APEC ENERGY DEMAND AND SUPPLY OUTLOOK 2006

ENERGY AT THE CROSSROADS

ASIA PACIFIC ENERGY RESEARCH CENTRE

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FOREWORD

We are pleased to present the report, "APEC Energy Demand and Supply Outlook 2006". This is the third outlook by the Asia Pacific Energy Research Centre.

The objective of the study was to investigate some of the key issues likely to influence the future course of energy demand and supply in the APEC region and to draw policy implications.

This report is published by Asia Pacific Energy Research Centre as an independent study and does not necessarily reflect the views or policies of the APEC Energy Working Group or individual member economies. But we hope that it will serve as a useful basis for discussion and analysis both within and among APEC member economies for the enhancement of energy security, promotion of regional cooperation and sustainable development.

Asia Pacific Energy Research Centre

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List of Abbreviations

ABARE	Australian Bureau of Agriculture and Resource Economics
APEC	Asia Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Centre
ASEAN	Association of Southeast Asian Nations
AUS	Australia
BCM	billion cubic metres
BD	Brunei Darussalam
CCGT	combined cycle gas turbine
CDA	Canada
CAN$	Canadian Dollar
CHL	Chile
CNG	compressed natural gas
CO_2	carbon dioxide
CT	Chinese Taipei
DOE	Department of Energy (USA)
DSM	demand-side management
EDMC	Energy Data and Modelling Center (Japan)
EIA	Energy Information Administration (USA)
EWG	Energy Working Group (APEC)
FEC	final energy consumption
FED	final energy demand
FDI	foreign direct investment
FPI	foreign portfolio investment
FSU	Former Soviet Union
FT	Fischer-Tropsch technology
GDP	gross domestic product
GHG	greenhouse gases
g/kWh	grams per kilowatt-hour (used to measure the emissions caused by the generation of one unit of electricity)
GMS	Greater Mekong Sub Region
GNP	gross national product
GTL	gas to liquids
GW	gigawatt
GWh	gigawatt-hour
GWP	gross world product
HKC	Hong Kong, China
IDR	Indonesian Rupiah
IEA	International Energy Agency
IEEJ	Institute of Energy Economics, Japan
INA	Indonesia
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power producers
JPN	Japan
kgoe	kilogram of oil equivalent

ktoe	thousand tonnes of oil equivalent
LEAP	Long-term Energy Analysis Programme
LHV	lower heating value
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MAS	Malaysia
mbd	million barrels per day
MCM	million cubic metres
MEX	Mexico
MMBTU	Million British Thermal Units
MOU	Memorandum of Understanding
MSW	Municipal Solid Waste
Mtoe	million tonnes of oil equivalent
NAFTA	North American Free Trade Agreement
NGV	natural gas vehicle
NRE	new and renewable energy
NYMEX	New York Mercantile Exchange
NZ	New Zealand
PE	Peru
PNG	Papua New Guinea
PPP	purchasing power parity
PRC	People's Republic of China
PV	Photo-voltaic
R&D	research and development
ROK	Republic of Korea
RM	Malaysian Ringgit
RP	the Republic of the Philippines
R/P	reserves-to-production ratio
RUS	the Russian Federation
SIN	Singapore
SUVs	Sports Utility Vehicles
tcf	trillion cubic feet
toe	tonnes of oil equivalent
TPED	total primary energy demand
TPES	total primary energy supply
TWh	terawatt hours
US or USA	United States of America
WTO	World Trade Organisation
VN	Viet Nam

EXECUTIVE SUMMARY

Energy is an integral part of economic development and economies in the world, not to mention the APEC region is striving to optimise energy mixes in the face of rising energy prices and environmental concerns.

The APEC energy demand and supply outlook reveals that over the period through 2030 energy demand growth will be robust at around 2.0 percent per annum despite high energy prices. Growing demand will be met for the most part by conventional resources such as coal, natural gas, oil, and marginally by new and renewable energy sources. The continued heavy reliance on conventional energy sources is likely to raise long-term security concerns for energy supply as most APEC economies will soon become net energy importers.

ENERGY DEMAND AND SUPPLY BY SOURCES

The energy demand and supply balance will become tighter over the outlook period, as the region's annual primary energy production is expected to grow at only 1.5 percent, which is significantly lower compared with total primary energy demand growth of 2.0 percent per year. By 2030 the APEC region will swiftly move from a net exporter of natural gas and coal to a net importer. Oil import will increase from 36 percent of total oil demand in 2002 to 52 percent in 2030. Notwithstanding this increasing import dependency, the energy intensity of the APEC region is expected to drop by 40 percent through to 2030, reflecting somewhat drastic efficiency improvement for Russia, China, and the US. Likewise, with the exception of New Zealand, Canada, China and Hong Kong, China, the remaining APEC economies will improve their Energy Diversity Indicator – that assesses the distribution of energy sources in the primary energy mix (range of 1 to 100 points) – over the outlook period. However, the Energy Diversity Indicator is expected to decrease slightly for APEC as a whole, reflecting China's share in total primary energy demand.

Oil

- The transportation sector is projected to maintain the largest share of total oil demand at 57 percent (1,973 Mtoe) in 2030, compared with 50 percent (1,077 Mtoe) in 2002.
- APEC oil import dependency will rise from 35 percent in 2002 to 44 percent by 2030, and four current net oil exporting economies − Indonesia, Malaysia, Papua New Guinea and Viet Nam − will become net importers by 2030.
- Unconventional oil sources – oil sands, oil shale, and enhanced oil recovery will account for an increasing share of oil supply in the future.
- To meet the demand for transportation fuels approximately 40 percent additional refining capacity will need to be constructed, with considerable increase in upgrading capacity/cracking to produce the required volumes of gasoline and middle distillates.
- Stricter environmental regulations and fuel standards in most APEC economies will likely precipitate expansion of hydro-treatment capacity – to reduce sulphur composition in fuels.

Coal

- APEC's coal demand is expected to more than double from 1,570 Mtoe in 2002 to 3,366 Mtoe in 2030, growing at an annual rate of 2.8 percent – the fastest annual growth rate among fossil fuels, due in part to cost competitiveness and coal's wide availability compared with other fuels.
- Near-term growth in coal demand is projected to be faster than long-term. By 2010, coal demand is expected to grow at a robust pace of 4.4 percent pear year driven mainly by the rapid projected economic growth of China.
- Demand for coal in Thailand and Malaysia are projected to increase, as coal consumption would rise for electricity generation.
- With the technological innovation for CO_2 sequestration in the electricity generation and expected increase in production, the US coal demand is projected to increase faster in long-term than in near-term. Between 2002 and 2015, the US coal demand is projected to grow at 0.9 percent per year, while it is expected to grow at a faster rate of 1.9 percent per year between 2015 and 2030.
- Coal resources are also under pressure from depletion and production and transportation costs have and will continue to steadily go up.

- Temporary regional supply shortages of coal are foreseeable over the outlook period, particular in Northeast Asia as the coal export capacities of Indonesia and China are starting to decline.

Natural Gas

- Natural gas demand is expected to increase from 1,255 Mtoe in 2002 to 2,050 Mtoe in 2030, growing at an annual rate of 1.8 percent, lower than the average growth rate of energy demand.
- Increased demand for natural gas will not be met by increased production within APEC, as production growth is only projected at 0.7 percent per year and inter-economy pipeline trade will decline – for example, between Canada and the US, or Indonesia and Singapore. Thus APEC will likely become a net importer of natural gas by 2015.
- LNG is expected to become an important natural gas supply source; with total LNG imports expected to increase from 101 million tonnes in 2004 to 389 million tonnes in 2030. In addition to existing LNG importers – Japan, Korea, Chinese Taipei and the US – by 2030, Canada, China, Chile, Mexico, Singapore and the Philippines are expected to be LNG importers.
- APEC governments have a catalytic role in creating a framework with which the upstream investment of natural gas is guaranteed and both suppliers and consumers make the necessary commitments for long-term supply contracts.

Nuclear

- To enhance energy supply security, several APEC economies may expand the utilisation of nuclear energy for electricity generation. This growth will predominantly be centred in the traditional nuclear APEC economies which includes Viet Nam after 2015.
- The share of nuclear energy in total primary energy demand will remain stable at 6 percent between 2002 and 2030, while the share in electricity production will decline slightly from 16 percent in 2002 to 14 percent in 2030. China will lead nuclear growth at 10.5 percent per year.
- The main impediment to nuclear expansion is low public acceptance due to safety issues arising from fuel handling and operation of nuclear power.
- Significant effort will be necessary by the scientific, business and governmental communities worldwide for the development of advanced nuclear technologies that further strengthen operational safety and alleviate public risk.

ENERGY DEMAND BY SECTOR

Over the outlook period, final energy demand is projected to grow at 2.1 percent per year, compared with the annual growth in the previous two decades of 2.3 percent. Demand will almost double from 3,819 Mtoe in 2002 to 6,759 Mtoe in 2030. By sector, the industry sector will maintain the largest share at 41 percent, followed by transport (30 percent), residential (18 percent) and commercial (11 percent).

Industry

- APEC dominates the world's manufacturing sector with respect to the production of steel, cement, and petrochemicals. The industrial value-added is expected to grow robustly at an average annual rate of 4.5 percent, compared with GDP growth of 4.1 percent over the outlook period.
- Driven by the industrialisation of several member economies, industrial energy demand is projected to grow at an average annual rate of 2.4 percent, higher than the average annual growth of 1.9 percent over the past two decades.
- Due to the expansion of non-energy intensive industry in developed APEC economies as well as the enhancement of energy efficiency through technological development, energy intensity will improve significantly, from 223 toe per US$ million in 2002 to 127 toe per US$ million in 2030, declining at annual rate of 2.0 percent.
- Electricity accounts for the largest share in total industrial energy demand in 2030, driven by increase in the use of electricity-specific processes in manufacturing such as mechanical pulping techniques in the pulp industry and electric arc furnaces in the steel industry.

Residential and Commercial

- Income growth, improvements in living standards and changes in lifestyle are the key drivers leading electricity and natural gas demand in the residential sector.
- Electricity is projected to grow the fastest of all energy sources at an annual rate of 2.8 percent, with the share of electricity in total residential and commercial energy demand approaching 50 percent by 2030.
- Residential energy demand is expected to grow at 0.9 percent per year through 2030. The slow projected growth reflects fuel switching from biomass to commercial energy sources in some developing APEC economies.
- Energy intensity in the residential sector will decline at 3.0 percent per year, from 35 toe per US$ million in 2002 to 15 toe per US$ million in 2030.
- Rapid growth in the value added for services will result in a two-fold increase in energy demand in the commercial sector, reaching 770 Mtoe in 2030.
- Energy efficiency improvements in cooling systems/office equipment and more stringent building codes will greatly improve energy intensity in the commercial sector declining at an annual rate of 1.3 percent from 23 toe per US$ million in 2002 to 16 toe per US$ million in 2030.
- Energy efficiency standards and labelling schemes for buildings and appliances/office equipment have proven to be an effective approach to slowdown energy demand growth.
- Governments could amend the regulations, laws and codes related to the residential and commercial building standards to establish an integrated energy-economic perspective.

Transport

- APEC's transport energy demand will almost double from 1,087 Mtoe in 2002 to 1,991 Mtoe in 2030, growing at an annual rate of 2.2 percent.
- Much of the increase in transport energy demand will come from the road sub-sector, accounting for about 81 percent of incremental growth, followed by the air sub-sector at 16 percent.
- Rising income will translate into substantial increase in the number of passenger vehicles from 396 million in 2002 to 668 million in 2030, or 9.7 million new/replaced passenger vehicles will be added every year through 2030.
- Economic growth will boost the need for freight transport, handled primarily by the road sub-sector.
- Due to the heavy reliance on the road sub-sector and limited potential for alternative fuels, oil products will take the dominant portion of total transport energy demand at around 99 percent through 2030.
- Effective measures to rein in transport oil demand vary by economy. Developing economies need to establish a raft of comprehensive measures, including fuel standards, vehicle registration systems and urban rail transport infrastructure, while developed economies need to continue to provide a combination of regulatory and tax incentives to transfer consumer preference away from a heavy dependence on road transport.

Electricity

APEC's electricity demand will rise substantially from 8,109 TWh in 2002 to 19,163 TWh in 2030 at an average annual growth rate of 3.2 percent. Electricity demand in the industry sector is projected to grow the fastest at a rate of 3.5 percent per year, followed by commercial at 3.2 percent, residential at 2.4 percent and transport at 3.0 percent. The industry sector will maintain the largest share at 49 percent, followed by commercial (27 percent), residential (24 percent) and transport (1 percent).

- Electricity demand in Southeast Asia and China is projected to grow rapidly at 5.4 and 6.3 percent per year, due mainly to growing income and increased access to electricity networks.
- APEC's total generating capacity will increase by almost double, from 2,139 TW in 2002 to 4,208 TW in 2030, growing at an average annual rate of 2.4 percent.
- Due to resource availability and the relatively low price, the share of coal in the generation mix is expected to increase. The increasing coal share is further supported by the use of advanced "clean-coal" technologies and the advent of carbon capture.

- Continued improvement in the thermal efficiency of electricity generating technologies will lower the amount of input fuel relative to the amount of electricity produced. The total fuel requirements will grow at average annual rate of 2.6 percent, which is 0.6 percent lower than the growth of electricity demand and 0.3 percent lower than electricity generation.
- Nuclear could expand significantly in Asia, once issues surrounding safety, public acceptance and political concerns are addressed.
- Pursuing a coordinated and multi-pronged attack by APEC member economies to promote and develop technology for the reduction of emissions – such as advanced coal-fired generation, carbon capture and sequestration – and policies to expand the share of renewable energy in electricity generation could be one way to improve the environmental impacts from the electricity sector.
- Difficulties in siting infrastructure and a lack of fiscal incentives are the two main barriers holding back additional investment in electricity transmission facilities in the US. In addition, investment may be discouraged by regulatory uncertainty over transmission pricing.
- In relation to oil and gas exploration and development, the investment environment has not always been favourable to investors. They not only have to deal with the risks arising from the geological conditions in finding profitable hydrocarbon deposits, but must also cope with difficulties above the ground that can arise through negotiations with host governments.
- Cooperation among APEC economies should be strengthened to promote a more regional view of energy security, with energy investment also allocated for the construction of natural gas pipelines and power interconnections that extend beyond borders.

ENERGY INVESTMENT OUTLOOK

The total investment requirements of the APEC region for the energy sector over the outlook period are estimated between US$5.95 and US$7.55 trillion. Major investment is expected in electricity generation and transmission estimated at US$4.8 trillion over the same period, which represents 60 percent of total investment requirement. Following the electricity sector is oil and gas production and processing (18 percent), domestic oil and gas pipelines (9 percent), international trade of oil and gas (8 percent), and coal production and transportation (5 percent).

- The energy investment requirement for China is the highest at US$2.3 trillion to support projected economic growth, followed by the US at US$ 1.7 trillion.
- For the APEC region the average total investment share in terms of GDP is 0.7 percent, with only six economies below this level – Japan, Hong Kong, China, New Zealand, the US, Chinese Taipei and Singapore.
- Five developing economies have an energy investment requirement greater than 2.0 percent of GDP. This will be problematic not only in terms of the portion of economic output, but also in terms of financing because the capital markets of these economies are less developed and offer fewer options for obtaining funds.

ENVIRONMENT

In 2030, emissions of various gases from energy consumption will be twice as high as the equivalent level in 2002. An estimated 155 million tonnes of sulphur dioxide (SO_2), 121 million tonnes of nitrogen oxides (NO_X), and 27,364 million tonnes of carbon dioxide (CO_2) will be emitted from energy consumption in 2030.

- The electricity sector will experience the fastest annual growth of SO_2, NO_X and CO_2 emissions at 2.9, 2.8 and 2.7 percent respectively. While, in the transportation and industry sectors, the growth rates of emissions are expected to be between 2.0 to 2.3 percent for all emission types.
- The accumulated Carbon Offset Price (COP) – the monetary value of CO_2 emissions if converted – in the APEC region is estimated to be US$14,708 billion, of which China and the US combined will account for the largest share at 65 percent.
- COP per capita as a quotient of GDP per capita is expected to reduce over the outlook period due mostly to technological advances, improvement in energy efficiency and reduction in the share of energy intensive industries in the region.
- In the APEC region, Chinese Taipei is expected to have the highest SO_2 emissions

per capita at 131 kg in 2030 as coal will become the leading fuel for electricity generation, followed by Australia at 116 kg per person.

- Singapore is projected to have the highest per capita NO_X emissions in 2030 at 159 kg per person because of increasing number of diesel-fuelled trucks for freight transport, followed by the US at 112 kg per person.
- Responding to environmental problems is a big challenge as the magnitude is influenced by energy demand growth and the type of energy sources utilised. Therefore, to reduce the environmental impacts, technologies to reduce and/or prevent the release of emissions could be established and instigated. However, the "cost factor" of implementation should be taken into consideration as it may affect the economy's competitive edge.

MAJOR ISSUES

Urbanisation and Energy Demand

- Growth in urban energy demand will be increasingly led by the growth in transport, residential and commercial sectors.
- At the early stages of economic development, urban energy consumption tends to be dominated by the energy-intensive industry sector. As economic development progresses, the industrial plants are generally relocated to the outside of the urban area due to high land cost and stricter environmental regulations.
- Urban transport energy demand is expected to grow robustly in particular, due to the rising vehicle stocks and the difficulty of shifting urban lifestyles away from dependence on vehicles.
- Rising vehicle use in urban areas might result in worsening air quality problems. In addition, rising vehicle dependence could pose threat to the enhancement of oil supply security because the potential for alternative fuels are still limited.
- The challenges posed by rising urban transport energy demand need to be overcome by bringing together the efforts of government – both local and central – and the private sector. Coordination among different policy goals, including those for energy, transportation, urban planning, and construction, are essential to minimise the impacts to energy security and the environment arising from urban transportation energy demand growth.

Energy Resource Constraints

- Projected cumulative extraction of oil and natural gas over the outlook period will substantially exceed current proven reserves for the six largest APEC energy producers namely; Australia, Canada, China, Indonesia, Russia and the US, thus enormous efforts should be put to exploration activity. Only in the case of Russian natural gas will cumulative production not exceed reserves.
- China and Indonesia will have to enhance proved reserves of coal in order to meet projected coal production levels.
- Regulatory and institutional constraints on which energy sources can be developed, utilised, and traded can impact on energy markets, disrupting the demand-supply balance and affecting prices.

Energy Transportation

- Energy transportation plays an important role in energy security therefore; the timely expansion of energy transportation infrastructure will be needed for shipping (oil tankers, LNG carriers, and bulk carriers), oil and gas pipelines, and electricity transmission lines.
- The shipping capacity requirement to meet APEC's oil demand will increase by 62 million deadweight tonnes to 230 million deadweight tonnes in 2030, of which 67 percent of this growth will be accounted for by China and the US. In 2030 a projected 194 thousand km of new pipelines will be required to transport an estimated 10.9 million B/D of oil.
- LNG will play a vital role to fill the gap between increasing demand and declining transportation of natural gas by pipeline. By 2030, an additional 81 LNG receiving terminals and 13 LNG liquefaction terminals are necessary to meet the projected demand. In addition, about 320 thousand km of additional pipelines will be required to facilitate both domestic and trans-boundary transport of natural gas.
- To meet electricity demand an additional 2.63 million km of transmission lines will be required by 2030.

- APEC policy makers need to create fair fiscal conditions that ensure investment is undertaken in a timely manner to facilitate the necessary domestic and international transportation requirements.
- Most oil and natural gas imports bound for Northeast Asia will pass through the Straits of Malacca adding to the congestion of maritime traffic and impacting on energy supply security policies for these economies.

Water and Energy Demand

- The distribution of water resources in the APEC region is not uniformly apportioned with some economies having a disproportionately large share of resources compared with others. Thus, the energy sector must compete with other water users for the allocations of water resources and this can have serious implications for the siting of new energy related infrastructure.
- Areas of Australia, China, Japan and the US suffer from a degree of water stress and scarcity, especially in regions of high population density.
- How the water/energy nexus is dealt with could have profound implications for electricity supply security in the APEC region and may impinge on how expansion of the electricity sector is undertaken and which mix of fuels can effectively be utilised for generation.

Human Resource Constraints

- The availability of reliable and quality human resources is a vital requirement for the continued functionality and success of the energy industry.
- A shortage of human resources, both in quantitative and qualitative terms, not only affects the future development of the energy sector, but also poses a threat to safety in energy related operations and raises the prospect of potential accidents.
- In order to manage bottlenecks posed by a shortage in the energy related labour force, many energy companies are striving to recruit and train more personnel.
- Apart from a return to the recruitment of university graduates many energy companies are looking into options that promote retention of workers after normal retirement age – even at the expense of higher average incomes.
- Similarly collective efforts between industry sector and government policy makers could be undertaken to maximise the investment in human resources.

Globalisation and Environment

- With globalisation, structural changes within an economy from agriculture to industry and finally a services-based economy has accelerated thereby increasing the rate of resource use and exacerbating environmental pollution.
- Climate change has been addressed along with reducing emissions, through technology development/transfer, and/or change of the energy mix. It is also being pursued through regional and international fora such as UNFCCC, G8 and AP6; however, the potential benefits of these initiatives on the environment have yet to be seen.
- In the development of environmental policy, energy efficiency, renewable energy utilisation and mitigating environmental impacts are gaining higher priority.
- Traditional regulatory programmes are not always suited to solving environmental problems, thus more flexible approaches that consider and emphasise market-based incentives should be introduced that possess clear and well-defined environmental standards in order to spur investment.

INTRODUCTION

The APEC region firmly forms the backbone of the world economy; in 2004, the GDP of APEC's 21 economies collectively amounted to approximately US$29 trillion or 55 percent of world GDP. APEC contains the world's two largest economies – the US and Japan – and the rapidly expanding economy's of China, Russia and Southeast Asia. The population of the APEC region at approximately 2,600 million is likewise large by world standards, accounting for 42 percent of the world total, and APEC contains five of the world's ten most populous nations.

This economic and population growth has driven energy consumption in the APEC region, which has increased significantly over the period from 2000 to 2003. Total Primary Energy Demand for the APEC region has increased at an annual average growth rate of 3.0 percent from 5,820 Mtoe in 2000 to 6,170 Mtoe in 2003, which represents 57 percent of total world energy demand during the same period. The share of incremental demand for the APEC region to total world energy demand was 58 percent between 2000 and 2003. By energy source, the share of incremental demand attributed to the APEC region was 84 percent for coal, oil (68 percent), natural gas (32 percent) and new and renewable energy (7 percent) over the same period.

RECENT TRENDS AND CHARACTERISATION

Robust growth in the economy's of China and the US over the past five years, in addition to remarkable economic recovery in Southeast Asia have contributed to a significant increase in energy consumption within the whole APEC region. However, this increased energy consumption has placed pressure on already tight international energy markets, which has in turn led to an increase in energy prices. It is under these conditions/factors that the current APEC outlook has been undertaken.

Since 2002, China's economy entered a fast and extended period of growth, with GDP growing at an annual average rate of 9.5 percent during the same period. The per capita GDP of households in both urban and rural areas has also increased at an annual average rate of 11.2 percent and 8.3 percent respectively over the past five years. The main driver of this economic growth has been the rapid expansion and industrialisation of the eastern seaboard. As industrialisation has progressed the transfer of labour from rural to urban areas has accelerated, with the percentage of the population living in cities increasing by almost 10 percent since the year 2000.

Accelerated industrialisation, urbanisation, and improvement in living standards, has resulted in China's energy consumption surging in recent years, with double digit growth in coal, gas and electricity consumption. Between the years 2002-2005, total primary energy, gas, coal and electricity consumption have grown at annual average growth rates of 11.6, 12.5, 13.7 and 13.9 percent respectively. In addition, motorisation of the economy, rising vehicle ownership and industrial development have resulted in a greater increase in oil consumption, with an annual average growth rate of 9.5 percent over the same period, which has increased oil imports and pushed China into second place in terms of world oil consumption.

Likewise the economic performance of the US economy has shown stable growth of over 3.0 percent over the past two years, in spite of the recent high energy prices. In addition, energy demand does not appear to have appreciably slowed down as a result of the continuous high energy prices. In fact, over the same period, US oil consumption sustained growth of 2.2 percent per year. On the other hand although natural gas consumption declined at an average annual rate of 1.5 percent between 2002 and 2004, this decline has been augmented by a shift to more cost competitive and domestically produced coal consumption, which grew from 1,067 million tonnes in 2002 to 1,107 million tonnes in 2004. Despite a suite of successful efficiency improvement programmes US energy demand shows no sign of letting up over the short-term.

Finally, many of the Southeast Asian economies that were mired in economic recession in 1998 as a result of the Asian Financial Crisis have begun to show strong recovery. In addition, progress in economic reform and expanding industrialisation has also helped to drive the recovery from recession. On the back of high energy prices (especially oil and gas), renewed investor confidence and expanded business activity, the economies of Southeast Asia have experienced robust economic growth in the period 2001 to 2003, which has boosted energy consumption in the region by 8 percent or 30 Mtoe. The growing energy consumption has predominantly been met through the expansion and development of energy resources within the region.

As a result of the aforementioned economic growth in China and the US, in addition to economic recovery in Southeast Asia, energy consumption has been boosted much higher than projected and may continue to do so in the foreseeable future. In contrast, on the supply-side within a climate of "resource nationalism" through which government/ national energy companies are scrambling to limit foreign participation in the ownership of energy resources, the energy producing economies and oil majors alike are not making sizable investment in either the upstream or downstream sectors, sufficient to improve the demand and supply balance as there is little incentive to jump the gun. With the two oil crises during the 1970s' and 80's these companies learned an invaluable lesson that high oil prices tend only to be short-lived and should supply capacity be increased prematurely, the resulting glut of oil on the market could led to precipitous decline in price. Therefore, since the 1980's the major players in the oil market have taken a very wary stance with respect to investment decisions as a result of the price collapse in the wake of previous oil crises.

BASIS FOR THIS OUTLOOK

As in the 1970's, international oil prices have recently surged and since the first quarter of 2004 oil prices – in addition to other energy prices – have escalated to the record high price of $78 per barrel in the second quarter of 2006. The current and 1970's oil price hikes are different largely in two aspects: their durations and volatilities. It is becoming evident that the latest hike has longer duration with lower volatility than the previous one. Arguably a structural shift may have occurred in the energy market during the last few years. Few economic and energy indicators signal that the price would fall in the near future. As outlined in the preceding section, three major factors that characterise the current trend of international energy prices are: robust energy demand growth in most economies irrespective of the price hike, little incentive for major energy producers to expand production and export capacity coupled with intensifying resource nationalism in natural gas/oil producing economies, and an ostensibly worsening geopolitical situation in the Middle East.

The "APEC energy outlook, 2006" – the third time this publication has been undertaken by APERC – is being carried out under the auspices of these changing market conditions and rising prices. Both of these factors are expected to have a profound impact on the approaches through which APEC economies formulate future energy policy and endeavour to secure energy supply over the outlook period. Therefore, it is important to pursue an updated energy outlook at this time given the fundamental changes in international energy markets and how these changes will influence the future energy demand and supply picture.

BRIEF SUMMARY OF FINDINGS

A key result of the outlook is the **dramatic expansion in the trade of energy resources** through to 2030, especially for the major oil and gas consuming economies. This increasing trade will expand the overall **import dependency** of the APEC region from 10 percent in 2002 to 20 percent in 2030. For the major fossil fuels, the import dependency of oil will swell from 36 percent in 2002 to 52 percent in 2030; likewise natural gas will escalate from a major net export position in 2002 to a net import position of 14 percent in 2030. This increasing import dependency will have serious consequences for supply security.

As the production of oil and natural gas resources are concentrated in an ever smaller number of geographical regions, **supply security** surrounding energy transportation issues and the inherent risk of supply disruption are expected to become the prominent policy focus of governments. This in turn is likely to precipitate the re-evaluation of **increased utilisation of domestic resources** – especially, coal and nuclear energy – for electricity generation to enhance both self-sufficiency and reduce reliance on imported energy.

The implications of future fuel choice and increased coal utilisation are expected to have repercussions on how each economy pursues **environmental policy** in a world ever-increasingly focused on global environmental concerns and **carbon dioxide (CO_2)** reduction. To this end, ambient pollution from fossil fuel use has taken center-stage in various international dialogues including Climate Change, the G8 and the recent six party talks constituting the founding framework of the Asia Pacific Partnership for Clean Development and Climate.

STRUCTURE OF REPORT

Following this introduction, the report describes the **energy demand and supply** in the APEC region **for each major energy source** – oil, natural gas, coal, nuclear and alternative energy sources – including a discussion on a number of key areas prevalent to each of these energy sources, for example, requirements for refining capacity expansion in the oil section and information in relation to evolution of the LNG market environment in natural gas.

After this section on individual energy sources, the **energy demand by sector** will be summarised. For each sector, the historical trends, characterisation and major assumptions will be outlined to present a snapshot of the current situation. Subsequently, the output of the model by region and economy, in addition to a brief discussion on the implications of these results for each sector through 2030 will be detailed. Next, an **investment outlook** detailing the amount of money required to finance the expansion and capacity building of energy infrastructure in the APEC region will be presented, including discussion on the major bottlenecks for financing within the sector. Finally, over the outlook period it is expected that the importance of the **environment** and concerns surrounding the control and abatement of emissions from the energy sector will gain prominence. Of particular importance will be the reduction of CO_2 emissions and internalising of costs – such as **Carbon Offset Price**.

In the final several chapters, the report will examine a number of the issues that are likely to arise as a result of the robust energy demand growth projected through to 2030. On the **demand side**, the nexus/interaction that exists between industrialisation, urbanisation and energy demand will be highlighted, especially in relation to developing economies in the APEC region just starting to climb the development ladder. In relation to the **supply side**, those themes that are expected to play a significant limiting/constraining role over the outlook period have been investigated, including resource constraints, energy transportation, water resource limitations, reduced human capital/know-how and energy efficiency and technology. Finally, a short section describing the issues prevalent to the environment in an ever increasingly globalised economy will be introduced.

ENERGY DEMAND AND SUPPLY OUTLOOK BY SOURCE

- *Total primary energy demand in APEC is expected to grow from 5,939 Mtoe in 2002 to 10,332 Mtoe in 2030, at an annual growth rate of 2.0 percent, which is much lower than GDP growth of 4.1 percent per year.*
- *Energy intensity in the APEC region is expected to drop by 40 percent over the outlook period.*
- *Energy diversity is expected to improve for all but four APEC economies: Canada, China, Hong Kong, China, and New Zealand.*
- *The net import of primary energy will grow at an annual rate of 4.7 percent – compared with 0.3 percent annual growth over the past two decades – led by oil in Asia and natural gas in Asia and Americas.*

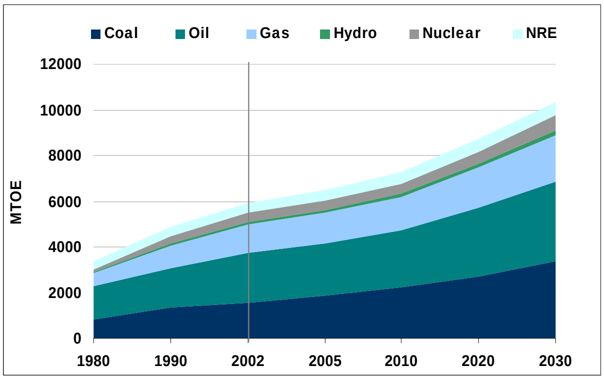
The demand and supply balance in the APEC region will **became tighter** over outlook period, as the region's annual primary energy production is expected to grow at 1.5 percent, which is significantly lower compared with the total primary energy demand growth of 2.0 percent per year. By 2030 the APEC region will swiftly move from a net exporter of natural gas and coal to a net importer, while net oil imports will increase from 36 percent of oil demand in 2002 to 52 percent in 2030. The **energy import dependency** of the APEC region as a whole is expected **to increase** in the future. **Energy intensity** in the APEC region is expected **to drop** by 40 percent through to 2030, following the overall global trend and reflecting high rates of improvement for Russia, China, and the US. **Energy diversity** is expected **to improve** for all but four economies: Canada, China, Hong Kong, China, and New Zealand, while decreasing slightly for APEC as a whole, reflecting China's share in total primary energy demand.

PRIMARY ENERGY DEMAND AND SUPPLY BY FUEL TYPE

Total primary energy demand (TPED) in the APEC region is expected to grow from 5,939 Mtoe in 2002 to 10,332 Mtoe in 2030, at an annual growth rate of 2.0 percent, which is lower than the rate of 2.6 percent per year over the previous two decades (Figure 1, Table 1).

Over the outlook period, **oil** demand is projected to grow at an annual growth rate of 1.7 percent from 2,165 Mtoe in 2002 to 3,488 Mtoe in 2030, and is expected to maintain the largest share of TPED in the APEC region in 2030 at 34 percent. Oil demand for the transport sector will dominate and contribute 68 percent of incremental oil demand growth through 2030. Oil production growth over the outlook period will be lead by Canada (prevailed with non-conventional oil from Alberta's tar sands), accounting for 37 percent of the incremental production in the APEC region, followed by the US at 25 percent and Russia at 21 percent. However, by 2030 some 52 percent of APEC's oil supply will be met by imports predominantly sourced from the Middle East.

Figure 1 Primary Energy Demand (1980-2030)



Source: APERC Analysis (2006)

Given the cost competitiveness relative to other fossil fuels, and the relative abundance in the APEC region **coal** demand is projected to grow the fastest over the outlook period at an annual rate of 2.8 percent from 1,570 Mtoe to 3,366 Mtoe, and account for the second largest share of TPED in 2030 at 33 percent. Approximately 87 percent of incremental coal demand is expected to be derived from the electricity sector, with China projected to be the major coal consumer in the APEC region accounting for 54 percent of TPED for coal in 2030. Coal production in the APEC region is concentrated in the six economies with the largest reserves: Australia, Canada, China, Indonesia, Russia, and the US. These six economies are expected to account for almost 99 percent of APEC's incremental production over the projected period; however, APEC is expected to become a marginal net coal importer of 2.8 Mtoe in 2030.

Table 1 Primary Energy Demand and Supply by Source for APEC (1980-2030)

Energy		1980	2002	2030	1980-2002	2002-2030
		Mtoe	*Mtoe*	*Mtoe*	*AAGR,%*	*AAGR,%*
Coal	Net import	-33	-78	3	4.0	-
	Production	860	1 644	3 364	3.0	2.6
	Demand	822	1 570	3 367	3.0	2.8
Oil	Net import	565	773	1 805	1.4	3.1
	Production	947	1 399	1 683	1.8	0.7
	Demand	1 445	2 165	3 488	1.9	1.7
Natural gas	Net import	4	-113	284		
	Production	591	1 383	1 766	3.9	0.9
	Demand	595	1 255	2 050	3.5	1.8
NRE	Demand	332	460	588	1.5	0.9
Nuclear	Demand	104	382	643	6.1	1.9
Hydro	Demand	65	114	167	2.6	1.4
Total primary energy	**Net import**	**536**	**577**	**2093**	**0.3**	**4.7**
	Demand	**3 363**	**5 939**	**10 332**	**2.6**	**2.0**

Source: APERC Analysis (2006)

Natural gas is projected to account for 20 percent of TPED in 2030. Through to 2020 natural gas is expected to experience fast growth of 2.0 percent per annum, followed by more moderate annual growth of 1.4 percent between 2020 and 2030. Incremental natural gas demand growth will be driven primarily by the electricity sector at 42 percent, followed by industry and residential/commercial on 28 percent each respectively. To meet demand within the APEC region production is expected to increase rapidly – especially in Australia, China, and the US. However, the region is expected to become a net natural gas importer over the outlook period.

The share of **nuclear** in TPED is expected to remain stable at 6 percent through 2030, growing at an annual rate of 1.9 percent from 382 Mtoe in 2002 to 643 Mtoe in 2030. China is expected to exhibit the highest growth over the outlook period rising at 10.5 percent per year. Viet Nam seems to be the first Southeast Asian economy to utilise nuclear power starting from the second decade of this century.

Hydroelectricity is expected to grow at 2.0 percent per year – the second fastest after coal – although the share will remain low at 2 percent in 2030. China, endowed with the largest hydroelectricity potential will see the fastest annual growth in the APEC region at 4.8 percent, and account for 78 percent of total incremental hydroelectricity growth through 2030.

New and renewable energy (**NRE**) which includes biomass, solar, wind, tidal and wave energy is expected to grow at 0.9 percent per year. The share of NRE is expected to fall from 8 percent in 2002 to 6 percent in 2030 due in part to a shift to commercial fuel sources in rural areas of less-developed regions that rely heavily on biomass for cooking and heating, as socio-economic conditions will improve.

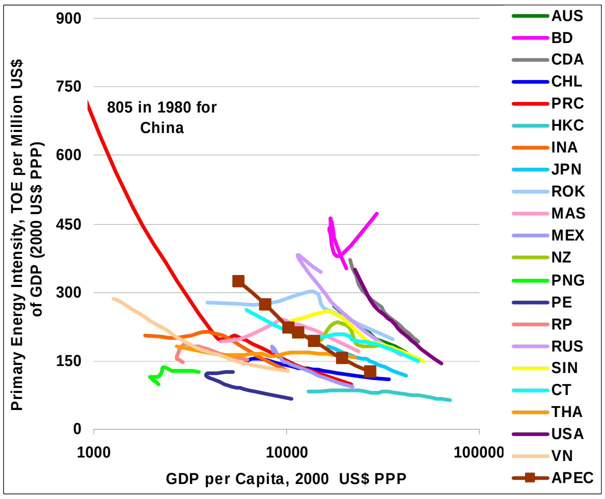
ENERGY INTENSITY AND PER CAPITA PRIMARY ENERGY DEMAND

Energy intensity (toe per GDP US$ million in constant 2000 dollars) for the APEC region is expected to decline significantly over the outlook period, indicating a less energy-intensive future (Figure 2).

Factors affecting the level of energy intensity include income level, industry structure, technology, energy prices and climatic conditions. There are wide disparities in energy intensity between economies in addition to changes in the trends historically. While energy intensity generally declines over time, this was not the case for seven APEC economies over the period 1980 to 2002. The energy intensity of these seven economies' – Indonesia, Malaysia, Papua-New Guinea, Philippines, Korea, New Zealand and Russia – has increased mainly due to the development of heavy industry, and partly, by ineffective management of existing industrial capacities and their underperformance. However, all APEC member economies are projected to improve their energy intensity over the outlook period.

Russia and China are expected to show the highest rate of energy intensity improvement at 3.0 and 2.5 percent per year respectively. Overall improvement in these economies will be largely driven by high economic growth, industrial retrofitting and introduction of advanced energy-efficient technologies. The US, Japan and Korea are also expected to exhibit annual energy intensity improvement of between one and three percent, and combined with China and Russia these five economies will account for more then 80 percent of APEC's industrial value added in 2030. As a result, energy intensity improvement in the whole APEC region will decline at 2.0 percent per year over the outlook period, compared with the 1.7 percent per year rate observed from 1980 to 2002.

Figure 2 Primary Energy Intensity (1980-2030)

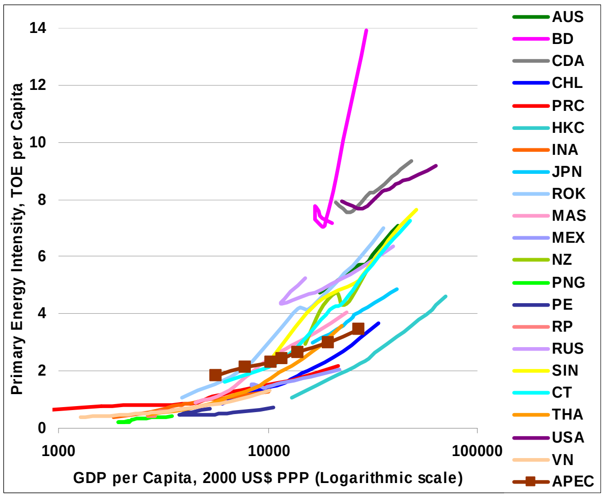


Source: APERC Analysis (2006)

Per capita primary energy demand in the APEC region is expected to increase from 2.3 toe in 2002 to 3.4 toe in 2030, equivalent to an annual rate of 1.5 percent. However, despite this robust growth there will be a wide range in demand among individual member economies in 2030 from 0.4 toe in Papua New Guinea to 9.4 toe in Canada (Figure 3). On the other hand, the per capita energy consumption of Brunei Darussalam has almost halved since 1980 as population has grown significantly while industrial activity has not shown much change. In 2030, Papua New Guinea, Peru, Philippines, Indonesia and Viet Nam are projected to have energy demand of less then one toe per capita, while Canada, the US, Singapore, Taiwan, Brunei Darussalam, Australia and Korea are expected to encompass demand of more then seven toe per capita.

The general trend observed is that economy's with higher per capita energy demand tend to exhibit slower growth over the long-term. The exemptions to this observation are Chinese Taipei and Korea which already had per capita consumption levels compatible to Japan (4 toe) in 2002, and are projected to increase to 7 toe (compatible to Australia) in 2030 at annual growth rate 2.0 percent and 1.9 percent, respectively. Singapore is very close to Australia in terms of per capita energy consumption, however it is going to over pace it at 1.5 percent annual growth rate comparative to Australia's 0.8 percent. In comparison, for the US and Japan per capita energy demand is expected to grow at 0.4 percent, and 0.8 percent, respectively.

Figure 3 APEC Primary Energy Demand per Capita vs. GDP per Capita (1980-2030)



Source: APERC Analysis (2006)

ENERGY DIVERSITY

The energy diversity indicator (that assesses the distribution of energy sources in the primary energy mix for each economy in range from 1 to 100 points) for the APEC region as a whole will change slightly from 89 to 87 during the outlook period (Table 2). The least diversified economies are Papua New-Guinea, Brunei Darussalam and Singapore with energy diversity indicators of at 44, 45 and 47 points respectively in 2030. Historically, Hong Kong, China has improved it's energy diversity since 1980 from almost full dependency on oil (resulted in just one point's value for this indicator) to high diversity at 70 points in 2002, by introducing coal and natural gas to the primary energy's mix. For three of the four economies noted above high dependency on one energy type – greater than 80 percents – was observed, with this phenomena being primarily explained by the small geographical scale of the economy, low domestic crude oil prices and therefore low petroleum product prices. For example, in case of Brunei Darussalam low energy diversity is explained by huge domestic natural gas resources that can be cheaply utilised within the economy.

While APEC has a high level of energy diversity (89 points in 2002), the net energy import ratio of the region was 10 percent, with the net oil import dependency of 36 percent in 2002. Securing future oil and natural gas supply through enhanced exploration and development activities within the region and enhancing external co-operation is of great importance.

Table 2 Energy Diversity Indicator, (points 1-100)

Economy	1980	2002	2030
Australia	73	76	81
BD	14	33	45
Canada	81	89	83
Chile	69	78	81
China	68	68	65
HKC	1	70	67
Indonesia	62	84	86
Japan	53	78	86
Korea	50	74	89
Malaysia	50	63	77
Mexico	51	65	70
NZ	74	82	74
PNG	7	30	44
Peru	55	58	75
Philippines	55	74	82
Russia	78	71	77
Singapore	1	28	47
CT	47	75	80
Thailand	56	78	83
USA	80	84	84
Viet Nam	36	64	92
APEC	**83**	**89**	**87**

Source: APERC Analysis (2006)

Canada, China, Hong Kong, China and New Zealand are the only economies expected to reduce their energy diversification over the outlook period. The underlying reasons for this occurrence are:

a) rising share of natural gas and oil at the expense of coal and nuclear in Canada;

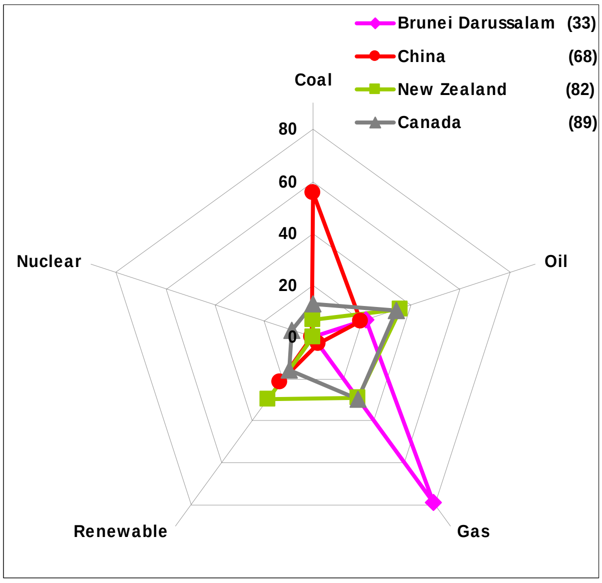
b) shrinking share of renewable energy in China and coal in Hong Kong, China;

c) rising share of renewable energy at the expense of natural gas in New Zealand.

More then half of all APEC economies will have in 2030 energy diversity indicators higher then 80 points. Viet Nam, Korea, Japan and Indonesia will head list with 92, 89, 86 and 86 points respectively.

The energy diversity indicator pattern by fuel for four selected APEC economies in 2002 is presented in Figure 4. Interpretation of this Figure shows a high dependency on natural gas for Brunei Darussalam and coal for China, which results in the lower energy diversity indicator for these economies. Whereas a more balanced energy supply as shown for New Zealand and Canada leads to much higher values for the energy diversity indicator.

Figure 4 Energy Diversity Indicator for Selected APEC Economies in 2002

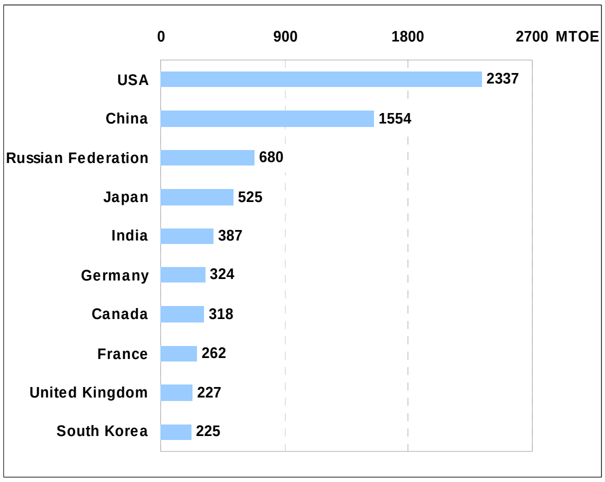


Source: APERC Analysis (2006)

ENERGY IMPORT DEPENDENCY

The APEC region is host to the top four energy consumers in the world, namely the US, China, Russia and Japan, which together account for about 48 percent of the world's primary energy demand (Figure 5).

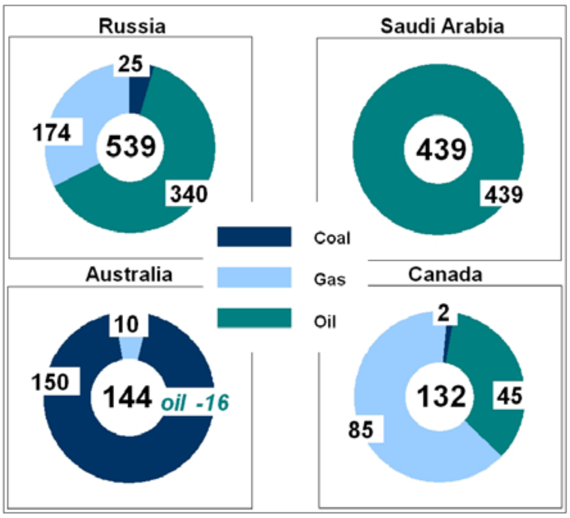
Figure 5 World's Top Ten Energy Consumers in 2005 (Mtoe)



Source: BP (2006)

APEC is also host to three of the world's four largest energy exporters – Russia, Australia and Canada, – and currently is a net exporter of natural gas and coal.

Figure 6 World's Four Largest Energy Exporters in 2005 (Mtoe)



Source: BP (2006)

Over the outlook period the energy **import dependence** of most APEC member economies is expected to increase. The only economies which are expected to increase their net energy ***export*** ratios are Australia, Papua New Guinea, and Brunei Darussalam. Current energy exporters Russia, Canada, Mexico and especially Indonesia are projected to decrease their export to domestic energy demand ratio, with Mexico and Indonesia approaching a net energy trade balance close to zero by 2030. Furthermore, Malaysia and Viet Nam are expected to swing from net energy exporters to importers, while China is expected to become one of the world's major energy importers, increasing from a net energy balance of zero percent in 2002 to an import dependency of 18 percent in 2030.

The status of import dependency (the ratio of net imported primary energy to total primary energy demand, with nuclear considered as a domestic energy source) for all APEC member economies is shown in Table 3. Only seven economies (Australia, Brunei Darussalam, Canada, Indonesia, Mexico, Papua New Guinea and Russia) will remain net exporters, while China, Malaysia and Viet Nam will switch from a net energy export to net import position over the outlook period.

Table 3 Net Energy Import Dependency of the APEC economies (%)

Economy	1980	2002	2030
Australia	-25	-121	-193
BD	-630	-668	-688
Canada	-6	-48	-33
Chile	41	63	84
China	-3	0	18
HKC	99	100	100
Indonesia	-120	-55	*negl.*
Japan	88	82	78
Korea	77	84	77
Malaysia	-44	-57	32
Mexico	-50	-59	-9
NZ	43	19	27
PNG	96	-100	-120
Peru	-25	27	18
Philippines	54	51	68
Russia	-42	-72	-67
Singapore	100	97	99
CT	81	87	89
Thailand	52	53	81
USA	17	30	36
Viet Nam	8	-26	15

Note: negative values mean net export to domestic consumption rate

Source: APERC Analysis (2006)

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OIL

- *The share of transportation in total oil demand is projected to increase from 50 percent in 2002 to 57 percent in 2030 making transportation the leading sector for oil demand growth*
- *APEC oil import dependency is expected to rise from 36 percent in 2002 to 52 percent in 2030, with the increase in the Asian and Oceania sub region's projected to be even higher, increasing from 59 percent in 2002 to 75 percent in 2030.*
- *The share of non-conventional oil will increase over the outlook period as price signals and technological advances are increasingly tapped to utilise these huge resources.*

Security of oil supply is directly related to society's mobility and its ability to provide energy service even to the very remote and small consumers. **Transportation, agriculture, construction and military almost completely rely on petroleum products** supply, while the most convenient way to produce latter is crude oil refining and treating. More expensive **unconventional technologies** - oil sands, oil shale, and enhanced oil recovery **will account larger share** in oil supply in the future, as technology development and strong prices eventually will encourage tapping of this resource in tight competition environment for international oil companies.

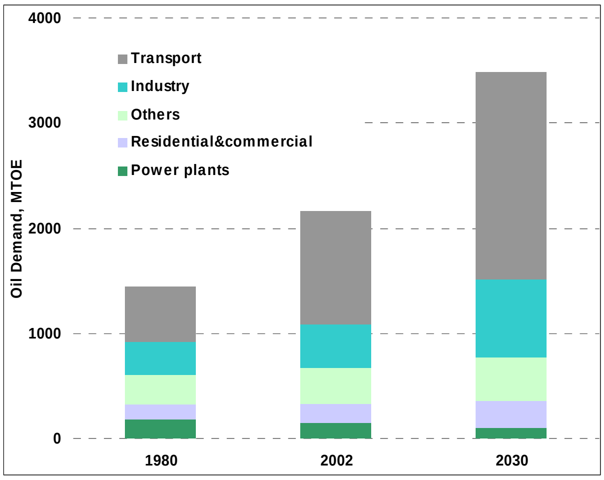
TRANSPORTATION TO LEAD OIL DEMAND GROWTH

Oil demand in APEC region is expected to increase from 2,165 Mtoe in 2002 to 3,488 Mtoe in 2030, at 1.7 percent annually. Oil demand patterns in the APEC region are shown on Figure 7, and transportation sector is expected to maintain principal position at 57 percent (1,973 Mtoe) in 2030, compared with 50 percent (1,077 Mtoe) in 2002 and 47 percent (591.2 Mtoe) in 1980. On the other hand oil shares almost 99 percent of the total fuel used for transport, and this share will not change radically up to the year 2030. Oil consumption in the industrial sector is projected to grow at an average annual rate of 2.1 percent and will maintain the second largest share of total oil demand at 25 percent. The share of the residential and commercial sectors in total oil demand will show a slight decrease over the outlook period – from 11 percent in 2002 to 8 percent in 2030 – as other energy sources are utilised in these sectors.

As mobility of society is expected to increase steadily in the future, and economic development will encourage global freight movement, transportation sector will grow robustly. Spurring demand for oil is the sharp increase in the number of the cargo ships, road vehicles and, more recently, the air transport. In APEC, the essential growth in road transport demand is to be expected over the outlook period, with the emergence of economies like China and Viet Nam. Some 4 million passenger vehicles are added every year in China and seven-fold increase of passenger vehicles in Viet Nam projected during the outlook period, show that a soaring in oil demand is foreseeable.

During the outlook period the APEC region is also expected to experience continuous growth in the air transport sub-sector. Greater global economic integration is likely to spur the growth in air passenger travel and cargo freight deliveries, which will translate into robust growth in aviation jet kerosene demand.

Figure 7 Oil demand patterns in APEC region (Mtoe)



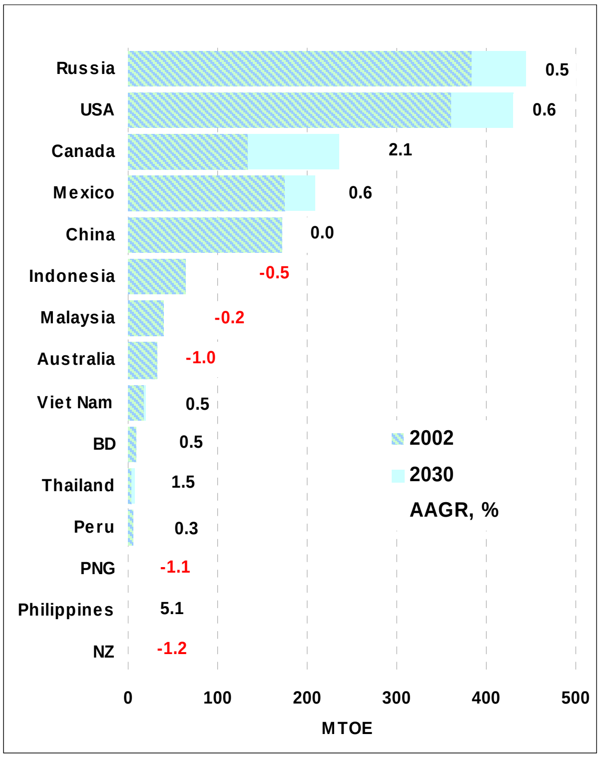
Source: APERC Analysis (2006)

OIL SUPPLY

The APEC region has five of the 10 largest crude oil producers in the world. However, the region also has five of the 10 largest crude oil consuming economies. Thus, while APEC produces around 42 percent of the world's oil supply, it also accounts for some 62 percent of world oil demand. In 2002, this imbalance resulted in the APEC region having an **oil import dependency of 36 percent, which is expected to rise to 52 percent by 2030**. Furthermore, while APEC oil demand is projected to increase by 61 percent between 2002 and 2030 at 1.7 percent annually, production over the same period is only expected to increase by 20 percent at an annual growth rate of 0.7 percent, further contributing to the expanding trade imbalance.

For the fifteen APEC economies in Asia and Oceania this supply and demand imbalance is even greater. Demand in this region is projected to increase by 60 percent between 2002 and 2030, while conversely production is expected to decrease by 5 percent, resulting in an overall **increase in the net import dependency of this sub-region from 59 percent in 2002 to 75 percent in 2030**.

Figure 8 Crude oil production in the APEC region (Mtoe)



Source: APERC Analysis (2006)

Three of the major APEC producers – Canada, the US and Russia – are projected to increase their crude oil production the most, while Australia, China, Indonesia, Malaysia, New Zealand and Papua-New Guinea may face oil production decline (Figure 8). Four APEC economies that are currently net oil exporters − Indonesia, Malaysia, Papua New Guinea and Viet Nam − may become net importers over the period 2020 to 2030. Already high reliance on imports is likely to increase substantially. Net imports of crude oil and oil products are projected to increase from 773 million tonnes in 2002 to 1,805 million tonnes in 2030, at growth rate of 3.1 percent per annum. At the end of the outlook period only four net oil exporters will remain in the APEC region, namely Brunei Darussalam, Canada, Mexico and Russia (Table 4).

The **structure of the resource base** (i.e., geological information of oil-bearing deposits quality and stratification) has a significant impact on oil supply patterns. Exploration and technological development (enhanced oil recovery, synthetic crude production from bitumen and oil shale's, oceanic deep water and Arctic oil fields, *etc.*) are increasing oil reserves greatly. In addition high oil prices will encourage exploration of undiscovered resources and their transition to proved reserves for hard-to-develop and non-conventional oil deposits.

Table 4 Net Oil Trade Position for the APEC Economies, Mtoe

Economy	2002	2030	AAGR, %
Australia	8.6	34.6	5.1%
BD	-9.2	-10.1	0.3%
Canada	-45.1	-111.2	3.3%
Chile	10.4	33.1	4.2%
China	48.6	470.1	8.4%
HKC	8.1	19.7	3.2%
Indonesia	-1.5	81.3	
Japan	254.4	247.7	-0.1%
Korea	106.4	135.6	0.9%
Malaysia	-14.1	17.6	
Mexico	-92.0	-70.9	-0.9%
NZ	5.3	9.3	2.0%
PNG	-1.4	0.9	
Peru	2.8	7.6	3.6%
Philippines	16.2	44.5	3.7%
Russia	-263.7	-294.0	0.4%
Singapore	17.7	31.3	2.1%
CT	42.4	69.5	1.8%
Thailand	31.4	96.6	4.1%
USA	655.6	965.1	1.4%
Viet Nam	-7.6	26.6	
APEC	**773**	**1 805**	**3.1%**

Note: (Net) Oil Imports (>0) and (Net) Exports (<0)

Source: APERC Analysis (2006)

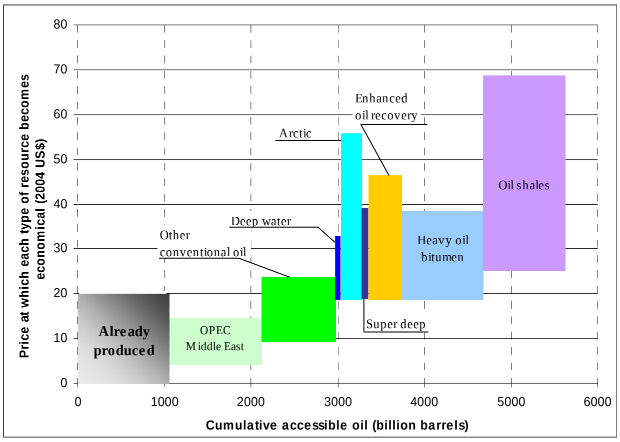
There are different assessments for global oil resources due to uncertainty, classification and accounting problems. The latest USGS Survey 2000[1] stated that **total remaining world conventional oil resources are more then 2.1 trillion barrels.**[2] It is assumed that unexplored petroleum provinces, such as East Siberia and Antarctica could still contain huge and yet undiscovered oil resources. In addition, the World Energy Congress estimates there are **2.6 trillion barrels of natural bitumen, 3.3 trillion barrels of oil shale, and 2.1 trillion barrels of extra-heavy oil** worldwide. "Clearly, many more deposits for natural bitumen and shale oil are

[1] USGS (2000)

[2] This is a low estimate, as this survey did not consider all terrestrial land mass, ocean deepwater, or unconventional heavy oil, tar accumulations, and oil shale.

identified but no resource estimate is possible." [3] While oil shale resources have been reported in some economies, they along with many other types of unconventional resources remain unreported in other economies. Therefore in most instances only conservative estimations for non-conventional oil reserves have been made due to insufficient data availability. It is important to note that non-conventional oil resources as a rule are more expensive to develop than conventional ones, as shown in Figure 9 prepared by International Energy Agency in 2004 for the supply potential as a function of the economic cost of extraction.

Figure 9 Availability of Oil Resources as a Function of Economic Price, 2004



Source: IEA (2005)

While a time lag exists between global oil market signals and supply response, the dynamic equilibrium between supply and demand also gives rise to substitution of other materials when scarcity looms (or the price is artificially elevated). For example, in 1973 as a result of the sudden four-fold increase in the price of oil, followed by a four month long oil embargo, several things happened at both the producer and consumer levels. The producers increased their exploration efforts, and implemented new techniques to boost oil recovery from previously "exhausted" or uneconomic wells and fields, which resulted in a dramatic increase in oil resources. Similar techniques have been used by North Sea producers in 1995, when fields that had originally been deemed too small to be produced economically, but due to a combination of ongoing infrastructure development (easier pipeline access) and improvements in technology (sub sea templates), have become viable. [4] Thus it follows that technological advances in extracting non-conventional oil combined with high oil prices will significantly enhance the share of synthetic crude produced in Canada's Alberta province. More expensive enhanced oil recovery and production of unconventional resources – oil sands, and oil shale – are thus expected to garner a greater share of future oil supply. **Increasing supply from non-conventional oil** resources will greatly affect the upstream and downstream oil industries because the new technologies implemented will influence the quality of oil produced, which in turn will have an impact on the configuration of oil refineries.

Oil Refining Capacity Growth Requirement

The refining capacity of the APEC region was 43.75 million B/D in 2002, which is approximately 50 percent of the world refining capacity. However, for APEC to meet the demand for oil products over the outlook period, an **additional 26.6 million B/D of capacity will need to be constructed**. In some economies "grassroots" refinery construction is seldom approved due to intense public opposition and therefore capacity addition is most likely to occur through expansion of existing facilities. In addition, for many economies, it is more economic to import a portion of petroleum products from the international market rather than construct additional refining capacity within the economy.

In addition to distillation capacity increases, there must be a **considerable increase in the upgrading capacity** to enhance the production of gasoline and middle distillates to meet demand in the transportation sector. At present Asian refineries are relatively poorly equipped in terms of upgrading capacity. In 2003, the cracking to distillation capacity ratio for the major Asian economies was 11 percent for Korea, 13 percent for Singapore, and 22 percent for both Japan and China, which is quite low in contrast to the 43 percent for the US. The decline in light sweet crude oil production in China and Southeast Asian economies and the resulting increase in dependence on heavy sour crude oils from the Middle East has motivated the refiners in these economies (except Singapore) to expand/ construct upgrading facilities to take advantage of the widening price spread between light and heavy crude oils.

The **introduction of stricter environmental regulations and fuel standards** in most APEC economies over the outlook period is likely to **precipitate expansion of hydro-treatment capacity** For example, in Japan with the introduction of "zero sulphur" (less than 10 ppm) gasoline from 2005, the hydro-treating to distillation ratio of the economy topped 92 percent.

[3] WEC (2004)

[4] Lynch (1997, 2005)

IMPLICATIONS

Lower rates of the region's oil production to demand lead to accelerated rate of oil import in the APEC region. High exposure of transportation energy demand to oil supply security and price volatility combined with high import ratio will facilitate introduction of improved efficiency standards for mobile vehicles, stimulate exploration and development for both conventional and non-conventional oil, alternative motor fuels production, and encourage government's efforts to secure oil supply.

Refining industry will become more complicated to process heavier oil and produce higher yield of environmentally friendly motor fuels.

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COAL

- *APEC's coal demand is expected to more than double from 1,570 Mtoe in 2002 to 3,366 Mtoe in 2030, growing at an annual rate of 2.8 percent – the fastest annual growth rate among fossil fuels.*
- *Coal is about to tread a stellar path as the fuel for the 21st century mainly due to its price advantage.*
- *Coal resources are also under pressure from depletion, thus production and transportation costs have been steadily increasing.*
- *A regional temporary coal supply shortage is not unforeseeable in particular in Northeast Asia as Indonesia and China's coal export capacities are starting to decline.*

Historically coal has been known to cause lots of problems. It was not until the 1970's that public sentiment turned against the large scale use of coal on a global scale and coal was denounced as the "dirty energy". Serious environmental problems associated with its extensive use were brought to the attention of the international community for the first time. The UN Framework Convention on Climate Change and the subsequent Kyoto Protocol were the culmination of numerous international meetings of policymakers on energy induced global warming from fossil fuel use in general, steering the world clear of coal burning as much as financially possible. It was seen that the Protocol and coal were as compatible as are good and the evil.

The social and environmental stigma attached to coal was created and sustained throughout the last three decades of the 20th century in spite of the advent of clean coal technology (CCT), which was still regarded unclean.

It may be serendipitous that world oil prices hovered around historically low levels at the time that these treaties were signed, adopted, ratified, and finally entered into force. During this period between 1986 and 2003 it was obvious that the world had grown blatantly complacent about the long-term availability of cheap energy sources including oil and natural gas. Added to this complacency was the overblown confidence in the role of new technologies and alternative energy sources overlaid the world energy future with a seemingly unrealistic CO_2 constrained one, whereby a lot less carbon intensive energy, ie coal, would be consumed.

Coal is now at the critical juncture for its future expansion. Provided the inherently "unclean" nature of coal is technologically resolved, coal could enter a new period of glory.

RENEWED INTEREST IN COAL

Coal consumption is for either coking or thermal use. The share of thermal coal is roughly 66 percent, almost twice as much as that of coking coal. Facing escalating oil and gas prices, the electricity sector, the major consumer of thermal coal is diligently looking for a feedstock fuel with a certain degree of long-term stability in both price and volume. Electricity generators now find coal more attractive than ever because of the widening price gap between coal and its alternatives, i.e., natural gas and residual oil.

Unlike oil or natural gas, coal can be found almost everywhere in the world, in other words supply sources are evenly distributed, preventing the formation of collective action/oligopolies by the producers. Besides coal resources are a lot larger in volume than oil and natural gas such that the resource/production ratio is currently estimated at around 200 years according to BP statistics. As a matter of fact, coal has been the major fuel for the world so far and is likely to be so for a long time yet to come.

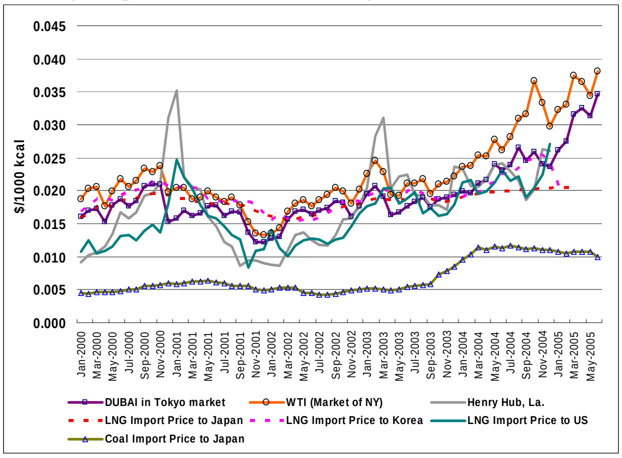
It was, however, in the 1970's when environmental awareness triggered a rather long-term shift away from coal and towards oil and natural gas. With the technological progress in LNG a number of economies implemented energy policies aimed at gradually displacing coal with natural gas and to a limited extent with new and renewables such as solar and wind. Switching to LNG turned out to be very successful and natural gas made major inroads into the electricity markets in many economies taking up a sizable share of primary energy supply. Even through to the beginning of 2005, this trend seems to be advancing robustly.

Faced with the surge in the short-term cargo price and the perceived supply shortage for the next several years LNG markets are expected to run out of steam. A couple of major LNG importing economies including the US have revised their outlook for LNG downwards reflecting the present market perception.

Once viewed as the "black sheep" of the energy family, coal is about to tread a stellar path as the fuel of choice for the 21st century mainly due to its price advantage. There are a few reasons that could well account for the recent reposition of energy policies towards coal, among which are the low relative price, the long-term price stability, the availability of supply infrastructure, and advance in clean coal technology and CO_2 capture and storage technologies.

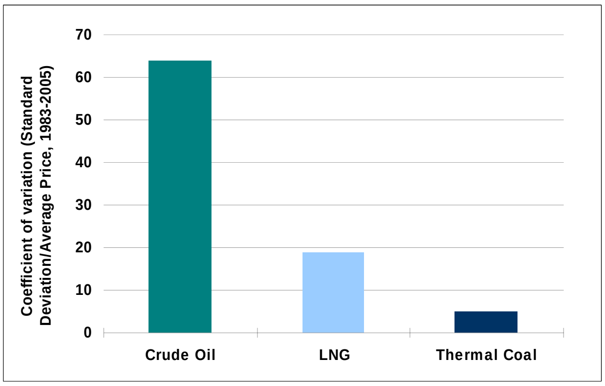
The coal price has been low relative to oil and natural gas for the last four decades because the coal price does not move in parallel with oil prices even at the time of the previous oil crises. Eventually the coal price was decoupled from oil prices around the end of the 1970's and stayed relatively low until 2004, when unexpectedly high oil prices prompted inter-fuel substitution in electricity generation sparked Australian coal prices to reach record high levels of $60/ton. While oil prices are still around $70/bbl, coal price have came down to $45/ton in recent months. It seems that the spikes in the price of coal between the last quarter of 2003 and the first quarter of 2006 were a temporary market response to higher demand rather than a fundamental shift in the market as they were relatively short-lived (Figure 10).

Figure 10 Monthly Trends in Coal, Oil and Natural Gas Prices (US$ per 1,000 kcal, 2000-2005)



Source: APERC Analysis (2006)

Figure 11 Comparison of coefficient of variation



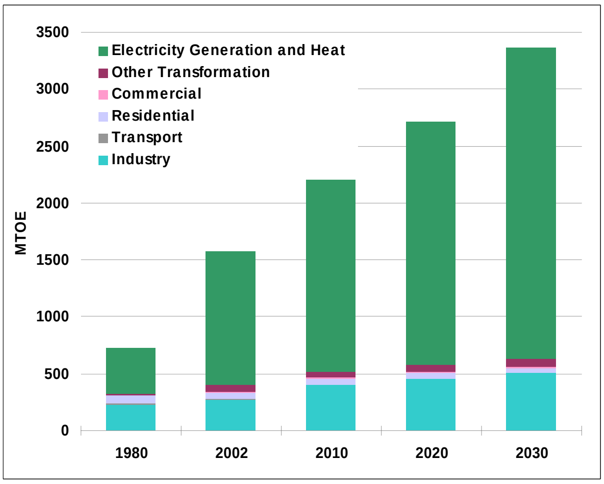
Source: Mimuroto (2006)

The low price volatility measured as the standard deviation from the historical mean for coal has also been low. Between 1983 and 2005, the coefficients of variation for crude oil, LNG and thermal coal were 64, 19, and 5 (Figure 11). From the pure economical point of view, it is not difficult to pick coal as the winner.

COAL DEMAND OUTLOOK

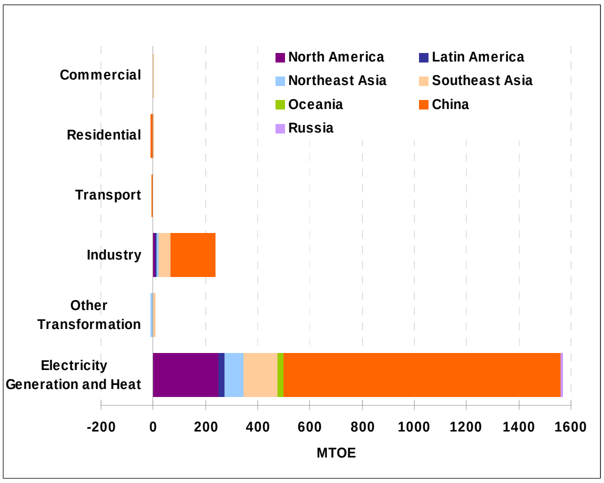
APEC's coal demand is expected to more than double from 1,570 Mtoe in 2002 to 3,366 Mtoe in 2030, growing at an annual rate of 2.8 percent. The projected growth rate of coal demand through 2030 is the fastest among the fossil fuels. In the near-term, stable supply as well as low prices are the key factors likely to attribute to the faster coal demand growth. In the long-term, technological development to minimise the impact on both the local and global environment will boost the demand for coal in electricity generation.

Figure 12 Coal Demand by Sector (1980 – 2030)



Source: APERC Analysis (2006)

Figure 13 Incremental Growth in Coal by Region (2002 – 2030)



Source: APERC Analysis (2006)

By sector, the electricity sector is projected to continue to lead coal demand growth. Over the outlook period, coal demand in the electricity sector is projected to grow at an annual rate of 3.1 percent, followed by the industry sector at 2.3 percent. With this robust growth, the share of coal in the electricity sector as a percentage of total coal demand is projected to increase from 74 percent in 2002 to 81 percent in 2030.

Near-term growth in coal demand is projected to be faster than that of the long-term. By 2010, coal demand is expected to grow at a robust pace of 4.4 percent pear year driven mainly by China's rapid economic development. China's projected GDP growth rate of 7.7 percent per year between 2002 and 2010, will translate into massive coal requirements to generate electricity, operate industrial facilities and produce cement and steel. In fact it is expected that China will account for about 80 percent of APEC's coal demand growth between 2002 and 2010.

Table 5 Coal Demand by Economy (Mtoe)

Economy	1980	2002	2030	1980-2002 (%)	2002-2030 (%)
Australia	27.3	46.9	66.2	2.5	1.2
BD					
Canada	21.2	33.8	24.3	2.1	-1.2
Chile	1.2	2.8	11.9	3.9	5.3
China	312.6	618.7	1833.9	3.2	4.0
HKC		4.8	7.7		1.7
Indonesia	0.2	18.7	68.3	22.9	4.7
Japan	59.6	95.4	107.6	2.2	0.4
Korea	13.5	34.5	62.8	4.4	2.2
Malaysia	0.04	2.5	33.7	20.7	9.7
Mexico	2.4	7.9	25.0	5.6	4.2
NZ	1.0	1.2	2.7	0.8	2.9
PNG					
Peru	0.1	0.6	2.1	8.5	4.6
Philippines	0.4	7.1	30.0	14.0	5.3
Russia		106.1	117.4		0.4
Singapore					
CT	3.9	32.4	65.0	10.1	2.5
Thailand	0.5	9.8	64.6	14.5	7.0
USA	376.2	541.2	807.9	1.7	1.4
Viet Nam	2.3	5.5	35.1	4.0	6.8
APEC	**822.3**	**1,570**	**3,366**	**3.0**	**2.8**

Source: APERC Analysis (2006)

Aside from China, economies like Thailand and Malaysia are projected to increase their demand for coal to diversify feedstock fuels for electricity generation. With further technological innovation in sequestration of CO_2 emissions from electricity generation and expected increase in production, the US coal demand is projected to increase faster in the long-term than in the near-term. Between 2002 and 2015, US coal demand is projected to grow at 0.9 percent per year, while between 2015 and 2030 growth is expected to be faster at a rate of 1.9 percent per year.

COAL SUPPLY ISSUES

The investment requirements for infrastructure expansion of coal are generally the lowest of conventional energy types, such that switching to coal can be done without much financial difficulty. As opposed to liquid fuels like oil and natural gas, coal can be transported by using existing railroads, roads, ports, and maritime bulk carriers. Similarly the distribution and storage of coal does not require sophisticated and expensive technologies. Therefore the scale of investment necessary for coal is a lot lower than that of oil or natural gas and coal supply could be expanded with little financial burden in comparison to coal's main rival LNG that requires a substantial amount of initial investment in liquefaction, re-gasification, and storage facilities.

The combination of various negative externalities from coal burning, which ranges from haze, detrimental health effects to worries over the possible consequences of global climate change from CO_2 emissions led to the Kyoto Protocol in 1997, which was expected to place limitations on the amount of future coal consumption for many economies

In recent years technological advance in CCT demonstrates that major environmental problems that arise from coal burning can be effectively dealt with. According to a JPOWER report (2004), current CCT technology can reduce emissions of SO_X, NO_X, and soot particulates by 90% compared to CCT technology utilised in the early 1980's. It is a remarkable achievement that some heavy users of coal including the US have announced plans to adopt advanced CCT in the near future. To illustrate, the US president's 2005 Clean Skies legislation called for a 90% reduction in power plant emissions of SO_X, NO_X and mercury in the next 15 years. In addition, the US announced a $1 billion, 10-year demonstration project to create the world's first coal-based, zero-emissions electricity and hydrogen power plant under the FutureGen Initiative.[5]

With the pace of technological progress in CCT and FutureGen, coal could easily pass the public acceptance test before long. We should not be surprised to witness a major comeback of coal as the reliable and sustainable fuel for the 21st century especially in Northeast Asia, where coal endowments are relatively large.

[5] Korea expressed its intention to join the projects at the informal US-Korea energy dialogue in April 2006

IMPLICATIONS

Coal has huge a potential to provide energy in the future, but this is not without challenges.

Coal resources are also under pressure from depletion and production and transportation costs have been steadily increasing. A temporary regional coal supply shortage is foreseeable, in particular in Northeast Asia as Indonesia and China's coal export capacities are starting to decline. Although coal consumption is expected to rise, it should be noted that while coal is one of the solutions, coal is not "the" solution to our energy and environment problems.

As for Northeast Asian economies, their coal consumption levels are already high, such that large scale investment in upstream exploration and development to ensure stable supply, as well as the introduction of CCT and perhaps FutureGen technologies to limit coal induced environmental problems seems inevitable, in the face of rising demand. In 2000, Japan and Korea collectively accounted for 55.2% of total world coal imports.

The new coal question is how we can ensure that coal provides energy security and sustainable development in the future until a set of technological breakthroughs that takes mankind away from depleting fossils fuels and opens the page to a new energy future. Until this time the rapid globalisation of coal trade has to be encouraged rather than banned.

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NATURAL GAS

- *APEC's natural gas demand is projected to grow at 1.8 percent per year – a slower rate than history. Despite the relative slow growth, natural gas will play an important role to meet the rising demand of APEC with the environmental advantages.*
- *With the slow growth in natural gas production relative to demand growth, APEC as a whole will become a net importer of natural gas by 2015.*
- *LNG import in APEC is expected to increase from 101 million tonnes in 2004 to 389 million tonnes in 2030.*

With the ease-of-use factor and environmental advantages, natural gas consumption in the APEC region has been growing robustly. From 1980 to 2002, natural gas consumption grew at an annual rate of 3.4 percent – a faster rate than the average annual growth rate of primary energy consumption at 2.6 percent. Cost reduction in natural gas supply – from production to end-user – has further spurred growth in the use of natural gas. Concerns with respect to the global environment and worsening local air quality have prompted energy industries to increase natural gas consumption.

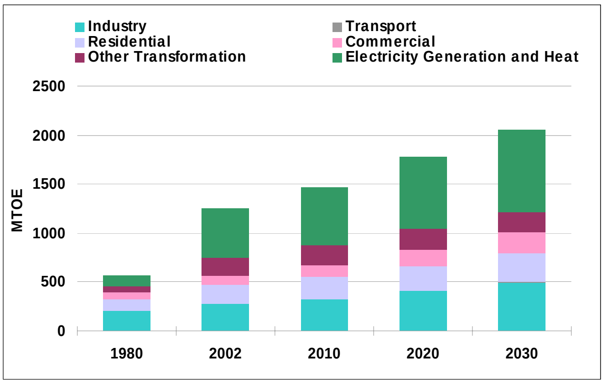
There is no doubt that natural gas has the potential to play a vital role in meeting APEC's rising energy demand. Nevertheless a number of challenges have to be overcome before we see further penetration of natural gas in the market. In electricity generation – the largest natural gas consumer – natural gas has to compete with coal, nuclear, and new and renewables, in terms of cost and stability of supply, especially in deregulated markets. In addition, an increasing amount of natural gas demand in APEC would have to be met by imports from both within and outside of the region. This means that APEC economies will face challenges on where to and how to secure long-term natural gas supply amid a rapidly changing as well as competitive market environment.

NATURAL GAS DEMAND OUTLOOK

Over the outlook period, natural gas demand is expected to increase from 1,255 Mtoe in 2002 to 2,050 Mtoe in 2030, growing at an annual rate of 1.8 percent. The projected growth rate is slower than that of the past two decades at 3.4 percent, reflecting some economies' shift in the choice of fuel for electricity generation. Due to the rise in natural gas prices and decline in domestic production, the power generators of several APEC member economies are projected to increase the use coal rather than natural gas. For example, Thailand and Malaysia have both been relying on natural gas for more than 70 percent of total electricity generation in the early 2000s; however the share of natural gas in electricity generation is expected to decline to 45 percent and 57 percent respectively in 2030. Similarly, in the US the share of natural gas in electricity generation is expected to decline from 18 percent in 2002 to 14 percent in 2030, in contrast, the share of coal in the generation mix is expected to increase from 50 percent in 2002 to 58 percent in 2030.

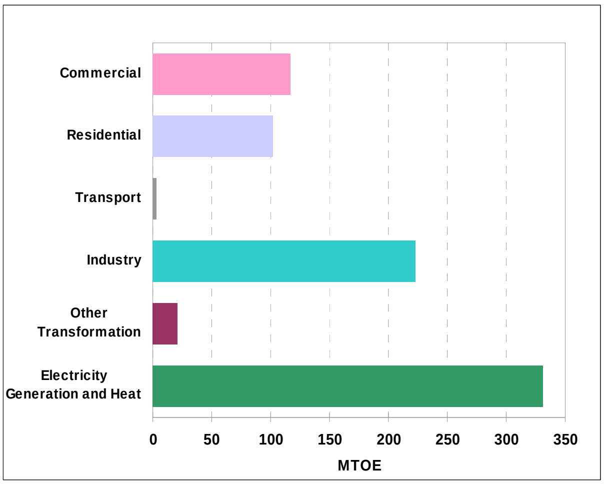
Despite a slower projected growth rate than historically, the electricity sector is expected to continue to be leading sector for natural gas demand growth. The electricity sector will account for 42 percent of total natural gas demand growth between 2002 and 2030, followed by the industry sector (28 percent), the commercial sector (15 percent), the residential sector (13 percent) and others.

Figure 14 Natural Gas Demand by Sector (1980 – 2030)



Source: APERC Analysis (2006)

Figure 15 Incremental Growth in Natural Gas (2002 – 2030)



Source: APERC Analysis (2006)

By economy, the projected growth rate of natural gas demand varies considerably (Table 4). In rapidly growing/developing economies such as China, Peru and Viet Nam, natural gas demand is expected to grow robustly at an annual rate in excess of 7.0 percent per year. For those economies at an early stage of development, natural gas has been a "premium fuel" compared with coal, hydro and biomass, that is, more expensive than other fuels; therefore the share of natural gas in total energy consumption remained low at around 3-5 percent in 2002. In addition, the large-scale capital investment requirements from upstream, midstream to the downstream have been a bottleneck to the market penetration of natural gas. Over the outlook period, driven by the steady economic development, these economies will strengthen their infrastructure to deliver natural gas to end users, thereby widening the customer base across all sectors.

Table 6 Natural Gas Demand by Economy (Mtoe)

Economy	1980	2002	2030	1980-2002 (%)	2002-2030 (%)
Australia	7.5	18.2	40.1	4.1	2.9
BD	2.46	2.02	2.23	-0.9	0.3
Canada	45.6	77.7	124.8	2.5	1.7
Chile	0.7	3.8	18.8	7.8	5.9
China	12.0	33.0	240.8	4.7	7.4
HKC		2.5	8.0		4.3
Indonesia	4.9	39.7	86.7	9.9	2.8
Japan	21.4	69.5	100.9	5.5	1.3
Korea		27.4	72.9		3.6
Malaysia	2.0	24.7	54.4	12.1	2.9
Mexico	19.1	35.7	89.5	2.9	3.3
NZ	0.8	5.4	3.3	9.2	-1.8
PNG		0.1	0.4		5.0
Peru	0.4	0.5	6.8	0.5	9.8
Philippines		1.8	11.8		7.0
Russia		364	386		0.4
Singapore		3.1	14.7		5.8
CT	1.6	7.4	25.2	7.2	4.5
Thailand		18.8	65.0		4.5
USA	477	535	681	0.5	0.9
Viet Nam		2.3	16.7		7.3
APEC	**595**	**1255**	**2050**	**3.4**	**1.8**

Source: APERC Analysis (2006)

By contrast, the demand for natural gas is not expected to grow rapidly in those economies that already have high consumption levels. For example, US natural gas demand is expected to grow at an annual rate of 0.9 percent due to the slow demand growth for electricity generation resulting from sustained high gas prices. Likewise, Russia's natural gas demand is expected to grow slowly at an annual rate of 0.4 percent reflecting the efficiency improvement and efforts to diversify energy sources away from natural gas across all sectors.

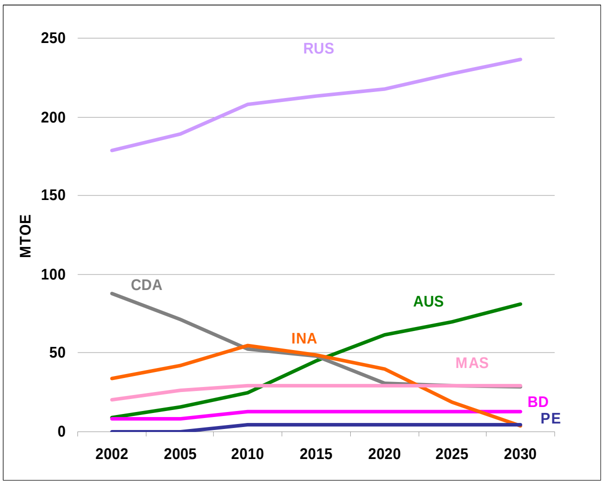
NATURAL GAS SUPPLY

Increased demand for natural gas is not likely to be met by increased production within APEC economies. Demand for natural gas is projected to grow at 1.8 percent per year, while the production of natural gas is projected to grow at 0.7 percent per year through 2030. With slow production growth relative to demand growth, APEC as a whole will become a net importer of natural gas by 2015 from the current net export position of –8 percent.

Several factors can explain why APEC will become a net exporter of natural gas. Currently APEC contains 6 net natural gas exporters including Australia, Brunei Darussalam, Canada, Indonesia, Malaysia, and Russia. Altogether these economies represented around 51 percent of global natural gas export volumes and 60 percent of the global LNG export volumes in 2003. With the exception of Australia and Russia, the other four net exporting natural gas economies will exhibit either a substantial decline or grow only modestly over the outlook period.

Natural gas export from Canada and Indonesia is expected to decline considerably. By 2030, Canada's natural gas exports are expected to drop by about 67 percent from the 2002 level as a result of declining domestic production combined with a rise in domestic natural gas demand, mainly for replacing Ontario's coal-fired electricity generation and for fuelling industrial demand. Likewise, Indonesia's natural gas export is expected to fall by 89 percent, due in part to dwindling natural gas reserves and rising domestic demand in the industry sector. Similarly, natural gas exports from Brunei Darussalam and Malaysia will not grow as quickly due mainly to the waning domestic natural gas reserves.

Figure 16 Natural Gas Export from the Major Producers in APEC (2002-2030)



Source: APERC Analysis (2006)

LNG

Over the outlook period, LNG is expected to become an important supply source to meet the demand increase. Given the projected decline in regional production and the only modest increase in natural gas exports, an increasing amount of natural gas in several economies is expected to be supplied from economies both within and outside of the region. Over long-distances exceeding 4,000 km, LNG becomes competitive relative to pipeline transport, therefore LNG has a big potential to fill the gap between increasing demand and declining supply.

Four APEC economies – Japan, Korea, Chinese Taipei and the US – buy natural gas in the form of LNG. In June 2006, China joined them with the economy's first LNG delivery arriving at the Guangdong receiving terminal.

In 2004, total LNG imports to Japan, Korea, Chinese Taipei and the US reached 100.7 million LNG tonnes or 77 percent of global LNG trade volume. Over the outlook period, as a result of expanded imports from existing importers combined with the addition of new importing economies, total LNG imports to APEC are expected to reach 389 million tonnes in 2030.

Table 7 LNG Import (Million Tonnes of LNG)

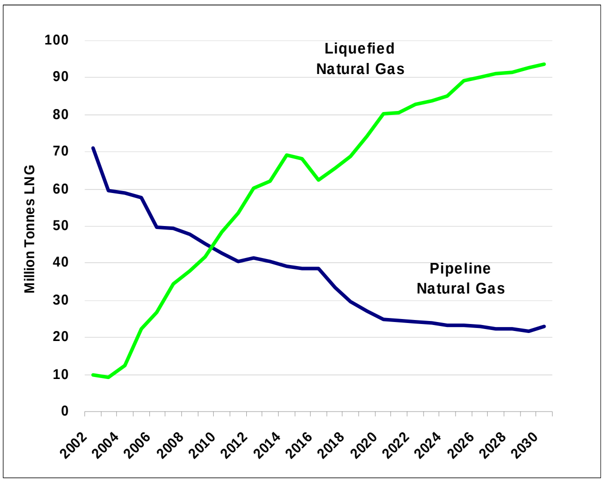
Economy	2004	2010	2020	2030
Northeast Asia				
China		6.6	26.2	52.0
Japan	57.0	60.7	74.1	81.2
Korea	22.3	35	48.4	58.7
CT	6.5	11	14.8	19.7
Southeast Asia				
Singapore		0.309	3.5	6.6
Philippines		0.929	0.929	0.929
North America				
Canada		7.8	25.8	31.8
USA	12.5	45.8	80.2	93.6
Latin America				
Chile		1.06	5.01	11.4
Mexico		14.3	26.2	33.2

Source: APERC Analysis (2006)

The Northeast Asian economies of Japan, Korea and Chinese Taipei are the biggest LNG importers in APEC as well as in the world. Due to the lack of domestic natural gas reserves, most of the economies' natural gas consumption is supplied through LNG. Over the outlook period, Northeast Asia's natural gas growth is expected to vary from economy to economy. It is expected that Japan's LNG imports will grow at a moderate rate of 1.3 percent per year, reflecting declining population and revival of nuclear and coal in electricity generation. Korea's LNG imports are expected to more than double between 2002 and 2030, to fuel the substantial growth in natural gas demand for the electricity and industry sectors.

Over the outlook period, the US is expected to expand LNG imports from 13.5 million tonne in 2004 to 93.6 million tonne in 2030. By sometime around 2015, US LNG imports are expected to surpass that of Japan and the US will become the biggest LNG importer in APEC and the world. In 2002, domestic natural gas production accounted for about 80 percent of total consumption, and pipeline natural gas from Canada accounted for about 90 percent of total imports. However, after 2010, LNG is expected to replace pipeline natural gas to become the primary source of imports, due in part to declining Canadian natural gas production in addition to the need to meet domestic natural gas demand growth.

Figure 17 Natural Gas Import to the US by Mode (Million Tonnes of LNG)



Source: APERC Analysis (2006)

Given the limited availability of natural gas reserves, China needs to rely on imports to meet natural gas demand growth. LNG imports are projected to increase from 3 million tonne in 2006 to 52.0 million tonne in 2030. However, near-term growth in LNG imports is expected to be slower than in the long-term due to the high LNG prices in the global market. By 2015, in addition to the Guangdong receiving terminal that started operation in late 2005, and the Fujiang receiving terminal planned to be operational in 2007, another one or two terminals are expected to start operation, receiving a combined total of around 15 million tonnes. By 2030, China's LNG imports have the potential to reach 52.0 million tonnes, which will account for 27 percent of total natural gas demand or 2 percent of primary energy demand in 2030. There are currently plans to build up to 15 LNG receiving terminals along the east coast under consideration.

To enhance natural gas supply security, Chile and Singapore plan to start importing LNG. In 2004, both economies experienced a loss in supply from their incumbent/neighbouring suppliers. In 2004, Chilean gas-fired power stations and methanol plants had to suspend operations because natural gas supply from Argentina – the exclusive natural gas supplier to Chile – was cut by half on some days. Similarly, Singapore was rattled by a natural gas supply disruption from Indonesia, which resulted in blackouts across the economy. These incidents drove Chile and Singapore to formulate a policy to develop LNG receiving terminals as LNG is considered to provide a strategic back-up in terms of supply diversification to augment existing pipeline gas supply from neighbouring economies.

IMPLICATIONS

Natural gas is expected to play a vital role to meet the APEC's rising energy demand.

To fill the gap between the increase in demand and decline in production, increasing number of APEC economies are expected to rely on natural gas import in a form of LNG. On top of existing major LNG importers, namely Japan, Korea, Chinese Taipei and USA, 6 APEC economies are expected to join them as LNG importers.

APEC economies will face challenges to secure LNG supply due to the distinctive features of the LNG industry. Because of the capital-intensive nature of the LNG project and the need to ensure stable supply, LNG will continue to be traded under long-term contracts. Nevertheless, securing long-term contracts will be an arduous process due to financial and technological challenges.

Recently, LNG supply costs are rising in parallel with the rise in material costs, shortage of engineering, unavailability of procurement and construction companies on large-scale LNG projects.[6] Also, balance between LNG demand and supply is expected to remain tight until 2010 when major supply projects from Australia, Qatar and Nigeria will start-up operations. This indicates that the difference between "proposed sales prices" and "purchase prices" will not narrow significantly in the near future.

Finding and developing natural gas reserves will become more difficult over time. In newly found fields, reserves are getting smaller, deeper, more remote and harder to reach. In other words, the execution out of future natural gas projects poses technological as well as financial challenges for developers.

Rising LNG imports may also increase the inter-dependence of economies both within and outside of APEC. Given the challenging environment for finding and developing natural gas and securing long-term supply, APEC governments have a catalytic role in terms of creating a framework through which upstream investment is ensured, and both suppliers and consumers make commitments for long-term contracts. The concerted efforts of APEC policy makers and energy industries, will lead to the enhancement of natural gas supply security and mutual prosperity.

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[6] The Daily Oil Bulletin (2006), "LNG supply build on track despite growing pain".

NUCLEAR

- *Demand for nuclear energy in electricity generation is expected to grow at 1.9 percent per year from 1,488 TWh in 2002 to 2,526 TWh in 2030; owed mainly to the growing concerns for energy supply security and activity to mitigate negative environmental effects of electricity generation.*
- *Perennial concern over safety and security will remain the major hindrances to public acceptance of nuclear energy.*
- *The development of new technologies will contribute to the expanded use of nuclear energy, and fertilize other hi-tech industries*

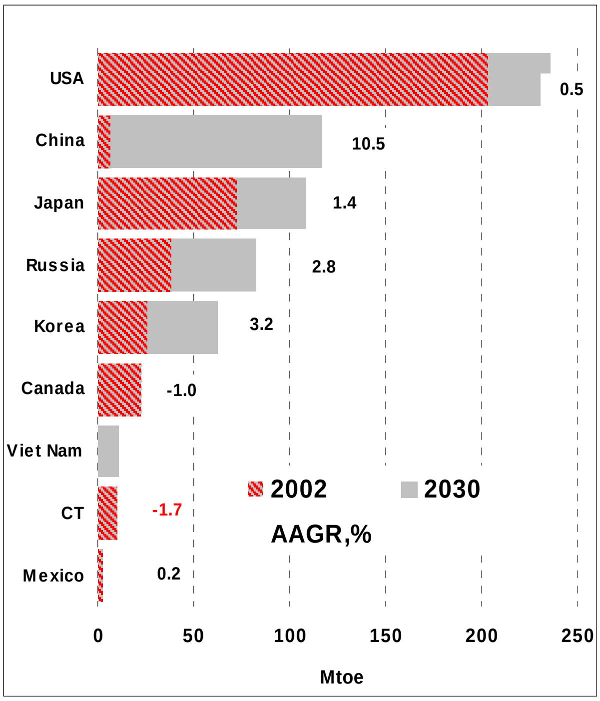
The economic advantages (low generation cost, reduced air pollutions, and low exposure to price volatility from the operation of nuclear energy) are likely to contribute to considerable growth of nuclear energy over the outlook period. This growth is expected to be predominantly centred in the traditional nuclear APEC economies with the addition of Viet Nam from Southeast Asia after 2015. However, the main impediment to nuclear expansion is low public acceptance of nuclear energy due to safety issues arising from the fuel handling and operation of nuclear power assets. To overcome this impediment enormous effort will need to be made by the scientific, business and governmental communities worldwide to develop advanced nuclear technologies that further strengthen operational safety and alleviate the public risk.

HISTORICAL TREND AND OUTLOOK PROJECTIONS

There has been renewed interest in nuclear energy worldwide, particularly in the APEC region. Over the past two decades, electricity generation from nuclear in the APEC region has grown at an average annual rate of 6.1 percent. In 2002 Korea and Japan were the leading users of nuclear energy, generating respectively 36 and 29 percent of total electricity from nuclear, followed by Chinese Taipei and the US each with a 20 percent share. However, unresolved issues and the perceived risks have remained a major barrier to the full deployment of nuclear industry within the APEC region. The nuclear industry is still fighting a legacy of fear in relation to radiation as a result of accidents, and the issues of waste disposal. Despite these perceived risks, nuclear is still considered a viable alternative from the viewpoint of supply security and low or near zero air pollutions. Supply security and low generation costs have made nuclear energy attractive in many APEC economies and offer a strong incentive to continue the operation. However, the economics of the nuclear fuel cycle may have negative impact on market competitiveness when all aspects of the nuclear supply chain, including fuel recycling and waste storage, are considered (see Box "Nuclear energy peculiarities").

The share of nuclear energy in total primary energy demand in APEC region is expected to remain stable at 6 percent between 2002 and 2030, while the share in electricity production will decline slightly from 16 percent in 2002 to 12 percent in 2030. In 2002, nuclear power plants accounted for 10 percent (204 GW) of total electricity generation capacity in the APEC region, and 16 percent of the electricity produced. With the exception of petroleum-based generation, nuclear generation capacity is expected to grow the slowest over the outlook period at 1.7 percent per year. Similarly, nuclear electricity generation is projected to grow the slowest at an annual rate of 1.9 percent. Nevertheless, electricity generation from nuclear power will increase from 1,488 in 2002 to reach 2,526 TWh in 2030. In the APEC region, China is expected to lead nuclear growth at 10.5 percent per year, with capacities increasing in Korea, Russia, Japan, and the US over that in 2002, and Viet Nam as new regional nuclear power (Figure 18).

Figure 18 Nuclear Energy Production (Mtoe)



Source: APERC Analysis (2006)

Many important issues currently existing in the APEC region can be addressed by nuclear power: scarcity of local energy resources, the need for energy diversification while meeting electricity demand, and the need to reduce the emission of pollutants and greenhouse gases. Nuclear power is a baseload energy source which significantly reduces dependency on fossil fuels. Nuclear fuel price has a history of stability, and because of the low contribution of the uranium price to total generation costs are much less vulnerable to fuel price volatility. Additionally, besides hydro nuclear power is the only large-scale, baseload energy source that does not create air pollution and emit greenhouse gases, and contrary to hydro did not impact heavy on river's ecosystems.

PUBLIC ACCEPTANCE[7]

There is an overstatement of nuclear energy's drawbacks; especially over issues such as safety, waste, and economics. Fears about nuclear power's safety are not necessarily well justified. Since its beginnings in mid-1950's it has proven to be the safest of all energy sources, even considering the one single accident, Chernobyl. Safety records in the operation of nuclear plants are improving and nuclear reactors in the future can be made even safer as more safety features are being incorporated into new designs.

The public perception of nuclear waste as being an 'unsolvable' problem is unfounded from a technological standpoint. Waste in the nuclear industry is but a small fraction of the burden that industrial waste represents worldwide, with the difference that nuclear waste decays to safe radioactive levels over time. There is no urgent need at present for final disposal of high level radioactive waste given that almost all is currently undergoing the required 40-50 year initial cooling down period. When sufficient volumes of spent fuel assemblies or of high-level waste are ready to be definitively disposed of, the technology for deep underground repositories will have been demonstrated and available. The technology is well advanced today and there is already one repository for military use in operation, while the construction of the first civilian repository is expected sometime after 2010.

For nuclear power to have a prominent position in the electricity generation sector, advances have to be made on the most controversial issues. The industry has to eliminate the public's scepticism concerning nuclear waste handling. On the part of governments, it will entail major responsibilities to ensure the continued safe operation of nuclear facilities, to make the required political decisions to develop and implement national waste management strategies, and to promote international action to strengthen non-proliferation controls. This should be closely coordinated with activities towards processing spent nuclear fuel that can effectively reduce the volume and toxicity while implementing advanced proliferation-resistant treatment and transmutation technologies.

ADVANCED FISSION AND FUSION[8]

In response to the challenges currently facing nuclear power, many countries are working to improve the economics, safety, waste management and proliferation resistance of advanced reactor-fuel cycle systems. For advanced nuclear power plant designs, efforts are focused on making plants simpler to operate, inspect, maintain and repair. In the near term, most new nuclear power plants are likely to be evolutionary designs building on proven systems while incorporating technological advances and often economies of scale. Over the longer term, the focus is on innovative designs, several of which are in the small-to-medium range (up to 700 MW_e). These envision construction with factory-built components, including complete modular units for fast on-site installation, creating possible economies of series production instead of economies of scale. Some are being designed for operation without on-site refuelling. Other advantages foreseen for smaller units are easier financing, greater suitability for small electricity grids or remote locations, and their potential for district heating, seawater desalination and other non-electric applications. Such advances should increase their attractiveness for many developing countries and some industrialised countries.

There are two major international efforts to promote innovation for nuclear energy – the IAEA's **International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)** and **Generation IV International Forum (GIF)**. Canada, Chile, China, Indonesia, Korea, and Russia are the APEC economies participating in INPRO project. INPRO published an initial report in 2003 that outlined the potential of nuclear power and specified guidelines and a methodology for evaluating innovative concepts. The next stage of INPRO is to facilitate assessments of innovative nuclear energy systems (INSs), to define and model INS deployment scenarios taking into account strategies considered by participating economies. Canada, Japan, Korea, and the US are the APEC member economies participating in the GIF project. GIF has reviewed a wide range of innovative concepts and, in 2002, selected six types of reactor systems for future

7 APERC (2004)

8 IAEA (2005)

bilateral and multilateral cooperation: gas cooled fast reactors, lead alloy liquid metal cooled reactors, molten salt reactors, sodium liquid metal cooled reactors, supercritical water cooled reactors and very high temperature gas reactors.

Much of the current experimental and theoretical research on nuclear fusion is focused on the **International Thermonuclear Experimental Reactor (ITER)**. ITER's "engineering design activities" stage has been completed, and the realization of ITER came closer with the announcement in June 2005 by Seven Parties to ITER – the European Union, Russia, Japan, China, India, Korea and the United States – that it will be sited at Cadarache in France. The aim of ITER is to demonstrate the scientific and technological feasibility of fusion energy by constructing a functional fusion power plant. ITER would take about 8 years to build and will then operate for a further twenty years. **It will be the first device in the world where a controlled nuclear fusion reaction will generate at least 5 times more power than it consumes**. ITER will open new horizons for nuclear science and technology for energy applications, with expected spin-offs in many other areas.

IMPLICATIONS

High growth rates for nuclear energy development, especially in China, and exhaustion of military stocks for nuclear fuel production renew issues of nuclear industry's safety. That is internal safety of nuclear reactor operations; nuclear fuel cycle safety for environment, human's health, and non-proliferation. Critical decisions for nuclear industry should be made and strong amendments to the international regime for peaceful utilisation of nuclear energy should be implemented in coming decades, based on technological developments and political willingness.

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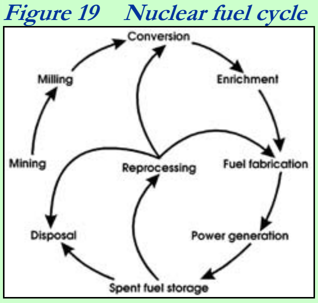
Nuclear Energy Peculiarities [based on WNA (2005)]

The fundamental difference in nuclear energy utilisation is the multi-stage nature: mining or production of fission materials from ore or other natural sources, conversion, enrichment, production of nuclear fuel for certain reactor design, spent fuel processing and disposal (temporary for spent fuel and permanent for wastes), see Figure 19. These fundamentals of the nuclear fuel cycle lead to multiply sources of nuclear energy transformation to more convenient energy carriers: electricity, heat, and, possibly in the future, hydrogen. One source of nuclear fuel is from processing row materials containing uranium (or thorium) in very low concentrations (sometimes less then one part per billion). Processing of waste tales of past nuclear enrichment is close to this process. The other way is to process high enriched nuclear materials from obsolete or terminated nuclear weapons. Or the third source for nuclear fuel production is to process spent nuclear fuel, which is treated as enriched nuclear materials.

Figure 19 Nuclear fuel cycle



Source: WNA (2005)

The physical process of fission requires strictly controlled conditions and a high purity of materials while utilising only a small amount of the energy held in the nuclear fuel. This last characteristic provides a unique opportunity to reuse the residual fissile materials contained in the nuclear fuel after reprocessing, creating the so-called nuclear fuel cycle. In addition, under some conditions even more fissile material can be accounted for in spent nuclear fuel after power generation than it held before power generation. This breeder concept of a self-sufficient and enhanced fuel cycle requires creation of expensive reprocessing and disposal facilities as preliminary conditions.

However, fuel reprocessing does not solve the waste disposal problem and unless it is blended as mixed oxide fuel (MOX) for use in conventionally designed reactors, creates large inventories of plutonium that must be safeguarded against weapons proliferation.[9]

Nuclear energy also seems to be the most likely means of large-scale hydrogen production without the release of greenhouse gases, using very-high temperature reactors coupled with thermo-chemical or high-temperature electrolytic water dissociation processes.

[9] WEA (2004), p 55

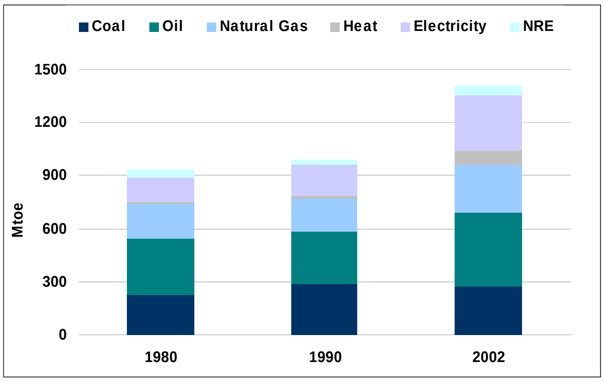
INDUSTRY

- *The APEC region dominates the world's manufacturing sector, having the largest steel, cement, shipbuilding, and petrochemical production.*
- *Growth rate of the most energy intensive industrial products in Asia's APEC economies is far outpacing the world's average.*
- *Industry is projected to remain the largest end-use sector, with it share of final energy demand expected to increase from 37 percent in 2002 to 41 percent in 2030.*
- *The industrial sector's energy intensity in the APEC region is expected to decline at an annual rate of 2.0 percent due to synergy effects of structural changes and higher energy efficiency*

HISTORICAL TRENDS AND FACTORS AFFECTING INDUSTRIAL ENERGY CONSUMPTION

The APEC region is the largest manufacturing base in the world. It dominates the world's pig iron and steel (69 percent and 64 percent, respectively), cement (65 percent),[10] and petrochemical production (69 percent)[11]. Over the last two decades, the region's industrial energy consumption has increased at an average annual growth rate of 1.9 percent from 933 Mtoe in 1980 to 1,407 Mtoe in 2002, which constitute about 59 percent of world industrial energy consumption. Historical patterns for industrial energy consumption in the APEC region dated back as far as 1980 is presented in Figure 20.

Figure 20 Historical Industrial Energy Consumption in the APEC region



Source: IEA (2004)

Note: the IEA data for Russia is available from 1992; hence this is included for 2002 only.

The growth was moderated by the decline in the US energy consumption at 0.4 percent annually while all other APEC economies (except Russia) have significantly increased industrial energy consumption at an annual rate of 2.5 percent. Between 1992 and 2002, the total industrial sector energy consumption in the APEC region has increased at an average annual growth rate of 1.7 percent from 1,188 Mtoe in 1992 to 1,407 Mtoe in 2002, or by 219 Mtoe. In 2002, the industrial sector (industry plus agriculture) energy consumption has accounted for 37 percent of total final energy consumption.

Energy consumption in the industrial sector was mainly driven by three major factors such as:

- growth in industrial value added,
- changes in economic and industry structure,
- output of energy-intensive products.

The type of technology employed in industry, availability of domestic energy resources, and government policy also played an important role, especially in the determination of the energy mix.

Growth in industrial value added

Industry energy consumption was mainly driven by the level of economic growth. As a rule, industrial energy demand per capita rises with economic growth, as observed in Figure 21, although the level varies across economies. Typical examples are Korea, Singapore, Chinese Taipei, and New Zealand where for the last two decades these economies have GDP grown annually at 7.0, 6.8, 6.5 and 2.6 percent respectively. Almost in parallel with this growth has been the rise in per capita industrial energy consumption, increasing rapidly at 6.5, 8.7, 3.4, and 2.7 percent, respectively. However, saturation was observed after reaching a certain level of per capita income, as has been the case in Japan, Canada, Australia, Hong Kong, China, and the US. Developing economies are projected to most likely follow a similar path to that of the developed economies in the past.

The industrial sector's energy intensity[12] was affected by a plethora of factors: a) the level of economic development, with more developed economies having relatively smaller industrial sectors and utilising more energy efficient technology; b) industry structure including the share of energy-

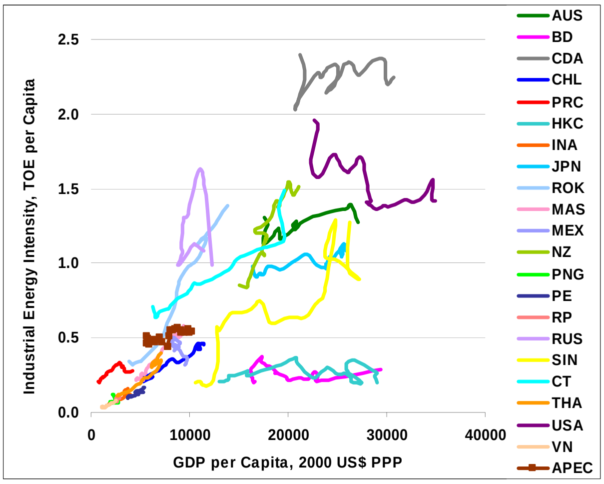
[10] USGS (2006)

[11] IEA (2004)

[12] The amount of energy needed to produce a dollar's worth of industrial sector's value added

intensive industries; and c) the type of technology employed in each industry. In general, it was observed that the correlation between energy consumption and economic growth was relatively weak in the developed economies, with energy consumption growth lagging behind that of economic growth. In the developing economies, however, the two have been more closely correlated, with energy consumption growth tending to track the rate of economic expansion.

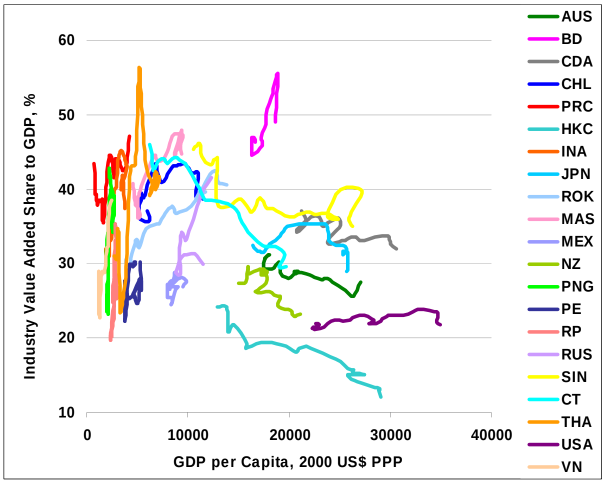
Figure 21 APEC Industrial Energy Consumption per Capita vs. GDP per Capita (1980-2002)



Source: APERC Analysis (2006)

economy in APEC, has a 22 percent share of industry to GDP, while China, a currently rapidly developing economy, has 47 percent. In general, the more an economy develops, the lower the share of industry to GDP. As another example, consider the case of Chinese Taipei. When this economy was still developing in the 1980s, the share of industry to GDP was 46 percent; but as the economy subsequently developed, the share fell to reach 30 percent in 2006.

Figure 22 APEC Share of Industry to GDP vs. GDP per Capita (1980-2002)



Source: APERC Analysis (2006)

Economic and industrial structure[13]

Another important factor which determined the path of future energy demand in the industrial sector is economic structure. It explained partly why economies with similar income levels have different per capita industrial energy consumption. For example in the case of Canada (Figure 21), per capita industrial energy consumption was much higher than that of the US, while they both share the same level of per capita GDP. The wide difference in levels of energy consumption was also observed between Japan and Hong Kong in the Northeast Asian region; again with a similar level of per capita GDP. In both cases, all were attributed to the difference in economic structures.

Figure 22 shows the historical share of industry (manufacturing, mining and construction) to GDP in relation to income in the APEC region. Most of the developed economies have a relatively low share of industry to GDP, compared with that of developing economies. For instance the US, the most developed

Energy-intensive industry

Energy is utilised in the industrial sector by a diverse set of industry sub-sectors including manufacturing, mining, construction, agriculture, and fishery. Each sub-sector requires a quite different amount of energy to produce a dollar's worth of the sector's value added. In general, energy use per unit of output is relatively high in industries that process raw materials than that of industries engaged in light manufacturing. For example, iron and steel, chemicals and petrochemicals, non-metallic minerals, mining, paper and pulp, which are collectively included in the energy-intensive industries for the analysis, use more energy to produce the same amount of value added than other manufacturing and construction processes.

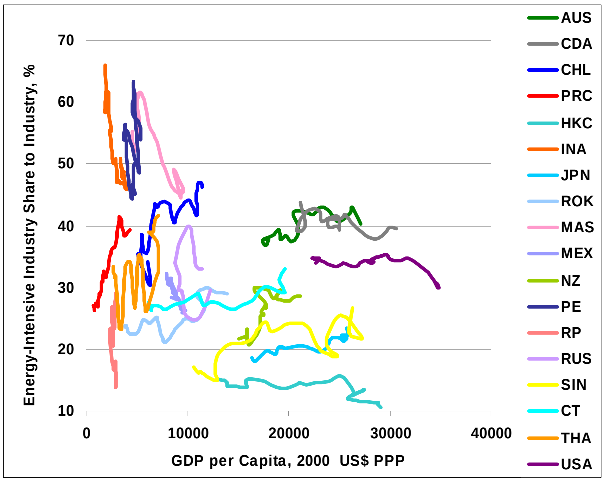
The sub-sectoral structure within the industry sector is also another important factor to explain the differences in energy demand across economies with similar stages of development. It gives some clue to understand why Australia's per capita industrial energy demand is higher than that of Japan (Figure 23), although both have almost the same share of industry in GDP, at around 30 percent – Australia's industrial production's reliance on energy-intensive industry reached about 40 percent in terms of

[13] To avoid confusion, here economic structure refers to structure between agriculture, industry and service, and industry structure refers to structure between sub-industries (energy-intensive industry and non-energy-intensive industry) within industry sector.

industrial value added in 2002; while Japan was only at 23 percent.

Figure 23 shows the historical share of energy-intensive industry within the industry value added in relation to income in the APEC region. No single trend that explains the share of energy-intensive industry to total industrial output can be easily discerned from this figure. In fact, Japan, Korea, New Zealand, Russia, Singapore and Chinese Taipei have increased the share of energy-intensive industries; while for Canada and the US it decreased. Similarly, the growing share of energy-intensive industries for more than two decades is observed for Chile, China and Philippines, and decreasing – for Indonesia, Malaysia, Peru and Thailand. The range of the share (between 10 percent and 40 percent) is quite diverse even among developed economies, basically because of their reliance on domestic resources, historical development path, industrial development strategy and industrial competitiveness.

Figure 23 APEC Energy-intensive Industry Share to Industry vs. GDP per Capita (1980-2002)



Source: APERC Analysis (2006)

Output of energy-intensive products

Aside from economic growth and the shifting of industry structure, the production of energy-intensive products such as crude steel, cement and ethylene has also influenced industrial energy consumption in the APEC region. The iron and steel industry – the single largest industrial coal-consuming sub-sector – accounted for nearly 35 percent of global industrial coal consumption in 2002. The production of basic petrochemicals such as ethylene, propylene, and butadiene is the single most energy-consuming process in the petrochemical industry.

APEC has remained the main manufacturing base of crude steel in the world. China dominated world raw steel production at 272 million tonnes in 2002, accounting for about 26 percent; Japan, the US, Russia, and Korea, were the next largest steel makers.

The APEC region, and especially the Asian APEC economies, recorded higher growth rates for almost all of the most energy intensive industrial products over the last five years (Table 8).

Table 8 APEC's Role in the World Production of Most Energy Intensive Industrial Products

		2000	2004	AAGR
Primary aluminium, Mt	World	24.3	29.8	5.2%
	APEC	14.4	17.9	5.5%
	Asian APEC	3.0	6.9	23.5%
Primary copper, Mt	World	10.6	11.2	1.4%
	APEC	7.6	7.8	0.8%
Pig iron, Mt	World	573	712	5.6%
	APEC	362	488	7.7%
	Asian APEC	247	373	10.9%
Raw steel, Mt	World	850	1050	5.4%
	APEC	509	670	7.1%
	Asian APEC	306	464	11.0%
Cement, Mt	World	1660	2130	6.4%
	APEC	998	1377	8.4%
	Asian APEC	814	1166	9.4%

Source: USGS (2006)

The APEC region is also the main manufacturing base of ethylene in the world. APEC ethylene production increased from 43 million tonnes in 1995 to 57 million tonnes in 2002 (60 percent of world's total), at an annual average growth rate of 4.2 percent. In 2002, the US with production of 23.6 million tonnes was the top ethylene manufacturer in APEC and the world. The US is followed by Japan, Saudi Arabia, China, and Korea, all in the APEC region with the exception of Saudi Arabia.

BASIC ASSUMPTIONS FOR INDUSTRIAL ENERGY DEMAND PROJECTIONS

The industrial sector's value added, rather than GDP, is projected to serve as the key determinant in projecting future industrial energy demand. For example in the case of Hong Kong, China the economy's annual increase in GDP of about 4.0 percent during the last decade has not increased but rather decreased the industrial energy consumption, equal to 1.3 percent over the same period. This is primarily due to the reason that economic growth in Hong Kong, China is mainly driven by the service sector such as finance, trade and logistics, rather than the industry sector. The current outlook considers Global Insights' forecasts up to 2025[14] as background for the industrial sector's value added projections to 2030 for the APEC member economies.

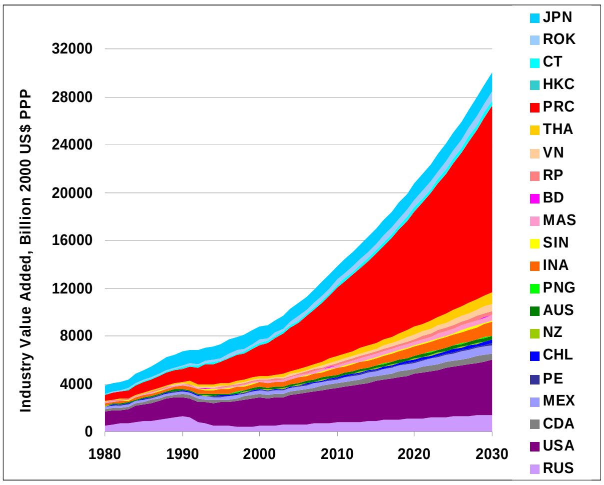
[14] Global Insights (2005)

Over the last decade, the economic structure of APEC has shifted from the industry to the services sector, with the share of the service sector to GDP increasing from 62.6 percent in 1990 to 64 percent in 2002. Over the outlook period however, the economic structure is expected to shift towards industry as a result of rapid industrialisation of developing economies, such as China and those in Southeast Asia. The share of industry to GDP is projected to increase from 30.6 percent in 2002 to 34.8 percent in 2030, while that of service will decrease from 64.0 percent to 61.8 percent. However, the share of energy-intensive industry to total industrial production is expected to decrease from 33.6 percent in 2002 to 30.5 percent in 2030. The share of agriculture is also projected to decrease from 5.7 percent in 2002 to 4.0 percent in 2030.

Over the outlook period, the APEC region is expected to experience 4.3 percent annual growth in the industrial sector's value added (agriculture of 2.8 percent and industry of 4.5 percent), a bit lower than the 4.7 percent annual industrial value added growth observed in the previous two decades (Figure 24).

In the coming years, Viet Nam and China are projected to have the fastest annual growth at 7.1 and 6.6 percent respectively, due in part to strong domestic demand growth and the influx of foreign investment. China is expected to continue to be the economy with the highest share of industry to GDP in the APEC region, at 44.2 percent in 2030. However, as the industry sector develops in China, the less energy-intensive light industries are projected to increase output faster than energy-intensive ones, in order to meet the growing demand for consumer products. Therefore, the share of energy-intensive industries to the total industrial production will fall from 33.6 percent in 2002 to 30.5 percent in 2030.

Figure 24 APEC Industrial Sector's Value Added



Source: APERC Analysis (2006)

Table 9 shows the history and projections for GDP structure and energy-intensive industry share for the APEC region, reflecting the decreasing share of agriculture and the increase in the industry sector relative to that of the service sector.

Recovering from the 1991-1998 economic crisis, Russia is projected to show robust industry sector growth of 4.1 percent per year, compared with minus 7.1 percent over the period 1990 to 2002. Continued robust growth of 4.2 percent is expected in Korea; while moderate growth of 2.4 and 2.2 percent is projected for the US and Canada, and modest growth of 1.5 percent in Japan.

Table 9 APEC Economic Structure: Share of Industry in GDP, %

Sectors	1985	1990	2002	2010	2020	2030
Agriculture	6.1	5.9	5.7	4.9	4.4	4.0
Industry	30.3	31.7	30.6	32.9	34.0	34.8
Energy-intensive Industry Share to Industry	*30.6*	*31.1*	*33.6*	*32.3*	*31.2*	*30.5*
Service	63.8	62.6	64.0	62.6	62.1	61.8

Source: APERC Analysis (2006)

Table 10 Assumptions for Steel and Ethylene Production, APEC and China

Indicators		2002	2010	2020	2030	AAGR for 2002-2030
Crude steel, Mt	APEC	544	697	784	864	1.7%
	China	171	290	338	385	2.9%
Ethylene, Mt	APEC	57.2	76.3	103.2	130	3.0%
	China	5.4	12.8	25.1	38.8	7.3%

Source: APERC Analysis (2006)

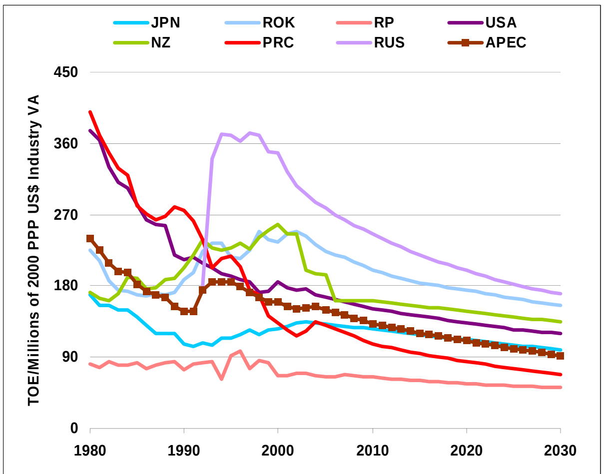
Table 10 shows the production of crude steel and ethylene by APEC and China over the outlook period. Steel production in the APEC region is projected to increase to 864 million tonnes in 2030, growing annually at 1.7 percent, while ethylene production is projected to reach 130 million tonnes in 2030, growing annually at 3 percent. China will account for the major share in incremental production of both steel and ethylene in the APEC region, contributing at 67 percent and 46 percent, respectively.

INDUSTRIAL ENERGY INTENSITY

Over the outlook period, the APEC region's energy intensity in the industrial sector is projected to improve from 179 toe per 2000 US$ million in 2002 to 103 toe per 2000 US$ million in 2030, declining annually at 2.0 percent, which is lower than the 2.6 percent rate of improvement in the past two decades. Figure 25 shows the trend in energy intensity for industry (without agriculture) over the period 1980-2030 for the whole of APEC and seven economies projected to show the greatest improvement.

Over the projected period, China, Russia and New Zealand are expected to improve energy intensity at 2.5 percent, 2.4 percent and 2.3 percent annually, followed by Korea at 1.8 percent, the US and the Philippines at 1.4 percent both, and Japan at 1.1 percent respectively. Thus one-third of APEC economies are expected to achieve energy intensity improvement of greater than one percent per year. The expansion of non-energy-intensive industries and service industries in the developed economies combined with continuing efforts/policies to enhance energy efficiency in other economies in the APEC region will improve the overall industrial energy intensity.

Figure 25 Trends of the Industrial Energy Intensity for the APEC and top performing economies



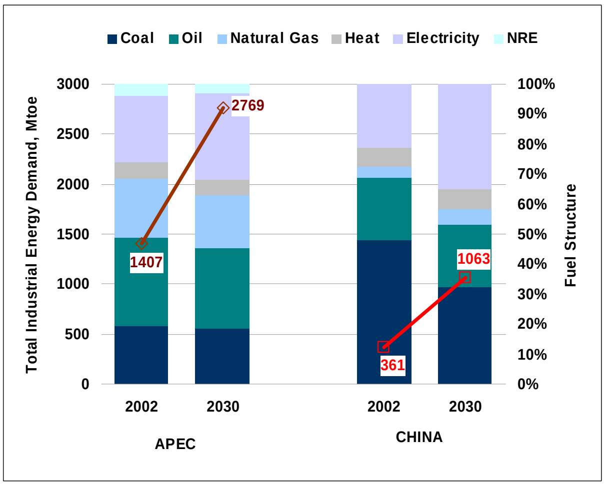
Source: APERC Analysis (2006)

THE EVOLVING ENERGY MIX

Reflecting the APEC region's combined industrial and agriculture sector robust GDP growth of 4.3 percent per year, industrial energy demand is projected to increase from 1,407 Mtoe in 2002 to 2,769 Mtoe in 2030, at an annual growth rate of 2.4 percent. Industrial energy demand per capita will also increase from 0.54 toe in 2002 to 0.92 toe in 2030, at 1.9 percent per year. Industry will remain the largest end-use sector in 2030, and it's share to total final energy demand will increase from 37 percent in 2002 to 41 percent in 2030.

Some shift in the fuel mix is also expected over the outlook period. Figure 26 shows the projected energy demand growth and relative fuel mixes in the industrial sector for the overall APEC region and China – the share of which will grow from 26 percent in 2002 to 38 percent in 2030.

Figure 26 Projected Changes in Industrial Sector's Final Energy Demand and Fuel Mix, APEC and China

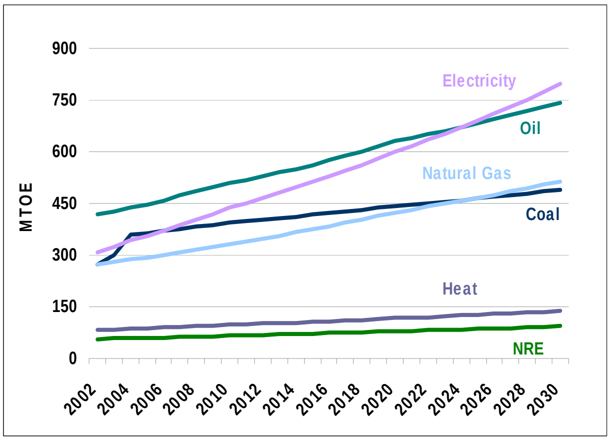


Source: APERC Analysis (2006)

The mix of fuels used in the industrial sector can vary widely from economy to economy, depending on a combination of regional factors, such as the availability of energy resources, the establishment/development of energy infrastructure, the level of economic development, the structure of processes used in the domestic industry, and government policy. As industry develops, further use of new and high-tech precision equipment will require greater demand for electricity. Increasing industrial activity is expected to lead the growth in the demand for natural gas, with several developing economies focused on expanding the infrastructure necessary for the delivery of this relatively clean fuel. Demand for naphtha as a feedstock for ethylene production is projected to lead the growth in industrial oil demand.

The structure of energy demand in the industrial sector will change to contain a greater share of electricity and natural gas at the expense of other fuels (Figure 27). The share of oil is projected to reduce from 30 percent to 27 percent over the outlook period, while oil demand increasing at an average annual rate of 2.1 percent, which is at lower pace then total industrial energy demand growth at 2.4 percent annually. Electricity is expected to be the fastest growing energy source at 3.5 percent per year with the share increasing from 22 percent in 2002 to 29 percent in 2030, overtaking oil to attain the highest share in total industrial energy demand. The rapid increase is due in part to the number of industries that are expected to apply efficient electrically operated technologies. The growth in demand for natural gas is also expected to be robust, with an annual growth rate of 2.2 percent. The share will however decline slightly from 19 percent in 2002 to 18 percent in 2030. Despite average annual growth rate of 2.3 percent, coal is expected to follow a similar trend, with the share also decreasing from 19 percent to 18 percent over the same period. Contraction in the share of coal will largely happen as a result of slowdown in China's coal demand, due mainly to the improved business performance and energy efficiency levels of Chinese crude steel and cement industries as a result of the consolidation of small-scale steel and cement producers over the outlook period. China's coal demand accounted for 64 percent of total industrial coal demand in the APEC region in 2002 and has experienced sharp growth in recent years.

Figure 27 Dynamics of APEC Industrial Sector's Final Energy Demand (by energy)



Source: APERC Analysis (2006)

IMPLICATIONS

As the APEC region currently dominates manufacturing in the world, especially for energy-intensive production, APEC's industrial energy demand is expected to double by 2030. The structure of the various energy/fuel consumed by the industrial sector will also change to a greater share of electricity at the expense of fossil fuels, thus intimately intertwining the industry sector with infrastructure development and expansion in the electricity generation and transmission sector.

The share of industrial energy demand of the Asian economies to total APEC industry energy demand will rise from 49 percent in 2002 to 63 percent in 2030, primarily driven by China's high economic growth, thus highlighting the urgent need of technology transfer and energy efficiency improvement to reduce the industrial energy intensity in China.

For the APEC region overall, industrial energy intensity is expected to decline at a lower rate, reflecting saturation trend of advanced technologies penetrating globally, being transferred from developed to developing economies.

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RESIDENTIAL AND COMMERCIAL

- *Residential energy demand is expected to grow at an annual rate of 0.9 percent through 2030; mainly due to income and population growth.*
- *Rapid growth in GDP of Services will result in a two-fold increase in commercial energy demand over the outlook period.*
- *Electricity is projected to grow the fastest of the fuel types and is expected to grow at an annual rate of 2.8 percent to take the largest share of total residential and commercial energy demand at 42 percent in 2030 from 29 percent in 2002.*

HISTORICAL TRENDS AND CHARACTERISATION OF RESIDENTIAL AND COMMERCIAL ENERGY CONSUMPTION

Energy consumption in the residential sector of APEC economies accounts for between 5 and 67 percent of total final energy consumption, the share typically being higher in many of the developing economies. Over the past decade, the total energy consumption of APEC's residential sector has grown in parallel with increasing income and population. In addition, the added requirements for space and water heating, space cooling, lighting, operating appliances and other equipment have boosted the energy consumption of the residential sector increasing from 603 in 1980 to 938 Mtoe in 2002, growing at annual rate of 2.0 percent.[15] Commercial sources of energy, excluding biomass, grew at annual rate of 2.6 percent during the same time period.

Depending on the level of economic development and weather conditions, energy use shows different characteristics for both developed and developing economies. In developed economies, for example Canada, energy consumption for spacing heating and cooling accounted for about 50 percent of total energy used. Canada's residential energy consumption per capita was around 50 times higher than that of many developing economies because of Canada's higher income level and greater heating requirements. On the other hand, cooking and water heating accounted for about 80 percent of household energy use in developing economies as electric appliances for space heating and cooling are not commonly used and to all intents and purposes are considered luxury items.

In 2002, the commercial energy consumption of APEC economies accounted for between 2 and 24 percent of total final energy consumption, depending on the level of economic development.[16] By comparison with the residential sector, the share of commercial energy consumption to total final energy consumption was higher in the developed economies than that of the developing economies.

As with the residential sector, the energy consumption of the commercial sector was mainly driven by the growth of GDP in Services and population. For example, increasing population affects the energy requirements for health, education, financial and government services. Along with economic and income growth, energy consumption has increased to meet business and leisure requirements in the form of hotels and restaurants; and to accommodate and provide services to new and expanding businesses. These factors have resulted in substantially energy consumption growth in the commercial sector. Between 1980 and 2002, APEC's commercial energy consumption grew robustly at 3.0 percent per year, increasing from 198 Mtoe in 1980 to 382 Mtoe in 2002.

Although energy consumption in the residential and commercial sectors has both common and different end uses, electricity is the dominant fuel type if excluding NRE in both sectors, accounting for 38 percent in 2002. Following electricity, natural gas accounted for the second largest share on 29 percent, oil (18 percent) and coal (6 percent). As a result of greater disposable income in addition to the development of infrastructure making commercial energy sources more readily available, the share of biomass in residential and commercial energy consumption has decreased from 31 percent in 1980 to 24 percent in 2002.

FACTORS AFFECTING RESIDENTIAL AND COMMERCIAL ENERGY DEMAND

Key factors affecting energy consumption in the residential and commercial sectors are presented as follows:

[15] Due to the lack of historical data for Russia, energy demand for Russia has been included only from 1992.

[16] The commercial sector consisted of businesses, institutions, and organizations that provided services, included many different types of buildings and a wide range of activities and energy-related services.

- Personal income and ownership of household appliances,
- Population growth and demographic changes,
- Weather conditions,
- Fuel switching and electrification, and
- Energy efficiency programmes.

PERSONAL INCOME AND OWNERSHIP OF HOUSEHOLD APPLIANCES

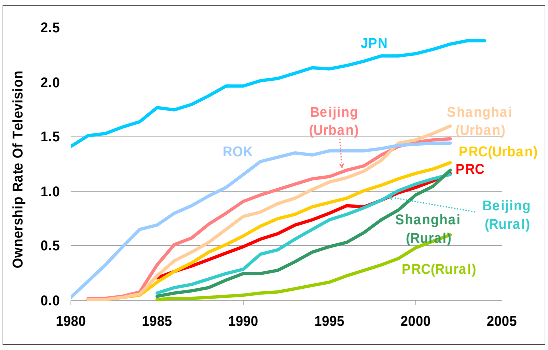
Many research studies have established the positive correlation that energy consumption per capita increases as GDP per capita (personal income) rises. The increase has been shown to become larger in developing economies while it becomes smaller in developed economies. Over the outlook period, the income level of the whole APEC region is expected to grow at an annual rate of 3.5 percent, with China expected to experience the fastest growth rate at 6.0 percent per year while Hong Kong, China will have the highest income level at US$70,912 per capita by 2030, compared with US$29,074 per capita in 2002.

As income increases, typically the share of energy used for basic requirements such as cooking and lighting declines while the energy demand for space heating and cooling, water heating, refrigeration, and electric appliances grows. However, in general the residential energy demand of developed economies increases slowly due to the saturation of electric appliances in each household, for example Japan.

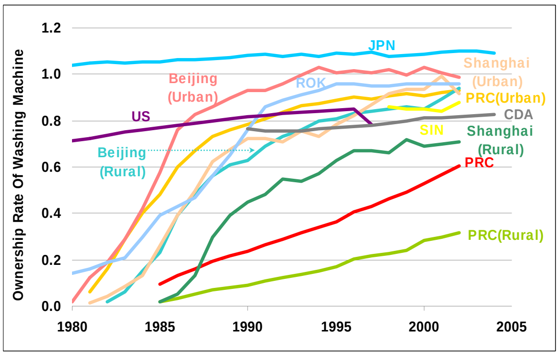
As people demand more entertainment, comfort and convenience, rapid diffusion of televisions, refrigerators, air conditioners and other electrical appliances occurs. The ownership rate of refrigerators, air-conditioners, televisions and washing machines for several selected APEC economies between 1980 and 2002 are given in Figure 28. The ownership of household appliances has increased in parallel with income growth, but the growth rates are very different when comparing urban and rural areas. Slow growth in rural areas was partly due to the lower income and electrification levels compared with those in urban areas. For the case of China, the ownership of televisions in urban areas was two times higher than that in rural areas in 2002 while urban household expenditure was 3.6 times higher than that of rural households. The ownership level of washing machines and refrigerators was three to six times higher in urban households than that of rural households.

Figure 28 Ownership Rate of Electric Appliances in Several APEC Economies

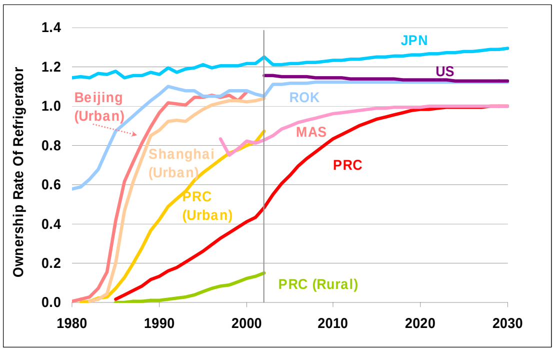
(a) Television



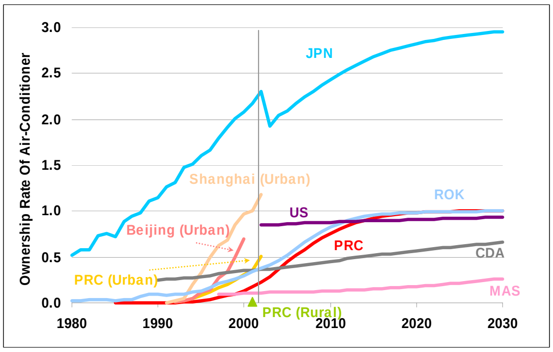
(b) Washing Machine



(c) Refrigerator



(d) Air-conditioner



Source: Various sources; APERC Analysis (2006)

The projected ownership rate of refrigerators and air conditioners for several APEC economies between 2002 and 2030 are given in

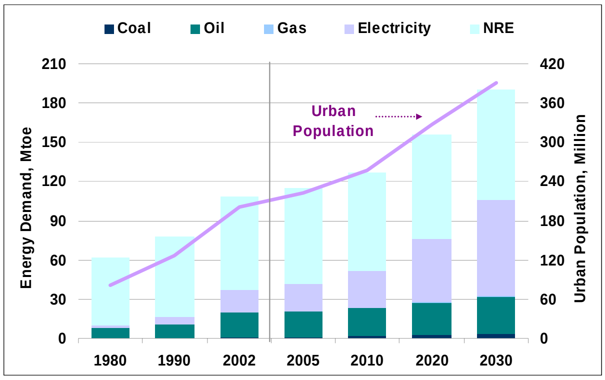
Figure 28. In the US the ownership of refrigerators and air conditioners has reached saturation, while in China levels are still growing and are expected to reach approximately one unit per household in 2030. The ownership of air-conditioners in China is expected to saturate at one unit per household and remain at this level due in part to the disparity in income levels between urban and rural areas. The difference in the ownership rate of air conditioners between North America and Asia is due to the difference in cooling systems. In North America central cooling systems are commonly used, while window mounted or split type air-conditioning units are typically utilised in Asia. The case is also similar with respect to heating systems.

POPULATION GROWTH AND DEMOGRAPHIC CHANGES

Population growth is another important factor that affects energy demand in the residential and commercial sectors. APEC's total population is expected to grow by 16 percent over the outlook period to reach three billion in 2030, which corresponds to approximately 36 percent of the total world population. By economy/region, China will account for the largest share of population at 48 percent, followed by Southeast Asia (21 percent), North America (13 percent), Northeast Asia (7 percent), Latin America (6 percent), Russia (4 percent) and Oceania (1 percent). The population of Japan and Korea will reach their highest levels in 2015, and decline thereafter.

Urban population growth also plays an important role in residential and commercial energy demand, especially for the Southeast Asia economies.[17] Over the outlook period, the urban population of the Southeast Asian economies is expected to expand significantly at a rate of 2.4 percent per year, compared with the APEC average of 1.6 percent per year. As urban dwellers typically have higher income and have a higher standard of living, they tend to demand more commercial energy sources, such as electricity and natural gas. Figure 29 shows the historical trend and projection for the urban population and residential and commercial energy demand for the Southeast Asian economies. Between 2002 and 2030, electricity use in the residential and commercial sectors of Southeast Asian economies is projected to grow robustly at an annual rate of 5.3 percent, compared with the average APEC growth rate of 2.8 percent per year.

Figure 29 Urban Population and Residential and Commercial Energy Demand in Southeast Asia Economies



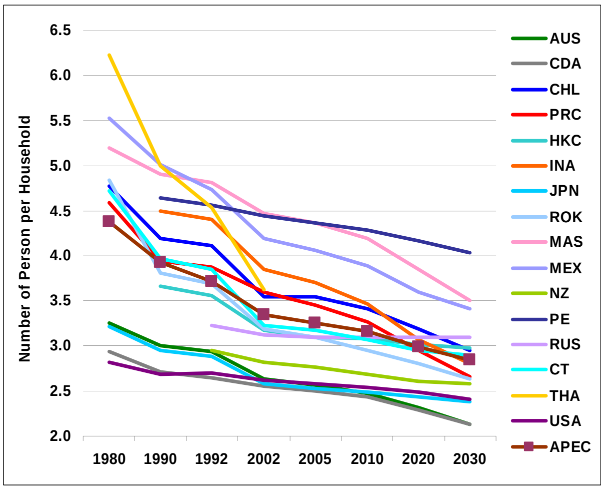
Source: Global Insights (2005); APERC Analysis (2006)

Household size also affects total energy demand, particularly for those economies with a smaller number of persons per household, especially China, Northeast and Southeast Asia. Heating and/or air conditioning of households in Asian economies is not centralised, but heating equipment and air conditioners are installed for each individual room. Each additional family member has their own equipment within the same dwelling. In addition, a larger sized household requires more energy to provide heating, air conditioning, lighting and electricity for appliances. However, the per capita cost of maintaining a given standard of living declines as the household size increases because the sharing of energy services, results in lower per capita energy use in larger households. Korea, for example, used more energy per person in small families than large families. Based on a survey conducted in 1998[18], it was found that a person in a 2-member family consumed 4 Mtoe per year, while a person in a household with more than 6 members consumed 1.3 Mtoe per year. Historically the trend toward smaller household size is progressing as the younger generation prefer not to live with their parents and choose to have smaller families. Moreover, in 2002, the fertility rate of APEC economies was between 0.96 and 4.3, depending on the development status of the economy. Over the outlook period, household size is expected to follow a similar trend to that of the period between 1971 and 2002 and decline through 2030 (Figure 30). By 2030, the expected average household size among the APEC economies is less than 3, with the exception of Malaysia, Mexico, Peru and Russia. However, it is important to note that while the number of persons per household is decreasing the total population of most economies is increasing; therefore, the total number of households is also expected to increase, which will in turn result in greater energy demand in the residential sector.

[17] Southeast Asia economies include Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam.

[18] KEEI (1998)

Figure 30 Number of Person per Household in Several APEC Economies



Source: Various sources; APERC Analysis (2006)

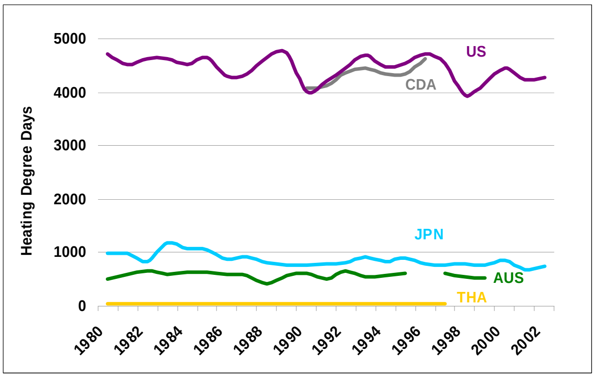
Currently, rapid aging of society has been found to be an emerging problem in many APEC economies, with Japan having one of the most aged populations in the world. According to United Nation statistics, the share of total population aged 60 or above in the world was 11 percent in 2006. Twelve APEC economies are either equal to or greater than this share, namely Australia, Canada, Chile, China, Hong Kong, China, Japan, Korea, New Zealand, Russia, Singapore, Thailand and the United States, of which three are developing economies.[19,20] In China, the share of total population aged 65 years and above has grown robustly at 5.2 percent per year, increasing from 7.0 percent in 2000 to 8.5 percent in 2004. In particular, the number of elderly people in rural areas of China is generally higher than in the cities as young and middle-aged people go to cities to seek employment and business opportunities. The aging phenomenon is expected to continue over the outlook period, for example, Japan's population aged 65 years and above is projected to reach 30 percent of total population in 2030.[21] Faced with an aging population, social security, social assistance (including both public and private pension schemes) and the health system should be enhanced to support and provide health services for the elderly, resulting in increased energy demand for the commercial sector.[22]

WEATHER CONDITIONS

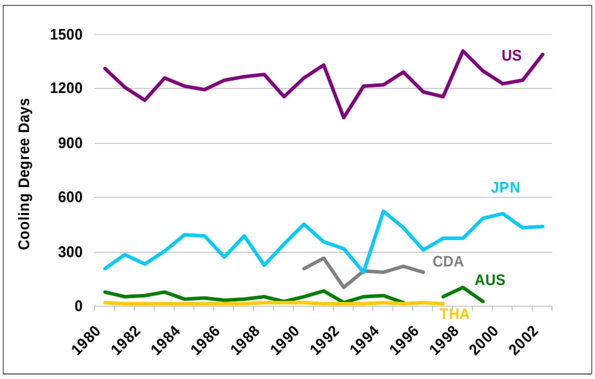
Climate plays an important role in residential and commercial energy demand and partly explains the reason why the per capita energy consumption in Russia, Canada and the US is higher than other economies. With extremely cold and long winters in Russia and Canada, heating accounts for more than 50 percent of total energy demand in the residential and commercial sectors. In 2000, spacing heating in Canadian residential energy consumption represented the largest share at 60 percent, followed by water heating (22 percent), appliances (13 percent), lighting (4 percent) and space cooling (1 percent).[23] Similarly, heating and cooling in the US accounts for more than 40 percent of end-use energy demand. Thus, energy demand in the residential and commercial sectors can vary significantly depending on the annual average temperature range of the economy. Figure 31 shows the heating and cooling degree days for selected APEC economies. Generally, energy demand for heating in the residential and commercial sectors is almost six times higher than for cooling, implying that heating consumes much more energy than cooling. For instance in the case of Japan – in which the climate varies from subtropical in the south to temperate in the north – heating degree days are two times higher than the cooling degree days. On the other hand, for economies located in tropical areas, the cooling demand is higher than that of heating.

Figure 31 Heating and Cooling Degree Days of Selected APEC Economies

(a) Heating Degree Days (HDD)



(b) Cooling Degree Days (CDD)



Source: Various sources; EDMC Database (2005)

[19] According to "*Encyclopaedia of Population*", the society is defined aging of population when the fraction of the population aged 65 and over exceeded 8 to 10 percent.

[20] United Nation (2006)

[21] METI (2005)

[22] Toru Matsumoto, Jian Zuo and Xindong Wei (2003)

[23] National Energy Board (2003)

SECTORAL DEVELOPMENT

Structural change within an economy from agriculture to industry and further to a services-based economy typically results in a similar shift in the energy demand. The increasing share of the services sector over time is mainly due to the economic development of the economy, competitive advantage of each sector, and the changing needs of society. For less developed economies most of the energy consumed in the residential sector is utilised for cooking and heating, as is the case of Southeast Asian countries where biomass accounts for more than half of residential energy demand. Subsequently, as the economy begins to industrialise and become saturated with basic durable consumer goods, the industrial energy demand begins to level-off at around 20 to 40 percent of total final energy demand. Finally, economies become post-industrial, such as Hong Kong, China and the US in which commercial energy demand growth increases much more rapidly than that of industry energy demand.

The share of incremental GDP in Services for the APEC region to total GDP will be 57 percent between 2002 and 2030. Over the same period, the GDP in services for APEC is projected to grow at 3.9 percent per year, reaching US$47,745 billion by 2030. The share of the services sector to GDP among APEC economies is expected to range from between 29 to 96 percent, while the share of commercial energy demand to total energy demand is expected to be between 3 to 21 percent.

FUEL SWITCHING AND ELECTRIFICATION

During the outlook period, as a result of infrastructure development, a shift from traditional biomass fuels to commercial fuels is expected to be observed in several developing economies. However, some developing economies will continue to rely on traditional energy sources. Fuel switching from biomass to natural gas or LPG will remain dependent on the fuel price, availability of fuels, gas pipeline development, and government policies. For example, gas pipeline infrastructure in Viet Nam has been constructed such that favourable conditions are created for the industry and electricity generation sectors. Residential and commercial consumers of natural gas can only access the gas if the distribution networks cover the areas where they live or do business in. On the other hand, in China the government has intensively promoted the use of natural gas in the residential and commercial sectors, as opposed to the electricity and industrial sectors.

Electricity is the main energy source utilised in the residential and commercial sectors, accounting for 29 percent of the total in 2002. One of the key factors affecting electricity demand growth is the number of consumers with access to electricity supply, which is dependent largely on income level and development of the electricity transmission system. The electrification level of the developing APEC economies is expected to grow rapidly reflecting the impact of urbanisation and rural electrification programmes. The electrification level of Indonesia, for example, is projected to increase from 58 percent in 2004 to 95 percent in 2030.

ENERGY EFFICIENCY PROGRAMMES

National energy conservation policies continue to play an important role in reducing residential and commercial energy consumption, especially with respect to the implementation of building codes and efficiency standards for electrical appliances.

Generally, energy efficient light bulbs and electrical appliances offer a substantial potential for energy saving. 1) Compact fluorescent lamps (CFL) are a good example of continuing energy efficiency improvement in electrical appliances as CFLs consume 84 percent less electricity than an equivalent incandescent light bulbs. 2) The electricity demand per unit volume (liter: L) of refrigerators in Japan has improved tremendously from 2.2 kWh/L in 1992 to 0.5 kWh/L in 2003. [24]

As a result of improvement in the energy efficiency of other electrical appliances over the outlook period, the electricity demand of the residential and commercial sectors could be reduced significantly, provided consumers are persuaded to buy and use energy efficient products. However, consumers are less inclined to pay more for energy efficient appliances if there is no perceived beneficial gain, that is, reduction in electricity consumption. In addition, in many low income economies the ability of consumers to pay more for the "efficiency premium" is not possible. The ENERGY STAR program in the US claims that if a household uses ENERGY STAR qualified appliances, energy and water savings of up to 10 to 15 percent compared with standard models can be achieved, such that the monetary savings from the utility bills can more than the make up for the cost of the more expensive energy efficient models.[25] It is expected that the cost of energy efficient appliances will decrease over time as the technologies utilised mature and become cheaper. In the meantime, the government could consider implementing a voluntary or mandatory energy efficiency scheme, especially for energy intensive appliances, such as space heating equipment, air-conditioners and refrigerators; while

[24] EDMC (2006)

[25] ENERGY STAR (2006)

providing sufficient incentives for manufacturers and/or enough subsidies to change consumer habits.

Over the outlook period, with the adoption of more stringent efficiency standards for electrical equipment and electrical appliances, especially for space heating and cooling, water heating, and lighting, as well as the introduction of more stringent building codes, residential and commercial energy demand is expected increase at a slower rate compared with the demand growth over the past two decades.

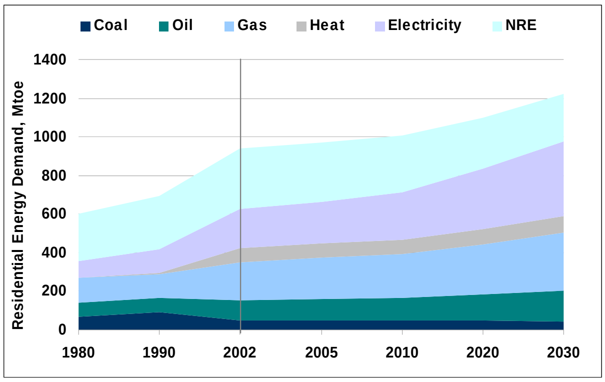
ENERGY DEMAND OUTLOOK

RESIDENTIAL

The share of residential energy demand to total final energy demand is projected to decline from 25 percent in 2002 to 18 percent in 2030. The declining share can be explained by two points. First, the continued industrialisation of the APEC region increases the share of industry energy demand relative to the others. Second, the replacement of biomass by commercial energy sources, which have higher efficiency, compared with the non-commercial energy sources. Over the outlook period, biomass demand is projected to decline at an annual rate of 1.0 percent but residential energy demand from commercial energy sources will grow at 1.6 percent per year until 2030. The projected growth in commercial energy sources – a slower rate than the previous two decades at 2.6 percent per year – is due in part to slow GDP and population growth, energy efficiency improvement in household appliances, and more stringent building codes. Thus, the energy intensity of the residential sector is expected to decrease from 35 toe per million GDP in 2002 to 15 toe per million GDP in 2030, declining at 3.0 percent per year over the same period. As diversification of the residential sectors energy mix has already occurred no significant difference from the current situation is expected over the outlook period. In 2030, APEC's total residential energy demand is projected to be 1,221 Mtoe, which by energy source equates to electricity (32 percent), natural gas (25 percent), new and renewable energy (20 percent), oil (13 percent), heat (7 percent) and coal (3 percent) (Figure 32).

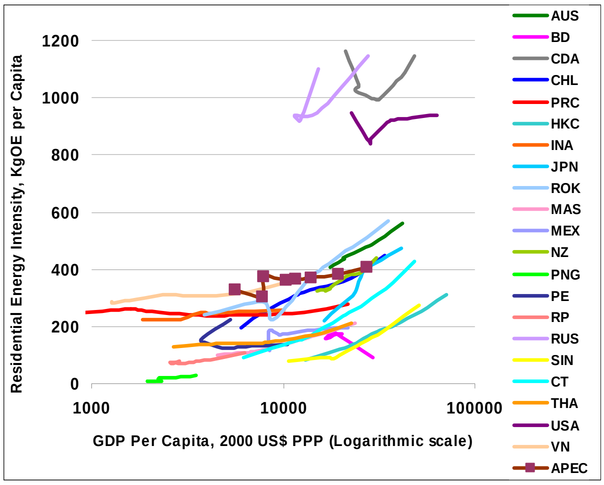
The average residential energy demand per capita for the APEC region is expected to increase from 362 kgoe per person in 2002 to 407 kgoe per person in 2030, growing at 0.4 percent per year. Due to extremely cold weather and low energy prices compared with other APEC economies, Russia's residential energy demand per capita is projected to be the highest in the region at 1,147 kgoe per person, followed by Canada on 1,146 kgoe per person and the US at 939 kgoe per person (Figure 33). For the developing economies such as China and Vietnam, growth in residential energy demand per capita is expected to grow faster than that of the average APEC at 0.5 and 0.6 percent respectively, but the resulting residential demand per capita is less than one-tenth of the APEC average. Another example from Southeast Asia is Thailand, with the economy's residential energy demand per capita expected to increase at an annual rate of 1.5 percent, growing from 141 kgoe per person in 2002 to 212 kgoe per person in 2030, approximately half the average APEC.

Figure 32 Residential Energy Demand in APEC



Source: APERC Analysis (2006)

Figure 33 Residential Energy Demand Per Capita by Economy



Source: APERC Analysis (2006)

By fuel type, APEC's electricity demand will grow at the fastest rate of 2.4 percent per year over the outlook period, supported by substantial growth in China and the US. The total incremental residential electricity demand growth of the APEC region is 189 Mtoe, of which China will account for 37 percent and the US 29 percent. In terms of growth, Viet Nam will experience the fastest growth at 8.1 percent per year with increase in the ownership of domestic electrical appliances such as air-conditioners, refrigerators and televisions, and the government's policy to promote rural electrification. On the other hand, the ownership of domestic electrical appliances in Japan is almost saturated, and this combined with slow growth in the number of households will result in electricity demand growth of 0.6 percent per year – the lowest in the APEC region.

Natural gas is projected to be the second most utilised fuel in the residential sector, with grow at an annual rate of 1.5 percent throughout the outlook period, compared with 1.1 percent per year over the previous decade. Robust growth in natural gas demand is expected as income levels expand and extensive development of infrastructure continues, whereby non-commercial fuels are replaced by natural gas. Natural gas demand in China, for example, is expected to represent the highest growth, at a rate of 7.8 percent per year, followed by Mexico at 6.0 percent and Indonesia at 4.5 percent.

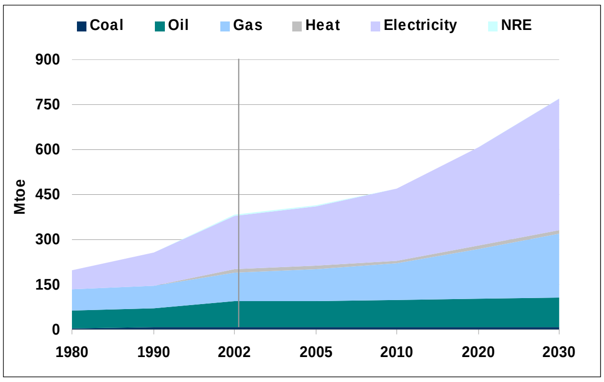
The replacement of biomass with commercial fuels, due in part to income growth and the increasing awareness of environmental and health concerns will result in a decrease in the share of combustible renewables and waste from 34 percent of total residential energy demand in 2002 to 19 percent in 2030. However, due to continued use of biomass in the rural areas of Indonesia and the Philippines as a fuel for cooking and water heating, limited growth in biomass of these two economies is expected over the outlook period. Slower demand growth for wind and solar, will result in new and renewable energy declining at a rate of 0.9 percent per year. Likewise, coal demand is expected to decline at 0.7 percent annually, as coal is replaced by electricity and natural gas or LPG. Demand for petroleum products – predominantly LPG – will increase faster in the near-term between 2002 and 2010 at 2.1 percent per year, while in long-term between 2010 and 2030, the growth rate of petroleum products is projected to be slower at 1.6 percent per year as LPG becomes increasingly replaced by natural gas owing to the relatively low price and expanded coverage of pipeline distribution networks.

Demand for heat – mainly in China and Russia – is project to grow at 0.5 percent per year throughout the outlook period, although the share is expected to remain unchanged over this period at 7 percent of total residential energy demand.

COMMERCIAL

Energy demand in the commercial sector will be mainly driven by strong GDP growth, which is projected to grow at 2.5 percent per year over the outlook period. As in the residential sector, electricity will account for the largest share of total commercial energy demand at 57 percent in 2030, followed by natural gas (28 percent) and petroleum products (13 percent) (Figure 34). Supported by energy efficiency improvement in cooling systems and office equipment and more stringent building codes, energy intensity[26] in the commercial sector for the APEC region is expected to decline at a rate of 1.3 percent per year from 23 toe per US$ million in 2002 to 16 toe per US$ million in 2030 (Figure 35). With the exception of Singapore and Thailand, this declining trend is expected in all the remaining APEC economies. In the case of Singapore and Thailand the growth rate of commercial energy demand is projected to be faster than that of growth in the value added for GDP in Services, resulting in elasticity that is higher than one. Meanwhile the absolute level of energy intensity among the APEC economies varies widely depending on both the state of economic development and prevailing weather conditions. To effectively describe the variation possible among APEC economies, commercial energy demand per capita can be used as an indicator (Figure 36). In 2030, Canada will have the highest energy demand per capita in the commercial sector at 1,055 kgoe, while Indonesia will have the lowest at 31 kgoe, which is 8.4 times lower than the average APEC energy demand per capita at 256 kgoe.

Figure 34 Commercial Energy Demand in APEC



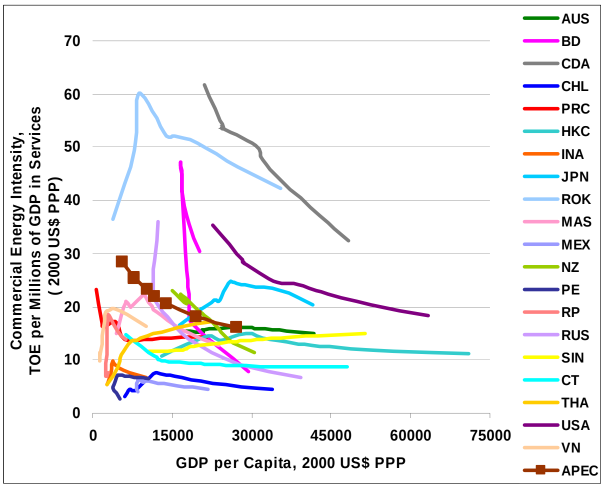
Source: APERC Analysis (2006)

With the increasing demand for cooling and lighting in commercial buildings, electricity is projected to grow at an annual rate of 3.2 percent – the fastest growth rate for an energy source. As electricity is projected to maintain the dominant share of total energy demand in the commercial sector, the pattern of growth among APEC economies is expected to follow a similar trend, in which the share of electricity in the commercial sector increases over time. In economies where the GDP per capita is below a US$20,000 threshold, the electricity demand

[26] The amount of energy needed to produce a dollar's worth of services sector's value added.

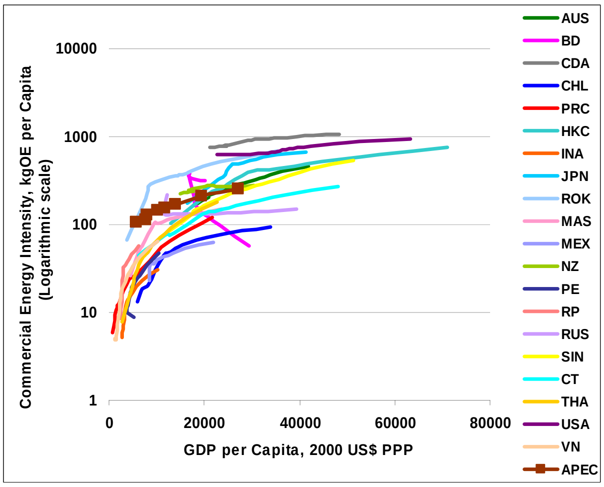
per capita is expected to increase significantly. On the other hand, when above this threshold electricity demand growth per capita slows down with incremental increase following an "S-shaped curve" (Figure 37). For instance, in Hong Kong, China the share of GDP in the services sector is projected to reach 96 percent in 2030, which in turn will drive electricity demand per capita to the highest level in the APEC region at 641 kgoe per person. By contrast, Indonesia is expected to continue undergoing industrialisation over the outlook period, which will increase industry electricity demand, while having very little influence on commercial electricity demand, which is expected to be the lowest in APEC at 31 kgoe per person.

Figure 35 Commercial Energy Demand per GDP in Services by Economy



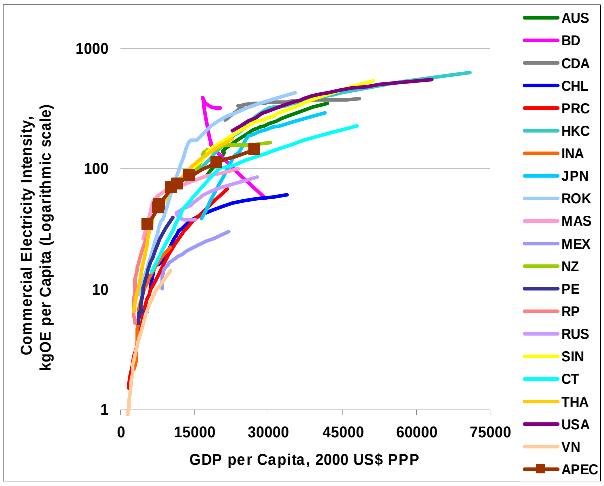
Source: APERC Analysis (2006)

Figure 36 Commercial Energy Demand per Capita by Economy



Source: APERC Analysis (2006)

Figure 37 Electricity Demand Per Capita in Commercial Sector by Economy



Source: APERC Analysis (2006)

Natural gas is projected to grow at 2.9 percent per year through 2030, supported by increased accessibility to gas distribution networks and fuel switching from more carbon intensive fuels (such as coal and diesel oil) to less carbon intensive natural gas for boilers and on-site/standby electricity generation.

Demand for petroleum products, particularly LPG in remote areas, is projected to grow at 0.5 percent per year, while the share of petroleum products to total commercial energy demand is expected to decrease by 10 percent between 2002 and 2030.

Over the outlook period, the demand for coal and heat is projected to decline slowly and the share of each will account for only 1 percent of total commercial energy demand respectively in 2030. On the other hand, combustible renewables and waste are expected to grow at an annual rate of 2.0 percent, but their share is expected to account for less than 1 percent of total commercial energy demand.

IMPLICATIONS

Energy demand in the residential and commercial sectors of the APEC region is projected to grow in parallel with economic and population growth. Economic growth will drive the additional energy requirements for space and water heating/cooling, lighting, operating appliances and other equipment.

Concern over continued growth in energy demand has prompted governments to pursue energy efficiency and conservation measures. Energy efficiency standards and energy labelling schemes for buildings and appliances/office equipment has proven to be a promising approach to slowing down/limiting (putting the brakes on) energy demand growth. Better insulation of residential buildings and offices would also act to reduce the energy requirements needed to heat and cool buildings, these energy requirements accounting for more than 40 percent of total energy demand in the residential and commercial sectors. The amendment of regulations, laws and codes related to residential and commercial building standards to establish an integrated energy-economic perspective that enhances and facilitates investment opportunities is one approach economies could pursue.

Changing the lifestyles of energy consumers – either through education or the promotion of energy conservation – is another challenge for many APEC economies. Governments have an important role in increasing public awareness/education on the impact of lifestyle to the economy's energy supply and demand balance and the impact of energy consumption on environmental quality.

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TRANSPORT

- *APEC's transport energy demand will almost double from 1,087Mtoe in 2002 to 1,991 Mtoe in 2030, growing at an annual rate of 2.2 percent.*
- *Much of the increase in transport energy demand will come from the road sub-sector, accounting for about 81 percent of incremental growth, followed by the air sub-sector at 16 percent.*
- *Rising income will translate into substantial increase in the number of passenger vehicles from 396 million in 2002 to 668 million in 2030, or 9.7 million new/replaced passenger vehicles will be added every year through 2030.*
- *Due to the heavy reliance on the road sub-sector and limited potential for alternative fuels, oil products will share the dominant portion in total transport energy demand at around 99 percent.*

HISTORICAL TRENDS AND CHARACTERISATION OF TRANSPORT ENERGY CONSUMPTION

Transport energy consumption in most APEC economies has been growing robustly over the last two decades. Between 1980 and 2002, APEC's transport energy consumption has grown at an annual rate of 2.7 percent, faster than that of final energy consumption at 2.3 percent per year. During the same period, APEC has accounted for as much as 70 percent of the world's incremental growth in transport energy consumption [27] driven mainly by income growth and improvement in living standards mostly from developing economies. Robust economic development and increasing economic activities across borders have likewise been boosting energy consumption for freight transport.

APEC's energy consumption in the transport sector relies heavily on the road sub-sector. For example, in 2002, the road sub-sector accounted for about 82 percent of total transport energy consumption. This was followed by the air sub-sector at 12 percent, rail sub-sector (3 percent) and the marine sub-sector (2 percent).

With heavy reliance on the road sub-sector, and limited use of alternative fuels, oil products accounted for the largest share at 98 percent of total transport energy consumption in 2002. By product, gasoline for passenger vehicles took the highest share of total transport energy consumption at 58 percent, diesel for freight trucks represented the second highest share at 23 percent, and jet kerosene for air transport at 12 percent in the same year.

[27] The figure excludes Russia and Viet Nam because the IEA data for Russia is available from 1992, and Viet Nam data is available from 1986.

FACTORS AFFECTING TRANSPORT ENERGY DEMAND

Energy consumption of the transportation sector has been driven mainly by two factors. First, income growth has increased passenger travel, leading to growth in energy consumption for the road and air sub-sectors. Second, economic growth has translated into the freight transport requirements for goods and services, thereby increasing energy consumption in the road, marine, rail and air sub-sectors.

Other than the two factors listed above, there are a number of factors that have affected the energy consumption in the transport sector. These factors include; 1) growth in the number of passenger vehicles, 2) population growth in particular in the urban area, 3) regulation on fuel economy, 4) government policy on automobile industry, and 5) technological development. Energy consumption of freight transport is affected by; 1) economic growth, 2) industry structure, and 3) regulation on freight transport industry, among others.

In this section, the assumptions which are expected to affect APEC's future energy demand in the transport sector are presented, with emphasis on the following key factors:

- Income growth and ownership of passenger vehicles,
- Market liberalisation of automobile industry,
- Regulation on automobile fuel economy standards, and
- Economic growth and freight transport requirements.

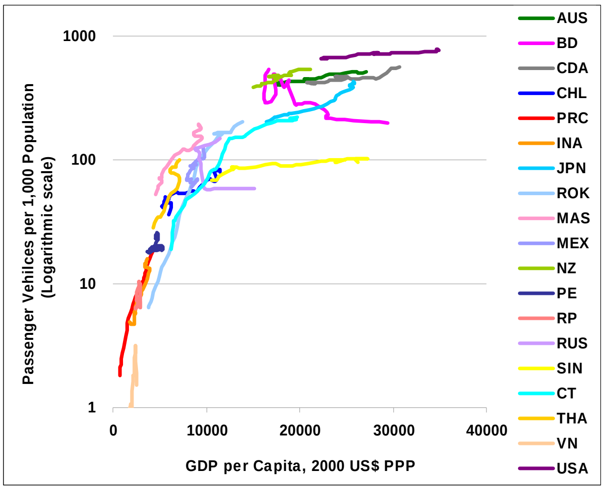
INCOME GROWTH AND OWNERSHIP OF PASSENGER VEHICLES

The rise in road transport energy consumption of APEC economies has been supported by the substantial growth in passenger vehicle stocks. Between 1990 and 2002, road transport energy consumption of APEC increased 1.8 times while the number of passenger vehicles grew almost two fold during the same year. This suggests that passenger vehicle stocks are the key impetus for energy consumption in the transport sector.

The increase in vehicle stocks is also affected by many factors. This includes income growth, availability of public transport, oil products price, and cost of passenger vehicle ownership. Among these factors, income growth is the key factor affecting passenger vehicle ownership as the historical trend of the APEC economies suggests. However, the growth trend varies across the APEC region.

For those economies with low and middle income levels, the number of passenger vehicles is expected to grow faster than that of those economies with high income levels. As shown in Figure 38, the number of passenger vehicles per 1,000 population started to grow rapidly when an economy reached an income level at US$ 2,500. It continued to grow rapidly until an income level reached around US$ 15,000. After surpassing the income level at US$ 15,000, the growth rate of passenger vehicles per 1,000 population generally slowed-down.

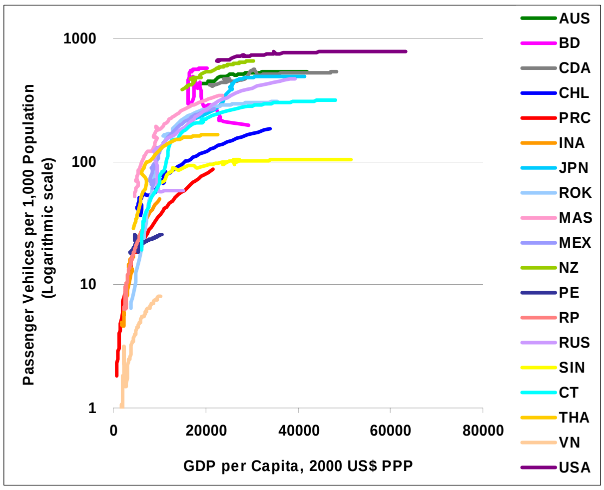
Figure 38 Passenger Vehicles per 1,000 Population in APEC with Respect to Income: History (1980-2002)



Source: APERC Analysis (2006)

Over the outlook period, the growth trend of passenger vehicle ownership will follow a similar pattern to that of historical trend. Those economies with relatively low-income level is projected to show a substantial growth in the ratio of passenger vehicles per 1,000 population. Such economies include Viet Nam and China, of which passenger vehicles per 1,000 population are projected to grow at an annual rate of 6.1 percent and 5.7 percent respectively. In Viet Nam and China, the absolute level of this indicator is expected to remain the lowest in APEC, however the number of stocks will grow considerably with China's passenger vehicle stocks increasing by 3.6 million per year and Viet Nam's passenger vehicle stocks increasing about 26,700 units per year.

Figure 39 Passenger Vehicles per 1,000 Population in APEC with Respect to Income: History and Projection (1980-2030)



Source: APERC Analysis (2006)

Table 11 Passenger Vehicles per 1,000 Population in APEC

Economy	1980	2002	2030	1980-2002 (%)	2002-2030 (%)
Australia	402	511	541	1.1	0.2
BD	198	539	579	4.7	0.3
Canada	419	560	532	1.3	
Chile	36	79	185	3.6	3.1
China	2	19	87	11.1	5.7
HKC	41	59	103	1.7	2.0
Indonesia	5	16	50	5.5	4.2
Japan	203	428	491	3.5	0.5
Korea	7	204	305	17.0	1.5
Malaysia	53	181	347	5.8	2.4
Mexico	60	128	270	3.5	2.7
NZ	388	541	660	1.5	0.7
Peru	18	23	27	1.0	0.4
Philippines	10	9	27.5	-0.3	3.9
Russia	30	148	476	7.5	4.3
Singapore	68	96	102	1.5	0.3
CT	19	223	315	11.8	1.2
Thailand	-	100	165	-	1.8
USA	656	766	783	0.7	0.1
Viet Nam	-	2	8	-	6.1
APEC	**109**	**153**	**222**	**3.2**	**1.9**

Source: APERC Analysis (2006)

In the middle-income economies such as Korea and Chinese Taipei, the number of passenger vehicles are expected to grow slowly compared with history. Korea's passenger vehicles per 1,000 population is projected to grow modestly at 1.5 percent per year, increasing from 204 in 2002 to 305 in 2030, a drastic slow-down from the previous two decades' annual growth of 17.0 percent. Chinese Taipei's passenger vehicle per 1,000 population is expected to grow annually at 1.2 percent from 223 in 2002 to 315 in 2030, likewise at a drastic slow-down from 11.8 percent per year during the period 1980 to 2002.

In the higher-income economies such as Australia, Brunei Darussalam, Canada, New Zealand and US, passenger vehicles per 1,000 population are projected to grow slowly at an annual rate of less than 1 percent. It is because these economies have already attained relatively high level that is well above 500, compared with the APEC average of 152 in 2002.

Among the high-income economies, Singapore provides an interesting case in terms of the relationship between income and the number of passenger vehicles. Despite the high income level at US$ 26,273 in 2002, the economy's number of passenger vehicles per 1,000 population stood at 96 compared with the APEC average at 152 in the same year. The economy has successfully slowed the growth in the number of passenger vehicles with the adoption and implementation of various instruments such as mandatory requirements for a certificate for passenger vehicle ownership and electronic road pricing on congested roads. Over the outlook period, with these measures implemented, the number of passenger vehicles per 1,000 population will not grow significantly, remaining at the 102 level.

MARKET LIBERALISATION OF AUTOMOBILE INDUSTRY

The automobile manufacturing industry is considered as a key component of industrial development because of its rippling effect on other industries, including iron and steel, electronics, glass and textile among others. Due to the strategic importance of this industry, economies at the early stages of development tend to regulate imports of automobiles and parts, and impose substantial tariffs.

Although the APEC automobile industry has been protected for quite some time, there is a general trend that the industry is being liberalised in recent years. China, for example, has gradually lifted tariffs on imported automobiles. The economy is scheduled to lower import tariffs on automobiles from 70 percent in 2001 to 25 percent in 2006. Economies in ASEAN adopted their own measure by lowering tariffs on imported automobiles from 70 percent in 2001 to 25 percent in 2006.

The liberalisation of the automobile market in APEC will eventually lead to reduced vehicle prices. As a result, consumers will be expected to increase vehicle ownership along with income growth.

AUTOMOBILE FUEL ECONOMY STANDARDS

The adoption and implementation of automobile fuel economy standards have proven to be one of the effective measures to control the growth in oil demand in the transport sector. Faced with rising oil prices, growing oil demand and worsening environmental problems, some economies in APEC are tightening regulations on automobile fuel economy standards while other economies have started to regulate fuel economy standards.

In APEC, there are seven economies that have automobile fuel economy standards. These include Australia, Canada, China, Japan, Korea, Chinese Taipei and USA.

The standards in these APEC economies have taken up a variety of types and forms. For example, United States has implemented Corporate Average Fuel Economy (CAFE) standards that require each manufacture to comply with fleet average fuel economy levels for passenger vehicles and light trucks. In China and Japan, automobile manufactures are required to meet the standard based on weight classification of automobiles. Manufacturers in Korea and Chinese Taipei need to comply with automobile fuel economy standards based on engine size.

Table 12 Market Liberalisation of Automobile Industry

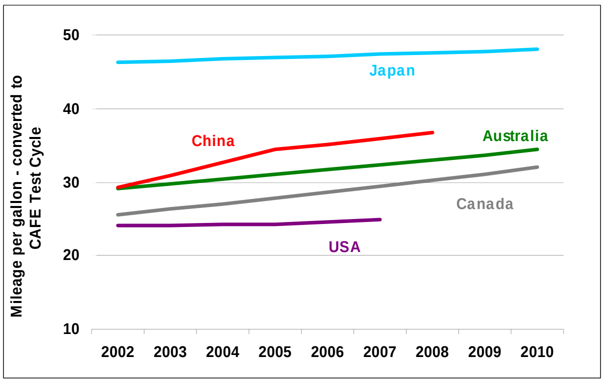
China	Korea	Indonesia	Thailand
Tariffs on imported automobiles were lowered from 70 in 2001, to 43.8 and further down to 25 in 2006.	**Tariffs** on imported automobiles have been completely removed.	Due to **the ASEAN free trade agreement,** tariffs on those automobiles produced among ASEAN economies have been lowered to less than 5 since 2002.	Free trade agreement on automobile imports has been signed with **ASEAN economies**. And free trade agreement on automobile imports has been signed respectively with Australia and **India.** By 2010, Thailand will gradually remove import tariff on automobiles and parts from India.

Source: APERC Analysis (2006)

Although not mandatory, manufacturers in Australia and Canada voluntarily follow fuel economy standards. In Australia, the Federal Chamber of Automotive Industries (FCAI) has set a voluntary target for the automobile industry to reduce fleet average fuel consumption. Canada's automobile industry has voluntarily agreed to follow the US CAFE standards.

Among the economies studied, there is a considerable difference in terms of the level of vehicle fuel standards. Assuming that the standards are designed as a fleet average, and the voluntary targets for fuel economy as well as emissions reduction target are achieved, a study by An and Sauer (2004) found that by 2010 Japan's fuel economy standards continues to account for the highest, followed by China, Australia and Canada. Standards of US rank the lowest among these economies, representing almost half of that of Japan.

Figure 40 Mileage per Gallon – Converted to CAFE Test



Source: An and Sauer (2004)

Achieving the target level poses a difficult challenge. It is partly because consumers' preference is shifting towards larger-sized vehicles, and partly because it takes more than a decade to replace total vehicle stocks.

Perhaps a mix of regulation and tax incentives need to be provided to improve the overall vehicle fuel economy. For example, although the US vehicle fuel standards are estimated to be the lowest among five economies, the economy provides a number of incentives for those who purchase efficient vehicles such as hybrids.

Effective measures to curb growth trend in oil demand vary by economy. Therefore policy needs to be well formulated to give appropriate incentives for both consumers and suppliers.

ECONOMIC GROWTH AND FREIGHT TRANSPORT

Energy consumption of the freight transport sector is mainly influenced by economic growth. Increase in economic activities lead to the increase in freight transport requirements. This translates into the growth in energy consumption for freight transport of the road, marine, rail and air sectors.

Growth trend of freight transport volumes varies both *between* economies and over time *within* economies. Figure 41 compares the per capita level of tonne km for Canada, China, Japan and the US from 1980 to 2030.[28] The comparison shows that the per capita level of tonne km tends to grow along with GDP growth.

From 1990 to 2002, China's tonne km per capita grew at the fastest rate among the four economies at 7.0 percent per year when the economy's GDP grew at 8.7 percent per year. This is followed by Canada at 4.2 percent per year driven mainly by the increase in cross-border economic activities through the integration to the North American market. The US tonne km per capita grew at 2.3 percent per year, at a time when the GDP grew at 3.1 percent per year. By contrast, Japan's tonne km grew at the slowest rate of 1.3 percent per year reflecting the recent slow-down in economic activities.

The industry structure is another important factor which affects the trend of growth of freight transport requirements. In fact, the economies dependent on heavy industry have bigger freight transport requirements than economies which were less reliant on the heavy industry. The projected slower growth rate of Japan's tonne km per capita at 0.02 percent per year, compared with history at 1.3 percent per year reflects the economy's shift in industrial structure towards the services industry from the industry based ones.

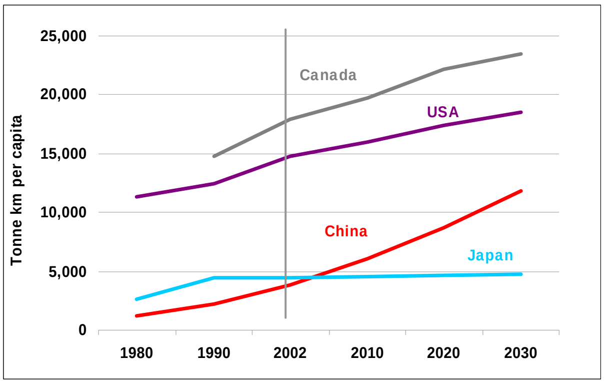
[28] Tonne km = Tonne (volume of freight transport) × km (distance travelled)

Table 13 Automobile Fuel Economy Standards

Economy	Measure	Structure	Test method	Implementation
Australia	L/100 km	Overall light-duty fleet	EU NEDC	Voluntary
Canada	L/100 km	Passenger vehicles and light trucks	US CAFE	Voluntary
China	L/100 km	Weight base	EU NEDC	Mandatory
Japan	km/L	Weight base	Japan 10-15	Mandatory
Korea	km/L	Engine size	US CAFE	Mandatory
Chinese Taipei	km/L	Engine size	US CAFE	Mandatory
USA	Mileage per gallon	Passenger vehicles and light trucks	US CAFE	Mandatory

Source: An and Sauer (2004)

Figure 41 Tonne km per capita (1980-2002)



Source: APERC Analysis (2006)

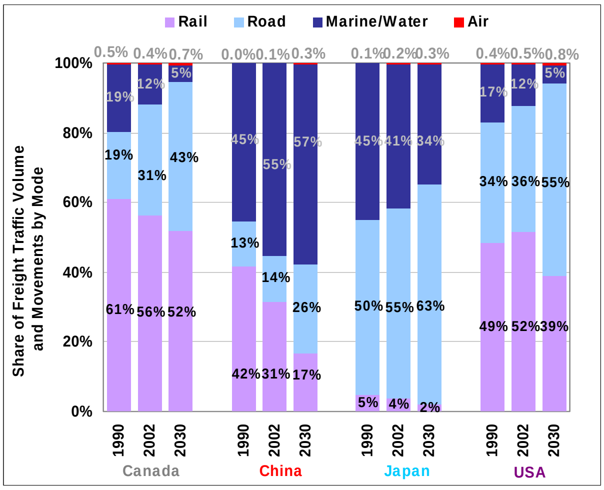
Shift in industry structure also affects the mode of transporting goods and services. In other words, industrial development from agriculture to industry and further to service based ones means change in goods and services that need to be transported. For example, heavy industry such as cement, construction and iron and steel require transporting bulk raw materials and products that can be most efficiently handled by the rail and marine/water sub-sectors. By contrast, manufacturing industry such as machinery and automobile production requires just-in-time delivery of parts and products for which road and air are the most suitable modes of transport.

Due to the change in industry structure, modal split in terms of tonne km have changed significantly over the past decade (Figure 42). In Canada, Japan and USA, the shares of rail and marine/water sub-sectors, in terms of tonne km, were reduced because of the shift in industry structure from heavy industry to manufacturing and further to services, while the shares of road and air sub-sectors, in terms of tonne km, increased.

China's modal split in terms of tonne km over the past decade showed a different trend from that of Canada, Japan and the US. The share of China's marine/water sub-sector, in terms of tonne km, increased from 45 percent in 1990 to 55 percent in 2002. The increase is a result of the modernisation of agriculture and the shift to heavy industry which has boosted the needs to transport large volumes of materials and products through marine/water transport. The share of rail, in terms of tonne km, has been reduced from 42 percent in 1990 to 31 percent in 2002. The decrease is mainly due to the reduced need to transport coal for power generation as a large number of coal-fired generation plants built near urban areas were shut-down.

Over the outlook period, a modal split in terms of tonne km will be expected to evolve following a similar pattern to that of history. In the developed economies such as Canada, Japan and the US, the shares of road and air transport sub-sectors are expected to continue to increase due to further shift in industry structure towards the services and increasing customers' needs for fast and speedy transportation of goods and services. In developing economies such as China, the economy's industrialisation from agriculture to industry will translate into more requirements for shipping of raw materials through marine/water sub-sector and the development of highway infrastructure which will spur the growth in road transport sub-sector with respect to both volume and travel distance of freight transport.

Figure 42 Modal Split in Terms of Tonne km (1990, 2002 and 2030)



Source: APERC Analysis (2006)

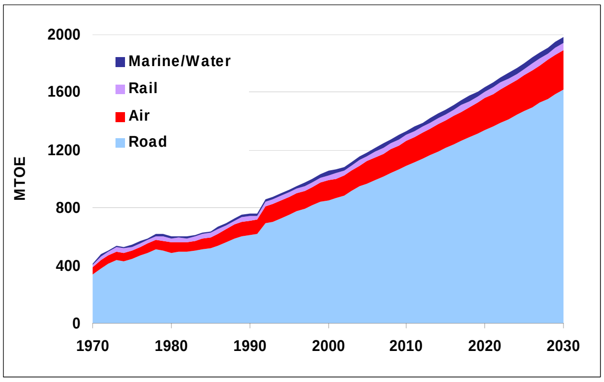
OUTLOOK

Over the outlook period, APEC's transport energy demand is expected to almost double from 1,087 Mtoe in 2002 to 1,991 Mtoe in 2030 at an annual rate of 2.2 percent. Near-term growth of transport energy demand is projected to be faster than that of long-term. Driven by income growth, improvement in the standard of living and infrastructure development, near-term transport energy demand is projected to grow at 2.4 percent per year (2002-2015). By contrast, the long-term growth will slow at 2.0 percent per year (2015-2030). The long-term moderate growth reflects a number of factors including, the saturation of passenger vehicle ownership, slower population growth, efficiency improvement and shift in industry structure.

Among the sub-sector of transport, energy demand of the road sub-sector is expected to grow at an annual rate of 2.2 percent per year and maintain the largest share in total transport energy demand. In 2030, energy demand of the road sub-sector is expected to account for around 81 percent – a slight decline the share from 82 percent in 2002. Energy demand of the air sub-sector is projected to grow at 2.6 percent – the fastest rate among the sub-sector of transport. Due to the fast growth, the air sub-sector will increase the share in the total transport energy demand from 12 percent in 2002 to 14 percent in 2030. Energy demand for marine/water sub-sectors will grow at 2.0 percent per year. Despite the steady growth trend of the marine sub-sector, the share in total transport energy demand is expected to remain small at around 2 percent. Rail energy demand is projected to grow at a slow rate of 0.9 percent per year due mainly to the replacement of rail for freight transport by the other modes, including road, air in the developed economies and rail for coal transport by electricity transmission lines in some developing economies.

By energy source, oil products are expected to maintain the dominant share at around 99 percent in total transport energy demand throughout the outlook period. In fact, the transport sector is expected to account for nearly 70 percent of the incremental growth of APEC's oil demand through 2030.

Figure 43 Transport Energy Demand in APEC (1970-2030)



Source: APERC Analysis (2006)

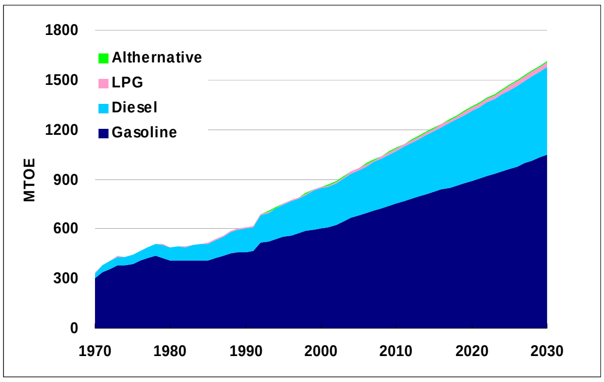
ROAD TRANSPORT

Road transport sub-sector energy demand is projected to almost double from 888 Mtoe in 2002 to 1,616 Mtoe in 2030, and maintain the largest share in total transport energy demand at above 80 percent. To the total incremental growth of road energy demand between 2002 and 2030, the US is expected to be the biggest contributor, accounting for 37 percent and followed by China at 23 percent.

Oil products are projected to maintain the dominant share in total energy demand of the road sub-sector despite efforts by a number of APEC economies to promote alternative fuels. The share of oil products is projected to remain at around 99 percent of the total road transport energy demand through 2030, while the share of alternative fuels is expected to be small at 1 percent due mainly to the relative high costs and shortage of infrastructure.

Gasoline, the main fuel for passenger vehicles – is expected to account for the largest share in the transport energy demand. However the share will fall from 71 percent in 2002 to 65 percent in 2030 because demand for gasoline is projected to grow slowly at 1.8 percent per year, compared with diesel at 2.8 percent per year and LPG at 3.6 percent per year through 2030. By economy, in high income economies such as Australia, Canada, Japan and the US that accounted for 78 percent of total road energy consumption in 2002, gasoline demand is projected to grow slowly compared with middle- and low-income economies. It is because of the saturation of passenger vehicle ownership, continued efficiency improvement through a combination of regulation and tax incentives and slower growth in population.[29]

Figure 44 Energy Demand in the Road Sub-Sector by Source (1970-2030)



Source: APERC Analysis (2006)

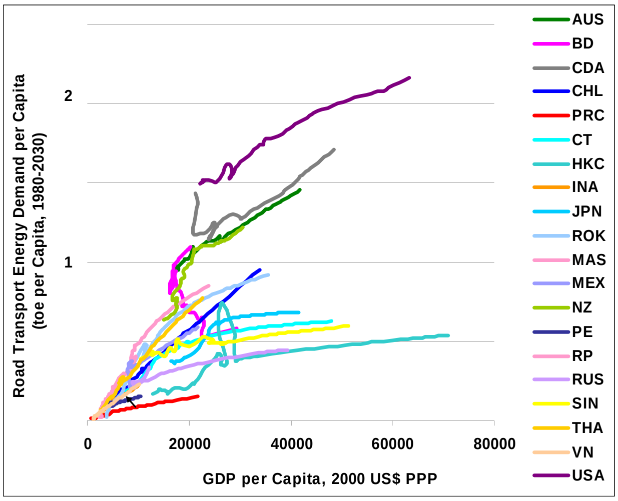
The decrease in share of gasoline is offset by the increase in share of diesel – a main fuel for freight trucks. Over the outlook period, the share of diesel in road transport energy demand is projected to increase from 28 percent in 2002 to 33 percent in 2030. Driven by the constant growth in industrial activities, further need for just-in-time delivery and expected export growth with integration of the sub-regional economic activities including ASEAN and NAFTA, it is expected that diesel demand will grow at an annual rate of 2.8 percent through 2030 – a faster rate than the average growth rate of road transport at 2.2 percent.

To mitigate the worsening air quality due to the rise in road transport energy demand, some economies in APEC promote the use of LPG for taxies and buses. With these efforts, APEC's demand for LPG will almost triple from 9.9 Mtoe in 2002 to 26.8 Mtoe in 2030 although the share of LPG to total road transport energy demand remains small, increasing slightly from 1 percent in 2002 to 2 percent in 2030.

Many of the APEC economies try to promote the use of alternative energy sources such as natural gas, and ethanol in order to diversify energy source away from oil and improve the worsening air quality problem. To promote use of natural gas for road transport, for example, Thailand has set a target to substantially increase the number of CNG powered vehicles from 12,400 in 2005 to 500,920 in 2010. Malaysia plans to convert diesel-powered buses to CNG. Driven by these plans, natural gas for road transport is projected to increase six times, however the share in total road transport remains less than 1 percent through 2030 due to high cost and inadequate infrastructure development. Ethanol for blending gasoline will grow fast in some economies in Southeast Asia, Australia, Canada and the US. In the US, for example, a number of subsidies are being provided to promote ethanol production. As a result of these incentives, ethanol demand will increase by about three-fold, while the share does not exceed 1 percent in total road energy demand in 2030.

Figure 45 compares the per capita energy demand for road transport in APEC. As the figure shows, income is the key driver boosting per capita road transport energy demand. As income grows, per capita energy demand for the road sub-sector generally increases. However the growth trend varies across economies.

Figure 45 Per capita Energy Demand for the Road Sub-sector in APEC (1980-2030)



Source: APERC Analysis (2006)

Aside from income growth, there are a number of important factors affecting the growth in per capita road transport energy demand. These include geographical condition, life style, level of road infrastructure development, prices of oil products and regulation. Different factors affect different economies in their growth trend as well as the level of per capita road transport energy demand. To understand better the factors affecting the growth trend in per capita energy demand for road transport, economies in APEC can be grouped into four.

Group I economies includes Australia, Brunei Darussalam, Canada and USA. In this group, per capita energy demand for road transport is expected to remain the highest in APEC ranging from Brunei Darussalam at 1.1 toe per person to the US at 2.2 toe per person in 2030, compared with APEC average at 0.5 toe per person in 2030. Given the relatively high income levels at above US$ 15,000, their passenger vehicle ownership per 1,000 population represent the

[29] The share of high income economies in total gasoline demand of APEC is projected to decrease from 78 percent in 2002 to 66 percent in 2030.

highest levels in APEC. Due to the sprawling suburban area, dispersed locations between production centres and residential suburbs, and well developed highway infrastructures, the road sub-sector provides the most efficient as well as fast means of transport. Over the outlook period, all these factors are expected to result in maintaining the relative high level of per capita energy demand for road transport of economies in Group I.

In Group II economies, namely Hong Kong, China, Japan, Singapore and Chinese Taipei, despite their relatively high income levels, per capita road transport energy demand is expected to remain considerably lower than that of Group I, remaining at around 0.6 toe per person through 2030. Given the relatively small land area and high population density, those economies in Group II has generally been developing a comprehensive transport infrastructure system through which they try to reduce dependence on road transport and encourage the use of mass transit system for passenger transport. The stricter automobile efficiency standards in future will come into play as an additional important factor that will reduce the growth trend in per capita energy demand for the road sub-sector in Group II.

Group III economies, including Chile, Korea, Malaysia, Mexico and Thailand, are characterised with their relatively high reliance on the road sub-sector. Due to the sprawling residential suburbs, commuters tend to rely on passenger vehicles and passengers tend to rely on the road sub-sector for their inter-city travel. Those economies in Group III equally strive to develop mass transit system both within the city and between cities. As a result, over the outlook period, the growth trend of per capita energy demand for the road sub-sector of economies in Group III will slowdown, but will still be higher than that of APEC average at 1.2 percent per year.

Economies of Group IV include China, Indonesia and Viet Nam. As a result of rapid income growth, and improvement in the standard of living, economies' in Group IV per capita energy demand in the road sub-sector will grow at a faster rate than APEC average. Through 2030, Viet Nam's per capita road energy demand will grow at the fastest rate of 5.2 percent per year, followed by China at 4.9 percent per year, and Indonesia at 3.0 percent per year. However, the average level of per capita road energy demand of this group will remain one of the lowest in APEC through 2030.

AIR TRANSPORT

Among the transport sub-sectors, the air transport sub-sector energy demand is expected to grow the fastest at an annual growth rate of 2.6 percent from 2002 to 2030, faster than the previous decade of 2.6 percent per year. With the robust growth rate, APEC's total air transport energy demand is projected to more than double from 135 Mtoe in 2002 to 279 Mtoe in 2030.

The rapid growth in air transport energy demand is driven by a number of factors. Income growth will boost the need for both long-distance travel within an economy and international air travel. Customers' need for timely as well as rapid delivery will expand the demand for freight transport by air. Increasing integration of global economic activities will also spur the growth in demand for international air travel.

By region, the air transport energy demand of Asia – including Northeast Asia, Southeast Asia and China is expected to spur the growth in air transport energy demand in APEC. Driven by income growth and increasing integration of sub-regional economic activities, Asia's energy demand for the air sub-sector will expand. Between 2002 and 2030, Asia will account for more than 55 percent of incremental growth of total air transport energy demand in APEC, compared with the combined total of Canada and USA at 34 percent. In view of the rising air transport demand, a number of international airports in Asia are upgrading and expanding airport infrastructure and seek to become the regional hub. These include international airports in Bangkok, Beijing, Shanghai, Seoul, Singapore, Hong Kong, China, Kuala Lumpur and Tokyo.

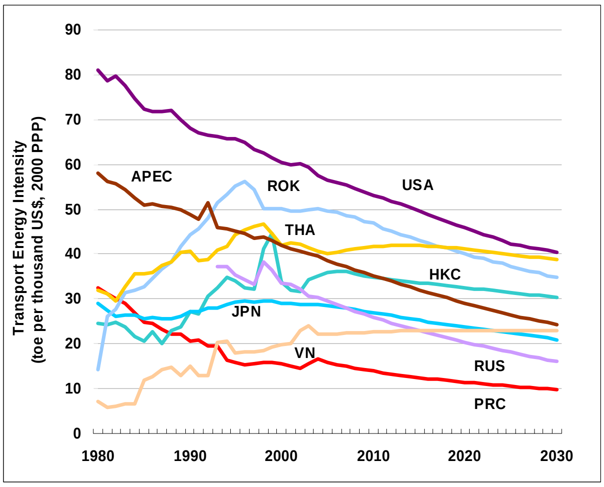
ENERGY INTENSITY

Over the outlook period, APEC transport energy intensity is projected to decline at an average annual rate of – 1.8 percent reflecting such factors as energy efficiency improvement and industry structure change.

By economy, Russia's energy intensity is projected to improve most rapidly in APEC at an annual rate of – 2.4 percent per year, followed by USA and China at – 1.4 percent per year respectively.

In some economies in APEC, transport energy intensity is not expected to change considerably. For example, in Hong Kong, China, transport energy intensity is expected to increase at an annual rate of 1.2 percent by 2010, and decline thereafter at an annual rate of –0.7 percent per year through 2030. Increase in transport energy intensity by 2010 is expected to take place as a result of new infrastructure development in Hong Kong international airport and expected growth in jet kerosene demand for air transport.

Figure 46 Energy Intensity for the Transport Sector



Source: APERC Analysis (2006)

IMPLICATIONS

With the heavy reliance on the road sub-sector and limited potential for alternative fuels, oil products will maintain the dominant share in total transport energy demand at around 99 percent throughout the outlook period. In fact, the transport sector will lead the oil demand growth, accounting for nearly 70 percent of the total incremental growth of oil demand in APEC.

Due to the dwindling domestic oil production, increasing amount of oil demand should be met by imports, rendering energy security concern. Increasing transport oil demand, especially in the urban area will worsen air quality problem. Therefore, how to manage the growth in road energy demand is a critical element for the enhancement of energy security and sustainable development.

Effective measures to curb the transport oil demand growth should vary from economy to economy depending on the difference in the level of economic development, life style, geographical conditions and resource allocations. In developing economies such as China, Viet Nam and Indonesia, a comprehensive measure needs to be established to curb the growth in the transport oil demand. This includes automobile fuel standards, vehicle registration system and urban transport design including rail mass transit system. In developed economies with relatively high per capita road transport energy demand, such as Australia, Canada and USA, how to provide incentives for consumers to shift to efficient vehicle will be a key to curb the long-term growth trend in the transport oil demand.

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ELECTRICITY

- *APEC's electricity demand is projected to increase by more than twofold from 8,019 TWh in 2002 to 19,163 TWh in 2030, growing at an average annual rate of 3.2 percent.*
- *Fuel costs will determine the ultimate mix for electricity generation in the future; increasing the share of the relatively cheap coal which is further developed through the use of advanced coal utilization technologies and carbon capture.*
- *Expected improvements in generation and demand side technologies would reduce the demand for fuel for electricity generation.*
- *Advancement in internet and information technologies would have a significant impact on the electricity sector both in raising electricity demand and increasing reliability of supply.*
- *Nuclear will most likely find the second momentum for its rapid development especially in Asia, once public acceptance on safety are addressed.*

HISTORICAL TREND AND CHARACTERISATION

APEC's final electricity consumption has grown robustly over the last two decades at an average annual rate of 3.0 percent per year, from 314 Mtoe in 1980 to 690 Mtoe in 2002. Rapid growth was observed in Indonesia (12 percent) and Viet Nam (11 percent) followed by Brunei Darussalam, and Thailand, each having an average annual growth of 10 percent per year. The biggest contributor to the high growth of electricity consumption is the residential and commercial sector at 4.1 percent, followed by industry at 3.1 percent, while electricity consumption in the transport sector grew at 5.1 percent. However, the share of transport in electricity was only 1 percent of total electricity demand in 2002. .

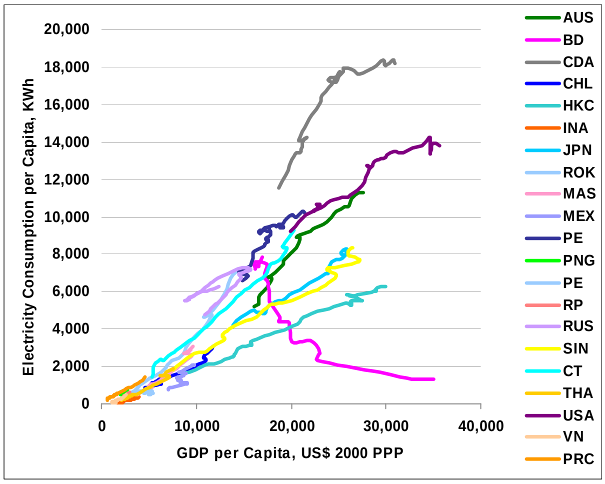
Since the 1980s, developed economies such as Australia, Canada, Japan and the US accounted for 84 percent of the region's total electricity consumption, with the US utilizing more than half or 53 percent of total electricity generation. However in 2003, the total share of these economies reduced to 69 percent due mainly to China's increasing electricity demand as a result of its rapid economic growth. The China's share has increased three-fold from 6 percent in 1980 to 19 percent in 2003.

Over the last two decades, the region's electricity generation mix has been determined according to each economy's national strategy, anchored mainly on the availability of resources and technology. In general terms, oil and coal were the major fuels in the 1980's; however with the development of CCGT, utilisation of natural gas as the fuel of choice was boosted in several APEC member economies, particularly in Brunei Darussalam, Malaysia and Thailand.

MAJOR ASSUMPTIONS

Several studies have revealed that economic growth increases electricity consumption and vice versa. Therefore, high levels of electricity consumption have a close correlation with high levels of real GDP (Figure 47). [30]

Figure 47 APEC Electricity and GDP per capita (1972-2002)

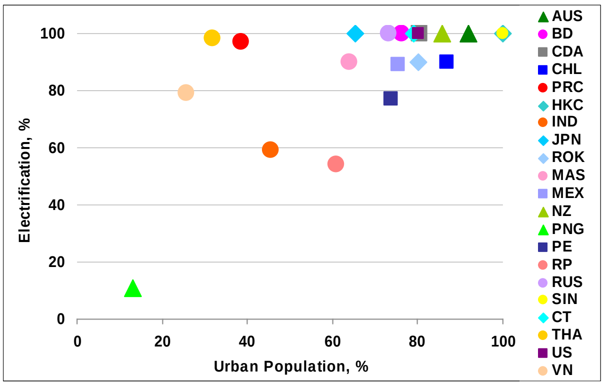


Source: APERC Analysis (2006)

In addition, urbanisation is projected to have a significant impact on future electricity demand. Figure 48 shows the urbanisation level and electrification ratio for the APEC economies. By 2030, a large percentage of APEC's population is projected to live in urban areas. A significantly higher level of urbanisation would imply greater demand for electricity, since urban households tend to have higher standards of living and can be more easily connected to the grid.

[30] Yoo, Seung-Hoon (2005)

Figure 48 Urbanisation and Electrification of APEC Economies (2003)



Source: APERC Database (2005)

Consumers who already had access to electricity before moving to urban areas are expected to increase their consumption, as consumers increase the utilisation of appliances such as air conditioners, televisions, audio and video equipment, and modern kitchen appliances.

In developing economies, rising personal income has been contributing to the increase in ownership of household appliances, resulting in the growth of residential electricity consumption. [31]

The advancement of computing and internet technology is also projected to affect the electricity demand. For example, a study conducted in the US has found that internet technology increased electricity consumption by 3 percent. However, the most significant impact brought about by internet technology is that the technology requires more stable/reliable electricity supply. [32]

Throughout most of the 20th century, electricity was used primarily to power lights and motors. These analogue devices are generally tolerant to voltage spikes and sags that can occur when large loads are turned on or off, for example, when a generating plant shuts down, or when natural events (lightning) or accidents disrupt the electricity grid. The electricity demand required to power internet technology, supported by digital devices requires a much more stable/reliable electricity source of higher quality. This requirement will therefore increase the need for more reliable and better quality electricity supply during the outlook period.

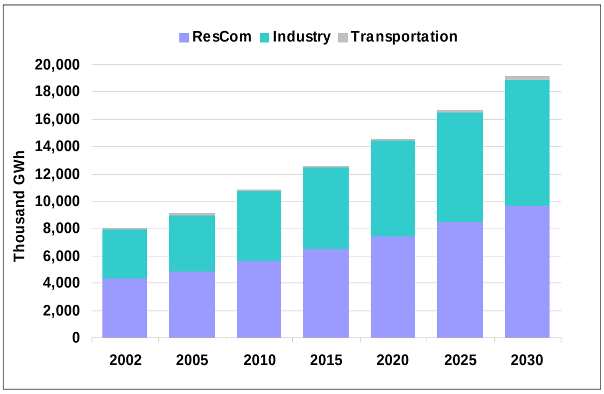
OUTLOOK RESULTS

ELECTRICITY DEMAND

APEC's electricity demand is projected to grow at an annual rate of 3.2 percent, increasing more than two-fold from 8,019 TWh in 2002 to 19,163 TWh in 2030.

By sector, the residential and commercial sectors are expected to have an equally robust growth of 3.0 percent per year over the outlook period. Despite this growth, the share of the residential and commercial sector to total electricity demand is projected to decrease over this period from 54 percent in 2002 to 50 percent in 2030, while electricity demand in industry increases from 44 percent in 2002 to 49 percent in 2030. The share of the transport sector will remain constant at 1 percent.

Figure 49 APEC Sectoral Electricity Demand



Source: APERC Analysis (2006)

The projected increase in the electricity demand for the residential and commercial sectors is mainly due to the improved accessibility to electricity, increasing economic activity, rising income and improved living conditions/lifestyle in most developing economies of the APEC region.

In developed economies however, various measures to increase energy efficiency and conservation are expected to restrain electricity demand. Such measures include, Demand Side Management (DSM) in the vein of energy efficiency programmes and technology development, which contribute to decreasing the utilisation of electricity in both the residential and commercial sectors.

Although various energy efficiency improvement programmes are also expected to be implemented in the industrial sector, industrialisation and the robust growth of this sector in developing APEC economies is likely to lead to more robust demand for electricity, resulting in an increase in the share of the industrial sector in total electricity demand.

The demand for electricity is highly correlated with economic growth. As income of any given economy increases, people are expected to use more electricity. Increasing income in line with the development of technology culminates in the creation of a digital society which continuously increases the

[31] Michael A. McNeil (2005)

[32] Walter S. Baer, Scott Hassell and Ben A. Vollaard (2002)

demand for electricity. Similarly, improvement of transmission and distribution infrastructure increases access to electricity and usage for domestic activities, including leisure, education, the production of goods, and other activities.

Table 14 shows the share of electricity in projected total final energy demand (TFED) for each APEC member economy. With the exception of Brunei Darussalam, the share of electricity in TFED is projected to increase continuously over the outlook period from 18 percent in 2002 to 24 percent in 2030. The anomalous result for Brunei Darussalam's electricity demand is mainly due to the small geographic size of the economy and the fact that the oil and gas industry has been extensively developed making current electricity consumption high. As more efficient electrical appliances and industrial motors are used over time the electricity demand is expected to decrease. Regionally, Southeast Asia and China's electricity demand are projected to grow the most robustly at 5.4 percent and 6.3 percent per year, respectively (Table 15).

Table 14 APEC Electricity as percentage of TFED (percent)

Economy	1980	2002	2010	2020	2030
Australia	15	24	24	25	26
BD	11	31	26	23	22
Canada	17	23	23	23	23
Chile	11	19	21	24	25
China	7	13	19	24	30
HKC	25	29	26	26	26
Indonesia	1.0	7.0	9.0	10	11
Japan	19	25	25	26	28
Korea	9.0	19	22	24	27
Malaysia	10	18	19	20	22
Mexico	7	16	18	19	21
NZ	24	21	25	26	27
PNG	20	23	23	22	23
Peru	8.0	16	18	21	23
Philippines	11	13	17	21	24
Russia	11	14	15	17	18
Singapore	16	21	20	21	22
CT	17	25	27	30	31
Thailand	7.0	15	17	20	23
USA	13	20	21	22	22
Viet Nam	1.0	7.0	11	16	19
APEC	**12**	**18**	**20**	**22**	**24**

Source: APERC Analysis (2006)

This rapid growth is mainly due to the current low level of electrification, revitalized electrification program, growing income and access to electricity grid in the region.

By region, North America, especially the US, is projected to contribute to the significantly high demand for electricity. Electricity demand in the US is projected to reach 5,648 TWh in 2030 or about 30 percent of APEC's total electricity demand in 2030. The expected high economic growth of China will however lead to the economy's high electricity demand, exceeding that of the US by 2030, reaching 6,582 TWh or 35 percent of APEC's total electricity demand in 2030.

Table 15 APEC's Electricity Demand (TWh)

Economy	1980	2002	2030	1980-2002 (%)	2002-2030 (%)
Australia	79.1	190.1	234.1	4.1	2.2
BD	0.3	2.3	2.7	9.7	0.6
Canada	303.5	486.7	689.4	2.2	1.3
Chile	9.3	40.8	160.8	6.7	5.0
China	247.7	1,193.9	6,582.3	7.4	6.3
HKC	10.5	38.1	82.8	5.9	2.8
Indonesia	5.8	87.0	307.5	12.7	4.6
Japan	512.8	983.5	1,280.3	3.0	0.9
Korea	32.6	294.2	821.4	10.5	3.7
Malaysia	8.1	68.8	249.0	9.9	4.7
Mexico	57.0	167.4	445.4	5.0	3.6
NZ	19.8	34.5	61.3	2.6	2.1
PNG	1.2	2.7	7.1	3.9	3.5
Peru	8.1	19.9	60.4	3.8	4.0
Philippines	17.4	39.2	184.5	3.9	5.7
Russia	n.a.	586.7	985.7	-	1.9
Singapore	5.8	29.2	82.4	7.9	3.8
CT	37.2	158.5	416.3	6.9	3.5
Thailand	12.8	98.4	495.6	9.6	5.9
USA	2,025.6	3,467.7	5,648.4	2.5	1.8
Viet Nam	2.3	30.1	245.7	11.6	7.8
APEC	**4,152**	**8,019**	**19,163**	**3.6**	**3.2**

Source: APERC Analysis (2006)

ELECTRICITY SUPPLY

The electricity supply projections have taken into account the information contained in the published national energy development plans of each of the 21 APEC member economies. For economies without such publications, the availability of energy resources and/or their proximity to energy sources abroad are instead used as major considerations for fuel assumptions in the future. The same technique is applied for over the long-term for economies that only have short-term projections.

Assumptions are also made on future system load factors, transmission and distribution losses, and power station use. For most economies, load factors are assumed to improve in view of the assumption that policies that would lead to load factor improvement such as DSM will be implemented or continuously implemented in the future. Likewise, transmission and distribution losses and station use, as a percentage of total generation, will also decrease as utilities enhance their competitive advantage through improvements in their transmission and distributions systems.

As a result, electricity generation will grow at a slightly lower rate of 3.0 percent. However, as demand increases, the supply mix is expected to change, driven by capital and fuel costs and resource availability considerations.

CAPACITY ADDITIONS

With the projected increase in total electricity demand, total generating capacity in APEC is projected to double from 2,139 TW in 2002 to 4,207 TW in 2030. Recent high oil prices, which consequently have increased natural gas prices, are expected to continue to increase over the outlook period. In response, each APEC member economy is expected to optimize their resources. This effort will promote the utilization of coal in electricity generation but would eventually dampen the demand for natural gas. The development of new nuclear power plant capacity is projected to gain momentum again, as Asian APEC member economies start to revitalize their nuclear program to meet rising electricity demand. Coal power generation capacity will grow the fastest among the conventional energy sources at 3.0 percent per year, from 752 GW to 1,710 GW, the share of coal increasing from 35 percent in 2002 to 41 percent in 2030. Natural gas will also grow at 3.0 percent per year the installed capacity increasing from 381 GW in 2002 to 963 GW in 2030, with the share of natural gas increasing from 18 percent in 2002 to 23 percent in 2030.

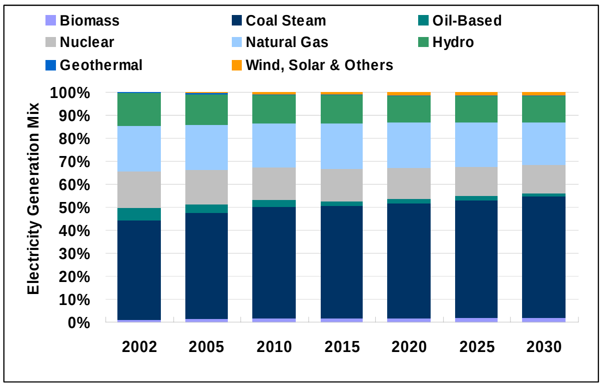
Over the outlook period the share of oil-based capacity will fall from 18 to 9 percent, and nuclear energy will decrease from 10 to 8 percent. Although in absolute terms the capacity of hydro will increase, the share of hydro will decrease from 18 percent in 2002 to 15 percent in 2030. Several initiatives by APEC member economies to promote the development of new and renewable energy (NRE) for electricity generation are projected. Therefore, the installed capacity of wind and solar PV is projected to increase at the fastest rate of 9.0 percent per year followed by biomass at 5.0 percent and geothermal at 4 percent. In absolute terms the level of NRE capacity will increase from 31 GW in 2002 to 170 GW in 2030, which will increase the share of NRE from 0.1 percent to 4 percent over the same period.

ELECTRICITY GENERATION MIX

Figure 50 shows the future APEC power generation mix. Coal is the most economic choice as a baseload [33] energy source in most economies. Electricity generation from coal is expected to continue to be the major contributor to APEC electricity generation, with the share increasing quite robustly from 44 percent in 2002 to 53 percent in 2030. This is due to the relatively low price of coal and coal's abundant availability in almost all APEC economies – making coal the most economic choice.

The high natural gas price is expected to curb electricity production from natural gas. Electricity from natural gas is mainly produced to meet peak demand. Although CCGT is very environment friendly, fast to construct and the initial capital cost/ requirements are lower than other power plant options; however, the risk of volatile prices and unstable supply are expected to prevent increase in the penetration of natural gas in many APEC economies. This will lead to a decline in the share of natural gas in electricity generation from 19 percent in 2002 to 18 percent in 2030.

Figure 50 APEC Electricity Generation (2002-2030)



Source: APERC Analysis (2006)

Most APEC member economies are projected to reduce the utilization of oil for electricity generation. Oil-based electricity generation is expected only in areas where no other fuels are available. As a result, electricity generation from oil is projected to decrease by almost half from 506 TWh in 2002 to 300 TWh in 2030. During the outlook period, the share of oil in APEC's total electricity generation is projected to decrease from 6 percent to 2 percent.

The share of electricity generation derived from hydro and nuclear will decrease as resource limits prevent the growth of hydro and public opposition limits the expansion of nuclear energy. Their respective contributions to the generation mix will

[33] The type of generation plant that comes first in dispatch order, meaning the one that is always in use.

decline, in the case of hydro from 14 to 11 percent, and nuclear 16 to 12 percent between 2002 and 2030.

The contribution of renewable energy (NRE), biomass, geothermal, solar, and wind energy, is currently at a very low level. Although the share of NRE will remain low it is expected to more than double from 2 percent to 4 percent.

ENERGY FUEL REQUIREMENTS

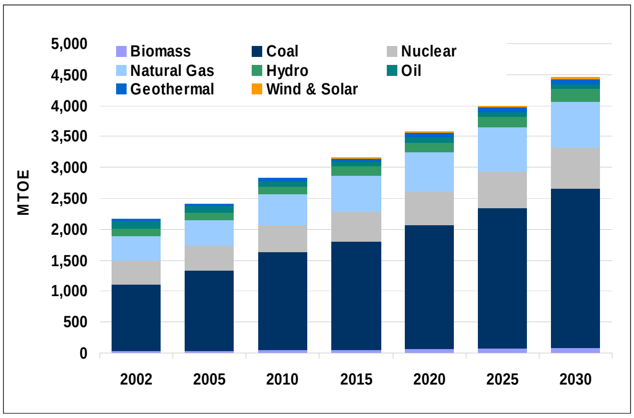
Energy inputs to electricity generation are influenced by energy conversion efficiency or thermal efficiency. In this outlook, it is assumed there will be improvements in thermal efficiencies of electricity generating technologies, particularly in coal, oil and natural gas-fired facilities. The installation of newly developed technologies for new generating facilities, retirement of older technologies and installation of new and more efficient ones will facilitate efficiency improvements. Therefore, growth in demand and generation can be expected to be higher than fuel as inputs alone would suggest.

Total fuel requirements for power generation will grow from 2,716 Mtoe in 2002 to 4,414 Mtoe in 2030, increasing at an average annual rate of 2.6 percent, 0.6 and 0.3 percent lower than the growth in demand and generation, respectively. With an annual growth rate of 3.1 percent, demand for coal for power generation will increase the fastest from 1,098 Mtoe in 2002 to 2,579 Mtoe in 2030, the share in the fuel mix going from 51 percent to 58 percent. While, natural gas will have a more moderate growth rate of 2.2 percent, demand will increase from 386 Mtoe in 2002 to 710 Mtoe in 2030, but the share will decrease from 18 percent in 2002 to 16 percent in 2030.

NRE will have the highest growth rate of 4.2 percent per annum, although the share will remain modest, not rising above 5 percent. Nuclear energy and hydro will have respective growth rates of 1.9 and 2.0 percent with their shares changing from 18 and 5 percent to 15 and 4 percent between 2002 and 2030 (Figure 51).

The generation mix varies from economy to economy, however, the resources utilised depends on domestic resource availability and/or proximity of the economy to energy-producing economies. For example, economies with huge potential for hydro or abundant natural gas reserves by and large tend to have higher shares of these resources in their energy mix. Likewise, economies that are not endowed with energy reserves will have to import coal and natural gas to fuel their power stations or build nuclear power plants to increase energy security and mitigate emissions harmful to the environment.

Figure 51 Energy Inputs for Electricity Generation



Source: APERC Analysis (2006)

Table *16* shows the projected energy mix of each APEC economy in 2002 and 2030. The fuel mix of China for example will continue to be dominated by coal, although the share will decrease from 87 percent in 2002 to 81 percent in 2030. This reduction is made up by increases in natural gas and nuclear energy, which will have respective shares of 4 and 7 percent in 2030 from 0.3 and 2 percent in 2002. The share of hydro will likewise decrease from 6 to 5 percent, while oil's contribution will decrease from 5 to 1 percent.

Meanwhile, Canada is seeking to reduce the economy's share of both coal and nuclear in electricity generation, which will result in an increase in the share of natural gas. The share of natural gas is projected to increase from 9 percent in 2002 to 25 percent in 2030. On the other hand, the combined share of coal and nuclear is expected to decrease from 55 percent in 2002 to 34 percent in 2030.

ELECTRICITY TRADE

Motivated by increasing demand for energy and security of supply, environmental benefit and economic efficiency, APEC member economies are expected to promote and enhance electricity trade within the region. Prospects for cross border trade of electricity in the APEC region exist when several economies are endowed with different types and sources of energy and varying electricity loading profiles. Based on current energy trade flow, the most prospective regions for electricity trade are in Southeast Asia, Northeast Asia, North America and the Andean region of South America.

Table 16 APEC Fuel Input for Electricity Generation (%)

Economy	Year	Oil	Coal	Natural Gas	Nuclear	Hydro	Other
Australia	2002	1.8	81.7	13	-	2.5	1.0
	2030	0.9	71.9	20.3	-	1.8	5.1
Brunei	2002	0.9	-	99.1	-	-	-
	2030	0.9	-	99.1	-	-	-
Canada	2002	3.6	31.6	8.6	23.1	30.9	2.2
	2030	2.8	19.0	25.3	15.2	29.6	8.1
Chile	2002	1.7	29.3	33.1	-	27.9	8.0
	2030	0.2	33.2	48.5	-	12.6	5.5
China	2002	4.5	86.9	0.3	1.8	6.2	0.3
	2030	0.6	81.3	4.2	7.3	5.5	1.1
Hong Kong China	2002	0.5	68.7	30.8	-	-	-
	2030	0.1	51.5	48.3	-	-	0.1
Indonesia	2002	13.3	38.0	27.1	-	3.4	18.2
	2030	1.9	50.3	33.3	-	2.4	12.2
Japan	2002	12.2	23.5	23.4	35.1	3.8	2.0
	2030	4.0	24.0	24.2	41.0	3.1	3.7
Korea	2002	7.3	30.29	21.9	38.7	1.8	-
	2030	1.2	30.6	23.9	41.7	1.1	1.5
Malaysia	2002	10.2	53.2	77.4	-	4.5	-
	2030	0.4	31.51	43.7	-	1.8	0.8
Mexico	2002	36.5	13.3	32.0	4.9	4.2	9.1
	2030	10.3	23.5	54.8	2.6	2.8	6.0
New Zealand	2002	-	4.8	29.3	-	27.6	38.4
	2030	-	10.3	9.8	-	15.3	64.6
Papua New Guinea	2002	59.5	-	18.7	-	14.9	-
	2030	38.8	-	26.0	-	10.1	-
Peru	2002	22.7	4.7	8.9	-	61.0	2.6
	2030	4.1	5.4	63.9	-	25.9	0.8
Philippines	2002	2.8	30.1	8.9	-	2.7	55.5
	2030	2.6	51.2	19.7	-	2.5	24.0
Russia	2002	5.1	19.5	49.5	18.2	6.7	0.9
	2030	1.3	22.8	40.7	26.3	6.7	2.3
Singapore	2002	54.3	-	38.5	-	-	7.3
	2030	7.9	-	88.1	-	-	4.0
Chinese Taipei	2002	10.0	55.7	10.8	21.8	1.2	0.5
	2030	1.6	56.4	22.3	6.8	0.6	12.4
Thailand	2002	2.5	21.0	72.5	-	2.8	0.8
	2030	0.4	43.0	52.1	-	0.8	3.6
USA	2002	2.6	54.7	15.0	21.9	2.4	3.4
	2030	1.8	58.5	12.6	18.0	1.8	7.3
Viet Nam	2002	27.1	23.2	25.1	-	24.6	-
	2030	-	38.0	21.9	22.3	12.4	5.4
APEC	2002	**5.8**	**50.5**	**17.7**	**17.8**	**5.2**	**3.0**
	2030	**1.6**	**58.4**	**16.1**	**14.8**	**4.4**	**4.6**

Source: APERC Analysis (2006)

In Southeast Asia, electricity trade is projected to continue between Thailand and Malaysia and extend with or among other neighbouring APEC economies such as Singapore with Malaysia, and Indonesia with Malaysia. Thailand's trade with Malaysia and Malaysia's with Singapore is however just for mutual backup, making absolute electricity trade almost nil. Indonesia is projected to import electricity from

Malaysia for utilization on Kalimantan Island (1,500 GWh in 2009), which would possibly increase to 5,000 GWh by 2014. Thailand is projected to increase electricity imports from Cambodia, Lao PDR and Myanmar from the current 3,000 GWh to almost 42,000 GWh; or about 10 percent of total electricity demand in 2030. Viet Nam, will also import electricity from neighbouring economies starting from 400 GWh in 2008 and potentially increasing to 9,000 GWh in 2030.

In the Outlook period, electricity trade between the US and Canada, and between Mexico and the US, are expected to continue, with the US and Mexico both being net importers. However, the volume of electricity traded will fall from current levels as a result of increasing demand in exporting economies.

Chile is expected to import electricity from Argentina from 2007 with the completion of a 400 MW interconnection line. Russia likewise will continue to export electricity to some of the neighbouring economies in Eastern Europe.

IMPLICATIONS

The share of coal for electricity generation in the APEC region will increase substantially, in turn causing the portion of emissions – including CO_2, SO_2 and NO_x – emitted by the electricity sector to grow. Over the outlook period measures to reduce the amount of emissions emitted from the electricity sector to combat both local and global environmental issues will become more prominent. To this end, the proactive engagement of all APEC member economy government's will be necessary, with a coordinated and multi-pronged attack to promote and develop technology for the reduction of emissions such as advanced coal-fired generation, carbon capture and sequestration and policies to expand the share of renewable energy in electricity generation being pursued. In addition the provision of incentives and other economic instruments by government to accelerate the development and diffusion of new technology and realize the investment requirements of the electricity sector could be employed.

Efficiency improvement in electricity consuming technology/appliances could help rein in demand growth. Several programmes such as the Energy Star and Top Runner programmes and DSM have shown some success in reducing energy demand. However, the introduction of new electrical equipment for leisure and work – such as office automation – could increase electricity utilisation in spite of efficiency improvements. In addition, changes in the population structure of APEC member economies, due mainly to an aging population could increase the demand of electricity as elderly people need more assistance from electricity consuming appliances, which in turn could also reduce the success of energy efficiency programmes. On the other hand, some APEC economies have not yet maximised their energy efficiency improvement efforts because of limited resources and technology. This condition opens an opportunity for cooperation among APEC economy to improve energy efficiency to slow down electricity demand in APEC region.

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ENERGY INVESTMENT

- *To meet the rapid energy demand growth, APEC economies will require between US$ 5.95 and 7.55 trillion.*
- *For the APEC region on average, the energy investment share of GDP is projected to be 0.7 percent. Only six APEC economies fall below this average: Japan, Hong Kong, China, New Zealand, United States, Chinese Taipei and Singapore. Five APEC economies – Indonesia, Malaysia, Russia, Papua New Guinea and Viet Nam – are projected to have energy investment burdens greater than two percent of GDP.*
- *Governments of host economies will need to provide conditions that can attract a mix of domestic and foreign investors to provide the investment capital needed for energy projects.*

INTRODUCTION

Energy is an integral part of economic activities, and thus, investment in energy infrastructure is essential to support activities and growth of APEC economies. It facilitates the mobility of people and goods, underlies the production of manufacturing and services, and sustains the comfort and convenience in living. All in all, quality of our living standards, performance of industries and business activities invariably depend upon stable and reliable energy supply.

Disruption of energy supply can create significant economic losses. For example, electricity blackout that took place on August 2003 in New York and neighbouring states has resulted in losses of some billions of US dollars. During the 1980s, about twenty percent of the industrial factories in China were kept idling due to the inadequate electricity supply. Costly incidents such as these are raising concerns over the reliability of future energy supply in the world and in APEC particular, as their future energy demand is expected to grow at the faster pace.

APERC projects that energy demand of APEC economies will grow 2.0 percent through 2030. The trend of energy demand growth for the APEC economies is somewhat faster than that of world average. In order for the fast energy demand growth to be realised, and hence to sustain economic growth, economies in APEC would require substantial investment from production, transportation and through to delivery. This would mean upstream investment in oil and gas, and midstream investment for oil and gas pipelines, transmission lines, and tankers, and downstream investment for oil refineries, and power plants.

Despite the importance in developing energy infrastructure, some APEC economies do not necessarily provide conditions attractive enough to invite investment. In the United States, for example, since deregulation of electricity industry had given a strong competitive pressure, efforts by companies to reduce capital investment have made transmission capacity insufficient to meet demand growth. China has been experiencing a slow progress in building new refineries or expanding production capacities as their regulated prices of gasoline and diesel cannot provide enough rate of return for investors. Meanwhile, some of the developing economies in APEC could not attract capital for energy projects because of the opaque laws, rules, and regulations and even because of the high political risks.

Financing energy project would pose challenges to the energy sector of APEC. Given the tight budgetary conditions, APEC economies should rely on their increasing share of energy projects for private financial sources. However, private financiers would ultimately see no boundary both in terms of *economy* and *sector*, therefore, attracting financial sources from private sources would face increasing competition. In brief, it would have to be met with appropriate or favourable conditions that can minimise cost and maximise benefit.

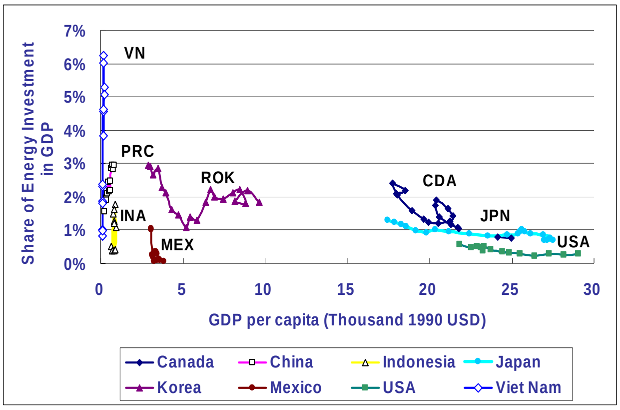
In this chapter, a brief introduction of the historical trend for energy investment from upstream, midstream to downstream are provided in consideration for the factors affecting the trends in energy investment. With the special focuses on upstream investment in oil and gas E&D, and midstream investment in power transmission, we will further investigate both drivers and constraints for energy investment. To evaluate the size of investment requirements to the energy sector, we will present an overview of a thirty-year investment requirement both by sector and by economy. An overview of historical trends in financing to the energy sector will be presented to highlight difficulties or enabling activities for attracting capital to the energy projects. Finally policy implications will be drawn to present how economies in APEC could give incentives to the private sector to participate in energy projects and to provide financial sources.

HISTORICAL TRENDS OF ENERGY INVESTMENT IN APEC

The fundamental driver for energy investment is economic activity and the resulting demand for energy services. Thus, requirements for investment in energy infrastructure may be particularly large in economies that are at an early stage of development and growing rapidly.

Figure 52 compares the share of gross domestic product that is taken up by investment for energy utilities with gross domestic product per capita in several APEC economies for the period from 1980 through 2001. The comparison clearly shows that the burden of investment, relative to GDP, often declines as GDP per capita increases, both between economies and over time within economies. The most developed economies, with the highest GDP per capita, have relatively low investment burdens, are shown by Canada, Japan and the United States. The least developed economies, with lowest GDP per capita, have relatively high investment burdens, as shown by China and Viet Nam.

Figure 52 Investment by Energy Utilities as share of Gross Domestic Product, Compared with GDP per Capita, in Selected APEC Economies (1980-2001)



Source: APERC Analysis (2003)

Less developed economies may tend to exhibit relatively high investment requirements for energy infrastructure because such economies are in the midst of a transition from reliance on non-commercial energy sources, which require little infrastructure, to commercial fuels like coal, oil, gas and hydropower, which require substantial infrastructure. In Viet Nam, for example, just 40 percent of total primary energy supply comes from commercial fuels, and a three-quarter of households do not have access to the national electricity grid. Development of commercial energy sources and expansion of the power grid will entail substantial new investment.

In middle-income economies, requirements for new energy infrastructure are likely to continue to exert a considerable burden. In Korea, for example, the share of energy utility investment in GDP declined roughly from 3 percent in 1980 to 1 percent in 1988 but grew again to around 2 percent during most of the 1990s. Increased investment for the last decade has been largely driven by natural gas infrastructure development. Since the introduction of LNG in 1986 to supply natural gas to power generation and a subsequent policy for the economy-wide introduction of natural gas, substantial investment has been needed to develop gas trunklines and distribution networks. Such downstream networks often have greater investment requirements than upstream gas development.

Higher-income economies like Canada, Japan and the United States have smaller energy utility investment requirement than other economies even though their absolute level of energy utility investment is higher since their GDPs are large. The main reason for their smaller energy utility burdens is that they have a substantial capital stock of energy infrastructure already in place. On of their main challenges is how best to replace obsolete facilities in a deregulated environment for gas and power production where utilities are faced with the competitive pressure to reduce costs.

ENERGY SECTOR REFORM AND INVESTMENT

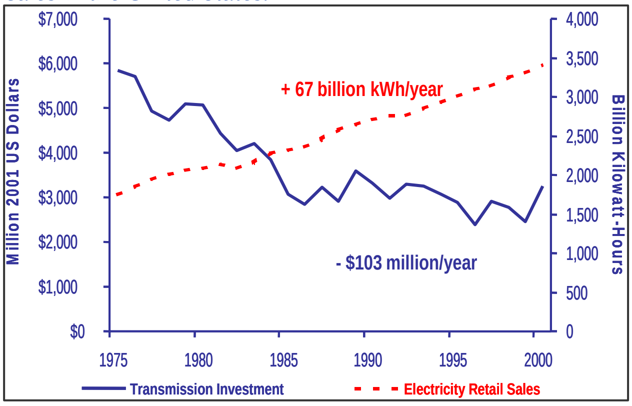
Energy investment is also influenced by institutional factors such as government rules, regulations and industrial structure. Many APEC economies are considering or have already taken market reforms and restructuring of energy sector. Such reform efforts are designed to encourage competition from additional energy producers and lower energy costs to consumers and for consumers to have a fair choice of suppliers.

Fair access to consumers means non-discriminatory access to transmission and distribution networks, which typically remain regulated as natural monopolies. The construction of transmission and distribution lines for natural gas and electricity as well as terminal facilities for receipt and processing of liquefied natural gas (LNG) in some places usually subject to rate-of-return on investment, based on the weighted average cost of debt and equity capital.

If regulators fail to sanction a market-based rate of return on investment in transmission and distribution facilities, such facilities will not be constructed. Regulatory failure of this sort is by no means confined to markets in which regulatory reforms have allowed competition among gas producers and electricity generators over the regulated transmission and distribution lines.

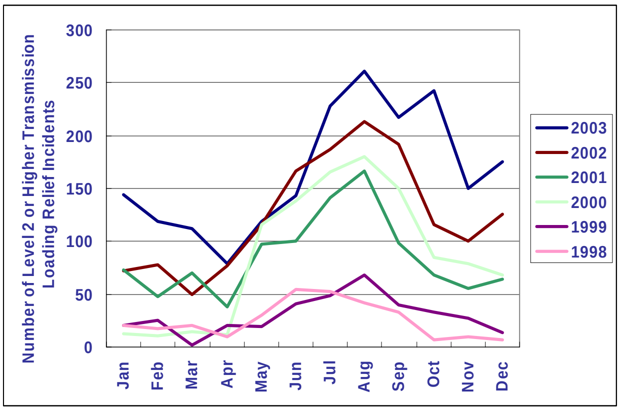
An interesting illustration concerning investment under deregulated environment is provided by the United States. As shown in Figure 53, US transmission investments have been falling by an average of US$103 million per year for the last 25 years. By the late 1990s, annual investment outlays for transmission facilities were around half of what they were in 1975. One could argue that the use of transmission is getting more efficient, moving more electricity per unit of transmission capacity. This could be due in part to the growing use of combined-cycle gas-fired power plants, which are often located close to demand centres.

Figure 53 Transmission Investment and Electricity Retail Sales in the United States.



Source: Edison Electric Institute (2001)

Figure 54 Growing Transmission Line Congestion in the United States (1998-2003)



Source: North American Electric Reliability Council (2003)

On the other hand, as shown in Figure 54 the transmission grid is becoming more congested, with incidents requiring transmission loading relief becoming much more frequent since 1998. This can be attributed to increased electricity generation to meet growing demand, combined with vigorous trading in the wholesale market for generation. The blackouts experienced in the Northeast in 2003, which affected 80 million people and were thus the most extensive in history, also suggest that the grid may be strained beyond its capacity. Together, the growing congestion and recent blackouts strongly indicate the need for additional transmission capacity to be built if market competition is to keep growing and the supply of electricity is to remain reliable.

The question then is: What are the barriers to additional investment in transmission lines? One of the most intractable obstacles relates to difficulties in siting. Transmission networks increase the options for customers to buy less expensive electricity from more distant sources. But siting new transmission facilities is difficult due to the complexity of environmental and land use regulations, as well as the NIMBY or "not in my backyard" syndrome. Regulations may require that before a construction permit is granted, environmental impact assessments must be performed and transmission investments must be shown to be the least-cost alternatives. NIMBY may be particularly pronounced where new lines are proposed in what might be called "transit" areas that contain neither major power plants (whose owners would profit from increased sales) nor major load centres (whose consumers would benefit from competition among more generators).

Another critical obstacle for transmission investment in the United States is that owners of transmission facilities often have little incentive to invest in new facilities. Current regulatory frameworks do not provide a mechanism for transmission owners to share the benefits that accrue to power plant owners and electricity customers from competition, even though transmission lines are what make the competition possible. Hence, returns on investment in transmission facilities may often be inadequate to attract such investment. According to a study by Hyman, transmission owners can earn an after-tax return on investment of 9 percent per annum over a 40-year period, which is less attractive than returns on other investments in the energy sector and elsewhere.

Investment in new transmission facilities may also be discouraged by regulatory uncertainty over transmission pricing, for which there are many different methodologies. For example, PJM is using license-place rates, charging an access price based on the location of the load. The New England Power Pool applies region-wide postage-stamp rates for transmission access which are the same regardless of where the load is located. Under these circumstances, transmission owners have little incentive to invest in the transmission facilities unless they are absolutely necessary. In the process of deregulating electricity markets in the US, discussion seems to have focused on the importance of non-discriminatory access to the transmission infrastructure. Recognising the benefits obtainable from competition between the generators, the complementary role played by transmission facilities to enable access to less expensive sources of generation, deregulated electricity markets need careful designing to facilitate investment in transmission lines in a manner that keeps pace with rising demand.

To this end, there are at least two important requirements for enhancing transmission network investment. One is to ensure the long-term regulatory framework and the second is to provide incentives for transmission owners in a manner so that they can recover costs and earn a competitive return on transmission investments. Transmission pricing should include economically efficient signals to transmission users.

THE OIL PRICE AND INVESTMENT FOR OIL AND GAS EXPLORATION AND DEVELOPMENT

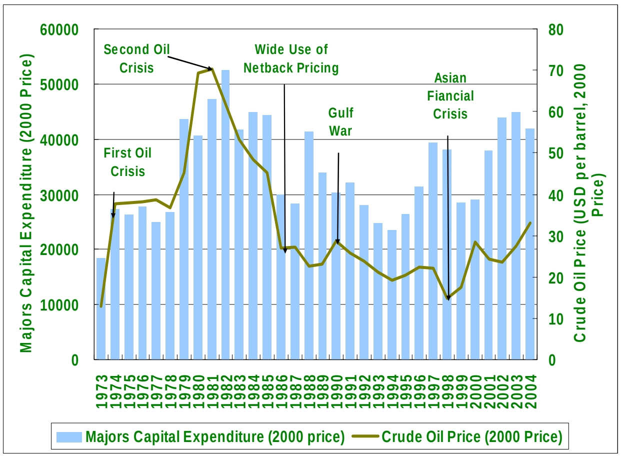
Oil and gas production is sustained by continued investment in order to add proved reserves to replace production. However, the investment environment for oil and gas upstream exploration and development has not always been favourable to investors. For one thing, investors have to deal with the risks arising from the geological conditions in finding profitable wells because exploration wells are mostly dry holes. Thus a small number of successful wells are required to cover the costs of unsuccessful field exploration.

In addition, investors, in particular foreign investors, must cope with further difficulties caused by the interaction with host governments. One of the difficulties lies in the fiscal policies of the host governments. Generally, underground mineral resources like oil and gas belong to sovereign Therefore, investors are subject to payment of taxes, royalties and surcharges to the host government. Sometimes the fiscal framework is either unattractive or inadequate in view of the potential risks involved. The fiscal regime may also be subject to frequent revision, which may deter investors out of fear that the terms of deals will be altered once they are in place or out of hope that better deals can be secured at a later date. Legal issues and political stability are additional hurdles as far as foreign investment in oil and gas field development is concerned.

Then the question posed is: What is the main driver of investment for oil and gas exploration and development (E&D)?

Figure 55 shows the historical trend of capital expenditure for exploration and development of oil and gas reserves by four major oil companies (BP Amoco, ExxonMobil, Royal Dutch Shell and ChevronTexaco), along with the world crude oil prices.

Figure 55 Oil Price and Investment in Oil and Gas E&D (1973-2004)



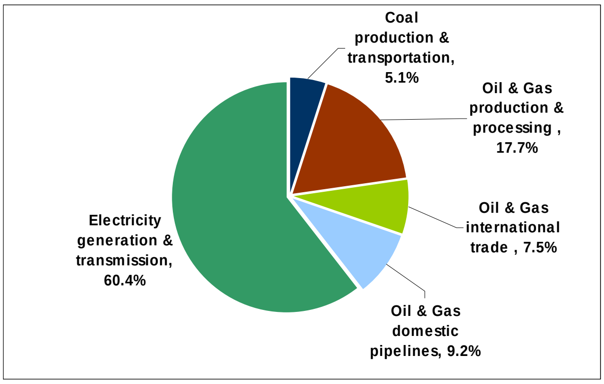
Source: APERC Analysis (2006)

As the above figure shows, oil investment for oil and gas upstream E&D has high correlation with the oil price movements. In particular, the major oil companies' investment activities share a common trend with oil price movements over the period between 1977 and 2004, while they do not share any common trend between 1973 and 2004. These coincide with the timing when investment of oil major companies changed. In the early 1970s, investment activities were led by political considerations to enhance security of oil supply, while since the end of 1970s, investment activities have been more driven by the commercial viability of investment in E&D, for which crude oil prices have played the key role as a determinant.

ENERGY INVESTMENT REQUIREMENTS IN APEC

To meet the rapid energy demand growth, APEC economies will require between US$ 5.95 and 7.55 trillion. As Figure 57 shows, electricity generation and transmission are projected to account for about 60.4 percent of the projected total investment requirements through 2030. Oil and gas production and processing are projected to account for about 18 percent of the total projected during the same period. Domestic oil and gas pipelines represent about 9.2 percent of the total. Investment for the international trade of oil and gas, which include the costs of tankers, LNG facilities, and pipelines used for international trade, represent about 7.5 percent of the total. Coal production and transportation has the smallest share at 5.1 percent of the total investment requirements.

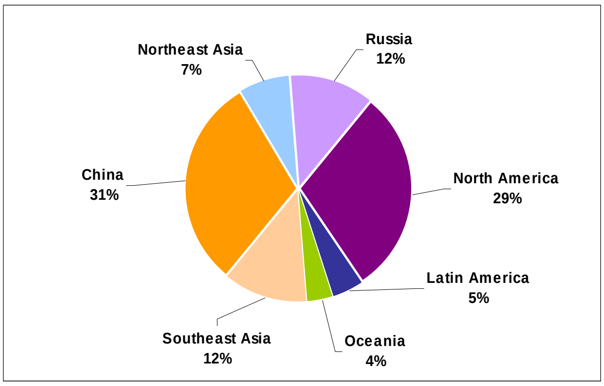
Figure 56 Total Investment Requirements by Sector



Source: APERC Analysis (2006)

Figure 57 shows the total investment requirements by region. China accounts for the largest share in total APEC energy investment requirements at 31 percent, followed by North America at 29 percent and Russia and Southeast Asia at 12 percent respectively.

Figure 57 Total Investment Requirements by Region

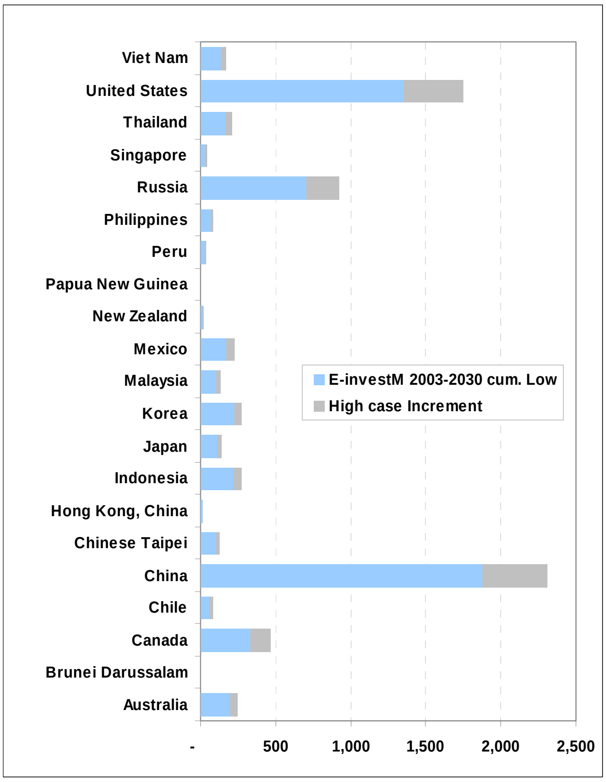


Source: APERC Analysis (2006)

Figure 58 shows total energy investment requirements for each APEC economy through 2030. The lower estimate of investment needs is shown by the blue portion of each bar. The higher estimate of investment needs is indicated by the sum of blue and grey portions of each bar. The economies are shown in order from the largest to smallest projected investment requirements over the outlook period. China will need about US$ 2.3 trillion through 2030 to supply energy needed to support robust economic growth. United States will require about US$ 1.7 trillion through 2030.

The magnitude of the energy investment requirements over the next three decades has raised concerns over whether sufficient financial resources can be obtained to meet them. Later portions of this study appraise the availability of financial resources for energy sector investment in APEC economies and examine policies and mechanisms to attract the resources required. But to put the issue in perspective, it is important to evaluate the burden of anticipated energy investment needs in relation to overall economic output. For economies where energy investment needs represent a small share of gross domestic product, the burden should be relatively light. For economies where energy investment needs are a larger share of GDP, they may be more difficult to satisfy.

Figure 58 Total Investment Requirements by Economy (2003-2030)

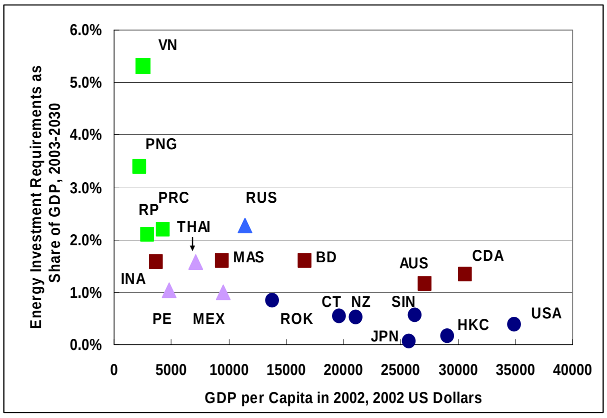


Source: APERC Analysis (2006)

Figure 59 shows the share of GDP that the projected energy investment requirements will represent in each APEC economy over the period from 2003 through 2030 compared with GDP per capita. For the APEC region on average, the energy investment share of GDP is projected to be 0.7 percent. It can be seen in the figure that only six APEC economies fall below this average: Japan, Hong Kong, China, New Zealand, United States, Chinese Taipei and Singapore, in ascending order of energy investment burden. All of these economies are highly developed, with high incomes per capita.

According to the World Energy Council and International Institute for Applied Systems Analysis, global capital spending on energy projects amounted to 1.5 percent of Gross World Product in the early 1990s and should not exceed 2 percent of GWP in the future.[34] But five APEC economies are projected to have energy investment burdens that exceed this 2 percent threshold: China, Philippines, PNG, Russia and Viet Nam.

Figure 59 Total Investment Requirements by Economy (2003-2030)



(Source) APERC Analysis (2006)

HURDLES FOR MOBILISING NEEDED CAPITAL: FINANCING ISSUES

Financing energy projects will pose challenges to energy industries throughout the region. However, the challenges are greatest for developing and transitional economies, not only because their energy investment burdens are often greater as a share of economic output, but also because their capital markets are less well developed and offer fewer options for obtaining funds.

In developing and transitional APEC economies, governments are less and less willing to finance energy projects from public budgets. Budgets are tight, and if energy projects can be financed from private sources, public moneys are better spent on social programmes for which private financing cannot be obtained. Yet capital markets in these economies are at an early stage of development, so private financing may be costly or unavailable. Opaque laws, inconsistent regulations, political risks and new firms without a proven track record can all raise the cost of financing to unsustainable levels.[35]

DEVELOPMENT OF DOMESTIC CAPITAL MARKETS

Many developing APEC economies are have high savings rates, representing 20 to 30 percent of GDP. However, their domestic capital markets are generally under-developed so that the necessary financial resources for energy sector investment may not be readily available from internal sources. Their equity markets have not been very liquid, and their bond markets usually lack the stabilizing presence of large institutional investors such as pension funds and insurance companies.

In the developing APEC economies of China, Indonesia, Papua New Guinea, Philippines, Thailand, Russia and Viet Nam (Peru is left out), financing energy projects rely mostly on bank lending for well over half of all project financing. This is mainly because their bond and equity markets are at an early stage of development. While stock market capitalisation amounts to more than three-fifths of GDP in the Philippines and nearly half of GDP in Indonesia, it is much smaller in the other economies listed. Bond financing represents about a fifth of overall funding for investment projects in Papua New Guinea and Thailand and Viet Nam but much less in the other economies shown.

In light of the way that most developing economies have industrialised and built up their energy sectors, their heavy reliance on bank lending is not surprising. Historically, the state has often intervenes in financing long-term investments, so a combination of self-financing and lending through state-owned banks and development banks has played a major role in financing long-term investments.[36] Later, as state intervention in the financial system was scaled back, commercial bank lending and self-financing have become the major financial sources forthe energy companies. In the transitional economies of China and Russia, state banks are still a major source of financing.

Generally speaking, commercial bank loans have short maturities that are not appropriate for long-term energy projects. The reason that a large numbers of energy projects have been financed through bank lending is borrowers' typical expectation that simply the loans of short maturities will be periodically renewed (rolled over) by banks over an extended portion of each project's life.

Bond financing is often preferable for large-scale investments for two reasons. Firstly, bonds provide long-term capital for investment in energy projects at lower interest rates than commercial loans. Secondly, bonds issue in domestic capital markets can replace some portions of borrowings denominated in foreign currency. This reduces the currency mismatch between domestic currency assets and foreign currency liabilities, which is a source of vulnerability in many financial systems.

[34] IIASA/WEC (1998).

[35] Petroleum Economist (2003).

[36] Sharma (2000).

IMPLICATIONS

While future energy sector investment requirements for APEC economies will be large in absolute terms, they should not be large relative to projected economic output. For the APEC region as a whole, energy investment over the next two decades should take up less than one percent of total GDP. With respect to electric power generation, which accounts for nearly a third of energy investment needs, there is a clear trend for the economic burden of investment to decline over time as economies grow, and this trend is projected to continue in most of the region.

Yet energy sector investment will generally absorb a greater share of output in less developed economies than in more developed ones. Five APEC economies are projected to have energy investment burdens greater than two percent of GDP. Several of these have substantial underdeveloped energy resources that might be of value for financing energy investment. These include Indonesia, Malaysia, Russia, Papua New Guinea and Viet Nam.

In the less developed economies, direct government financial supports to energy projects are declining because of growing public budgetary deficits. Thus, the role of governments is shifting form direct intervention to establishment of regulatory regimes that will be favourable to capital formation. Governments of host economies will need to provide conditions that can attract a mix of domestic and foreign investors to provide the investment capital needed for energy projects.

Cooperation among APEC economies should be strengthened to promote energy investment. Many economies are building or planning natural gas pipelines and power grid interconnections that extend beyond their borders. Such projects can reduce investment requirements by taking advantage of differences in the timing of peak demand and efficiently mobilising diverse energy endowments. To help ensure that trans-boundary projects can be put in place, APEC economies should work together to harmonise differences in laws, regulations, environmental standards, and technical standards and to establish dispute settlement mechanisms that investors can rely upon.

Demand for energy in APEC is growing, so there are many opportunities for investment in energy projects. But building and operating energy projects entails a broad range of risks. And the needs of host economies, the interests of investors, and requirements of financial institutions do not always coincide. By building channels for dialogue, APEC governments can help to better evaluate investment risks and bridge diverse interests so that needed energy projects can get built.

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ENVIRONMENT

- *Emissions of sulphur dioxide, nitrogen oxide and carbon dioxide in 2030 is estimated to reach 155 million tonnes of SO_2, 121 million tonnes of NO_X, and 27,364 million tonnes of CO_2, about two-fold increase from the 2002 value of 79 million tonnes of SO_2, 65 million tonnes of NO_X, and 14,740 million tonnes of CO_2.*
- *The electricity sector will have the highest growth of emissions rate of SO_2, NO_X and CO_2 at 2.9, 2.8 and 2.7 percent per year respectively.*
- *The accumulated carbon offset price in APEC region between 2003 and 2030 is estimated to be US$14,708 billion, which China and the US will account the largest share at 65 percent combined.*

INTRODUCTION

The energy sector and environmental problems are intimately related since production and utilisation of energy almost always results in some environmental effects. The negative impacts can be broadly categorised as local and global impacts.

For the local impacts, there are various reports that record the negative effects of unrestrained energy utilisation on the environment. For example, the extensive use of coal in China's electricity sector has caused the acid rain phenomena, which has led to widespread soil acidification and is likely to have negative effects on agricultural production and forest growth.[37] Another example is from the US, exposure to fine particulate pollution from the combustion of fossil fuels in power plants has resulted in an estimated 603,000 asthma attacks nationwide, and over 30,000 people die prematurely each year (the Abt Associates' study). Similarly in the transport sector, increase in the number of vehicles has consequently led to an unavoidable increase in toxic substances, such as, fine particulates and lead, in addition to carbon monoxide, hydrocarbons and nitrogen oxide. The fine particulate matter from vehicle emissions penetrates deep into the lung tissue causing respiratory problems, aggravating asthma and other cardiovascular diseases, while other pollutants in emissions can cause neurodevelopment problems (especially from lead), and carcinogens.

For the global environmental impacts, the increase in CO_2 concentration in the atmosphere is expected to result in a 1-2 degree rise in average global temperature by 2030.[38] Similarly, for the next 100 years, it is predicted that the global mean surface temperature will rise by 1.4 -5.8 degree Celsius.[39] If this effect continues into the twenty-second century polar ice would then begin to melt eventually bringing about sea level rise.

[37] Environmental Science & Technology (2006)

[38] UNFCCC (2005)

[39] IPCC (2001)

In order to tackle environmental problems with a degree of success it is very important to learn from history. It is also essential to visualise and understand future environmental conditions, specifically from the perspective of the energy sector, as to enable proper measures to be planned and put into action on time. With that purpose in mind, this section will first describe the historical trend of carbon dioxide emissions in the region, and then the estimated emissions of sulphur dioxide (SO_2), nitrogen oxides (NOx), carbon dioxide (CO_2) during the outlook period, as per the BAU scenario. Finally, in order to present the magnitude of the emissions from the energy sector, the CO_2 emissions are describe in monetary terms – carbon offset price.

HISTORICAL TREND OF CO_2 EMISSIONS

The CO_2 emissions in the region have grown by 2.0 percent over the last three decades – a two-fold increase from the 1972 level reaching 14 billion tonnes of CO_2 in 2002.[40,41] The huge increase is mostly related to robust economic growth, population increase and improvement in living standards throughout the APEC region.[42] Among APEC economies, the total CO_2 emissions in Indonesia have grown the fastest at a rate of 9.0 percent per year, followed by Malaysia, Brunei Darussalam and Thailand each at 8.0 percent per year.

By sector, the electricity sector is found to be the major contributor to CO_2 emissions, maintaining a share of more than 30 percent of total emissions from 1983 onwards. CO_2 emissions from the electricity sector have grown at 4.0 percent annually from 1972 to 2002, increasing three-fold to reach 5 billion tonnes of CO_2 in 2001 (Figure 60), this increase is partly due to the utilisation of fossil-fuels

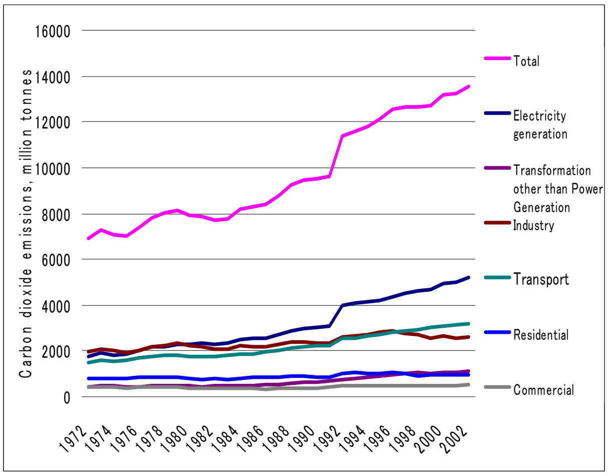
[40] The CO2 emissions from Papua New Guinea was not included.

[41] IEA Database (2005)

[42] The GDP for the APEC region has grown at 3.0 percent per year from 1972 to 2002. And the population has grown at 2.0 percent per year over the same period.

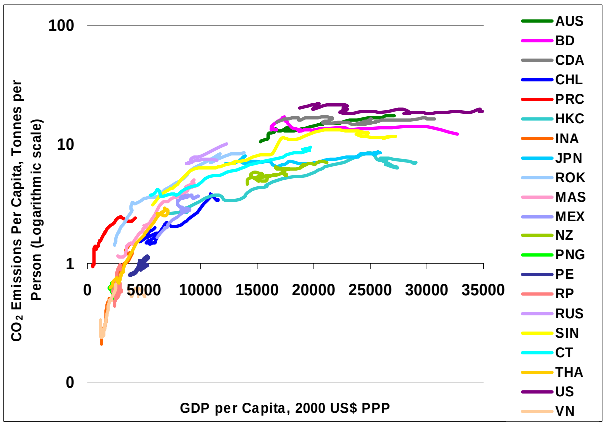
in the electricity sector. As for the transformation sector, substantial progress has been observed in the past three decades in order to meet the increased energy demand in the market. As a result of this development, CO_2 emissions from the transformation sector have also increased by three-fold from the 1972 level to reach 1 billions tonnes of CO_2 in 2002, growing at an annual rate of 3.0 percent. Similarly, CO_2 emissions from the transport sector have also grown by 3.0 percent per year from 1972 to 2002 to reach 3 billion tonnes of CO_2 in 2002, mainly due to increase in vehicle ownership, air transport utilisation and freight transport as a result of increasing population, growth in income levels and increasing urbanisation that leads to improvement in the standard of living.

Figure 60 CO_2 Emissions (1972-2002)



Source: IEA (2005)

Figure 61 CO_2 Emissions per Capita as a Function of Gross Domestic Product per Capita (1972-2002)



Source: IEA (2005); Global Insight (2005)

Figure 61 illustrates that between 1972 and 2002 CO_2 emissions per capita have varied with income level, that is, the higher an economy's income the greater the CO_2 emissions produced, however, emissions tend to saturate at a certain level over time, which is dependent on the economic structure of the economy. For the case of Brunei Darussalam, the energy consumption per capita has been reduced in the past decade, thus CO_2 emissions per capita have decreased. For less developed economies, such as Viet Nam and Thailand, the trend of CO_2 emissions per capita has increased in the past decades. In high-income economies, CO_2 emissions per capita have fluctuated at a certain level. For instance, Hong Kong, China is a service based economy, which has lower CO_2 emissions per capita than other industrial economies, such as Canada or the US.

EMISSIONS PROJECTION

Emissions from the energy sector are expected to increase over the outlook period in parallel with the projected increase in total primary energy demand to cater for the population and economic growth in the region.[43, 44]

Sulphur dioxide (SO_2) is projected to increase from 79 million tonnes in 2002 to 155 million tonnes in 2030, with the electricity sector accounting for 63 percent of total SO_2 emissions. Similarly, nitrogen oxides (NOx) are projected to increase from 65 million tonnes to reach 121 million tonnes over the same period, with the largest contributor to total NOx emissions being the transportation sector at 44 percent followed by the electricity sector at 31 percent. For CO_2, emissions are projected to increase almost two-fold over the 2002 level, from 15 billion tonnes in 2002 to 27 billion tonnes in 2030, with 47 percent of total CO_2 emissions emitted by the electricity sector. Over the outlook period, the electricity sector will experience the fastest growth in SO_2, NO_X and CO_2 emissions, at annual rates of 2.9, 2.8, and 2.7 percent respectively. While in the transportation and industry sectors, the growth rates of these emissions will be between 2.0 to 2.2 percent for all three types.

The average SO_2 emissions per capita in the APEC region are projected to grow at an annual rate of 1.9 percent, increasing from 30 kg in 2002 to 52 kg in 2030 (Figure 62). Among the APEC economies, Chinese Taipei is expected to have the biggest SO_2 emissions per capita at 131 kg in 2030. This is because coal will become the leading fuel for electricity generation, and will account for 68 percent of total SO_2 emissions in the economy. On the other hand, Singapore's SO_2 emissions per capita are

[43] Total primary energy demand is projected to increase at an annual average rate of 2.0 percent, increasing from 5,939 Mtoe in 2002 to 10,332 Mtoe in 2030.

[44] Projection of sulphur dioxide, nitrogen oxides and carbon dioxide emissions from fuel combustion is calculated using the "default method" and "IPCC Tier 1 default emissions factors" within LEAP.

projected to decrease, partly due to successful switching from fuel oil to natural gas for electricity generation. Per capita SO_2 emissions are expected to decline from 78 kg in 2002 to 52 kg in 2030. Similarly to Singapore, Canada's SO_2 emissions per capita will decline at 1.0 percent per year over the same period due to phasing out of coal-fired power plants in the Province of Ontario.[45]

For the APEC region, average per capita NO_X emissions are expected to increase 1.6 times from 25 kg in 2002 to 40 kg in 2030 (Figure 63). Singapore is projected to have the highest per capita NO_X emissions at 159 kg in 2030, increasing from 80 kg in 2002 as a result of an increase in the number of diesel-fuelled trucks for freight transport.

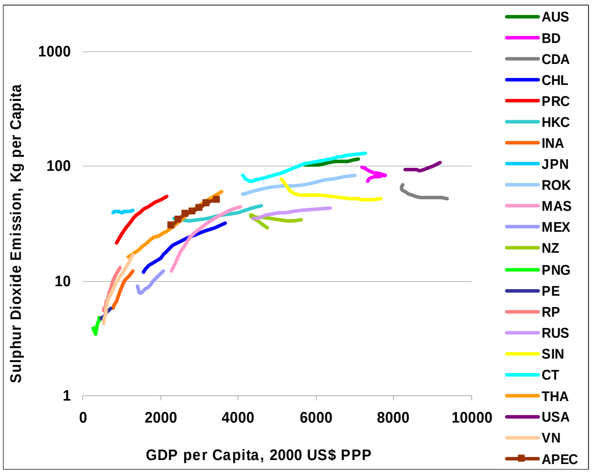
Over the outlook period, the average per capita CO_2 emissions in the APEC region are projected to grow at 1.7 percent per year, increasing from 6 tonnes per person in 2002 to 9 tonnes per person in 2030 (Figure 64). With the exception of New Zealand[46] all economies are expected to increase per capita CO_2 emissions. The decreasing trend for New Zealand is due to the reduction of CO_2 emissions from the industry sector, reflecting actions taken to meet commitments under the Kyoto Protocol and the closure of a number of energy intensive industries.

The general trend observed from the analysis is that increasing per capita Total Primary Energy Demand (TPED) will increase the per capita emissions of all emissions for all economies. Interestingly, the per capita TPED of Japan is lower than the average per capita TPED of the other APEC economies; due in part to the high energy efficiency of the economy, however in contrast, the per capita emissions for Japan are much higher than the average per capita emissions of APEC.

CARBON OFFSET PRICE

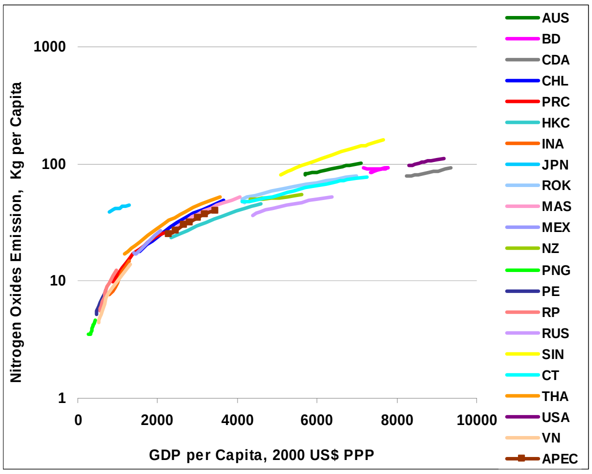
CO_2 emissions will be used as an indicator for comparison among APEC economies. The impact of CO_2 emissions from the energy sector can be assessed in terms of Carbon Offset Price (COP), which could help to ascertain the magnitude of environmental problems caused by burning conventional fuels. In other words, COP represents the monetary value of CO_2 emissions from the energy sector and represents a "hidden cost".

Figure 62 SO_2 Emissions per Capita (2002-2030)



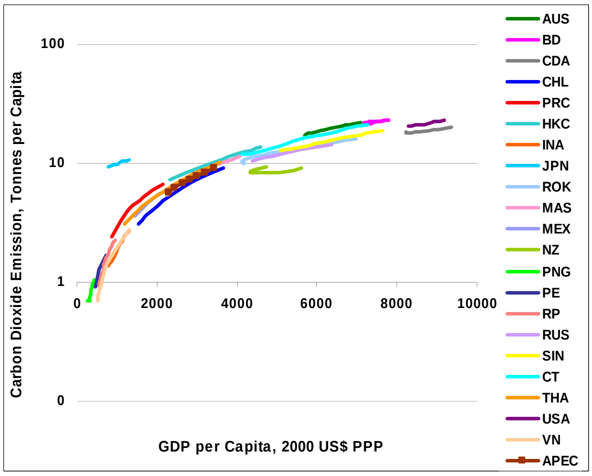
Source: Global Insight (2005); APERC Analysis (2006)

Figure 63 NOx Emissions per Capita (2002-2030)



Source: Global Insight (2005); APERC Analysis (2006)

Figure 64 CO_2 per Capita (2002-2030)



Source: Global Insight (2005); APERC Analysis (2006)

COP is expressed in US$ per tonne of CO_2. By multiplying the COP by the amount of CO_2 emitted per year, the value of CO_2 emissions in monetary terms can be determined. COP is computed by the CO_2 emission rate by fuel and the current price of

[45] The share of coal in electricity generation mix will decrease from 20 percent in 2002 to 12 percent in 2030.

[46] The average CO2 emission per capita of New Zealand is projected to decline at 0.1 percent per year throughout the outlook period from 9.3 tonnes per person in 2002 to 9.0 tonnes per person in 2030.

CO_2 in the market. Estimations of the CO2 emissions rate by fuel is calculated using the "default method" and "IPCC Tier 1 default emissions factors" within LEAP. The current price of CO_2 emissions in the market is derived from the European Union Emissions Trading Scheme (EU ETS) carbon price published by Point Carbon[47], in the units €/tonne of CO_2. EU ETS is used in this study as it is the standard price used by the European Union for emissions trading.[48,49]

In this article, the CO_2 price for the 10th January 2006[50] is retained as the basis for the analysis of COP from 2003 to 2030 scenarios. Even though the COP calculated does not represent the exact future value, this analysis can be used as a basis for quantifying and comparing the monetary value of CO_2 emissions between economies and therefore emphasize the importance of considering CO_2 emission reduction measures in energy project development.

ASSESSMENT OF COP

If COP is considered as a penalty for CO_2 emissions from the energy sector, how much is each APEC economy accountable for their emissions over the outlook period? Based on the BAU situation, the COP for each APEC economy was calculated and showed in Table 17. The results reveal that in the year 2003, the energy sector of the APEC region is responsible for emitting CO_2 amounting to US$378.8 billion of COP with the North American region as the highest contributor at 43 percent.

In 2030 it is projected that COP will increase by 1.8 times to reach US$673.8 billion due to rapid development in the region, particularly in China, Viet Nam and Chile where GDP are expected to grow robustly at an annual growth rate of 6.4 percent, 6.3 percent and 4.9 percent respectively.

In 2003 the US has the highest COP in the APEC region at US$146.92 billion, followed by China at US$89.23 billion. In 2030, China is expected to become the largest contributor of COP in the APEC region, accounting for 35 percent.[51] This is due to the economy's rapid growth in energy-intensive industry[52] and high dependence on coal-fired power plants, which emit more CO_2 compared with other fossil fuel-fired power plants.[53] In China the share of coal-fired power plants in the electricity generation mix will remain high at above 70 percent over the outlook period with the amount of electricity generated from coal-fired power plants projected to increase four-fold over the same period.

Table 17 Carbon Offset Price for CO_2 Emissions from Energy Sector for APEC (Billion US$ 2000 price, 2003 and 2030)

	Carbon Offset Price		Accumulated
	2003	**2030**	**2003-2030**
North America	161.2	223.6	5339.9
Canada	14.3	18.5	454.1
USA	146.9	204.0	4885.1
Latin America	11.3	24.0	473.3
Chile	1.3	4.6	75.2
Mexico	9.3	17.8	368.3
Peru	0.6	1.6	29.9
Northeast Asia	49.4	67.2	1659.7
HKC	1.2	2.6	55.4
Japan	29.9	31.9	873.7
Korea	11.9	20.0	459.4
CT	6.3	12.7	271.2
Southeast Asia	21.1	63.6	1133.9
BD	0.2	0.3	6.4
Indonesia	7.7	18.4	357.5
Malaysia	3.5	10.2	185.5
Philippines	2.0	6.5	112.7
Singapore	1.3	2.8	57.7
Thailand	4.9	18.1	306.0
Viet Nam	1.5	7.4	108.1
Oceania	9.5	15.0	339.4
Australia	8.5	13.5	307.1
NZ	0.9	1.2	28.0
PNG	0.1	0.2	4.2
China	89.2	237.6	4627.9
Russia	37.2	43.1	1134.6
APEC	**378.9**	**673.9**	**14708.6**

Source: APERC Analysis (2006)

Note: The values represented in this table are estimated and should not be taken as definite projections of the monetary values of future CO_2 emissions.

47 Point Carbon is an analytical company in the European Union.

48 In contrast with the Certified Emission Reductions (CERs) price which can be different from one project to the other depending on the project's attributes and the negotiation between the Annex I country with the project developer.

49 The EU ETS is determined by bid-offer close methodology by Point Carbon and the methodology is based on the over-the-counter (OTC) brokered prices. Point Carbon's bid and offers close levels reflect the best bid and the best offer at a specified time of the day.

50 Eu€23.28/tonne of CO_2 , exchange rate US$1.20582/Eu€

51 Equivalent to US$237.59 billion

52 The value-added of energy-intensive industry to GDP will grow at 5.8 percent annually throughout the outlook period.

53 In China, coal-fired power plants emit 0.97 kg of CO_2/kWh while natural gas power plants emit only 0.48 kg of CO_2/kWh of electricity generated.

The cumulative COP price for the period 2003 to 2030 for the APEC region is US$14.71 trillion. This huge amount of money indicates the hidden cost to the environment that should be taken into consideration when planning energy sector development. Of the accumulated COP, the combined shares of the US and China will account for 65 percent of APEC's total COP.

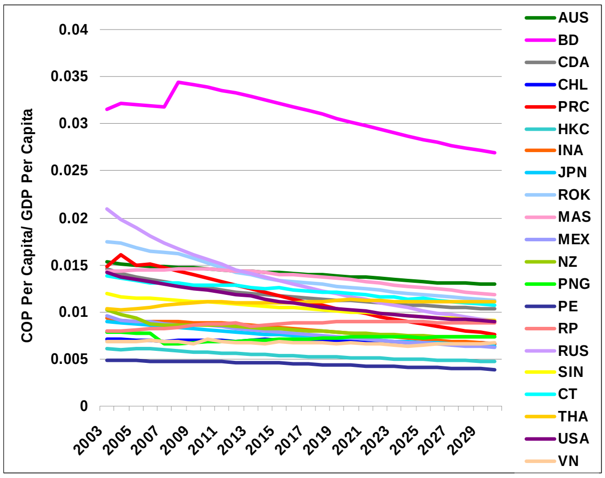
The per capita COP in relation to per capita GDP is depicted in Figure 65. The higher the number, the more money each person "pays" for how productive they are. The value of per capita COP over per capita GDP in the APEC region is estimated to decrease over the outlook period from 0.014 in 2003 to 0.008 in 2030, mostly due to technological advances, improvement in energy efficiency and reduction in the share of energy-intensive industry over the entire APEC region.[54]

With the exception of Thailand, all other economies are expected to reduce their per capita COP over per capita GDP value. Thailand's COP per capita over the GDP per capita is expected to increase from 0.010 in 2003 to 0.011 in 2030 and is due in part to an increase in use of coal for electricity generation resulting in greater CO_2 emissions from this sector, increasing from 61 million tonnes to 294 million tonnes over the same period. Likewise, the industry and transportation sectors in the economy also contribute to the high COP growth as the combined CO_2 emissions from the two sectors will increase from 118 million tonnes in 2003 to 395 million tonnes in 2030.

Brunei Darussalam will continue to have the highest per capita COP with respect to per capita GDP value due to the economy's high dependence on oil and natural gas production and oil refining activities. Throughout the outlook period the COP from the oil and gas sector is estimated to account for about 60 percent of the economy's total COP. The oil and gas sector combined with small population base[55] will result in the economy having the highest per capita COP in the APEC region throughout the outlook period.[56] As the GDP of the economy is expected to only grow at 1.7 percent annually to reach US$9.3 billion in 2030 from US$5.8 billion in 2003, the COP per capita over the GDP per capita will remain high at 0.027 in 2030 although decreasing from 0.032 in 2003.

Russia on the other hand will experience the fastest decline in per capita COP over per capita GDP at 3.0 percent per year over the outlook period. This is because COP per capita will grow at a slower rate of 1.2 percent per year compared with per capita GDP, which is expected to grow at 4.4 percent per year from 2003 to 2030, supported by economic development and energy efficiency improvement.

Figure 65 COP per Capita in relation to GDP per Capita in APEC Economies (2003-2030)



Source: Global Insight (2005); APERC Analysis (2006)

IMPLICATIONS

Due to increase in energy consumption in the APEC region, emphasis on environmental problems is expected to intensify. However, responding to environmental problems is a big challenge, as the magnitude of environmental problems will be influenced by energy demand growth. In addition, the seriousness and extent of environmental problems differ from one economy to another depending on the economy's economic conditions and on the type of energy sources used. For example, if the economies have to depend on coal-fired power plants for a large percentage of their electricity generation, it is important that appropriate technologies are utilised; such as clean coal technology, which can reduce emissions of SO_2, NO_X and soot particulates; scrubbers that can reduce SO_2 emissions and soot particulates; or even CO_2 capture and storage/sequestration technologies that can catch and store CO_2 to prevent release to the atmosphere. Therefore, to help reduce the negative environmental impacts these technologies should be established and instigated at the earliest possible time. Paradoxically, the question of the cost of these technologies must also be taken into consideration by the economies in order for them to ensure that they will not lose their competitive edge.

[54] All economies the APEC region will have a reduction (or maintain) in the energy intensive industry value-added share to the GDP, except for Singapore which is projected to increase from 9.4 percent in 2002 to 11.1 percent share in 2030.

[55] Total population Brunei Darussalam is 0.36 million in 2003 and is projected to increase to 0.46 million in 2030.

[56] The COP per capita of Brunei Darussalam is expected to remain high and increasing from US$532.57 in 2003 to US$546.53 in 2030.

As for COP, it is a question of who will take the responsibility – whether it is government, the developer or the consumer. If it were the responsibility of government, policies and regulatory frameworks could be enforced in order to reduce CO_2 emissions which will in turn reduce COP. To cope with these policies and frameworks, developers could either invest in advanced technologies that emit less CO_2 or utilise emission trading schemes. However, if the consumer has to bear the burden of COP, the cost incurred must be at a level that is fair and equitable.

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URBANISATION AND ENERGY DEMAND

Urbanisation – with respect to both migration from rural to urban areas and structural transformation of rural areas into urban ones – is one of the key factors affecting energy demand growth. The higher personal incomes and greater economic potential of urban areas transfer labour and other inputs from agricultural regions to the industrial and services sectors of urban areas. This in turn leads to increases in urban energy requirements for industrial facilities and office buildings because energy is integral to support these activities. Driven by the growth in disposable income urban dwellers seek greater comfort and convenience in their lives, which culminates in a substantial increase in the energy requirements for households and transport.

URBANISATION AND ENERGY DEMAND IN ASIA

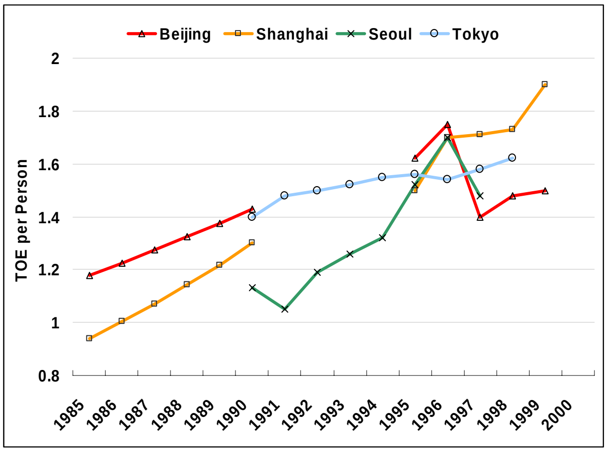
The energy demand of a number of APEC economies is expected to grow rapidly in parallel with urbanisation. The phenomenon will be in particular pronounced in Southeast Asia and China because their urban populations are expected to grow at a faster rate than other APEC economies. The United Nations projects that between 2003 and 2030, the urban population of APEC as a whole will grow at an annual rate of 1.6 percent, while that of Southeast Asia and China are expected to grow at 2.3 percent and 2.1 percent respectively.

As a result of this urbanisation, the urban energy demand of several Southeast Asian economies and China is foreseen to grow robustly. Nevertheless, the growth trend of urban energy demand will vary by economy, depending on the pace of economic development, industrial structure, population density and infrastructure development.

With respect to the factors affecting urban energy demand growth, interesting observations are obtained from a comparison of historical trends for energy consumption in Beijing, Shanghai, Seoul and Tokyo. Historical per capita energy consumption for these cities show that of the four, the per capita energy consumption of Shanghai reached the highest level at around 1.9 toe per person in 1999 compared with that of Beijing at 1.5 toe per person, which was the lowest (Figure 66). For Tokyo and Seoul, the corresponding values of per capita energy consumption were Tokyo at 1.62 toe per person in 1998 and Seoul at 1.5 toe per person in 1997.

The per capita energy consumption of Shanghai was the highest mainly because of the dominant share of industry within the urban area. In Shanghai, the share of the industry sector to total energy consumption was the highest at 80 percent in 1998, while the share of transport, residential and commercial sectors accounted for only a small part of total energy consumption (Table 18). By contrast, in Seoul and Tokyo, the share of industrial energy demand accounted for the smallest share at 18 percent and 11 percent respectively in 1998, with the remainder distributed within the transport, residential and commercial sectors. Despite the relatively high share of the industry sector in Beijing at 62 percent in 1998, the per capita energy consumption of Beijing was the lowest among the four cities. This is due in part to the relocation of the industrial facilities to the outside of Beijing, which has in turn reduced the per capita energy consumption by 14 percent in 1999 from the peak in 1996.

Figure 66 Comparison of Urban Energy Consumption (Beijing, Shanghai, Seoul and Tokyo, 1985-1999)



Source: Dhakal (2004).

Table 18 Sectoral Share of Urban Energy Consumption in 1998

	Industry	Transport	Residential	Commercial
Beijing	62%	8%	17%	13%
Shanghai	80%	10%	7%	3%
Seoul	18%	25%	37%	20%
Tokyo	11%	37%	22%	30%

Source: APERC Database (2005) and Dhakal (2004).

Comparison of the sectoral share of urban energy consumption in the major cities of Asia offers an interesting insight into how urban energy consumption evolves over time. At the early stage of economic development/industrialisation, urban energy consumption tends to be dominated by the energy-intensive industry sector. As economic development progresses and economies become more prosperous, factors that impinge on wellbeing and living standards increasingly gain prominence, and stricter environmental regulations and high land prices within the urban area lead to the relocation of industrial plants to the city outskirts or industrial complexes. Subsequently, industrial energy consumption within the urban area is gradually replaced by the transport, residential and commercial sectors.

URBANISATION, MOTORISATION AND RISING TRANSPORT ENERGY DEMAND IN ASIA

Urbanisation is expected to boost transport energy demand in Asia. Migration from rural areas to urban centres will play an important role in increasing transport energy demand because urban transport has a higher concentration of passenger vehicles compared with that of rural areas. The transition to greater use of passenger vehicles entails significant increase in transport energy demand. In addition, the rising personal income of urban dwellers has subsequently brought about a shift from less energy intensive modes of transport, such as feet/bicycles to passenger vehicles that are more energy intensive.

The stock of passenger vehicles in the urban areas of Asia has been growing robustly over the past two decades. To allow comparison, passenger vehicle ownership per 1,000 population for several cities and economies in Asia are shown in Table 19.

The comparison *between economy and city* shows that with the exception for Tokyo, for the *cities* in Asia, passenger vehicle ownership per 1,000 population has reached a higher level than that of the *economy* average. This is mainly because higher income in cities drives the increase in the number of passenger vehicles. For example, in 2002 the ratio of vehicle ownership per 1,000 population for Beijing and Shanghai was 4 times and 2 times higher than that of average for China respectively. This ratio for Jakarta was 9 times higher than that of Indonesia as a whole in 2002.

The comparison *among the major cities* in Asia also offers an interesting illustration in terms of the different factors affecting the number of passenger vehicles. For example, Shanghai's passenger vehicle stocks per 1,000 population was almost half that of Beijing in 2002 due to the Shanghai's higher cost of passenger vehicle ownership resulting from a mandatory requirement to purchase a licence plate through an auction.[57] This regulation is expected to continue limiting the growth in Shanghai's stock of passenger vehicles. In Tokyo and Hong Kong, China, the ratio of passenger vehicle stocks per 1,000 population in 2002 were both low relative to their high incomes. This is because both Tokyo and Hong Kong, China have developed a rail/subway network which connects the city centre with residential suburbs.[58] In the future, due to the availability of rail/subway infrastructure and the high cost of parking, urban dwellers of these two cities will continue to be less reliant on passenger vehicles. In Seoul, urban dwellers are expected to continue relying on passenger vehicles due partly to the difficulty of changing lifestyle and partly to the government policy promoting the automobile industry.[59]

Table 19 Passenger Vehicle Ownership per 1,000 Population (1980, 2002 and 2020)

Economy	1980	2002	2020	1980-2002 (%)	2002-2020 (%)
China	2	19	65	10.8	7.1
Beijing	9	80	177	10.4	4.5
Shanghai	5	47	100	10.7	4.3
HKC	41	59	70	1.7	1.0
Indonesia	5	16	26	5.4	2.7
Jakarta	34	143	161	6.7	0.7
Japan	203	428	522	3.4	1.1
Tokyo	159	266	271	2.4	0.1
Korea	7	204	284	16.6	1.9
Seoul	15	205	288	12.6	1.9
Thailand	-	100	158	-	2.6
Bangkok	-	324	389		1.0

Source: APERC Analysis (2006).

Comparison among the cities in Asia suggests that aside from income, a combination of various factors come into play to determine the passenger vehicle stocks per 1,000 population in urban areas. Those factors include cost of vehicle ownership, availability of mass transit systems, regulation on vehicle ownership and automobile industrial policy.

IMPLICATIONS

Urbanisation in the selected Asian economies will lead to robust growth in energy demand. Growth in urban energy demand will be increasingly led by the growth in transport, residential and commercial sectors. Urban transport energy demand is expected

[57] To limit the number of passenger vehicles and avoid traffic congestion, the Shanghai government requires those who wish to own a vehicle to purchase a licence plate through an auction. With rising demand for vehicles, at a recent number plate auction the resulting average price was US$4,000.

[58] In Tokyo, over 5 decades, urban areas have sprawled along with development of the railway/subway network. Those residents of suburban areas have good access to the railway/subway for commuting, thereby successfully reducing vehicle dependence.

[59] Although a subway network is well established in Seoul, a large number of urban dwellers still rely on passenger vehicles for commuting.

to grow robustly in particular, due to rising vehicle stocks and the difficulty of shifting urban lifestyles away from dependence on vehicles.

Rising vehicle use in urban areas might result in worsening air quality problems. In addition, rising vehicle dependence could pose threat to the enhancement of oil supply security because the potential for alternative fuels are still limited.

The challenges posed by rising urban transport energy demand need to be overcome by bringing together the efforts of government – both local and central – and the private sector. Coordination among different policy goals, including those for energy, transportation, urban planning, and construction, are essential to minimise the impacts to energy security and the environment arising from urban transportation energy demand growth.

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ENERGY RESOURCE CONSTRAINTS

The core issue arising from long-term energy projections is "**Are there enough reserves/ resources to meet primary energy demand?**" It is most likely that for APEC as a whole the situation of domestic energy supply will worsen in the long run because of the rapid depletion of oil and gas resources in Southeast Asian economies, natural gas in North America, and a low reserve to production ratio for coal in China. Concerns in relation to whether sufficient energy supplies will be available in the future are concentrated on the availability of energy resources and bottlenecks along the production and transportation chain – at both the global and national levels. The physical availability and quality of primary energy resources are the most important factors, and availability is often complicated by barriers to investment that would otherwise enhance energy production.

The APEC region possesses over 60 percent of the world's known coal reserves; with natural gas accounting for 37 percent and oil 14 percent. In general APEC's share of world energy resources is low compared with consumption, with APEC's share of world consumption exceeding 50 percent for all the main energy sources (Table 20). For coal and uranium reserves, the share located in the APEC region is of a similar magnitude to that of consumption; however, for natural gas and oil regional reserves are much lower than consumption.

For the APEC's six largest energy producers, responsible for 99 percent of coal, 91 percent of natural gas and 81 percent of oil extracted within region, the "call on additional reserves" was calculated. That is comparison of projected resource extraction to current proved reserves (Table 21). It was also determined that for all three energy sources the reserves to production rate in 2030 would be 15 years.

For example, in the case of Canada 7.3 Gtoe of additional oil reserves will be required by 2030 to extract oil in order to meet domestic oil demand and export requirements, which equates to an additional 120 percent more reserves compared with the current level.

Table 20 Current State of Conventional Energy Reserves (World versus APEC)

Fuel Type (units)	Region	Reserves	Reserve share (%)	Consumption share (%)	Reserve/Consumption Ratio (Years)
Oil (Billion barrels)	World	1 201			40
	APEC	169	14	55	10
Gas (Trillion cubic meters)	World	180			67
	APEC	67	37	55	45
Coal (Billion tons)	World	909			164
	APEC	168	67	70	308
Uranium (Million tons)*	World	4.7			115
	APEC	2.2	46	56	85

* Note: Identified uranium resources cost less than US$ 130 per kg of uranium.

Source: BP (2006), Red Book (2005)

Table 21 Major APEC Energy Producer's "Call on Additional Reserves"

Economy	"Call on Additional Reserves", **Gtoe/% over current reserves**		
	Oil	**Natural gas**	**Coal**
Australia	0.7/84	1.6/77	-
Canada	7.3/120	4.0/105	-
China	6.5/114	2.0/88	9.3/24
Indonesia	1.9/113	2.1/69	2.8/76
Russia	8.5/71	-	-
USA	15.3/123	18.8/124	-

Note: "Call on additional reserves" is equal to the sum of cumulative production of the specified energy source during 2002-2030 plus 15 years extraction at 2030 level, minus current proved reserves.

Source: BP (2006), APERC Analysis (2006)

With the exception of natural gas in Russia, cumulative production over the outlook period is expected to substantially exceed the current proven reserves in 2005 for all six of APEC's largest oil and gas producers. In contrast, only two economies will have to enhance their proved coal reserves; Indonesia by at least 76 percent and China by 24 percent. However, coal supply constraints in China are expected to have the greatest impact on a global scale given the economy's high energy intensity and high reliance on coal as the main source of primary energy supply. Thus the problem of augmenting/replacing reserves through exploration and production activities and the development/incorporation of non-conventional resources, such as oil shale and methane hydrate will become very important in coming years.

Currently there are two major players in the upstream oil and natural gas sectors – National Oil Companies (NOC) and International Oil Companies (IOC), (see Table 22). NOC's hold the majority of reserves, raising concerns for energy importing countries in relation to fair access to energy resources in a tight market environment, as economies with large energy reserves are apt to impose **restrictions on foreign participation** in the upstream sector. Such ownership restrictions are often a barrier to free trade in capital markets, and in some instances can contribute to restrictions in international energy trade.

Regulatory and institutional constraints on which energy sources can be developed, utilised, and traded (for example, the exclusion of nuclear energy) can have an adverse impact on energy markets by concentrating competition on a smaller number of energy sources, disrupting the demand-supply balance and affecting prices. In a similar way some economies provide obstacles for access to their energy reserves/resources, or impose bilateral or international sanctions, embargoes and/or other **restrictions on energy trade**, thus tightening the supply/demand situation on energy markets and constraining primary energy supply.

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Table 22 Share of NOC's and IOC's in World Oil and Gas Reserves and Production

	Extraction		Proved reserves		Reserves to production ratio[1]	
	Liquids	Natural gas	Liquids	Natural gas	Liquids	Natural gas
	%	%	%	%	years	years
29 NOC (*state holds more then 51percent of shares*)	50	43	79	68	64	106
21 IOC and 200 private oil companies listed in the USA	27	32	9	6	13	12
250 companies worldwide	77	75	88	74	46	66
World	100	100	100	100	40	67

[1] Note: values represent the number of years to extract all proved reserves at current production rates

Source: OGJ (2005), BP (2006)

ENERGY TRANSPORTATION

Energy transportation plays an important role in energy security in relation to the appropriate delivery of energy sources through inter-regional or international trade in order to avoid supply disruption. Therefore timely expansion of energy transportation infrastructure will be needed in shipping (oil tankers, LNG carriers, and bulk carriers), oil and gas pipelines, and electricity transmission lines. Failure to make timely energy investment could have serious socio-economic and security consequences. Costly incidents, such as the power failure in North America in 2003 – estimated to have cost US$6 billion in financial losses – have raised concern over how to secure the timely build-up of energy transportation infrastructure. These concerns are particularly prevalent in APEC economies whose energy demand is growing fast.

RECENT DEVELOPMENT IN ENERGY TRANSPORTATION

Oil transportation for international trade is either by maritime transportation or through pipelines, and by trains and tucks for domestic transportation. The maritime transportation of petroleum products roughly accounts for 62 percent of all movement, with the remaining 38 percent transported through pipelines. In 2002, the estimated oil tanker fleet capacity owned within the APEC region was 168 million deadweight tonnes, accounting for around 50 percent of world tanker fleet capacity at 331 million deadweight tonnes.[60,61,62] In 2004, utilization of the world's tanker fleet hit almost 90 percent and consequently the daily oil ship rates almost doubled, due partly to the shortage of tankers and the lack of investment in oil infrastructure.[63] By the end of 2005, world tanker feet capacity had increased to 388 million deadweight tonnes.

As in oil transportation, natural gas movement between points of production and points of consumption is either through pipelines or liquefying the gas (LNG) and moving it in ships. LNG imports to the APEC region totalled 134 BCM in 2004, or 12 percent of total natural gas consumption and accounting for 76 percent of total LNG imports in the world, while natural gas trade through pipelines to the APEC region totalled 144 BCM.[64] Currently, there are 9 LNG liquefaction terminals and 36 receiving terminals in the APEC region, of a total 30 LNG liquefaction terminals and 52 receiving terminals worldwide.[65] The total existing vaporization capacity at LNG receiving terminals in the APEC region was 282 million tonnes per annum (mtpa) in mid-2006, with total storage capacity of 20 BCM, accounting for 85 percent of total world LNG receiving terminal storage capacity. On the liquefaction side, there are 33 liquefaction trains in APEC region accounting for 42 percent of the total number of trains at liquefaction terminals in the world. The number of LNG tankers in the world is estimated at 209, of which 72 tankers carried the flag of APEC economies in 2006, and over 140 new tankers are on the order books of shipyards. In addition, the total capacity of LNG tankers in the world is estimated at 25 BCM.

Maritime oil and LNG transportation passages in the APEC region involve five important chokepoints, namely the Strait of Hormuz, the Bab el-Mandab, the Straits of Malacca, the Suez Canal, and the Panama Canal. Among the chokepoints, the most strategic passage in regards to the supply of oil to the APEC region is the Straits of Malacca, in which any disruption in oil shipments by accident or piracy could cause supply difficulties. Transporting 13 million barrels of oil per day the Straits of Malacca are the main route of maritime trade between Europe/the Middle East and the Asia Pacific. These straits which pass between the economies of Indonesia, Malaysia and Singapore, have on average 171 ships per day carrying all cargoes to locations around the Asia Pacific.[66]

Coal is generally transported by conveyor or truck over short distances and trains and barges are used for longer distances (within domestic markets). Alternatively coal can be mixed with water to form coal slurry and transported through pipelines. For international transportation, ships are commonly used. In 2003, around 700 million tonnes of coal was traded internationally and 90 percent of this was through seaborne trade. China has significant internal trade in coal, much of which is carried by rail from the producing provinces in the north and west

[60] Based on fleet capacity, it is estimated that around 3,338 tankers are available on the international oil transportation market.

[61] Deadweight is the displacement at any loaded condition minus the lightship weight and tonne is a measure of the size or cargo capacity of a ship.

[62] ISL (2006)

[63] Mathew Leising (2004)

[64] BP Statistics (2005)

[65] LNG Journal (2006)

[66] The narrowest width of the Straits of Malacca – the Singapore Strait – is 530 metres, and while highly controlled allows ships to move in both directions at once. In addition, almost one third of all international trade passes through these straits.

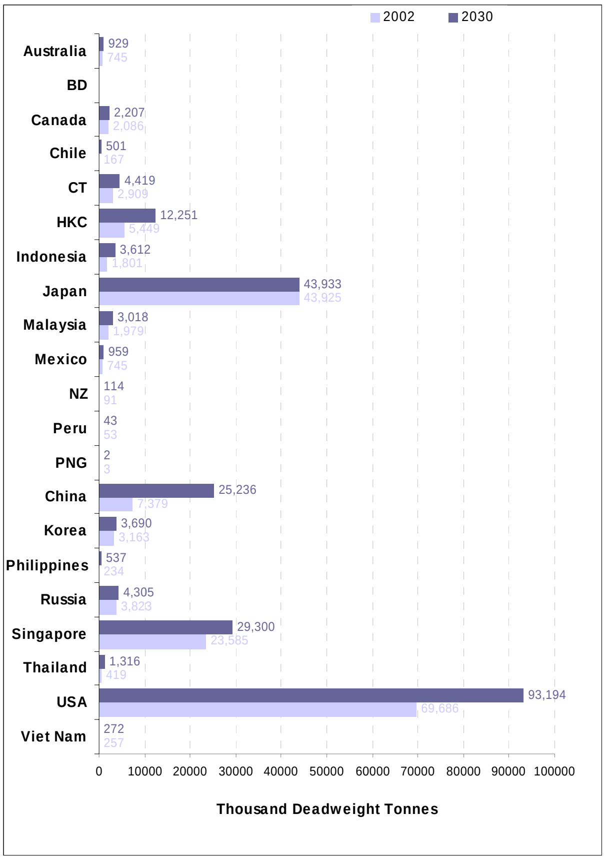
to ports, and then shipped to the consuming provinces in the south. Due to insufficient railway transportation capacity in the past decade, China has experienced a shortage of coal for electricity generation, which caused brownouts in many Provinces and municipalities. In 2004, the power shortage was estimated to exceed 30 GW as the expansion in coal transport capacity has lagged behind the demand growth for coal. These bottlenecks also caused higher coal prices and influenced the investment decisions of foreign investors interested in entering the coal exploitation business in China.

Well-functioning electric power grids are essential for the reliable provision of electricity to consumers. Although investment in transmission lines/grids is costly, reliable electricity supply is important in terms of energy security. For example, the blackout in North America in 2003 took some 34,000 miles of transmission lines out of service, or more than a fifth of the transmission network in the US, along with more than 531 generating units with 61 GW of capacity. While most services in the US were restored within two days, in some areas it took up to four days to restore and power restrictions were in place for over a week. Several developing countries have suffered power shortages for varying reasons, including breakneck demand growth in China, and insufficient investment in power generation and transmission in Indonesia. Under the traditional regulatory system in the electricity sector, there is no incentive for efficiency improvement from generation to transmission.

FUTURE ENERGY TRANSPORTATION REQUIREMENTS

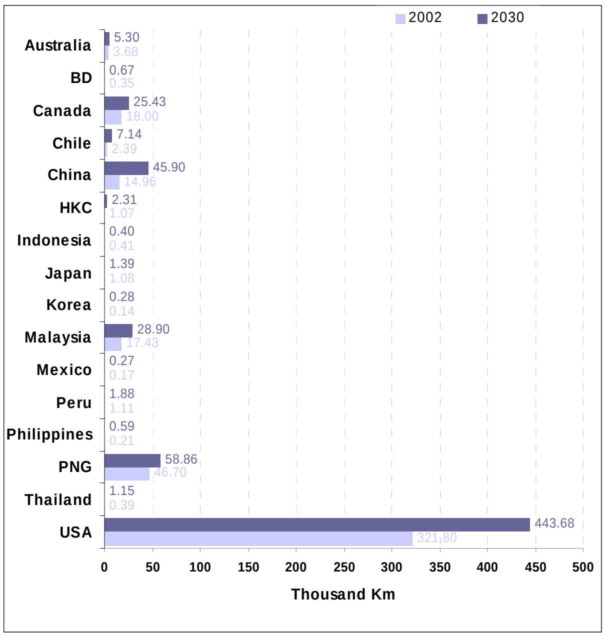
As tankers will remain the dominant means of oil transport, the estimated oil tanker fleets owned within the APEC region, including ships registered under Foreign Flags, is expected to increase from 168 million deadweight tonnes in 2002 to 230 million deadweight tonnes in 2030. Combined China and the US will account for almost 67 percent of incremental growth in the call on oil tankers in the APEC region (Figure 67). On the other hand, international oil trade through pipelines in APEC is projected to increase from 7.1 million B/D in 2002 to 10.9 million B/D in 2030, growing at 1.6 percent per year over the same period. In addition, the estimated incremental growth in domestic oil pipeline length is expected to increase by 194 thousand km, from 430 thousand km in 2002 (Figure 68).

Figure 67 Estimated Oil Tanker Fleet Owned in APEC Economies



Source: APERC Analysis (2006)

Figure 68 Estimated Domestic Oil Pipeline Length in APEC Economies



Source: APERC Analysis (2006)

To support the strong natural gas demand growth in the APEC region, intra-regional or international trading of natural gas will have to increase substantially. Over the outlook period, estimated LNG trade, including import and export in the APEC region is expected to grow at an annual rate of 4.9 percent, from 142 billion tonnes in 2002 to 541 billion tonnes in 2030. The number of new LNG receiving terminals expected in the APEC region up to 2030 is 81, with the total annual handling capacity of these terminals estimated at 473 mtpa. China is considering the construction of 12 LNG receiving terminals on the eastern coast, while the US has proposed building up to 40 receiving terminals. The current net natural gas exporters of Canada and Indonesia are expected to become net importers by 2030, with LNG being considered as a possible supply option. Canada has plans to construct up to nine LNG receiving terminals and Indonesia is considering the construction of one terminal. It is estimated that the number of LNG liquefaction terminals in the APEC region will increase by at least 12, while the number of trains increases by 16. Australia has plans to build five new LNG liquefaction terminals and expand two existing terminals in the coming decade (Table 23).

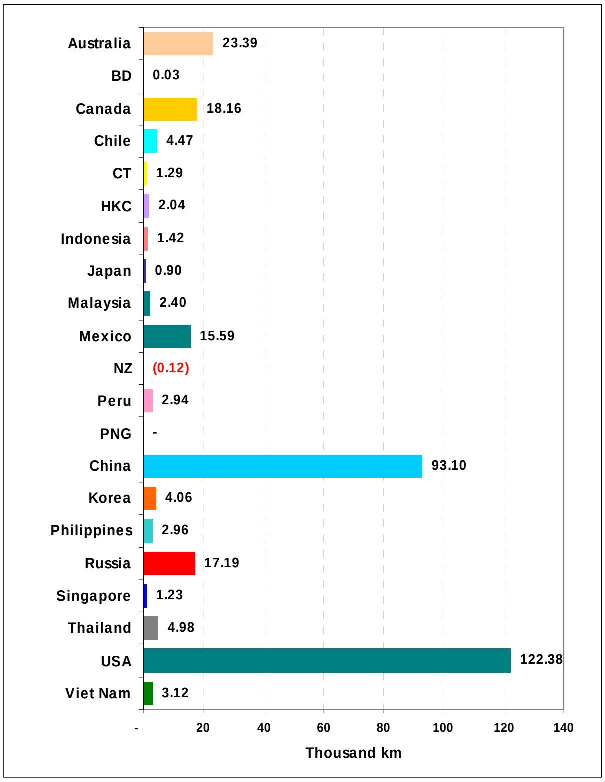
Table 23 Number of Existing and Planned New LNG Receiving and Liquefaction Terminals

Economy	Receiving		Liquefaction	
	Existing	New	Existing	New
Australia	-	-	3	5
Canada	-	9	-	-
Chile	-	1	-	-
China	1	12	-	-
Indonesia	-	-	2	3
Japan	25	4	-	-
Korea	4	-	-	-
Malaysia	-	-	3	-
Mexico	-	8	-	-
NZ	-	1	-	-
Peru	-	-	-	1
Philippines	-	2	-	-
Russia	-	-	-	2
Singapore	-	1	-	-
CT	1	1	-	-
Thailand	-	2	-	-
USA	5	40	1	1
APEC	**36**	**81**	**9**	**12**

Source: LNG Journal (2006); APERC Analysis (2006)

In terms of natural gas pipelines, an estimated 0.32 million km of additional pipelines will be required by 2030 (Figure 69). The volume of international natural gas trade through pipelines, including import and export is expected to increase from 466 BCM per year in 2002 to 530 BCM per year in 2030.

Figure 69 Estimated Additional Length of Gas Pipeline



Source: APERC Analysis (2006)

Total electricity generation in the APEC region is projected to increase from 9,279 TWh in 2002 to 20,518 TWh in 2030, requiring substantial growth in the length of transmission lines to transport electricity from generation to distribution stations and consequently to end-users. The additional length of transmission lines required in the APEC region is estimated at 2.63 million km through 2030.[67]

DISRUPTION IN OIL AND GAS TRANSPORTATION

As inter-regional trade expands, the risk of transportation disruption/accidents at strategic transport channels or chokepoints is expected to grow. Of particular concern in regards to this issue is the growing dependency on Middle East oil imports through strategic chokepoints, for example the Straits of Malacca, and increasing global LNG trade. The security and reliability of cross-regional oil and gas pipelines and electricity transmission lines is also expected to be a great challenge that APEC economies will face.

If a single tanker were to become blocked at one of the five main chokepoints that bring oil/LNG into the APEC region during a period of high seasonal demand, the consequences for the regional and/or global economy could be severe. For example, a

[67] In 2005, the estimated total length of transmission lines in APEC region was 2.01 million km.

spike in oil prices could result in, an increase in transport costs due to the need to use alternative routes/detours, congestion in sea-lanes and ports, marine pollution as a result of an oil spill, and an increase in maritime insurance. If for example, the Straits of Malacca and Indonesian Archipelagic Waters were blocked (including the Sundas and Lombok Straits), all crude oil and other freight bound for Northeast Asia would have to make a detour around the south coast of Australia, which would add two weeks to the voyage and approximately 80 tanks would be needed to supply daily oil requirements. This would have a significant economic impact not only on Japan, China, and Korea in Northeast Asia, but also on many Southeast Asia economies.

Another serious disruption is the impact of piracy in and around many chokepoints. Statistics from the International Maritime Bureau (IMB) show that the frequency and violence of acts of piracy have increased in recent years. The number of seafarers killed or taken hostage in attacks has doubled between 2002 and 2003. In 2003, the number of reported attacks by pirates amounted to 445, in which 359 were assaulted or taken hostage and 92 seafarers were killed or went missing. The financial cost of piracy, due to the damage to ships and loss of cargo as well as rising insurance costs, is estimated to be around US$16 billion per year.[68]

To combat these issues and diversify supply routes many alternative oil and gas trade routes into the APEC region have been recommended, with such proposals including, a route across the Malay Peninsula, a route from Myanmar to China, and routes from Russia to Northeast Asian economies. To facilitate and underline this proposed cross border trade, regional frameworks such as Energy Charter Treaty need to be established.

Although maritime transportation will remain the dominant means of energy transport, oil and gas transported through pipelines will significantly increase. Consequently the impact or disruption caused by accidents or acts of terrorism on energy pipelines should not be discounted. For instance, in January 2006, explosions on a natural gas pipeline in the southern Russian region of North Ossetia by a suspected terrorist attack, that exported gas from southern Russia to Georgia and Armenia, led to gas supply disruption in Georgia and Armenia while these two economies were suffering a cold snap. Heat production in both countries relied on natural gas supply from Russia. Also, two gas-fired power plants in these economies were stopped due to a lack of gas supply. As natural gas is being increasingly used for electricity generation, natural gas supply security will be highly linked to electricity supply security.

CHALLENGE FOR ELECTRICITY TRANSMISSION LINES DEVELOPMENT

Robust electricity demand growth translates to substantial investment requirements for electricity generation and transmission with this investment amount estimated at between US$3,777 and 4,566 billion for the APEC region. Almost half of this investment will be required in the transmission networks development. However, regulatory reform in the electricity industry has placed considerable burden on the development of electricity grids as the rate of return on investments in regulated transmission facilities is often too low to warrant more than "just-in-time" network development. Public concern on the negative externalities, including transmission systems and local health effects are the biggest obstacle to expanding transmission capacity, that is, the zoning and siting of additional transmission lines. Transmission tariffs should be high enough to create sufficient incentives for companies to develop transmission networks in a timely manner. In some APEC economies, the returns may not be sufficient enough to fund and build new transmission facilities. Economies in APEC urgently need to create an attractive investment framework that allows the opportune expansion/development of both generation facilities and transmission networks.

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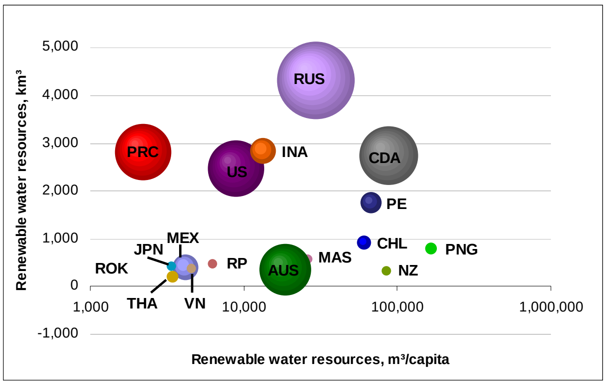
WATER AND ENERGY DEMAND

The fast-growing demand for clean, fresh water for economic development, coupled with the need to protect and enhance the environment, have made many areas of the APEC region vulnerable to water shortages. Water is an essential resource that is used in practically every manufacturing and production process, with the energy production and transformation sectors being no exception. Water is utilized in almost all stages of the production chain, particularly for cooling in the electricity generation and refining sectors.

WATER RESOURCES IN THE APEC REGION

As with most natural resources the distribution of water resources in the APEC region are not uniformly apportioned with some economies having a disproportionately large share of resources compared with others. With the exception of Australia, typically economies with a larger land mass typically have more water resources available for utilization (Figure 70).

Figure 70 Renewable Freshwater Resources in APEC



Source: World Resources Institute

Note: The size of each bubble indicates the relative size of each economies land area in square kilometers. No data is available for Brunei Darussalam, Hong Kong, China, Singapore and Chinese Taipei.

According to the United Nations, the state of water stress is defined as less than 1,700 m^3 of freshwater available per person per year, which becomes acute at less than 1,000 m^3/cap/y – termed water scarcity. In 2002, Korea was the only APEC economy below the 1,700 m^3 threshold; however, areas of Japan, China, the US, Australia, and Southeast Asia also suffer from a degree of water stress and scarcity – especially in regions of high population density.

WATER UTILISATION IN THE ENERGY SECTOR

Water utilization in the energy sector can be broken down into two main types; instream use/withdrawal, which encompasses water used for cooling purposes in thermoelectric power stations – usually returned to the influent water body[69]; and consumptive use – after utilization water not fit for use in any other activity prior to treatment – which encompasses water used for drinking, sanitary purposes, prevention of wind blown dust, and water that is lost as vapour from cooling towers. It should be noted that as a general rule the energy sector must compete with other water users, namely; the agricultural, domestic and industrial sectors for the allocation of water resources and this can have serious implications for the siting of new energy related infrastructure.

IMPLICATIONS

It should be noted that unlike longer-term environmental concerns such as climate change, where long lead times allow for the development of adaptive strategies, water and energy shortages predominantly occur suddenly and usually have an immediate adverse impact on local and regional economies. If APEC economy's dependence on reliable supplies of electricity, in addition to fresh water availability, continues to increase without regard to the potential conflict these two demands can create, sustainability of economic growth and electricity supply could be challenged over the long term.[70] At the least, these conflicts could cause shortages in supplies of electricity, or cause an increase in generation costs, and have a direct impact on future electricity system planning and expansion.[71]

How the water/energy nexus is dealt with over the next several decades will have profound implications for the economic prosperity of the APEC region and may impinge on how expansion of the electricity sector is undertaken and which mix of

[69] Note that after fuel, water is the second most important input within the electricity sector; especially for thermoelectric generation.

[70] In China rapid economic development and industrialisation/ urbanisation of the economy has led to rapid increase in the demand for water resources and insufficient/ineffective water treatment systems has led to severe pollution of water bodies and placed limitations on the availability of fresh water resources.

[71] In the arid US states of Arizona, Nevada, and California there have been cases where regulatory permission for the siting of power plants has been declined as a result of insufficient water resources for cooling purposes.

fuels can effectively be utilised for electricity generation.

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HUMAN RESOURCE CONSTRAINTS

Quality and reliable human resource capacity is a vital requirement for the survival and success of the energy industry. A shortage of human resources could constrain developments in the energy industry, which in turn could place limits on the development of the economy. Human resources in the energy sector can be broadly divided into two categories that of manual and professional workers.

The shortage of manual workers, both in quantitative and qualitative terms, not only poses a threat to safety in energy related operations but also has the potential to cause accidents. When an accident happens, a domino effect usually follows, for instance the shutdown of plant operations usually creates a shortage in supply, which leads to economic loss. Accidents can also create unnecessary loss of life as well as damage to the facilities.

Similarly, the shortage of professional workers in the energy sector; such as scientists, engineers and geologists, could significantly affect future development of the energy sector. For example, a lack of scientists often limits the amount and scope of R&D related activities that can be carried out, while a lack of high ranking managers with expertise in the sector can bring about an adverse affect on the energy sector as a whole as they are important for planning business strategy.

Because of the importance of human resources in the energy industry, the issue will be explored in this section. The current situation will be discussed, the bottlenecks of human resources availability in the outlook period will be identified and some countermeasures will be proposed.

CURRENT SITUATION

The combination of bad working conditions, which discourages people from joining the workforce in the energy sector; and an aging population, including the loss of skilled labour due to retirement, has caused a large decline in the workforce of the energy sector over the past decade. This phenomenon is fast becoming a problem for the energy sector as the recent surge in energy demand has placed emphasis on the need for stable energy supply from upstream, midstream and downstream operations that in turn require a sufficient and sustainable supply of labour.

For example, the nuclear industry in the US and Japan[72] face similar concerns with regards to an aging workforce and decrease in the number of skilled workers. According to a survey conducted by the US Nuclear Energy Institute (NEI), nuclear power generation companies in the US might lose an estimated 16,000 workers over the next five years, as nearly half of current employees in the industry are over 47 years old, and less than 7 percent of employees are younger than 32 years old.[73] Likewise, in Japan at the peak of the nuclear industry in 1990, 60,000 persons were engaged in nuclear-related work at utilities and manufacturers however by 2002, the number had declined to 54,000.[74] In the future there will potentially be an inadequate supply of trained employees to replace departing personnel, thus putting the industry in an awkward position.

As for the oil sector, dwindling human resource capacity has not only been caused by the aging worker issue, but also by the lack of effort by the oil industry to recruit young skilled workers due to the merger boom at the end of the 1990s accompanied by low oil prices during that period. After 2001, the oil market has gradually turned around and incremental oil demand has started to pick up. But the number of employees in 2004 was still about the same level as that of 2000 with 649,717 employees.[75] Decrease in the number of employees may have resulted in an increase in productivity, but on the other hand the loss of human capital to the organization put a constraint on the future development when market recovered.

For the LNG industry, the growth of LNG trade has caused an increase in the LNG fleet. According to a study conducted by the International Association of Maritime Universities, the world's LNG fleet at the end of 2009 will reach 339-354 vessels or more[76], increasing from 209 LNG vessels in 2006[77,78]. By 2009 it is estimated that between 12,870 to 14,040 seafarers will be required to man the LNG fleets worldwide. In view of this rapid development, human resource capacity is a major concern in the

72 In 2004, there were 240 nuclear power units installed in APEC. The US and Japan have 157 units accounting for 65 percent of total installed units.

73 US Nuclear Energy Institute (2005)

74 Japan Nuclear Cycle Development Institute and Japan Atomic Industrial Forum, Inc. (2005)

75 Petroleum Intelligent Weekly (2005)

76 The International Association of Maritime Universities

77 LNG Journal (2006)

78 APEC has a total of 72 LNG fleets in 2006

LNG maritime sector. These concerns also raise the spectre of a possible shortage of qualified workforce for these LNG fleets, and insufficient time to educate and train the work force to fulfil the human resource demand required in 2009, due in part to a lack of capacity to educate and train the work force and shortage of opportunities to exchange accumulated know-how, and expertise of all kinds.[76] The growth in LNG trade also means growth in liquefaction facilities and receiving terminals, both in numbers and volume.[79] To maintain the safety and security of LNG trade it is essential that the new facilities and ports are operated to the highest standards. Thus the availability of experienced LNG operators, marine pilots, surveyors, port state inspectors and the training of a new generation of personnel is becoming an issue in the LNG sector.

BOTTLENECKS FOR HUMAN RESOURCE

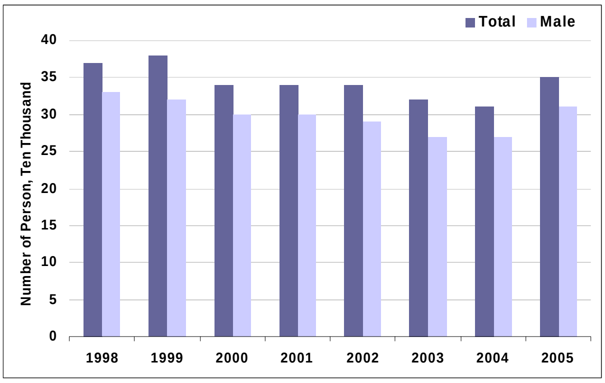
The decline in the labour force of the energy industry is due to a number of reasons. The most crucial reasons are aging of the work force, working conditions and industrial characteristics.

In 2002, the total population in the APEC region reached was 2.6 billion persons and population growth is expected to slow down in the next 25 years. As a result of aging of the population, the percentage of the population of working age[80] will reach a plateau in 10 years time.

This trend will lead to a reduction in the availability of human resources for energy sector. For example, in Japan the growth of work force in the electricity, gas, heat supply and water sector declined at an annual rate of 0.8 percent from 1998 to 2005, reduction of 20,000 work force in the same period (Figure 71).[81] The issue of an aging work force thus brings to the forefront the importance of training new energy industry professionals and workers to ensure that retiring workers will be replaced by competent, reliable and available labour force in a timely manner.

In addition, the nature of working conditions in the energy industry, which is among other things dangerous, dirty and challenging, makes it harder to attract qualified and skilled people to work. For example, field occupations involve rugged outdoor work in remote areas in all kinds of weather, drilling rigs operate continuously, and drilling crews usually work six days on for eight hours a day and then have a few days off. In addition, scheduling usually depends on where they are working; many oil workers are away from home for days, weeks or months at a time. Similarly, exploration crews generally have to move from place to place until the work at a particular site is completed.

Figure 71 Japanese Workforce in the Utilities Sector



Source: Statistics Bureau, Japan (2006)

Furthermore, industrial characteristics are considered to be challenging. For example, in the nuclear industry the 'radioactive nature' of nuclear fuels has deterred many engineers and concern over national security on the diffusion of nuclear technology has made the recruitment of engineers across national borders difficult. Moreover, most aspects of the energy industry require specific expertise and skills thus limiting the pool of human resources available. For example, expertise in interpretation of particular geographic regions as well as advanced technologies is needed in order to ensure the success of the exploration and production business. And well trained engineers are needed to man the world's maritime oil and LNG fleets, due to the dangerous nature of the operations.

ADDRESSING THE CHALLENGES

In order to manage the bottlenecks in human resource availability and sustainability, many energy companies have stepped-up their efforts to recruit and train more personnel. For example, oil companies – such as Shell, BP and Exxon Mobil – have started to resume recruitment from the university careers circuit and have changed their strategy in order to attract more students to join their companies by for example providing incentives – i.e. prize raffles of mountain bikes - and building up their brands. Apart from the recruitment of graduates from universities many energy companies are also looking at options that aid in the retaining of those members of the workforce that have passed normal retirement age, with these employees often demanding slightly higher salaries compare with

[79] In APEC there are currently 36 receiving terminals, and 91 more receiving terminals are either planned/new or expended (LNG Journal 2006)

[80] Ages between 15-64 years

[81] Statistics Bureau, Japan (2006)

junior workers[82] Alternatively, some companies have tried to minimize the number of skill workers needed for their operations by utilising new technologies such as the 'digital oilfield' which enable operations to proceed with fewer engineers. [83]

There are also many other possible actions that can be considered in dealing with human resource constraints; including, making the working conditions more attractive for workers; providing more incentives to the skilled work force as to increase the competitiveness of employment in the energy sector compared with other sectors; establishing schools or universities specifically offering energy related courses; undertaking cooperation between companies and universities to secure qualified researchers; and conducting international cooperation at the APEC level while establishing joint ventures in business, thus enabling the training of workers to operate new emerging technologies and undertake R&D related activities.

In addition, collective efforts could be made between the industry sector and government policy makers to maximise investment in human resources. This is because the industry needs to pursue initiatives to supplement internal training and development programs with academic institutions for qualified personnel. However, on the other hand, government input to promote education and nurture the next generation of skilled workers will be an important aspect for each APEC economy.

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[82] A study conducted by the Society of Petroleum Engineers has found that average incomes in 2004 rose by 5.5 percent.

[83] Financial Times (2005).

GLOBALISATION AND ENVIRONMENT

Globalisation is defined by the International Monetary Fund as "the growing economic interdependence of countries worldwide through increasing volume and variety of cross-border transactions in goods and services, freer international capital flows, and more rapid and widespread diffusion of technology".[84] It is an on-going process of global integration including economic integration through trade, investment and capital flows, political interaction, information exchange and information technology, and culture.[85] In terms of economic integration, four aspects of cross-boundary flows, referring to the flow of goods/services, people, capital, and technology, have consequently been increasing the interrelations/interactions among the industrial players in different parts of the world.

The impact of economic globalisation on the environment can be regarded either positively or negatively depending on the financial or technological instruments employed. With economic globalisation, structural change within an economy from agriculture to industry and further to a services-based economy has sped up and thereby accelerated resource use and exacerbated environmental pollution. Likewise, intensive flows of capital and technology across boundaries may improve or deteriorate the environment, depending on the environmental characteristics relative to existing facilities and technology. For example, the government of Japan carried out a demonstration project focused on the transfer of energy efficiency technologies, such as coke dry quenching installations in China's steel industry with the target of reducing CO_2 emissions by 68,300 tonnes per year. Not only CO_2 emissions, but emissions of other pollutants such as SO_X, dust, and water demand can and have been reduced.[86] However, the following is an example where environmental degradation has been observed. Many manufacturing industries have relocated their production bases to developing economies, such as China and Viet Nam, because of lower labour cost and less stringent environmental policy on the use of carbon intensive energy. This has resulted in the energy demand of these developing economies increasing substantially, subsequently increasing emissions.

Environmental problems are a perfect agenda for international cooperation. All economies affected should be willing to participate in the effort to cease environmental degradation. However, it is far from easy to agree what to do, and how to do it. For example, it is a challenging task to reduce the utilisation of fossil fuel energy while increasing standards of living in developing economies and similarly avoiding cuts in the standard of living in developed economies that would produce adverse public reaction and political impasse.

In the international arena, one of the most important political developments has been the United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992. The Convention has the objective of "stabilisation of atmospheric greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system". In 1997, a substantial extension to the Convention that outlined legally binding commitments to emission cuts was adopted in Kyoto, Japan. Among APEC economies, Canada, Japan, New Zealand and Russia have ratified the Kyoto Protocol and are bound to reduce emissions. Along similar lines, the Asia Pacific Partnership on Clean Development and Climate (AP6) was established in 2005 to promote an enabling environment for the development, deployment, diffusion and transfer of existing technologies. Likewise, the Group of Eight (G8) signed a communiqué which included a political statement and an action plan covering climate change, clean energy and sustainable development in 2005. The regional and international cooperation, climate change has been primarily addressed through reducing emissions levels, technology development and transfer, and/or change of energy mix. Gaps or overlapping issues between those initiatives would be identified in the forthcoming APERC study on "Understanding International Energy Initiatives".

Besides international cooperation among government, some international energy companies have developed their own environmental policies to deal with global environmental issues, such as, mitigating carbon emissions and other harmful pollutants from their operations. For example, Shell has a target to reduce greenhouse gas emissions from their oil and gas facilities by five percent or more below 1990 levels by 2010, through capturing associated gases at oil production wells, applying

[84] International Monetary Fund (1997)

[85] Theodore Panayotou (2000)

[86] Toshi Sakamoto (2005)

sequestration of carbon dioxide, emissions trading, and improving energy efficiency.[87]

Although significant research/initiatives have been undertaken on methods to reduce emissions through international cooperation, emission reduction targets are not be achieved without the help of local or regional governments. Support from local or state governments in regards to formulating stringent environmental policies would alleviate loopholes found in federal environmental policies. Recent environmental policy developments, at both the national and regional levels are based on economic and regulatory instruments, in addition to technology improvement/transfer to enhance the reduction of emissions. Energy efficiency, renewable energy and environmental impact mitigation have also been given a higher priority on the energy policy agenda. For example, energy efficiency policy can help to reduce energy demand and subsequently lower the environmental impacts. It has been documented that efficiency improvements and proper pricing in the electricity sector can reduce emissions in developing economies by up to 30 percent.[88] Environmental policy and energy policy have become more closely linked as most air pollutants and a significant amount of carbon dioxide emissions are derived as a by-product of fossil fuel combustion.

In general, environmental regulations energy supply and demand, as well as the how the energy industry is operated. For example, in the US with the implementation of the Clean Air Act Amendments, 1990[89], the composition of gasoline burned in vehicles in several cities has been affected, and the growth of domestic refining capacity to supply gasoline has gradually slowed down.[90] In addition, the provision of New Source Review[91] has been challenged by the electricity industry in regard to older coal-fired power plants which were built before the provision was adopted. The administration of the electricity industry spent the last five years trying to free themselves from the New Source Review. They redefined the major modifications in power plants as "routine maintenance" and thereby placed them outside the scope of the law and spared the power companies the need to invest in additional pollution abatement controls. The second argument raised by the electricity industry was how to measure the emissions from power plants. The electricity industry supported the hourly rate of emissions as the appropriate standard of measurement while the state judicial authority decreed the plant's annual emissions should be counted as more emissions would be produced over a year.[92, 93] To solve this conflict, more flexible environmental policies to integrate old and new sources should be adopted rather than applying specific uniform emission requirements to all plants. Emission caps could offer greater flexibility and lead to a more efficient and effective system of allowance that fosters the trading of emission permits among the industries inside or outside the economy.

Traditional environmental regulatory programmes using end-of-the pipe technology requirements may not be able to solve environmental problems, including smog and climate change. More flexible approaches to environmental regulation should be considered and emphasized that focus on market-based incentives, such as providing incentives for technological innovation for civic involvement and collaboration; and cap-and-trade systems for control of emissions. Additionally, environmental standards should be clear and well-defined in order to spur investment from energy investors as vague environmental standards could be a barrier to them investing in the energy market.

As environment becomes an important factor in shaping and determining energy consumption, the major challenge is how energy is used efficiently to minimise the adverse effects on the environment. Over the outlook period, energy demand is expected to double, which it is hoped will drive advanced technology development along with the improvement in energy efficiency.

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