URBANISATION AND ENERGY DEMAND

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

URBANISATION AND ENERGY DEMAND IN ASIA

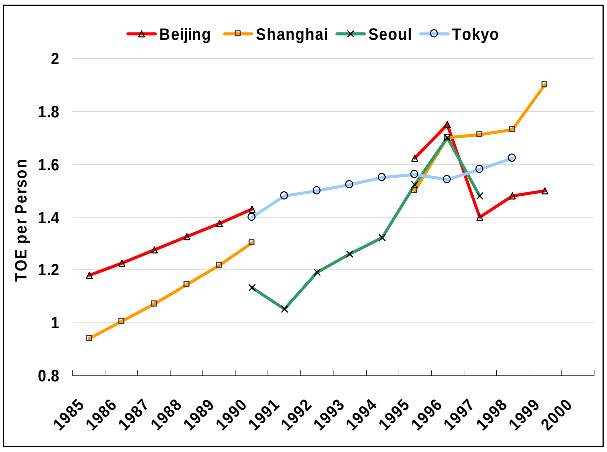
The energy demand of a number of APEC economies is expected to grow rapidly in parallel with urbanisation. The phenomenon will be in particular pronounced in Southeast Asia and China because their urban populations are expected to grow at a faster rate than other APEC economies. The United Nations projects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

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

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

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

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



Source: Dhakal (2004).

Table 18 Sectoral Share of Urban Energy Consumption in 1998

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

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

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

URBANISATION, MOTORISATION AND RISING TRANSPORT ENERGY DEMAND IN ASIA

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

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

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

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

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

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

Source: APERC Analysis (2006).

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

IMPLICATIONS

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

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

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

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

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

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

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

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ENERGY RESOURCE CONSTRAINTS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Source: OGJ (2005), BP (2006)

ENERGY TRANSPORTATION

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

RECENT DEVELOPMENT IN ENERGY TRANSPORTATION

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

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

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

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

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

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

[62] ISL (2006)

[63] Mathew Leising (2004)

[64] BP Statistics (2005)

[65] LNG Journal (2006)

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

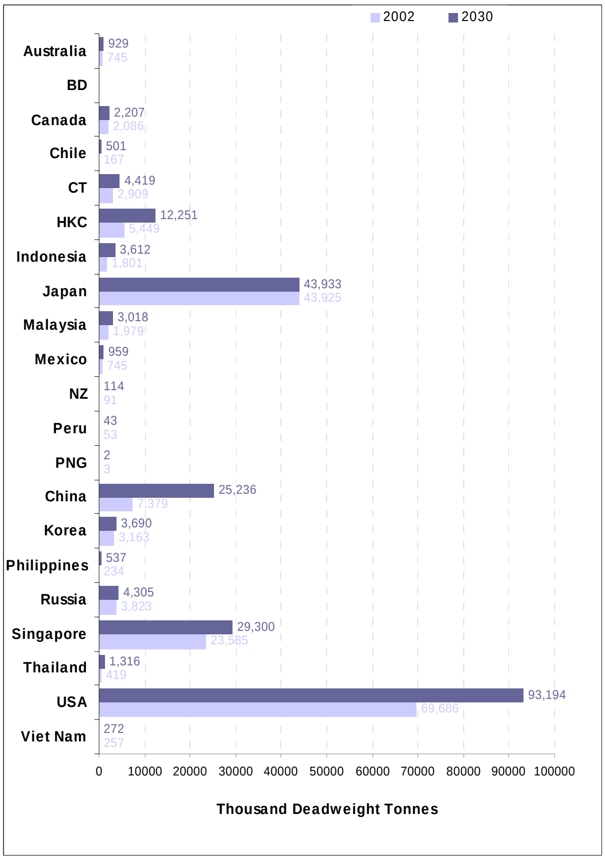
to ports, and then shipped to the consuming provinces in the south. Due to insufficient railway transportation capacity in the past decade, China has experienced a shortage of coal for electricity generation, which caused brownouts in many Provinces and municipalities. In 2004, the power shortage was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

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

FUTURE ENERGY TRANSPORTATION REQUIREMENTS

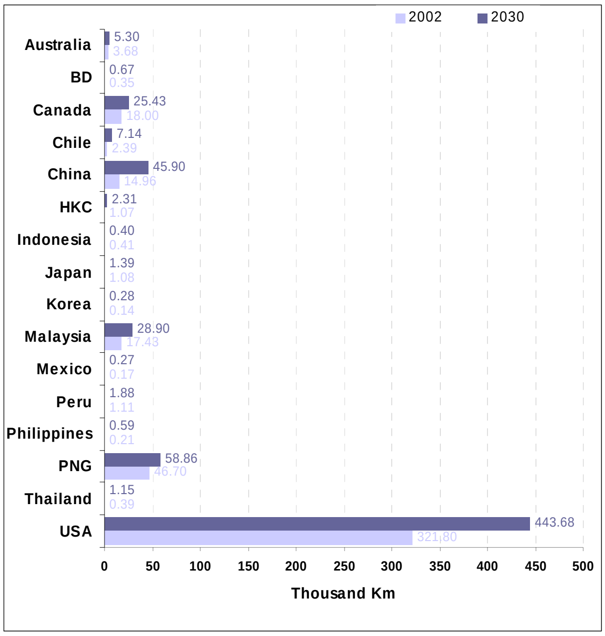
As tankers will remain the dominant means of oil transport, the estimated oil tanker fleets owned within the APEC region, including ships registered under Foreign Flags, is expected to increase from 168 million deadweight tonnes in 2002 to 230 million deadweight tonnes in 2030. Combined China and the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

Figure 67 Estimated Oil Tanker Fleet Owned in APEC Economies



Source: APERC Analysis (2006)

Figure 68 Estimated Domestic Oil Pipeline Length in APEC Economies



Source: APERC Analysis (2006)

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

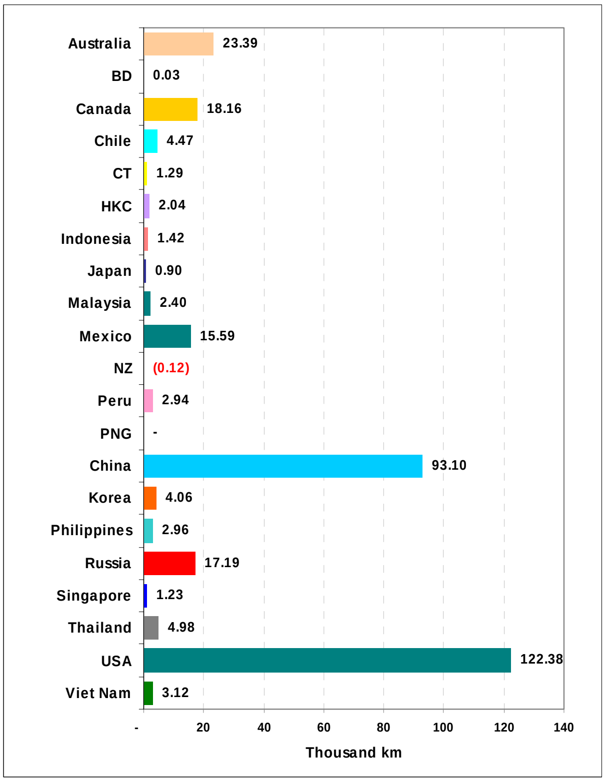
Table 23 Number of Existing and Planned New LNG Receiving and Liquefaction Terminals

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

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

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

Figure 69 Estimated Additional Length of Gas Pipeline



Source: APERC Analysis (2006)

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

DISRUPTION IN OIL AND GAS TRANSPORTATION

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

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

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

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

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

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

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

CHALLENGE FOR ELECTRICITY TRANSMISSION LINES DEVELOPMENT

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

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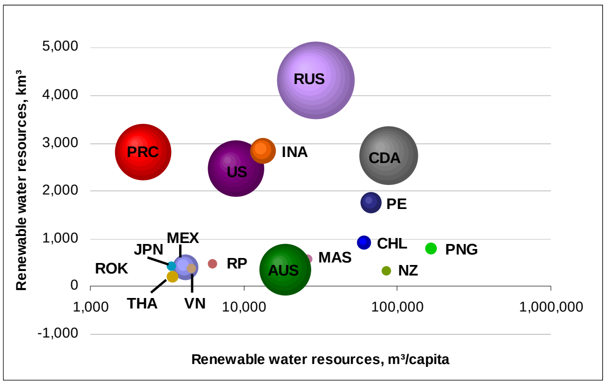
WATER AND ENERGY DEMAND

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

WATER RESOURCES IN THE APEC REGION

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

Figure 70 Renewable Freshwater Resources in APEC



Source: World Resources Institute

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

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

WATER UTILISATION IN THE ENERGY SECTOR

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

IMPLICATIONS

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

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

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

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

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

fuels can effectively be utilised for electricity generation.

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HUMAN RESOURCE CONSTRAINTS

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

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

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

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

CURRENT SITUATION

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

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

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

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

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

[73] US Nuclear Energy Institute (2005)

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

[75] Petroleum Intelligent Weekly (2005)

[76] The International Association of Maritime Universities

[77] LNG Journal (2006)

[78] APEC has a total of 72 LNG fleets in 2006

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

BOTTLENECKS FOR HUMAN RESOURCE

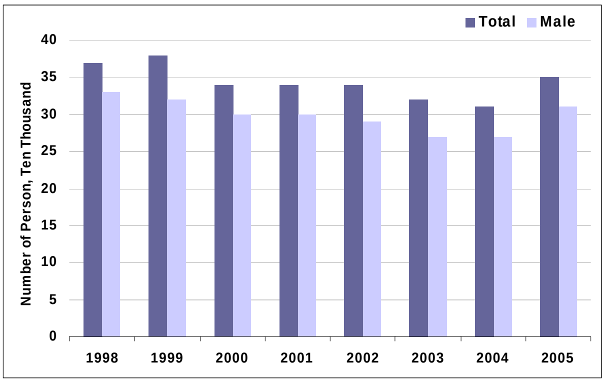
The decline in the labour force of the energy industry is due to a number of reasons. The most crucial reasons are aging of the work force, working conditions and industrial characteristics.

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

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

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

Figure 71 Japanese Workforce in the Utilities Sector



Source: Statistics Bureau, Japan (2006)

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

ADDRESSING THE CHALLENGES

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

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

[80] Ages between 15-64 years

[81] Statistics Bureau, Japan (2006)

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

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

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

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

[83] Financial Times (2005).

GLOBALISATION AND ENVIRONMENT

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

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

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

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

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

[84] International Monetary Fund (1997)

[85] Theodore Panayotou (2000)

[86] Toshi Sakamoto (2005)

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

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

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

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

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

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