Descriptive statistics: 1972–2002									
Average	0.3	4.2	0.9	1.2	0.3	6.8	2.6	2.6	1.5
Std deviation	0.9	4.0	1.3	0.6	0.3	4.1	3.5	1.8	1.4
Range **b**	4.7	16.1	5.6	3.0	1.4	16.3	14.7	7.7	5.9
– maximum	3.5	12.1	5.0	2.8	1.2	13.9	9.2	5.9	5.0
– minimum	–1.2	–4.0	–0.6	–0.1	–0.2	–2.4	–5.5	–1.8	–0.9
% years < 0 **c**	32	13	13	3	16	10	29	6	10
Correlation **d**	0.3	0.9	0.0	0.3	–0.1	1.0	0.8	0.5	0.2

57 Decomposition of annual growth in TFEC by fuel type and end use sector

Mexico Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.3	6.1	1.1	0.7	0.1	8.4	3.1	3.5	1.8
1973	0.4	3.4	2.0	0.6	0.5	7.0	3.1	2.9	1.0
1974	0.1	6.1	0.2	0.7	0.3	7.4	3.0	3.2	1.3
1975	–0.1	6.9	1.0	0.5	0.0	8.3	3.5	2.1	2.7
1976	0.2	5.9	0.5	0.6	0.0	7.3	3.2	2.9	1.2
1977	0.3	1.2	0.7	0.6	0.2	3.0	0.5	2.0	0.6
1978	0.2	5.4	3.8	0.8	0.6	10.7	6.4	2.8	1.6
1979	0.0	5.3	2.4	0.6	0.3	8.6	2.7	4.5	1.4
1980	–0.2	5.8	1.8	0.6	0.0	7.9	1.1	4.2	2.6
1981	0.1	6.8	3.0	0.6	–0.1	10.5	5.5	4.1	0.9
1982	–0.2	1.6	0.8	0.7	0.2	3.1	1.7	–0.1	1.5
1983	0.5	–3.1	1.3	0.1	0.1	–1.1	3.5	–3.6	–0.9
1984	0.0	3.8	–2.4	0.5	0.3	2.1	–0.5	1.6	1.0
1985	0.0	3.0	0.4	0.5	0.0	3.9	2.8	0.4	0.8
1986	–0.4	–0.9	–2.7	0.3	0.2	–3.5	–2.6	–0.3	–0.6
1987	0.2	2.5	1.4	0.5	0.3	4.9	3.0	0.8	1.0
1988	–0.5	0.9	–0.4	0.5	–0.3	0.1	–1.2	0.4	1.0
1989	0.4	4.5	–0.6	0.7	0.0	4.9	1.6	3.4	–0.1
1990	–0.1	1.5	1.4	0.5	–0.1	3.2	–0.7	2.6	1.3
1991	–0.2	2.4	0.9	0.3	0.4	3.7	0.6	2.6	0.6
1992	0.1	2.6	–0.5	0.3	–0.1	2.3	–0.2	0.8	1.8
1993	0.0	–0.2	0.0	0.0	0.3	0.1	0.2	0.8	–1.0
1994	0.2	1.5	0.9	0.8	–0.3	3.0	0.9	0.9	1.2
1995	0.2	–3.2	1.4	0.4	0.3	–1.0	1.8	–1.4	–1.4
1996	0.2	–1.7	–1.2	0.8	0.0	–1.9	–1.0	–1.1	0.2
1997	0.2	1.1	–1.5	0.9	0.2	0.9	–0.4	0.9	0.4
1998	0.0	1.5	–2.0	0.5	–0.4	–0.3	–2.2	1.3	0.6
1999	–0.9	–0.9	–1.2	0.7	–0.5	–2.9	–1.9	0.1	–1.0
2000	0.0	2.9	–0.4	1.0	0.0	3.5	–0.2	1.9	1.8
2001	–0.3	0.1	–2.0	0.1	0.1	–2.0	–2.6	0.7	0.0
2002	–0.1	–1.0	0.6	0.4	0.0	–0.1	–0.8	0.6	0.1
Descriptive statistics: 1972–2002									
Average	0.0	2.3	0.3	0.5	0.1	3.3	1.1	1.5	0.7
Std deviation	0.3	2.9	1.6	0.2	0.3	4.0	2.3	1.8	1.0
Range **b**	1.4	10.1	6.4	0.9	1.1	14.3	9.0	8.1	4.1
– maximum	0.5	6.9	3.8	1.0	0.6	10.7	6.4	4.5	2.7
– minimum	–0.9	–3.2	–2.7	0.0	–0.5	–3.5	–2.6	–3.6	–1.4
% years < 0 **c**	42	23	39	0	35	26	39	16	23
Correlation **d**	0.4	0.9	0.7	0.4	0.3	1.0	0.8	0.8	0.7

58 Decomposition of annual growth in TFEC by fuel type and end use sector

Russian Federation Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–	–	–	–	–	–	–	–	–
1973	–	–	–	–	–	–	–	–	–
1974	–	–	–	–	–	–	–	–	–
1975	–	–	–	–	–	–	–	–	–
1976	–	–	–	–	–	–	–	–	–
1977	–	–	–	–	–	–	–	–	–
1978	–	–	–	–	–	–	–	–	–
1979	–	–	–	–	–	–	–	–	–
1980	–	–	–	–	–	–	–	–	–
1981	–	–	–	–	–	–	–	–	–
1982	–	–	–	–	–	–	–	–	–
1983	–	–	–	–	–	–	–	–	–
1984	–	–	–	–	–	–	–	–	–
1985	–	–	–	–	–	–	–	–	–
1986	–	–	–	–	–	–	–	–	–
1987	–	–	–	–	–	–	–	–	–
1988	–	–	–	–	–	–	–	–	–
1989	–	–	–	–	–	–	–	–	–
1990	–	–	–	–	–	–	–	–	–
1991	–	–	–	–	–	–	–	–	–
1992	–	–	–	–	–	–	–	–	–
1993	0.1	–3.5	1.0	–0.7	–0.5	–3.7	15.0	–3.0	–15.7
1994	–1.1	–4.8	–3.1	–1.1	–4.0	–14.1	–8.0	–2.0	–4.0
1995	0.8	–0.6	–1.3	–0.3	–2.9	–4.3	–0.5	–1.3	–2.4
1996	–1.1	–1.1	–0.9	–0.3	–6.4	–9.8	–5.1	–0.8	–3.9
1997	–1.0	–0.1	–1.3	–0.2	–1.6	–4.2	–1.0	–1.4	–1.7
1998	–0.1	–2.1	0.8	–0.2	–0.4	–2.1	–2.6	2.7	–2.2
1999	0.5	2.0	0.7	0.3	0.4	3.9	1.5	0.2	2.2
2000	0.3	2.3	0.6	0.3	0.0	3.4	3.6	–0.9	0.7
2001	0.2	0.3	0.0	0.2	–0.1	0.6	–0.3	0.6	0.3
2002	–0.3	–0.9	–0.4	0.0	–1.5	–3.0	–0.6	0.5	–2.9
Descriptive statistics: 1993–2002									
Average	–0.2	–0.9	–0.4	–0.2	–1.7	–3.3	0.2	–0.6	–3.0
Std deviation	0.7	2.2	1.3	0.4	2.2	5.5	6.1	1.6	4.9
Range **b**	1.9	7.0	4.1	1.4	6.8	18.0	23.1	5.6	17.9
– maximum	0.8	2.3	1.0	0.3	0.4	3.9	15.0	2.7	2.2
– minimum	–1.1	–4.8	–3.1	–1.1	–6.4	–14.1	–8.0	–3.0	–15.7
% years < 0 **c**	50	70	50	60	90	70	70	60	70
Correlation **d**	0.7	0.8	0.8	0.9	0.8	1.0	0.5	0.4	0.4

59 Decomposition of annual growth in TFEC by fuel type and end use sector

Thailand Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–0.1	6.4	0.0	0.7	0.9	7.9	1.5	4.6	1.8
1973	0.1	5.9	0.0	0.8	1.2	7.9	1.2	3.5	3.2
1974	0.1	–2.0	0.0	0.3	4.1	2.5	1.3	–3.0	4.2
1975	–0.1	2.5	0.0	0.7	10.0	13.1	–3.5	2.1	14.5
1976	0.1	5.2	0.0	0.7	2.2	8.1	4.0	3.3	0.8
1977	0.1	1.7	0.0	0.8	1.9	4.6	2.5	0.7	1.3
1978	0.1	2.5	0.0	0.8	–2.1	1.3	–1.0	1.2	1.1
1979	0.1	4.4	0.0	0.6	2.9	8.0	4.7	2.2	1.1
1980	0.1	–1.8	0.0	0.4	–2.9	–4.2	–2.6	–0.7	–0.9
1981	0.0	0.0	0.0	0.3	3.2	3.4	2.4	0.8	0.2
1982	0.7	–0.6	0.0	0.6	3.1	3.8	2.3	0.2	1.3
1983	0.0	4.5	0.2	0.9	–13.0	–7.4	–0.2	4.0	–11.2
1984	0.3	4.7	0.9	1.0	3.3	10.2	2.4	4.5	3.3
1985	0.8	0.8	–0.1	0.7	4.4	6.5	1.6	1.6	3.3
1986	0.4	3.0	–0.4	0.9	2.4	6.2	0.4	2.0	3.8
1987	0.9	5.4	–0.2	1.2	1.3	8.7	1.6	4.6	2.5
1988	0.7	6.7	0.1	1.4	1.2	10.2	2.1	5.1	3.0
1989	1.2	9.3	0.2	1.7	5.3	17.6	7.1	6.5	4.0
1990	0.9	6.9	0.5	1.7	0.6	10.6	3.3	4.2	3.0
1991	0.7	1.9	0.3	1.4	1.3	5.7	2.7	0.9	2.0
1992	0.5	5.6	0.2	1.6	1.4	9.3	5.0	3.1	1.3
1993	2.3	5.6	0.1	1.7	–3.2	6.4	2.0	4.9	–0.5
1994	1.5	6.7	0.2	1.4	–0.7	9.1	5.7	4.2	–0.8
1995	1.4	7.4	0.4	1.8	1.1	12.1	5.9	5.9	0.3
1996	1.7	6.7	0.3	1.1	0.1	10.0	5.5	3.3	1.2
1997	–0.9	0.9	0.0	0.9	0.4	1.2	–2.0	0.2	3.0
1998	–1.5	–5.2	–0.1	–0.3	–1.4	–8.5	–4.6	–3.8	0.0
1999	1.1	3.1	0.5	0.2	0.9	5.8	5.4	–0.1	0.5
2000	–0.6	1.2	0.5	1.1	0.5	2.7	2.1	–0.4	1.1
2001	1.4	2.5	0.3	0.7	–1.3	3.6	1.4	1.1	1.1
2002	1.5	2.1	0.3	1.3	1.1	6.3	3.8	1.7	0.9
Descriptive statistics: 1972–2002									
Average	0.5	3.4	0.1	0.9	1.0	5.9	2.1	2.2	1.6
Std deviation	0.8	3.2	0.3	0.5	3.6	5.5	2.8	2.5	3.6
Range **b**	3.7	14.4	1.4	2.2	23.0	26.1	11.7	10.3	25.7
– maximum	2.3	9.3	0.9	1.8	10.0	17.6	7.1	6.5	14.5
– minimum	–1.5	–5.2	–0.4	–0.3	–13.0	–8.5	–4.6	–3.8	–11.2
% years < 0 **c**	19	16	13	3	23	10	19	16	16
Correlation **d**	0.5	0.7	0.3	0.6	0.6	1.0	0.6	0.7	0.6

60 Decomposition of annual growth in TFEC by fuel type and end use sector

Peru Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Elec-tricty	Other		In-dustry	Trans port	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–0.2	–0.5	0.0	0.4	0.4	0.1	1.1	1.6	–2.6
1973	0.3	2.8	0.0	0.2	0.5	3.8	1.4	2.8	–0.3
1974	–0.1	4.9	0.0	0.4	0.5	5.7	1.1	–0.4	5.0
1975	0.0	2.8	0.3	0.3	–1.0	2.4	3.1	1.5	–2.2
1976	–0.1	0.7	0.0	0.3	0.3	1.2	0.2	–0.6	1.5
1977	0.0	–2.7	0.1	0.6	0.4	–1.6	0.2	–1.5	–0.2
1978	0.0	–0.6	0.0	0.1	0.1	–0.5	–0.1	–1.1	0.6
1979	0.0	2.0	–0.1	0.4	–0.1	2.2	1.4	0.8	0.1
1980	0.1	2.7	0.0	0.6	–0.3	3.0	0.6	2.2	0.3
1981	0.2	3.5	0.0	0.6	0.3	4.7	0.3	2.7	1.7
1982	–0.1	–1.1	0.1	0.6	1.1	0.5	–0.7	–0.6	1.8
1983	0.0	–8.3	–0.4	–0.4	0.4	–8.7	–3.4	–2.0	–3.2
1984	–0.1	1.0	0.6	0.9	0.4	2.8	0.7	0.1	2.0
1985	0.4	–1.2	–0.1	0.1	–0.2	–0.9	1.0	–1.6	–0.4
1986	0.1	4.1	0.0	0.6	–2.6	2.1	–0.5	1.5	1.1
1987	–0.1	6.1	–0.2	0.6	–2.1	4.3	1.0	3.5	–0.2
1988	0.1	0.1	0.1	–0.5	–2.0	–2.2	–2.2	0.1	–0.1
1989	0.1	–6.9	–0.1	–0.6	–1.4	–9.0	–3.1	–2.5	–3.3
1990	–0.3	0.1	–0.1	1.0	–1.0	–0.2	0.1	1.6	–1.9
1991	1.1	–1.7	0.0	0.9	–1.1	–1.0	1.4	–3.1	0.7
1992	1.1	0.2	–0.4	–2.1	–1.0	–2.2	–3.5	1.8	–0.6
1993	–0.1	3.2	–0.2	1.4	–1.1	3.1	2.6	0.8	–0.2
1994	0.1	4.3	0.0	0.5	–0.5	4.3	–1.0	4.0	1.3
1995	0.0	8.3	0.0	0.5	–0.3	8.3	3.8	2.7	1.8
1996	0.2	3.5	0.0	1.0	–0.4	4.4	2.1	2.0	0.3
1997	0.1	–0.7	0.0	0.6	–0.1	–0.1	0.0	–0.1	0.0
1998	0.4	–1.6	0.0	0.9	0.0	–0.2	1.3	0.5	–2.0
1999	–0.1	7.7	0.0	0.5	–0.2	7.8	4.3	1.8	1.7
2000	0.8	–2.9	0.0	0.6	0.0	–1.4	0.4	–0.9	–1.0
2001	–0.5	–3.8	0.0	0.7	0.2	–3.3	–1.6	–1.7	0.0
2002	0.8	–0.1	0.0	0.9	0.0	1.6	1.9	–1.9	1.6
Descriptive statistics: 1972–2002									
Average	0.1	0.8	0.0	0.4	–0.4	1.0	0.4	0.5	0.1
Std deviation	0.4	3.7	0.2	0.6	0.9	3.9	1.9	1.9	1.7
Range **b**	1.6	16.6	1.1	3.5	3.7	17.3	7.7	7.1	8.3
– maximum	1.1	8.3	0.6	1.4	1.1	8.3	4.3	4.0	5.0
– minimum	–0.5	–8.3	–0.4	–2.1	–2.6	–9.0	–3.5	–3.1	–3.3
% years < 0 **c**	39	42	52	13	58	42	29	42	48
Correlation **d**	–0.2	1.0	0.3	0.4	0.1	1.0	0.8	0.7	0.7

61 Decomposition of annual growth in TFEC by fuel type and end use sector

China Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	4.0	1.8	0.2	0.5	0.0	6.6	3.3	0.8	2.5
1973	1.1	1.9	0.2	0.5	0.0	3.7	1.5	0.7	1.5
1974	–0.7	4.0	0.3	0.1	0.0	3.6	2.3	0.8	0.5
1975	12.6	1.4	0.4	0.9	0.0	15.3	8.7	0.9	5.7
1976	1.0	3.2	0.2	0.2	0.0	4.5	3.7	0.2	0.7
1977	9.3	2.9	0.4	0.6	0.0	13.1	7.9	0.9	4.4
1978	6.0	2.3	0.4	0.8	0.0	9.5	5.5	0.7	3.3
1979	1.3	–1.6	0.1	0.6	0.0	0.4	–1.2	0.3	1.3
1980	–1.1	–3.4	0.0	0.4	2.3	–1.7	3.6	–0.3	–5.1
1981	0.6	–1.1	–0.1	0.2	0.1	–0.3	–1.7	0.0	1.3
1982	3.8	0.2	–0.1	0.5	0.0	4.5	3.0	0.5	1.0
1983	4.0	0.7	0.0	0.6	0.1	5.4	3.4	0.5	1.5
1984	6.9	1.0	0.1	0.5	0.1	8.7	5.5	0.6	2.6
1985	2.3	0.3	0.6	–0.1	0.2	3.3	–0.9	0.3	3.8
1986	3.0	1.5	0.2	0.6	0.2	5.5	2.8	0.6	2.1
1987	4.4	1.4	0.0	0.8	0.3	6.9	4.2	0.5	2.2
1988	4.2	1.3	0.2	0.7	0.0	6.5	3.6	0.5	2.3
1989	–0.4	0.6	0.2	0.5	0.3	1.1	0.5	0.3	0.3
1990	1.9	0.0	0.1	0.8	0.1	2.9	1.6	–0.4	1.7
1991	1.3	1.8	0.0	0.8	0.3	4.1	3.0	0.7	0.3
1992	0.9	1.2	–0.1	1.0	0.2	3.2	3.0	0.6	–0.3
1993	0.5	1.8	0.1	1.0	0.5	3.9	2.3	1.2	0.5
1994	2.1	0.9	0.1	1.2	38.7	43.1	5.2	–0.6	38.5
1995	1.5	1.5	0.0	0.5	–0.3	3.2	2.4	0.5	0.3
1996	1.5	1.9	0.0	0.7	0.4	4.6	2.6	0.3	1.7
1997	–7.0	1.4	0.0	0.3	0.1	–5.1	–4.9	0.7	–1.0
1998	–1.4	0.8	0.2	0.4	0.2	0.2	1.4	0.7	–2.0
1999	–5.9	1.3	0.1	0.6	0.5	–3.4	–4.9	0.6	1.0
2000	–2.5	1.5	0.2	1.1	0.5	0.8	–0.6	0.6	0.8
2001	–0.7	0.6	0.3	1.0	0.4	1.6	0.3	0.2	1.0
2002	0.2	1.7	0.2	1.4	0.6	4.1	2.2	0.6	1.3
Descriptive statistics: 1972–2002									
Average	1.8	1.1	0.2	0.6	1.5	5.1	2.2	0.5	2.4
Std deviation	3.8	1.4	0.2	0.3	6.9	8.2	3.0	0.4	7.0
Range **b**	19.6	7.4	0.8	1.5	39.0	48.2	13.6	1.7	43.5
– maximum	12.6	4.0	0.6	1.4	38.7	43.1	8.7	1.2	38.5
– minimum	–7.0	–3.4	–0.1	–0.1	–0.3	–5.1	–4.9	–0.6	–5.1
% years < 0 **c**	26	10	10	3	13	13	19	10	13
Correlation **d**	0.5	0.2	0.2	0.4	0.8	1.0	0.6	–0.3	0.9

62 Decomposition of annual growth in TFEC by fuel type and end use sector

Philippines Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.0	2.7	0.0	0.9	0.1	3.7	1.9	0.2	1.6
1973	0.0	3.4	0.0	2.0	0.2	5.6	2.8	0.7	2.2
1974	0.0	–4.8	0.0	0.0	3.0	–1.7	–2.0	–2.5	2.8
1975	0.0	7.9	0.0	0.3	–0.5	7.8	4.3	0.8	2.6
1976	0.0	1.1	0.0	0.7	2.2	4.0	0.6	–0.3	3.7
1977	1.0	1.0	0.0	0.1	0.9	2.9	1.1	0.3	1.5
1978	0.2	3.5	0.0	0.3	0.6	4.6	0.0	0.8	3.8
1979	0.0	–0.6	0.0	0.9	0.0	0.2	1.4	–0.5	–0.6
1980	0.4	–5.7	0.0	1.1	0.6	–3.7	–3.1	–2.8	2.1
1981	–0.3	–3.3	0.0	–1.2	–0.6	–5.4	–1.0	–1.6	–2.8
1982	0.2	2.9	0.0	0.2	0.5	3.9	1.5	2.2	0.1
1983	1.6	–0.2	0.0	1.0	1.6	4.1	0.1	–0.8	4.8
1984	0.6	–7.0	0.0	0.0	0.6	–5.9	–2.0	–0.6	–3.2
1985	0.2	–3.4	0.0	0.7	1.9	–0.7	–3.5	–0.6	3.4
1986	–0.8	2.0	0.0	–1.4	–0.3	–0.5	–1.3	0.8	0.0
1987	0.9	5.6	0.0	0.8	–0.9	6.4	1.9	1.9	2.6
1988	0.8	3.6	0.0	1.2	–0.9	4.8	3.8	1.5	–0.5
1989	–1.4	5.9	0.0	1.0	1.2	6.7	2.3	2.1	2.2
1990	0.3	2.0	0.0	0.1	0.7	3.1	–1.5	0.6	4.1
1991	1.4	–1.4	0.0	0.3	–0.4	–0.2	1.9	–1.4	–0.7
1992	–0.8	6.1	0.0	–0.4	–0.1	4.8	–0.6	2.4	2.9
1993	0.3	7.1	0.0	0.6	–1.3	6.6	1.0	2.2	3.5
1994	2.1	9.6	0.0	1.4	0.3	13.5	–1.3	16.6	–1.8
1995	0.2	4.8	0.0	0.9	7.0	13.0	15.0	2.7	–4.7
1996	0.2	4.3	0.0	1.0	1.8	7.4	0.9	3.8	2.7
1997	0.4	1.5	0.0	0.9	0.5	3.4	0.7	3.6	–0.9
1998	–0.7	0.3	0.0	–0.3	–0.4	–1.0	0.1	–0.7	–0.5
1999	–0.4	3.7	0.0	1.0	0.6	4.8	0.7	2.0	2.2
2000	–0.2	–1.2	0.0	1.0	0.6	0.1	–0.7	–0.3	1.1
2001	–0.3	0.0	0.0	0.9	0.7	1.3	0.8	1.9	–1.4
2002	0.7	1.3	0.0	–0.8	0.8	2.0	0.6	0.9	0.5
Descriptive statistics: 1972–2002									
Average	0.2	1.7	0.0	0.5	0.7	3.1	0.9	1.2	1.1
Std deviation	0.7	4.0	0.0	0.8	1.5	4.5	3.2	3.3	2.3
Range **b**	3.6	16.7	0.0	3.4	8.4	19.5	18.5	19.4	9.5
– maximum	2.1	9.6	0.0	2.0	7.0	13.5	15.0	16.6	4.8
– minimum	–1.4	–7.0	0.0	–1.4	–1.3	–5.9	–3.5	–2.8	–4.7
% years < 0 **c**	35	29	0	19	32	26	32	35	32
Correlation **d**	0.2	0.9	–	0.5	0.3	1.0	0.6	0.7	0.1

63 Decomposition of annual growth in TFEC by fuel type and end use sector

Indonesia Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Electricty	Other		Industry	Transport	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	0.0	2.3	0.1	0.0	1.1	3.5	0.4	0.7	2.4
1973	–0.1	1.9	0.0	0.0	1.1	2.9	0.4	0.6	2.0
1974	0.1	3.1	0.3	0.1	0.8	4.4	0.8	1.4	2.1
1975	0.1	3.9	0.3	0.1	1.4	5.8	1.8	1.1	2.9
1976	–0.1	1.9	0.1	0.1	1.2	3.2	0.3	0.8	2.1
1977	0.0	3.7	1.5	0.1	1.3	6.5	3.0	0.9	2.6
1978	0.0	4.6	1.2	0.1	1.2	7.2	3.3	1.4	2.5
1979	0.0	3.7	1.2	0.2	1.1	6.2	2.6	0.8	2.8
1980	0.1	4.4	1.1	0.2	1.0	6.7	2.9	1.6	2.2
1981	0.0	2.8	0.6	0.2	1.1	4.6	1.3	1.2	2.0
1982	0.0	0.7	0.0	0.2	1.0	2.0	0.1	0.7	1.2
1983	0.0	–0.8	1.0	0.2	1.0	1.4	1.2	–0.5	0.7
1984	0.0	–1.6	1.1	0.2	1.0	0.6	–0.1	0.2	0.5
1985	0.2	1.1	2.1	0.2	0.9	4.5	3.2	0.4	0.9
1986	0.0	0.0	1.0	0.3	0.9	2.2	0.3	0.8	1.1
1987	0.0	1.2	0.3	0.3	0.9	2.8	0.4	1.4	1.0
1988	0.2	3.1	0.2	0.4	0.9	4.9	1.4	1.2	2.3
1989	0.4	2.8	–0.9	0.5	0.8	3.7	–0.4	1.3	2.7
1990	0.0	4.1	0.2	0.6	3.4	8.3	3.7	2.3	2.3
1991	0.1	1.8	0.7	0.5	0.8	3.9	1.2	1.3	1.4
1992	0.0	2.6	1.1	0.4	0.8	4.9	1.1	1.3	2.5
1993	0.1	2.9	0.7	0.4	0.8	4.9	1.9	1.3	1.7
1994	0.7	3.5	–0.1	0.6	0.6	5.3	1.4	2.3	1.6
1995	0.2	2.8	1.1	0.7	0.5	5.2	2.5	1.4	1.4
1996	–0.2	3.5	0.4	0.7	0.3	4.8	0.7	2.2	1.9
1997	0.8	2.1	0.2	0.7	1.1	5.0	1.0	2.3	1.7
1998	0.9	–0.7	0.3	0.1	0.5	1.1	0.5	–0.3	0.9
1999	0.6	2.5	2.3	0.5	0.5	6.4	4.3	–0.4	2.5
2000	1.9	3.6	1.1	0.7	0.2	7.4	3.7	1.8	1.9
2001	–0.1	1.4	–0.7	0.4	0.5	1.5	–0.6	1.2	0.9
2002	0.3	–0.4	1.5	0.2	1.1	2.7	1.8	0.1	0.8
Descriptive statistics: 1972–2002									
Average	0.2	2.2	0.6	0.3	1.0	4.3	1.5	1.1	1.8
Std deviation	0.4	1.6	0.7	0.2	0.5	2.0	1.3	0.7	0.7
Range **b**	2.1	6.2	3.2	0.7	3.2	7.6	4.8	2.8	2.4
– maximum	1.9	4.6	2.3	0.7	3.4	8.3	4.3	2.3	2.9
– minimum	–0.2	–1.6	–0.9	0.0	0.2	0.6	–0.6	–0.5	0.5
% years < 0 **c**	32	13	10	0	0	0	10	10	0
Correlation **d**	0.2	0.9	0.3	0.4	0.3	1.0	0.8	0.5	0.7

64 Decomposition of annual growth in TFEC by fuel type and end use sector

Viet Nam Percentage point contributions

	By fuel type					Total final energy consumption	By end use sector		
	Coal	Oil	Gas	Elec-tricty	Other		In-dustry	Trans port	Other a
	% pt	% pt	% pt	% pt	% pt	%	% pt	% pt	% pt
1972	–5.5	1.3	0.0	–0.1	0.0	–4.3	–0.1	–2.6	–1.7
1973	6.5	–1.8	0.0	0.2	0.0	4.9	0.0	–1.3	6.2
1974	5.5	–35.5	0.0	–0.3	0.0	–30.3	0.0	–18.3	–12.0
1975	13.2	–4.6	0.0	0.5	0.0	9.1	0.1	–2.2	11.2
1976	–5.4	–45.0	0.0	0.7	0.0	–49.7	0.2	–26.6	–23.3
1977	4.1	1.3	0.0	1.3	0.0	6.7	–0.3	–3.6	10.5
1978	–2.5	6.8	0.0	0.3	0.0	4.6	0.1	0.9	3.6
1979	5.1	4.6	0.0	0.0	0.0	9.8	–0.3	1.2	8.8
1980	–13.0	17.7	0.0	–0.3	0.0	4.4	46.4	12.8	–54.8
1981	7.0	–7.7	0.0	0.2	0.0	–0.4	–0.7	–3.5	3.8
1982	7.0	–0.3	0.0	0.5	–0.1	7.1	4.3	0.6	2.2
1983	–1.8	5.8	0.0	0.3	0.0	4.3	6.5	1.7	–3.8
1984	–2.7	–0.8	0.0	1.2	0.0	–2.4	5.5	–0.4	–7.5
1985	–0.5	–0.4	0.0	0.6	0.0	–0.3	–1.9	9.7	–8.1
1986	4.7	5.3	0.0	0.7	0.0	10.7	4.9	3.1	2.7
1987	5.0	7.2	0.0	1.0	0.0	13.1	4.7	4.1	4.2
1988	–12.1	1.3	0.0	0.8	0.0	–10.0	–10.5	2.1	–1.6
1989	–3.3	–2.0	0.0	1.4	0.0	–3.9	–2.0	–2.6	0.7
1990	–3.9	8.5	0.0	1.1	0.0	5.7	–2.5	4.7	3.4
1991	6.5	–1.7	0.2	0.8	0.0	5.9	4.1	–1.8	3.6
1992	3.8	9.5	0.1	0.7	0.0	14.0	3.2	3.8	7.1
1993	0.3	19.0	0.0	1.5	0.0	20.8	3.1	16.3	1.4
1994	0.7	6.3	0.0	2.0	324.6	333.6	1.5	3.9	328.2
1995	2.9	1.0	0.0	0.6	1.2	5.8	3.1	–0.2	2.9
1996	0.3	2.3	0.0	0.7	3.4	6.6	0.9	0.9	4.8
1997	2.1	0.1	0.0	0.6	1.4	4.1	2.0	0.7	1.4
1998	–0.1	1.7	0.0	0.7	1.5	3.8	0.7	0.6	2.5
1999	–0.4	2.1	0.0	0.5	–1.6	0.5	0.4	0.9	–0.7
2000	0.2	1.7	0.0	0.8	0.9	3.4	1.1	0.9	1.4
2001	1.5	2.0	0.0	0.8	0.8	5.3	1.8	0.9	2.6
2002	0.8	3.7	0.0	1.0	0.8	6.3	2.1	2.5	1.7
Descriptive statistics: 1972–2002									
Average	0.8	0.3	0.0	0.7	10.7	12.6	2.5	0.3	9.7
Std deviation	5.5	12.2	0.0	0.5	58.3	61.0	8.7	7.5	60.3
Range b	26.3	64.0	0.2	2.3	326.3	383.3	56.9	42.8	383.0
– maximum	13.2	19.0	0.2	2.0	324.6	333.6	46.4	16.3	328.2
– minimum	–13.0	–45.0	0.0	–0.3	–1.6	–49.7	–10.5	–26.6	–54.8
% years < 0 **c**	39	32	19	10	29	26	26	35	29
Correlation **d**	0.1	0.3	0.1	0.5	1.0	1.0	0.0	0.3	1.0

impacts of oil supply disruption scenarios for nineteen APEC economies

Detailed GTEM simulation results for the oil supply disruptions in 2005 and 2020 are reported for nineteen APEC economies in tables 65 and 66 respectively. See chapter 6 for a discussion of the simulation results.

65 Impacts of 2005 oil supply disruption scenario, by APEC economy
relative to the reference case

	Real GNP	Primary energy consumption				Electricity consumption
		Total	Oil	Gas	Coal	
	%	%	%	%	%	%
Australia	–0.3	–3.4	–15.0	–0.1	0.9	0.5
Canada	0.3	–2.9	–11.0	0.2	0.2	0.3
Japan	–0.5	–2.8	–2.4	–7.0	0.1	0.1
New Zealand	–0.7	–1.4	–7.7	0.8	1.2	0.6
United States	–0.2	–2.3	–6.1	0.4	0.9	0.4
Hong Kong, China	–0.3	–1.0	na	4.3	0.0	0.0
Republic of Korea	–1.4	–2.4	–6.0	–8.7	1.1	1.2
Singapore	–2.1	–4.6	–13.8	12.5	na	0.7
Chinese Taipei	–0.7	–3.7	–6.8	–16.1	0.4	0.0
Chile	–1.1	–2.1	–6.4	2.0	0.2	0.8
China	–0.3	–0.2	–3.2	0.1	1.3	0.9
Indonesia	3.4	4.4	4.4	0.3	6.3	0.8
Malaysia	1.4	–2.5	–11.4	2.9	0.0	0.3
Mexico	0.9	–1.5	–8.1	6.7	2.8	–2.5
Peru	0.1	–21.7	–12.0	0.0	–0.2	–1.0
Philippines	–1.6	0.4	–4.9	–14.1	0.1	–0.7
Russian Federation	1.6	–6.4	–20.7	–0.8	–2.5	–2.1
Thailand	–1.1	–2.7	–7.2	1.1	0.6	0.5
Viet Nam	2.4	–3.9	na	0.9	–0.6	1.2

na Not available.

66 Impacts of 2020 oil supply disruption scenario, by APEC economy

relative to the reference case

	Real GNP	Primary energy consumption Total	Oil	Gas	Coal	Electricity consumption
	%	%	%	%	%	%
Australia	–0.3	–2.1	–11.3	0.8	0.9	0.8
Canada	0.1	–2.2	–8.6	0.1	0.4	0.4
Japan	–0.4	–2.8	–2.3	–5.8	0.0	0.1
New Zealand	–0.5	–1.4	–7.3	0.7	1.0	0.5
United States	–0.2	–3.0	–8.1	0.3	1.0	0.5
Hong Kong, China	0.2	–0.8	na	4.2	0.0	0.3
Republic of Korea	–1.0	–2.2	–5.4	–8.2	0.7	1.2
Singapore	–1.8	–4.9	–10.8	6.7	na	1.0
Chinese Taipei	–0.6	–4.6	–6.6	–15.0	0.4	–0.3
Chile	–1.2	–1.8	–6.6	2.0	0.3	1.2
China	–0.4	–1.6	–10.7	1.0	1.2	0.7
Indonesia	1.8	0.0	–3.1	1.0	3.1	1.1
Malaysia	0.3	–3.8	–11.2	0.4	0.0	0.7
Mexico	0.3	–1.4	–7.1	4.2	1.3	–1.6
Peru	–0.9	–9.4	–14.8	2.8	0.1	0.1
Philippines	–1.5	1.1	–1.2	–13.4	0.1	–0.5
Russian Federation	0.9	–6.4	–20.6	–0.7	–2.1	–1.5
Thailand	–1.1	–3.0	–7.4	0.5	0.3	0.2
Viet Nam	0.7	–4.1	na	1.1	–0.8	0.7

na Not available.

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