ENVIRONMENT

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

INTRODUCTION

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

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

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

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

HISTORICAL TREND OF CO_2 EMISSIONS

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

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

[37] Environmental Science & Technology (2006)

[38] UNFCCC (2005)

[39] IPCC (2001)

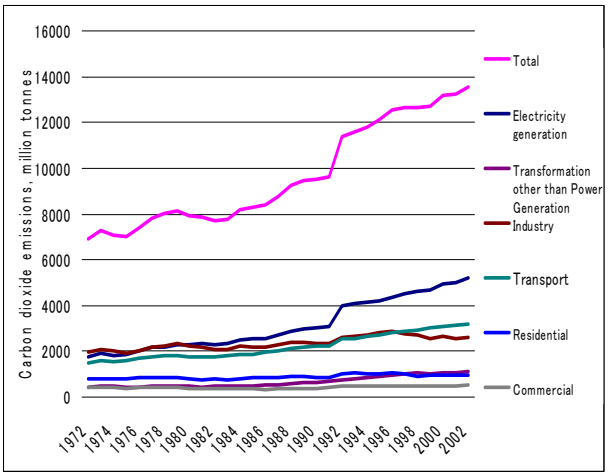
[40] The CO2 emissions from Papua New Guinea was not included.

[41] IEA Database (2005)

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

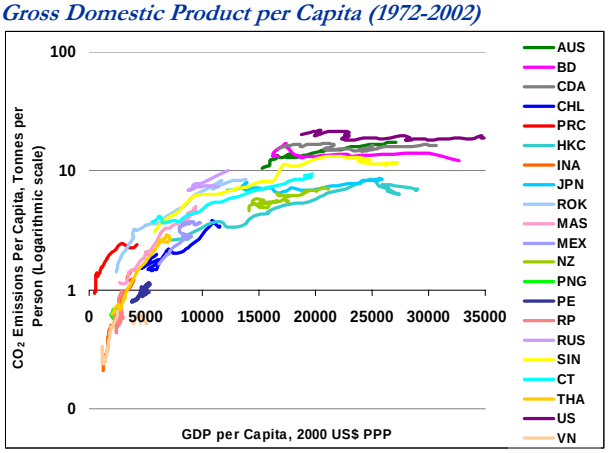
in the electricity sector. As for the transformation sector, substantial progress has been observed in the past three decades in order to meet the increased energy demand in the market. As a result of this development, CO_2 emissions from the transformation sector have also increased by three-fold from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

Figure 60 CO_2 Emissions (1972-2002)



Source: IEA (2005)

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



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

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

EMISSIONS PROJECTION

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

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

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

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

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

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

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

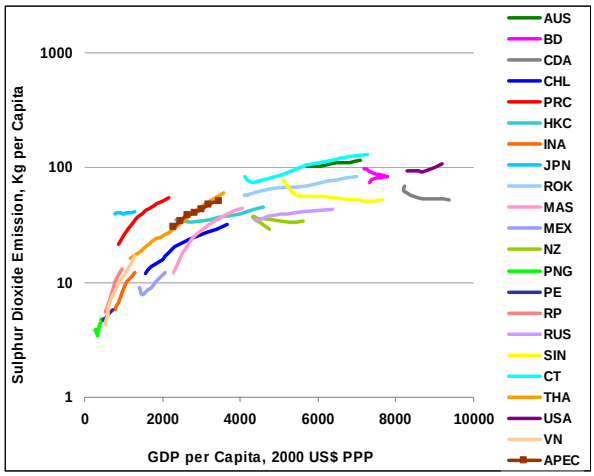
Over the outlook period, the average per capita CO_2 emissions in the APEC region are projected to grow at 1.7 percent per year, increasing from 6 tonnes per person in 2002 to 9 tonnes per person in 2030 (Figure 64). With the exception of New Zealand[46] all economies are expected to increase per capita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

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

CARBON OFFSET PRICE

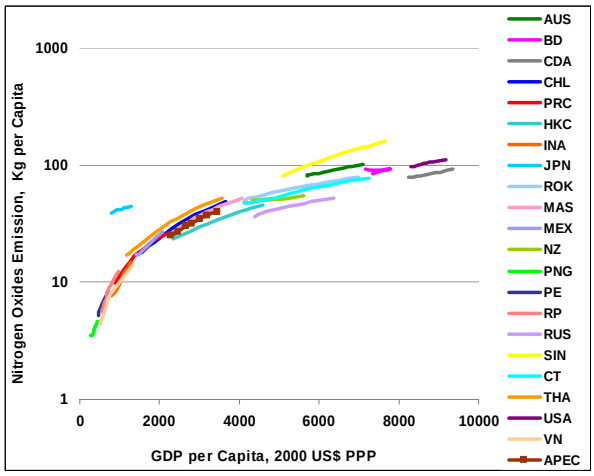
CO_2 emissions will be used as an indicator for comparison among APEC economies. The impact of CO_2 emissions from the energy sector can be assessed in terms of Carbon Offset Price (COP), which could help to ascertain the magnitude of environmental problems caused by burning conventional fuels. In other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

Figure 62 SO_2 Emissions per Capita (2002-2030)



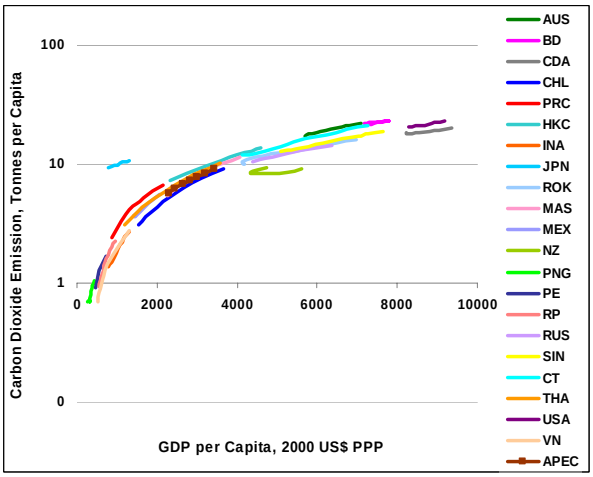
Source: Global Insight (2005); APERC Analysis (2006)

Figure 63 NOx Emissions per Capita (2002-2030)



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

Figure 64 CO_2 per Capita (2002-2030)



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

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

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

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

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

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

ASSESSMENT OF COP

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

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

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

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

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

Source: APERC Analysis (2006)

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

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

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

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

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

[51] Equivalent to US$237.59 billion

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

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

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

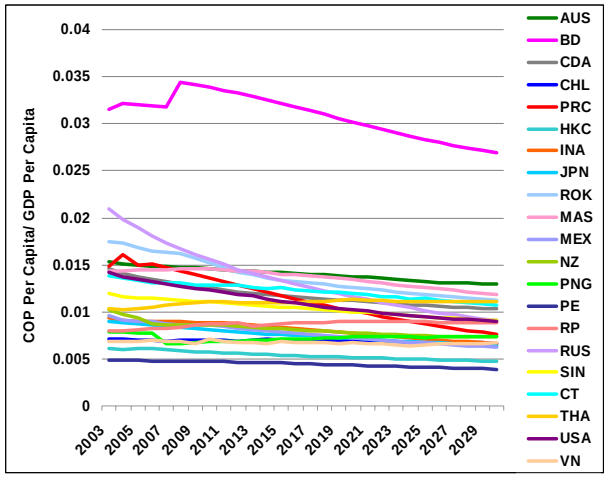
The per capita COP in relation to per capita GDP is depicted in Figure 65. The higher the number, the more money each person "pays" for how productive they are. The value of per capita COP over per capita GDP in the APEC region is estimated to decrease over the outlook period from 0.014 in 2003 to 0.008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

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

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

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

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



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

IMPLICATIONS

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

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

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

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

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

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