

## 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 per 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<sub>2</sub> 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<sub>2</sub>), 121 million tonnes of nitrogen oxides (NO<sub>x</sub>), and 27,364 million tonnes of carbon dioxide (CO<sub>2</sub>) will be emitted from energy consumption in 2030.

- The electricity sector will experience the fastest annual growth of SO<sub>2</sub>, NO<sub>x</sub> and CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>x</sub> 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.