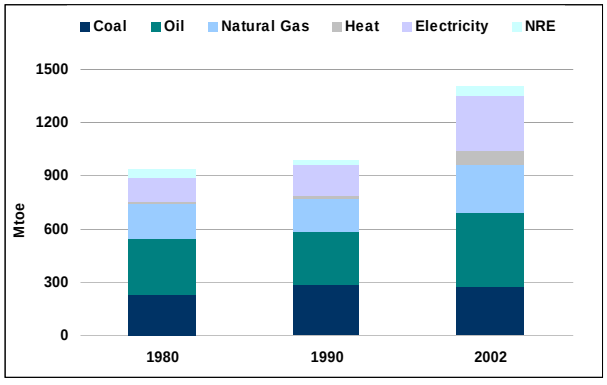
INDUSTRY

- *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-

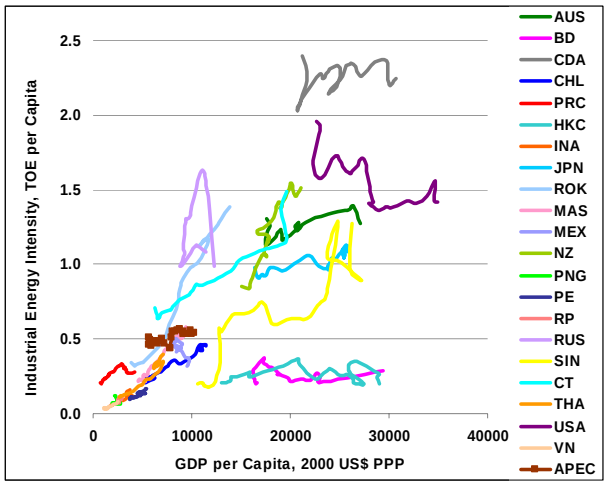
[10] USGS (2006)

[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)



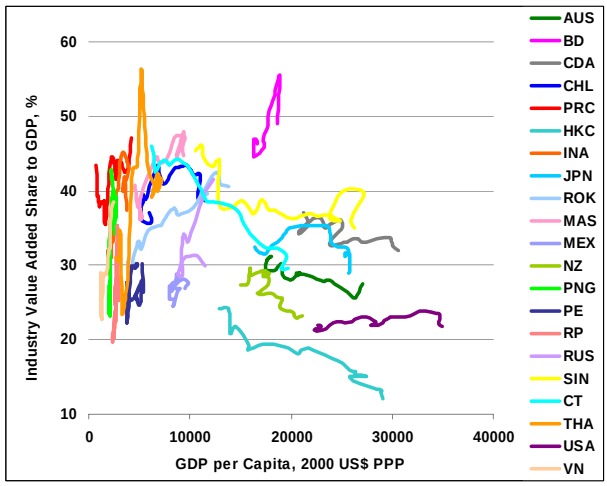
Source: APERC Analysis (2006)

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 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)

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.

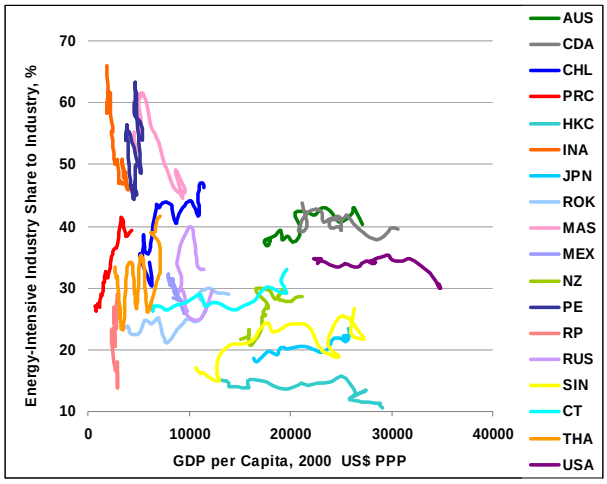
The sub-sectoral structure within the industry sector is also another important factor to explain the differences in energy demand across economies with similar stages of development. It gives some clue to understand why Australia's per capita industrial energy demand is higher than that of Japan (Figure 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.

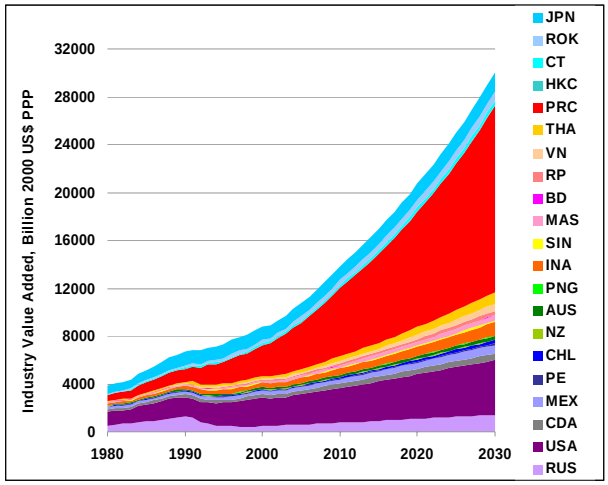
[14] Global Insights (2005)

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)

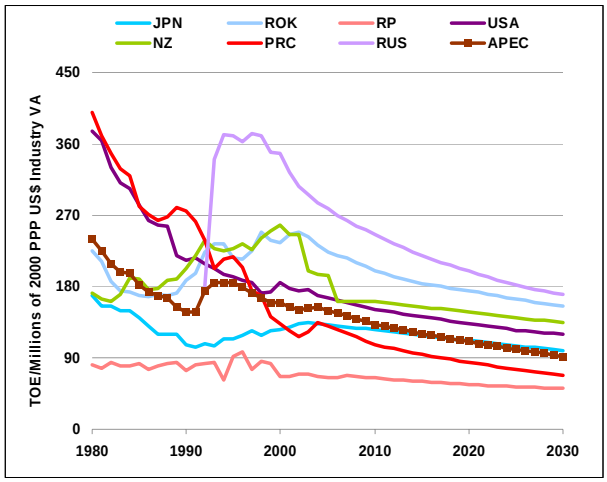
Table 10 shows the production of crude steel and ethylene by APEC and China over the outlook period. Steel production in the APEC region is projected to increase to 864 million tonnes in 2030, growing annually at 1.7 percent, while ethylene production is projected to reach 130 million tonnes in 2030, 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



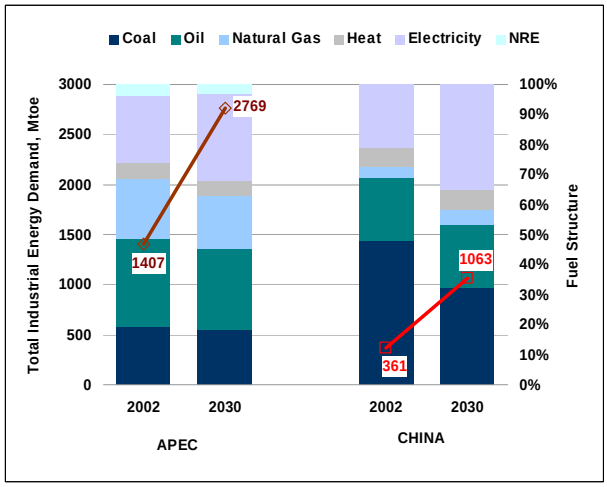
Source: APERC Analysis (2006)

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



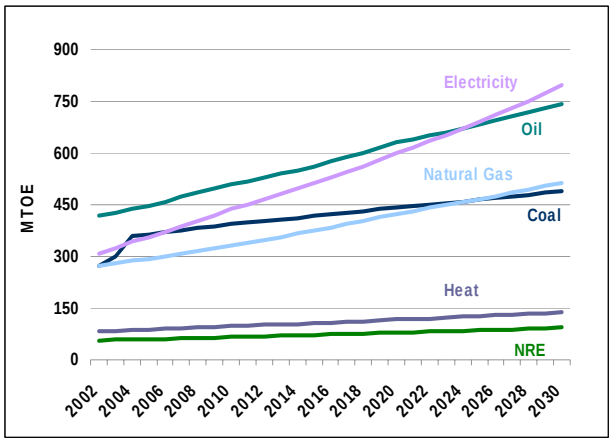
Source: APERC Analysis (2006)

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

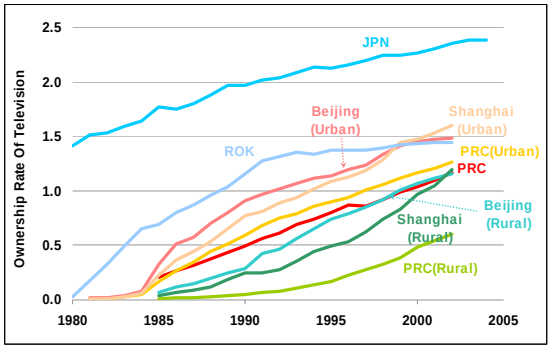
Many research studies have established the positive correlation that energy consumption per capita increases as GDP per capita (personal income) rises. The increase has been shown to become larger in developing economies while it becomes smaller in developed economies. Over the outlook period, the income 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.

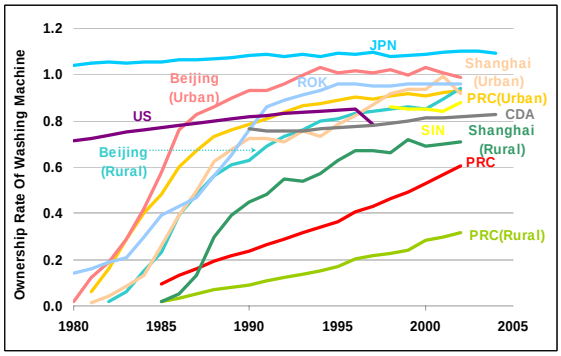
As people demand more entertainment, comfort and convenience, rapid diffusion of televisions, refrigerators, air conditioners and other electrical appliances occurs. The ownership rate of refrigerators, air-conditioners, televisions and washing machines for several selected APEC economies between 1980 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

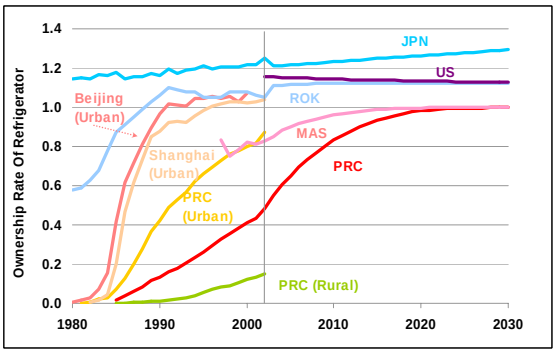
(a) Television



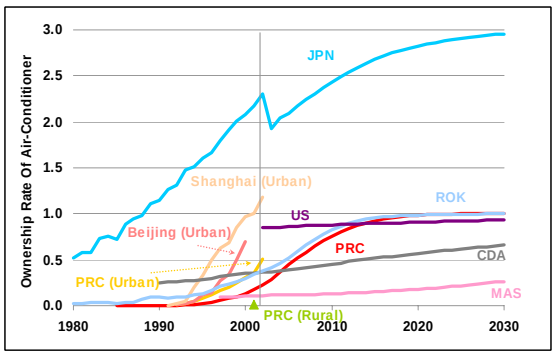
(b) Washing Machine



(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.

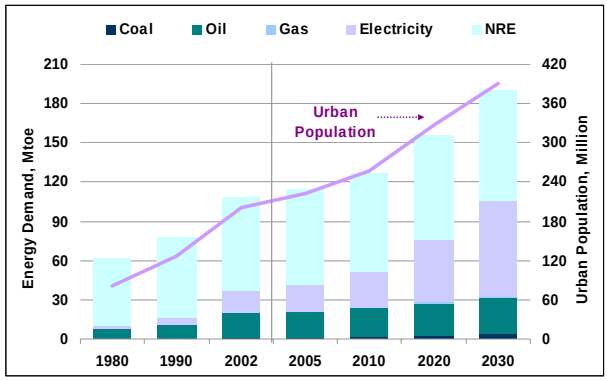
POPULATION GROWTH AND DEMOGRAPHIC CHANGES

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.

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

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

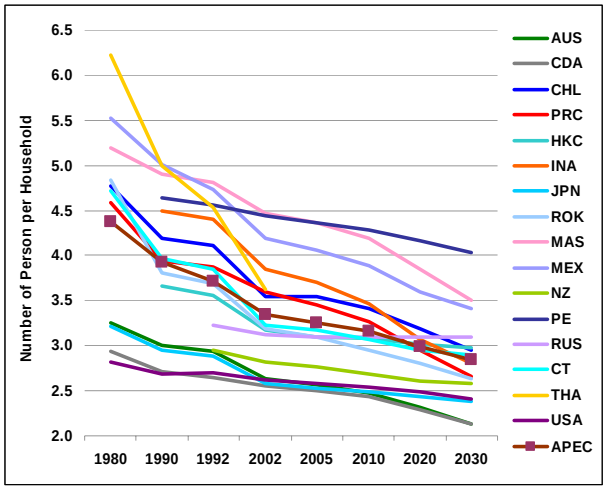


Source: Global Insights (2005); APERC Analysis (2006)

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.

[18] KEEI (1998)

Figure 30 Number of Person per Household in Several APEC Economies



Source: Various sources; APERC Analysis (2006)

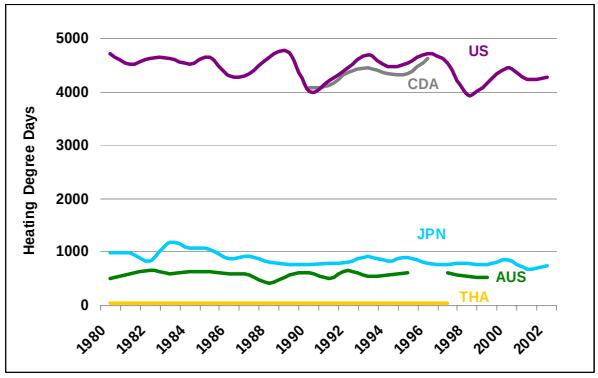
Currently, rapid aging of society has been found to be an emerging problem in many APEC economies, with Japan having one of the most aged populations in the world. According to United Nation statistics, the share of total population aged 60 or above in the world was 11 percent in 2006. Twelve APEC economies 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

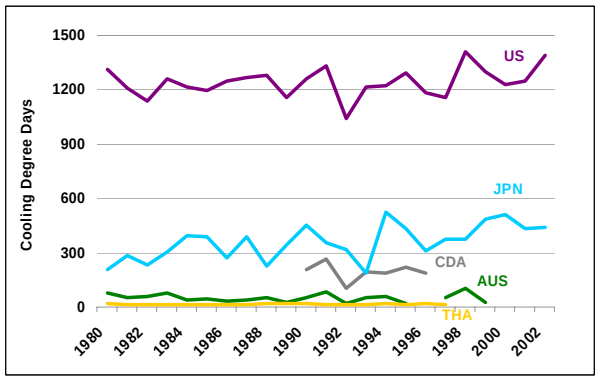
Climate plays an important role in residential and commercial energy demand and partly explains the reason why the per capita energy consumption in Russia, Canada and the US is higher than other economies. With extremely cold and long winters in Russia and Canada, heating accounts for more than 50 percent 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.

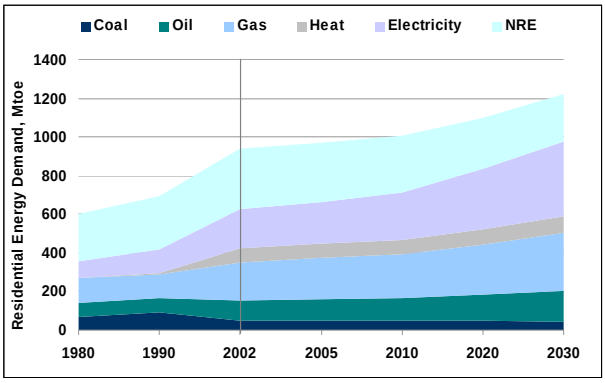
ENERGY DEMAND OUTLOOK

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).

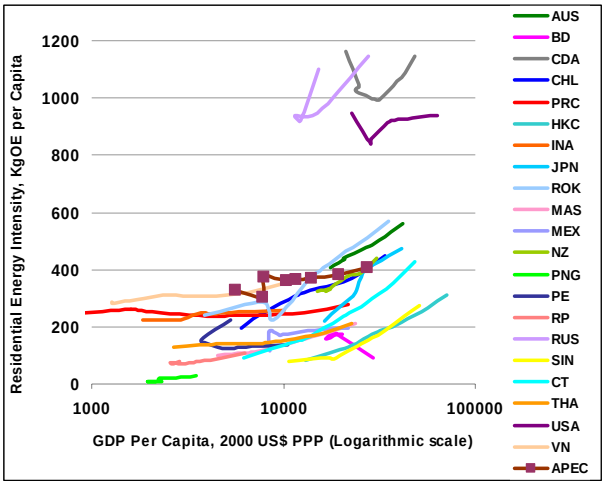
The average residential energy demand per capita for the APEC region is expected to increase from 362 kgoe per person in 2002 to 407 kgoe per person in 2030, growing at 0.4 percent per year. Due to extremely cold weather and low energy prices compared with other APEC economies, Russia's residential energy 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.

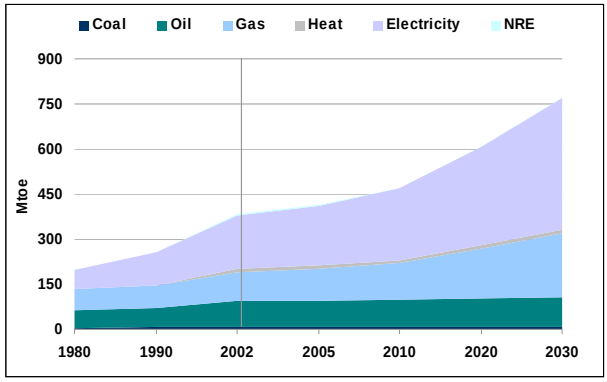
The replacement of biomass with commercial fuels, due in part to income growth and the increasing awareness of environmental and health concerns will result in a decrease in the share of combustible renewables and waste from 34 percent of total residential energy demand in 2002 to 19 percent in 2030. 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



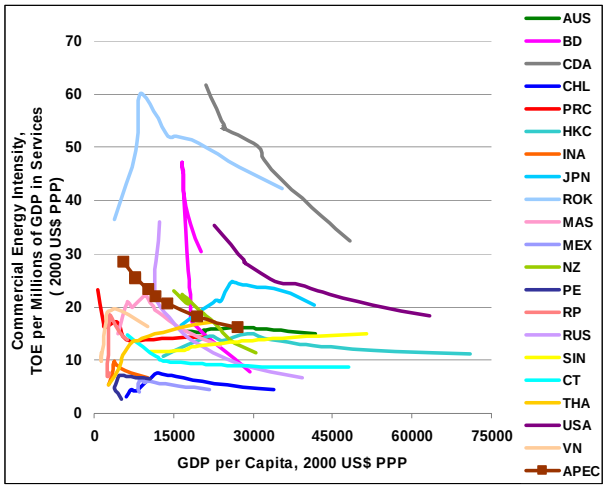
Source: APERC Analysis (2006)

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.

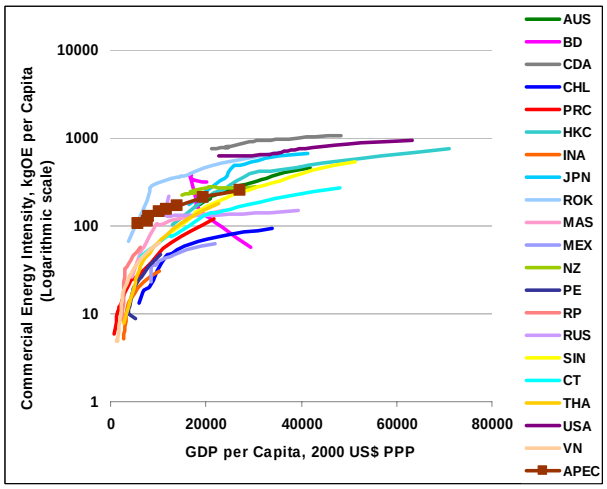
per capita is expected to increase significantly. On the other hand, when above this threshold electricity demand growth per capita slows down with incremental increase following an "S-shaped curve" (Figure 37). For instance, in Hong Kong, China the share of GDP in the services sector is projected to 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



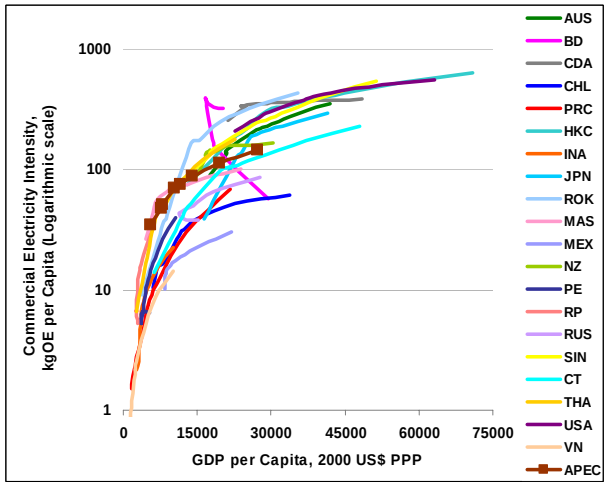
Source: APERC Analysis (2006)

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

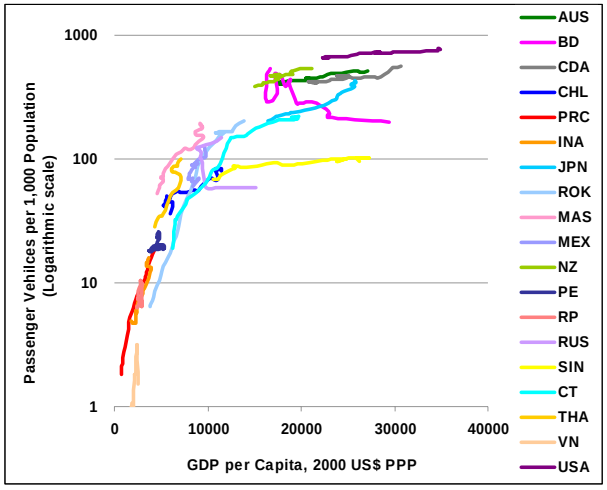
The rise in road transport energy consumption of APEC economies has been supported by the substantial growth in passenger vehicle stocks. Between 1990 and 2002, road transport energy

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.

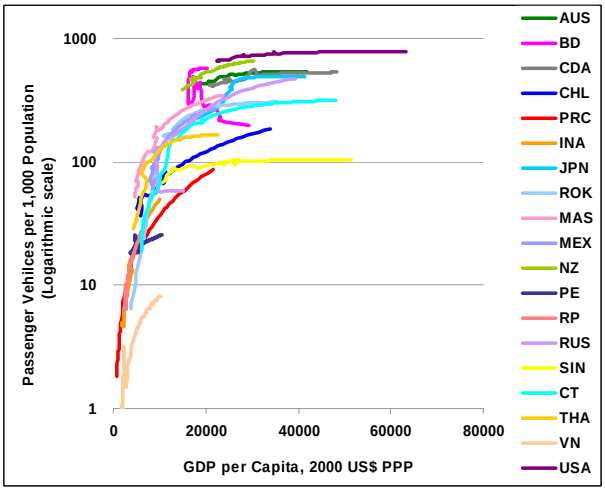
Figure 38 Passenger Vehicles per 1,000 Population in APEC with Respect to Income: History (1980-2002)



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

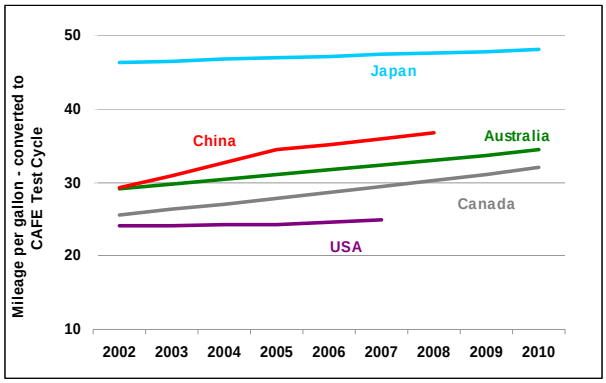
China	Korea	Indonesia	Thailand
Tariffs on imported automobiles were lowered from 70 in 2001, to 43.8 and further down to 25 in 2006.	**Tariffs** on imported automobiles have been completely removed.	Due to **the ASEAN free trade agreement,** tariffs on those automobiles produced among ASEAN economies 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.

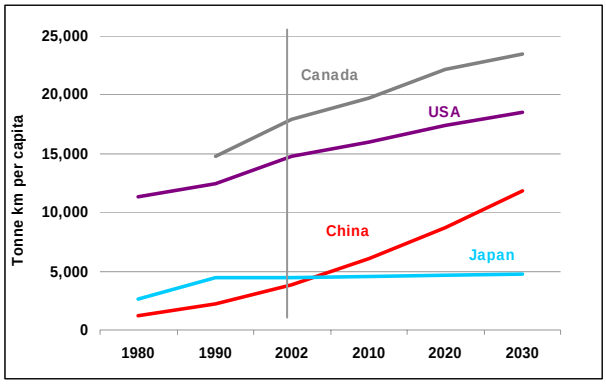
[28] Tonne km = Tonne (volume of freight transport) × km (distance travelled)

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)

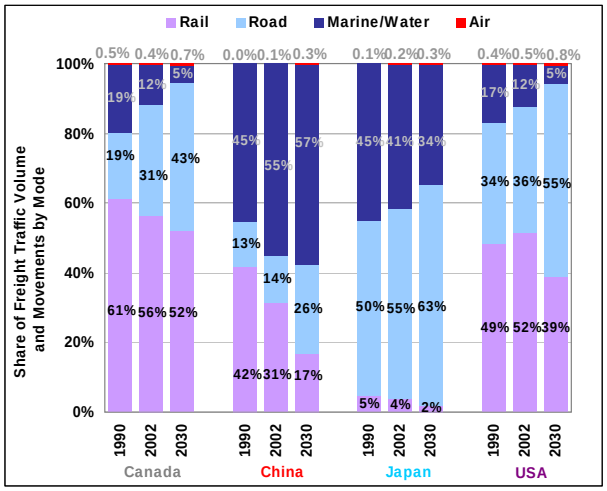
Shift in industry structure also affects the mode of transporting goods and services. In other words, industrial development from agriculture to industry and further to service based ones means change in goods and services that need to be transported. For example, heavy industry such as cement, construction 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)

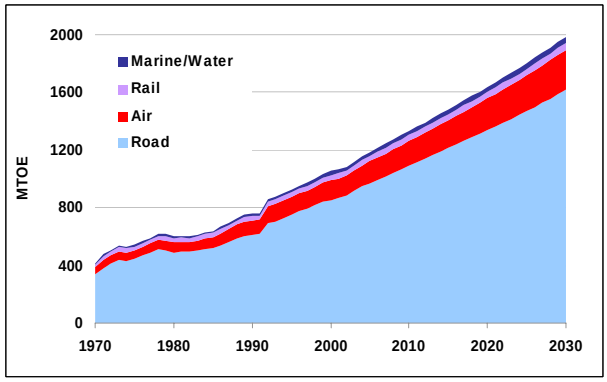
OUTLOOK

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

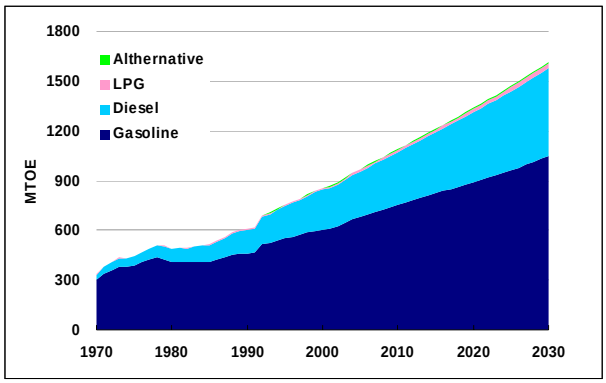
Road transport sub-sector energy demand is projected to almost double from 888 Mtoe in 2002 to 1,616 Mtoe in 2030, and maintain the largest share in total transport energy demand at above 80 percent. To the total incremental growth of road energy demand between 2002 and 2030, the US is expected to be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

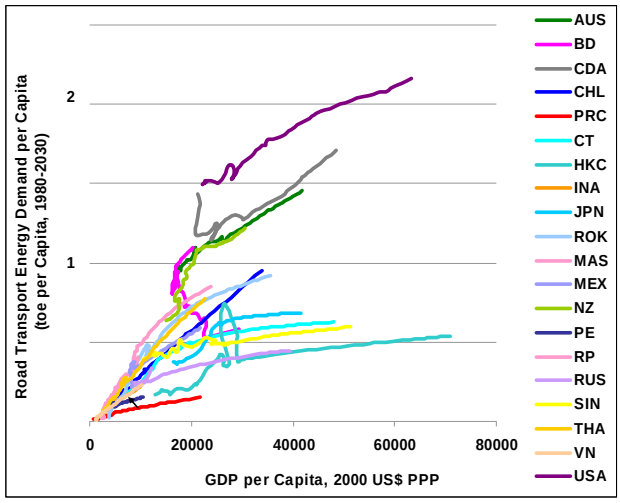
The decrease in share of gasoline is offset by the increase in share of diesel – a main fuel for freight trucks. Over the outlook period, the share of diesel in road transport energy demand is projected to increase from 28 percent in 2002 to 33 percent in 2030. Driven by the constant growth in industrial 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

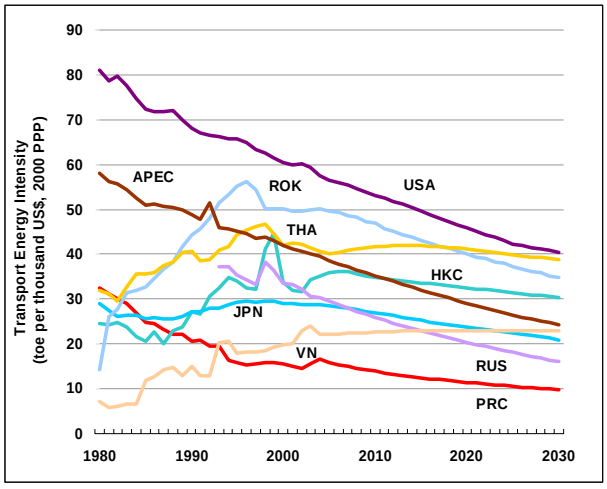
Over the outlook period, APEC transport energy intensity is projected to decline at an average annual rate of – 1.8 percent reflecting such factors as energy efficiency improvement and industry structure change.

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. .

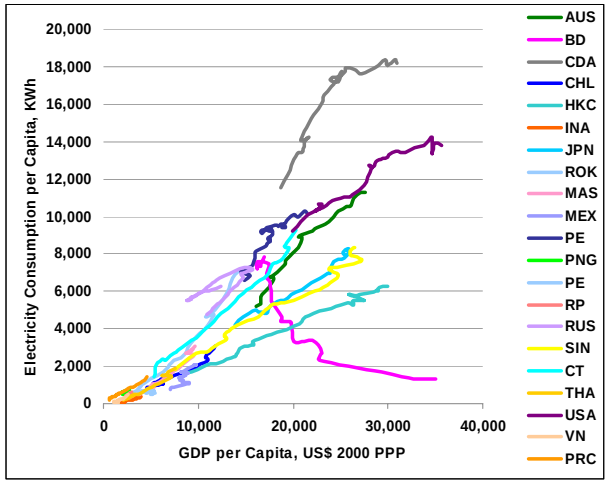
Since the 1980s, developed economies such as Australia, Canada, Japan and the US accounted for 84 percent of the region's total electricity consumption, with the US utilizing more than half or 53 percent of total electricity generation. However in 2003, the total share of these economies reduced to 69 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)

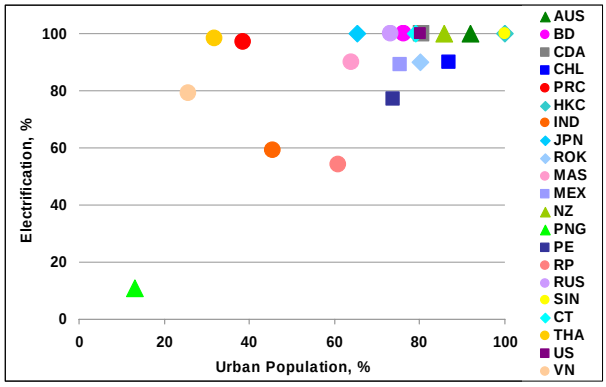


Source: APERC Analysis (2006)

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.

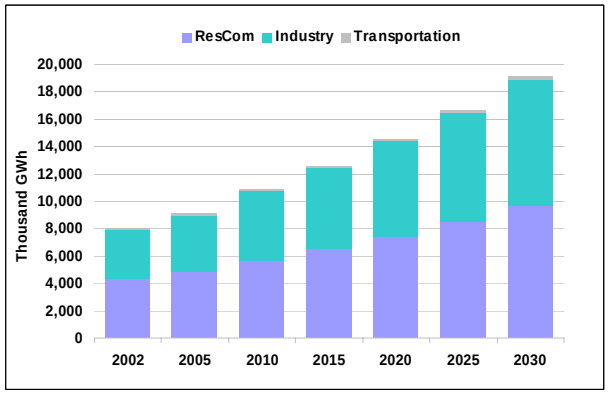
OUTLOOK RESULTS

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.

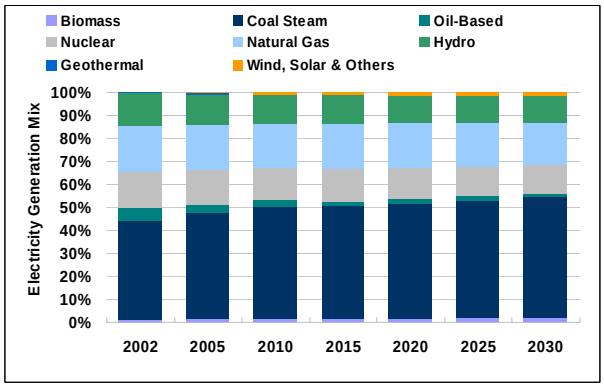
Over the outlook period the share of oil-based capacity will fall from 18 to 9 percent, and nuclear energy will decrease from 10 to 8 percent. Although in absolute terms the capacity of hydro will increase, the share of hydro will decrease from 18 percent in 2002 to 15 percent in 2030. Several initiatives 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

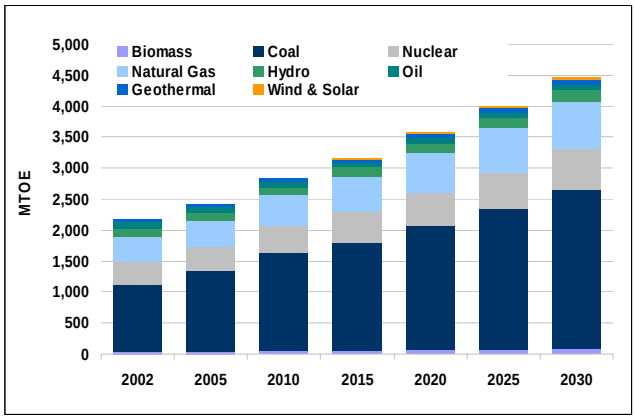
Energy inputs to electricity generation are influenced by energy conversion efficiency or thermal efficiency. In this outlook, it is assumed there will be improvements in thermal efficiencies of electricity generating technologies, particularly in coal, oil and natural gas-fired facilities. The installation 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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