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# **From poverty to prosperity**

## **Energy consumption and economic growth in the Asia and Pacific Region**

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**‘Countdown to Kyoto’: The Consequences of the Mandatory Global Carbon Dioxide Emissions Reductions, Australian APEC Study Centre, Canberra, 19–21 August 1997**



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\* Acting President, Thailand Environment Institute. The author would like to thank Ms Jennifer Thambayah for her assistance in preparing this paper.



## The nexus between energy, economic growth and the environment

Energy is fundamental to human survival and well being and to economic activity. Economic growth and social modernisation have been the cherished goals of nations in the 20th century in order to alleviate poverty. Pursuance of these goals is characterised by major changes in the demand for and in the use of energy. It has resulted in a rapid rise in energy consumption to meet the demands of intensified agriculture, construction and industrialisation. Over the same period as end uses of energy diversified primary energy sources shifted from traditional renewables like wood and other biomass to fossil fuels. World commercial energy use has been rising rapidly since the 1950s and in 1993 consumption levels were almost 50 per cent greater than in 1973 (United Nations 1997, p. 20)

The increase in energy use has resulted in serious environmental consequences. It has led to ground water and air contamination, land degradation and changes in use, marine and coastal pollution, ecosystem destruction and the loss of biodiversity, damage to human health and finally to greenhouse gas emissions which have long term implications for the global environment. The World Commission on Environment and Development in its well known report *Our Common Future*, which is better known as the Brundtland Report, points to the tensions between increased levels of energy required for economic growth and the environmental costs that could be expected from following business as usual growth policies. It calls for a major reorientation of policies towards efficient technologies and conservation efforts but anticipates that even this solution will not prevent increased levels of global and regional environmental degradation. The challenge is to meet the demand for energy through the use of new technologies and consumption patterns so as to provide rising standards of living for all while minimising costs and risks to human health and the environment (United Nations 1997, pp. 1,19).

## The developing countries dilemma

Economic growth and poverty alleviation, are the overriding policy objectives of most developing countries (DCs). This is due to the fact that almost 80 per cent of the world's population reside in developing countries and this includes a large proportion of those living below the poverty line. As a consequence of following policies of economic expansion, there has been an increase in industrialisation caused by the switch from agriculture to manufacturing and an increase in the use of products and processes that require energy. This coupled with the transition from traditional energy sources to commercial sources has resulted in energy demand in the developing countries growing rapidly and outstripping growth in energy production and power generation capacities, thus creating shortages in primary fuels and electricity. To meet this rising energy demand

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developing countries will require tremendous financial resources and increased investment to expand energy supply and prevent the environmental and health impacts of conventional patterns of energy use (Kleindorfer, Kunreuther and Hong 1996, p. 4).

It would not be wrong to say at this juncture that DCs economies will continue to grow; in fact they will need to grow. The World Bank estimates that the GNP of developing countries will grow at the rate of 4.8 per cent annually over the 1994–2003 period. Average growth for the same period in East and South Asia is estimated at 7.6 per cent and 5.3 per cent annually. In addition it is estimated that the world's population is expected to grow by 3 billion during the period 1990–2020 with 90 per cent of this increase being attributed to developing countries. It is also estimated that world primary energy consumption will double to roughly 17.2 megatons of oil equivalent in the next 30 years. The share of OECD countries will drop from over 50 per cent in 1990 to under 30 per cent by 2020 while the share of DCs will almost double to 60 per cent during the same period (Kleindorfer, Kunreuther and Hong 1996, p. 5).

This paper will focus on energy consumption and economic growth in developing countries in the Asia Pacific region. The consequences of economic growth, the rising demand for energy, environmental problems and policies that reconcile the goals of economic growth, energy demand and protection of the environment will be dealt with.

## The Asia Pacific region

The Asia Pacific region is unique and extraordinary in many respects and several factors have to be taken into account when considering the region as a whole. It possesses enormous diversity in cultures, geography, geology, markets and systems of governments. It is also home for the majority of the world's population and despite the envious economic growth of some countries in East Asia, the region still carries the burden of about 600 million people living below the poverty line (this constitutes more than the entire EC and US populations). Lastly, the region is also unique because there are four NICs — South Korea, Taiwan, Singapore and Hong Kong — as well as Indonesia, Malaysia and Thailand which have quadrupled their per capita income during the past 25 years and Japan which has made it to the top leagues of developed industrialised countries (Kleindorfer, Kunreuther and Hong 1996, p. 84).

## Economic growth and outlook

The region's economic performance during the past three decades has been impressive. Overall GDP growth rates have steadily increased from 5 per cent in the 1960s, to 6.5 per cent in the 1970s, to 7.3 per cent in the 1980s and to over 8 per cent in the 1990s. In terms of economic performance it will continue to be the most dynamic region in the world.

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Economic growth rates together with population increases are presented in table 1. Despite the dynamic economic growth in the region the data in table 2 demonstrate that income distribution and poverty remain a serious problem in many countries.

Although economic performance in Asia will vary considerably from country to country the following forecasts may be made. In the case of OECD countries of the region, their economies have been maturing and their GDP growth rates will be considerably lower than in the past. In the case of the NICs GDP growth will remain strong but will become slower when economies mature in the 2000–2010 period. In South East Asia the five major economies of Indonesia, Malaysia, the Philippines, Thailand and Vietnam will continue to grow though not as rapidly as they have done in the last three decades. South Asia will experience moderate growth. In the case of other Asia Pacific economies though they are relatively small this does not mean that growth will be slow as they will be influenced by the economic growth experienced by their neighbours (Fesharaki, Clark and Intarapavich, pp. 15–16).

Table 1: Economic and population growth, 1980–1993, with projections to 2010

Economy	GDP growth rate (%)				Population growth rate (%)			
	1980–1990	1990–1993	1993–2000	2000–2010	1980–1990	1990–1993	1993–2000	2000–2010
Australia	3.4	2.3	2.0	1.6	1.54	1.51	1.50	1.40
Bangladesh	4.3	4.0	4.5	4.5	2.54	2.45	2.43	2.29
China	9.5	11.4	8.5	6.3	1.47	1.47	1.29	0.85
Hong Kong	7.1	5.0	6.0	5.0	1.21	0.87	0.77	0.55
India	5.3	3.0	5.0	6.0	2.06	1.96	1.90	1.66
Indonesia	5.5	6.6	6.3	6.0	1.99	1.93	1.79	1.43
Japan	4.1	2.7	2.4	1.8	0.56	0.46	0.51	0.26
Malaysia	5.2	8.2	7.5	7.0	2.62	2.43	2.16	1.75
New Zealand	1.9	1.1	1.2	1.2	0.86	1.01	1.01	0.79
Pakistan	6.3	5.3	5.5	6.0	3.26	2.70	2.80	2.48
Philippines	0.9	0.4	7.5	8.0	2.48	2.13	1.98	1.71
Singapore	6.4	7.5	7.5	6.0	1.15	1.11	0.97	0.66
South Korea	9.7	6.0	6.0	5.0	1.29	0.86	0.83	0.53
Taiwan	9.0	6.7	7.0	5.0	1.51	1.06	0.95	0.65
Thailand	7.6	7.8	6.8	6.2	1.57	1.35	1.18	0.99
Vietnam	5.2	7.4	9.0	8.0	2.17	2.16	2.05	1.80
Others	6.3	6.1	6.7	6.1	1.95	1.73	1.62	1.33

Source: East-West Center, 1995.



Table 2: Key indicators of developing Asian countries

Country	Population in poverty (%) <sup>a</sup>			Income ratio of highest 20% to lowest 20%	Gini coefficient
	Total	Urban	Rural		
Bangladesh	5.16	56.0	51.0 (1985/86)	4.5	0.3
China, People's Rep. of	8.6	0.4	11.5 (1990)	7.3	0.3
India	29.9	20.1	33.4 (1987-88)	5.4	0.4
Indonesia	13.7	13.4	13.8 (1993)	4.8	0.3
Korea, Rep. of	4.5	4.6	4.4 (1984)	.....	0.4
Malaysia	10.5	4.4	14.9 (1993)	10.8	0.5
Nepal	42.6	19.2	43.1 (1984/85)	.....	0.5
Pakistan	.....	20.0	31.0 (1984/85)	5.0	0.4
Philippines	41.3	28.8	53.7 (1994)	10.6	0.5
Sri Lanka	39.4	27.6	45.7 (1985/86)	4.3	0.5
Thailand <sup>b</sup>	14.0	1.8 (8.5) <sup>c</sup>	(1994)	.....	5.25

<sup>a</sup> Based on the concept of an 'absolute' poverty line, expressed in monetary terms, that is the income or expenditure level below which a minimum nutritionally adequate diet plus essential non-food requirements are not affordable. <sup>b</sup> From Kakwati and Krongkaew, 1997, the urban areas are municipal areas. <sup>c</sup> The figure in parentheses is for sanitary districts.

Source: Economics and Development Resource Center ADB, 1996; Bangkok Post, Yearend'96 Economic Review, 1997.

## Energy use<sup>1</sup>

The Asia Pacific region, especially East Asia, has the most rapidly growing energy demand in the world and will continue to have an increasing impact on world energy demand. In East Asia, for example, the total primary energy demand was 1 078.9 MTOE in 1993 and was expected to grow at an average of 4.8 per cent per year by 2010 while the final energy demand will grow at the rate of 4.5 per cent per year (Fujime 1997, p.3). Issues of particular importance for the region include the supply and demand balance of energy resources and the substitutability of fuels. In addition, environmental concerns and problems will need to be addressed. It would be relevant at this point to assess the nature of energy use and production in the region by energy source.

## Oil

The Asia Pacific region is the only part of the world that has created demand in the world oil markets in recent years. Between 1990 and 1993 the region's demand rose by 3.0 million barrels per day thus, making it the centre of gravity of the world oil market. Continued economic growth and population growth will result in the region possessing the highest growth rate of oil demand. The region's oil demand has already surpassed Western Europe's and will soon overtake North America. Scenarios for oil product demand are set out in

<sup>1</sup> This section is drawn mainly from Fesharaki, Clark and Intarapavich (1995), pp. 37-90.



table 3. In the base case scenario oil product demand will average an annual growth rate of 3.4 per cent from 1993–2010. The high case scenario envisages annual average growth at the rate of 4.1 per cent whilst the low case scenario is 2.9 per cent from 1993–2010. The demand pattern will skew towards lighter oil products with liquid petroleum gas, gasoline and diesel shares increasing and fuel oil decreasing (table 4).

The Asia Pacific region has a relatively small oil resource base. Proven oil resources in 1993 were about 44.6 billion barrels which constitutes only 4.5 per cent of the world total. More than 80 per cent of these reserves are in China, India and Indonesia. The region produced 6.7 mmb/d in 1993 and the reserves to production ratio is about 18 years which is well below the world average of 46 years and the Middle East average of 104 years. Asia Pacific crude production is unable to satisfy existing regional demand thus ensuring a major increase in import dependence. Oil imports from outside the region will account for two thirds of the region's consumption by 2000 and three fourths by 2010

In 1993 a total of 6.7 mmb/d of crude oil was produced within the region, 4.5 mmb/d was required to satisfy domestic demand in the producing countries leaving only 2.2 mmb/d for export. 86 per cent of this was traded in the region and the remainder went mostly to the United States. By the year 2000 the oil available to the region's net exporters is projected to fall to 1 mmb/d. China and Indonesia will become net crude oil importers. After 2000 the region's net exporters will be Brunei, Malaysia, Papua New Guinea and Vietnam. By 2010 all countries in the region will become net crude oil importers. The region's net oil imports in 1993 consisted of 6.9 MM./d of crude and 1.7 MM./d of products. Net imports are projected at 10.5 MM./d of crude and 2.8 MM./d of products in 2000 and 16.6 MM./d of crude and 3.5 MM./d of products at 2010. Net products from outside the region satisfied 8.8 per cent of total oil demand in the region in 1993. This share is expected to rise to about 14.2 per cent in 2000 and would remain as high as 13.2 per cent in 2010.

## **Natural gas**

Natural gas is relatively new in the Asia Pacific region but is rapidly becoming the fuel of choice among the region's electric power utilities which place a premium on gas because of security of supply, minimal price volatility and environment-friendly qualities. Demand for natural gas has increased substantially in the region over the past two decades. In 1993 the Asia Pacific countries consumed 6.2 trillion cubic feet (tcf) of natural gas compared to 1.1 tcf in 1973. Japan is the largest consumer accounting for 32 per cent followed by Australia 10 per cent, and India 9 per cent and China 9 per cent. Demand will continue to increase to 16.2 tcf in 2010.

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Table 3: Oil product demand, 1980–1993, with projections to 2010

Scenario and item	Demand (thousand barrels per day)				
	1980	1990	1993	2000	2010
Base case	10 158	12 358	14 935	19 787	26 570
By product					
LPG	633	1 033	1 263	1 696	2 251
Gasoline	1 453	2 168	2 609	3 719	5 597
Naphtha	629	932	1 257	1 754	2 245
Kero/jet	1 094	1 383	1 617	2 258	3 073
Diesel	2 113	3 494	4 529	6 306	8 928
Fuel Oil	3 836	2 833	3 095	3 383	3 683
Others	400	515	565	671	794
By consumer					
Australia	630	667	678	780	922
China	1 489	2 043	2 678	3 876	6 288
India	626	1 095	1 343	1 886	2 750
Indonesia	408	610	764	1 247	1 942
Japan	4 741	4 481	4 659	5 093	5 139
South Korea	508	980	1 646	2 382	2 886
Taiwan	392	549	647	887	1 203
Thailand	224	402	564	985	1 689
Others	1 140	1 532	1 956	2 651	3 750
High case	–	–	–	21 015	29 644
Low case	–	–	–	19 001	24 324
Scenario and item	Growth rate (%)				
	1980–1990	1990–1993	1993–2000	2000–2010	1993–2010
Base case	2.0	6.5	4.1	3.0	3.4
By product					
LPG	5.0	6.9	4.3	2.9	3.5
Gasoline	4.1	6.4	5.2	4.2	4.6
Naphtha	4.0	10.5	4.9	2.5	3.5
Kero/jet	2.4	5.3	4.9	3.1	3.8
Diesel	5.2	9.0	4.8	3.5	4.1
Fuel Oil	–3.0	3.0	1.3	0.9	1.0
Others	2.6	3.1	2.5	1.7	2.0
By consumer					
Australia	0.6	0.5	2.0	1.7	1.8
China	3.2	9.4	5.4	5.0	5.1
India	5.8	7.0	5.0	3.8	4.3
Indonesia	4.1	7.8	7.3	4.5	5.6
Japan	–0.6	1.3	1.3	0.1	0.6
South Korea	6.8	18.9	5.4	1.9	3.4
Taiwan	3.4	5.6	4.6	3.1	3.7
Thailand	6.0	11.9	8.3	5.5	6.7
Others	3.0	8.5	4.4	3.5	3.9
High case	–	–	5.0	3.5	4.1
Low case	–	–	3.5	2.5	2.9

Note: Rounding errors occur.

Source: East–West Center, 1995.



Table 4: Shares of Asia Pacific oil product demand, 1980–1993, with projections to 2010

	%	%	%	%	%
Product	1980	1990	1993	2000	2010
LPG	6.2	8.4	8.5	8.6	8.5
Gasoline	14.3	17.5	17.5	18.8	21.1
Naphtha	6.2	7.5	8.4	8.9	8.4
Kero/jet	10.8	11.2	10.8	11.4	11.6
Diesel	20.8	28.3	30.3	31.9	33.6
Fuel Oil	37.8	22.9	20.7	17.1	13.9
Other	3.9	4.2	3.8	3.4	3.0
Total	100.0	100.0	100.0	100.0	100.0

Source: East–West Center, 1995.

Table 5: Natural gas reserves and production by producer, 1993

	Reserves		Production		R/P
	Volume	Share of total	Volume	Share of total	Ratio
	trillion cubic feet	%	trillion cubic feet	%	yrs
Australia	19.6	0.39	2 321.4	1.10	23
Brunei	25.2	0.50	856.2	0.41	81
China	59.0	1.18	1 602.2	0.76	>100
India	25.4	0.51	1 511.2	0.72	46
Indonesia	64.4	1.28	5 154.2	0.72	46
Malaysia	76.7	1.53	2 006.6	0.95	>100
New Zealand	3.2	0.06	460.8	0.22	19
Pakistan	22.9	0.46	1 472.4	0.68	44
Papua New Guinea	15.0	0.30	7.9	0.00	>100
Thailand	5.7	0.11	860.8	0.41	18
Vietnam	3.7	0.07	67.4	0.03	>100
Other Asia-Pacific	33.7	0.67	977.8	0.46	94
Asia-Pacific Total	354.5	7.07	17 251.0	8.19	56
Middle East Total	1 581.0	31.52	10 858.9	5.16	>100
World Total	5 016.2	100.00	210 635.1	100.00	65

Note: Rounding errors occur.

Source: Oil Gas Journal.



The region produced 17.3 billion cubic feet per day (bcf/d) of natural gas in 1993. Indonesia alone produced nearly 5.2 bcf/d and Australia 2.3 bcf/d (see table 5). About 7.1 per cent of the proven world reserves of natural gas are in the region. Since the rate of exploitation is low the reserves to production ratio is around 56 years. Although new gas reserves have been discovered in the region, many of them tend to be in areas where the cost of development will be significantly higher than those already developed. Thus rampant demand and the high cost of developing gas reserves will result in buyers looking to the Middle East. In addition, exploitation of new gas reserves will probably be used domestically with little left over for export.

## Coal

Dependence on coal is higher in the Asia Pacific region than in any other region in the world. About 46 per cent of the region's commercial energy requirement is filled by coal compared with 21 per cent for the remainder of the world. This is due to the fact that coal is the region's most abundant fossil fuel and will remain the dominant primary fuel source. Total coal production is expected to grow at an average of 3.7 per cent per year from 1.67 billion tonnes in 1993 to 2.22 billion tonnes in 2000 and 3.07 billion tonnes in 2010. Australia, China and India are expected to account for 94 per cent of the region's growth in coal production (see table 6).

Total consumption is expected to increase by an average of 3.4 per cent per year from about 1.7 million tonnes in 1993 to 2.3 million tonnes in 2000 and 3.1 billion tonnes in

Table 6: Coal production, 1993, with projections to 2010

Producer	1993	1995	2000	2010	Change 1993–2010
	Mt	Mt	Mt	Mt	Mt
China	1 141	1 244	1 500	2 000	859
India	249	278	352	568	319
Australia	185	196	225	305	120
North Korea	34	37	45	50	16
Indonesia	28	39	68	105	77
South Korea	9	8	7	4	-5
Japan	7	6	3	1	-6
Vietnam	5	6	9	18	13
Philippines	2	2	3	4	2
Other Asia Pacific	6	7	9	13	7
Total	1 666	1 825	2 221	3 068	1 402

Source: East-West Center, 1995.



Table 7: Coal consumption, 1993, with projections to 2010

Producer	1993	1995	2000	2010	Change 1993–2010
	Mt	Mt	Mt	Mt	Mt
China	1 123	1 224	1 478	1 975	852
India	257	288	365	590	333
Japan	118	124	138	150	32
Australia	53	56	62	75	22
South Korea	40	44	54	77	37
North Korea	35	39	48	58	23
Taiwan	25	28	35	53	28
Hong Kong	12	12	13	15	3
Indonesia	10	17	34	68	58
Philippines	3	6	14	21	18
Vietnam	3	4	5	11	8
Thailand	2	4	8	15	13
Other Asia Pacific	9	11	16	23	14
Total	1 690	1 857	2 270	3 131	1 441

*Note:* Consumption includes adjustments to coal stocks but does not include lignite. Data for 1993 are preliminary.

2010. China and India will continue to account for more than 80 per cent of the region's coal consumption during this period (see table 7).

The region has four net coal exporters: Australia, China, Indonesia and Vietnam. Among these four countries net exports are expected to increase at an average of 3.4 per cent per year from 170 million tonnes in 1993 to 223 million tonnes in 2000 and nearly 3000 million tonnes in 2010. The region as a whole is a net importer and its net imports are expected to increase on average by about 10 million tonnes per year from 194 million tonnes in 1993 to 362 million tonnes in 2010. 86 per cent of all net imports in 1993 went to the three leading importers Japan, South Korea and Taiwan. Their share of the total is expected to decrease to about 76 per cent in 2010 as imports increase in countries such as India, the Philippines and Thailand. The region will be a net coal importer. However, in comparison with total consumption, the region's net imports will remain relatively small because of the region's large coal resource base.

## Hydropower

This is the second largest energy source for power generation in the Asia Pacific region but is concentrated in a few countries. China, India and Japan account for 76 per cent of all hydro generation in the region and their combined share is expected to increase to 80



Table 8: Hydro generation, 1980–1993, with projections to 2010 (terawatt hours)

Economic group	1980	1990	1993	1995	2000	2010
OECD Pacific	119.0	125.5	121.2	125.6	135.4	169.5
NIEs	4.9	13.4	12.0	13.3	15.5	21.7
South Asia	57.5	77.9	111.2	130.3	195.5	392.3
Southeast Asia	7.3	20.6	21.2	26.1	35.0	72.8
China	58.2	126.7	146.9	163.7	223.0	508.0
Pacific Islands	0.3	0.9	1.0	1.0	1.2	1.7
Total Asia Pacific	247.2	365.1	413.5	460.0	605.6	1 166.0

Note: Rounding errors occur.

per cent by 2010. South Asia depends heavily on hydropower which accounts for more than 90 per cent of total generation in Nepal and Sri Lanka. It is also the main domestic resource for power generation in countries such as New Zealand and the Pacific Islands. China has the largest hydro capacity and hydropower is China's second largest electric power resource. India's hydro potential is estimated at 84 GW but about two thirds of this potential is in the Himalayan mountain range far from industrial centres.

In 1993 hydropower provided only about 4 per cent of total generation in the NIEs whereas it provided more than 10 per cent in other parts of the region. Hong Kong and Singapore have no domestic hydro resources at all, South Korea utility had 2.5 GW and Taiwan had 2.56 GW of installed hydro capacity and each utility generated 6.0 TWh of electricity from its hydro plants. The Southeast Asian countries are planning big increases in hydro capacity and thus increases are likely. The annual average growth rate of hydro generation is projected to increase at 5.6 per cent during 1993–2000 and 6.8 per cent during 2000–2010. The region's hydro generation is expected to increase from 413.5 TWh in 1993 to 605.6 TWh in 2000 and 1166.0 TWh in 201 (table 8).

## Nuclear power

The Asia Pacific region is the only region in the world that is adding nuclear capacity. China, India, Japan, North Korea, Pakistan, South Korea and Taiwan currently have nuclear programs. In 1993 their combined nuclear capacity (excluding North Korea) was 55.3 GW and their combined nuclear generation was about 321.2 TWh. The region's nuclear capacity will still be growing in 2004 and nuclear generation in the region will grow at an average annual rate of 6.6 per cent and would increase from 321 TWh in 1993 to 953 TWh in 2010. Japan would account for 478 TWh followed by South Korea 173 TWh, China 123 TWh, India 95 TWh, Taiwan 64 TWh and Pakistan 20 TWh. It must be noted that nuclear power has an environmental image problem because of past nuclear accidents and waste disposal problems.



## **Geothermal power**

Only 0.5 per cent of total power generation in the Asia Pacific region is provided by geothermal power plants and most of the capacity is in Southeast Asia. In 1993 the Philippines had 1.1 per cent GW of geothermal capacity (56.3 per cent of the region's total) and generated about 5.6 TWh (53.9 per cent of the region's total geothermal generation). New Zealand and Japan together had about 560 MW of geothermal capacity and generated about 3.6 TWh of electricity from this source in 1993. Indonesia has the world's largest geothermal reserves: a potential of about 16.0 GW. Only 273 MW has been developed so far, although the country's total geothermal capacity in 2010 is expected to reach 10.2 GW. The Asia Pacific region's total geothermal generation in 2010 is projected at 66.8 TWh; 56 per cent of the total will be generated in the Philippines, 22 per cent in Japan, 18 per cent in Indonesia and 4 per cent in New Zealand.

## **Other renewable resources**

The development of renewable resources for power generation is actively pursued on a large scale in only two nations in the region. In India, about 167 gigawatt hours (GWh) was generated in 1993 from power plants that make use of renewable energy such as wind, biomass cogeneration, solar energy and biotechnology. This is expected to increase to 566 GWh in 2000 and 1133 GWh in 2010. In Japan, renewable resources such as waste fired, photovoltaic and wind power are being developed and installed capacity of these renewable resources is targeted at 520 MW in 2000 and 1800 MW in 2010. Japan's generation from these plants is expected to be 1000 GWh in 2000 and 5000 GWh in 2010.

Overall if the region's rates of economic growth is sustained at current levels, the energy scenario will worsen unless the supply is substantially increased. Energy supply may be a problem due to the high costs of energy exploration and development, political and strategic uncertainties associated with some economically exploitable energy deposits and a decline in recovering oil reserves. Oil production in Indonesia for example has fallen steadily since the 1970s and it might become a net importer shortly after 2000. The dependence of Asia on oil as a source of energy has been particularly great. Alternative energy sources may help fill some of the potential gaps in supply. However, the problems associated with the increased use of these alternative sources of power, solar, geothermal, LNG, coal and nuclear will limit oil's substitutability (Calder 1996).

## **Environmental consequences and concerns<sup>2</sup>**

Increasing awareness of the environmental consequences of economic activities and energy activities and the link between them has led to growing concern about a

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<sup>2</sup> This section is drawn mainly from the International Energy Agency Authority (1989), pp. 27–34.

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continuously growing range of pollutants, hazards and ecosystem degradation which has national, regional and global consequences. A significant number of these environmental issues relate to energy production, transformation and end use either as contributing factors or as the main cause. Consequences include air and water pollution, maritime pollution, land use and degradation, radioactivity and radiation, solid waste disposal, acid deposition, stratospheric ozone depletion and global climate change.

## **National environmental concerns**

Air pollution is caused by the production of energy, as well as the use of energy in the manufacturing and transportation sectors, all of which are directly or indirectly key components of industrial development. Global/regional statistics on air pollution by source are scarce. However, it may be surmised that air pollution levels in the Asia Pacific region are high because the main source of industrial energy is fossil fuels of which coal is a primary energy source (United Nations 1995, pp. 27–34). Statistics for East Asia alone are extremely high, in 1993 CO<sub>2</sub> emissions totalled 1041 million tons carbon equivalent, SO<sub>x</sub> emissions totalled 30.05 million tons and NO<sub>x</sub> emissions totalled 12.33 million tons. This is expected to increase by an average of 4.5 per cent per year up to 2010 (Fujime 1997, p. 11).

Air pollution is caused by the following

- oil and coal fired plants, emitting sulfur dioxide, carbon monoxide, nitrogen oxides, hydrocarbons, polycyclic organic matter and in the case of coal additional pollutants such as fly ash, trace metals and radionuclids.
- hydrocarbons which are emitted as a result of oil and gas extraction and the use and combustion of petrol and diesel for transport
- the combustion of coal and heavy fuel oil in power plants and industrial boilers releases small quantities of mercury, arsenic, beryllium and radionuclids into the atmosphere.

Ground water pollution may also be caused by energy activities such as

- power plants and refineries producing effluent that contains hazardous chemicals like chlorine and metals and suspended and dissolved solids
  - onshore oil and geothermal energy production pose the problem of brine disposal and geothermal fluids can contain chemicals which release gases such as carbon dioxide and methane
  - acid drainage from mines and coal preparation thermal pollution from the discharges of cooling systems of power plants or geothermal facilities can threaten aquatic life.
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Maritime pollution may result from large accidental oil spills, tanker accidents and the regular discharge of oil by ships at sea which results in damage to marine ecosystems.

Land degradation may result from economic and energy activities which cause deforestation, inadequate disposal of waste, mining, environmental effects of constructing dams and hydroelectric reservoirs. Land use also becomes a relevant environmental issue when it comes to the siting of fuel refining and electric power generation plants as well as industrial complexes.

Radiation and radioactivity may be caused by the use of nuclear energy. Nuclear reactor operations that produce low level radioactive emissions are not considered harmful. However, accidents such as those at Chernobyl make safety a primary concern where human health and environmental consequences are concerned. In addition, fission reaction does generate long lived highly radioactive wastes, the disposal of which is of great importance.

The disposal of waste also poses an environmental concern especially in the case of bottom ash from power plants and sludge and fly ash from particulate control devices. Though this waste is not classified as hazardous as chemical concentration is low, it may pose a threat as quantities grow and the commercial use of these wastes in the building industry are saturated. Over time they may require vast tracts of land to ensure containment and adequate disposal in order to prevent them being pollutants.

## **International environmental concerns**

Climate change, stratospheric ozone depletion, and acid rain are some of the consequences of increased industrialisation and energy use which have a global impact due to trans-boundary effects.

Acid deposition has been found to mainly relate to emissions of  $\text{SO}_2$  and  $\text{NO}_x$ , the transformation of this into acid rain has resulted in regional air pollution. Acid deposits and acid rain contribute to a wide range of environmental effects. They include the acidification of lakes, streams and ground waters, resulting in damage to fish and other aquatic life, damage to forests and agricultural crops and the deterioration of man made materials such as buildings, metal structures and fabrics. Acid deposits are formed by electric power stations, residential heating and industrial energy use which emits  $\text{SO}_2$ .

The distortion and regional depletion of the stratospheric ozone layer is caused by chlorofluorocarbons, halons and  $\text{N}_2\text{O}$  emissions. Ozone depletion can lead to increased levels of damaging ultraviolet radiation which is harmful to all biological species. Energy activities contribute to ozone depletion as fossil fuel and biomass combustion are

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responsible for 65 to 70 per cent of nitrous oxide emissions. CFC is used as refrigerants in transport and building air conditioning and refrigeration equipment, or as blowing agents in foam insulation which accounts for about 60 per cent of CFC uses.

As Asian economies are growing rapidly and are dependent heavily on non-renewable natural resources for their energy requirements, combustion of such fuels has been a major source of atmospheric warming. The concern about global climatic change resulting from the effect of excessive concentrations of greenhouse gases is potentially the most important emerging environmental problem. Population growth and mankind's activities are increasing concentrations of these gases and this could lead to global warming of the earth's lower atmosphere resulting in higher global temperatures, changing precipitation and seasonal patterns and causing rises in sea level. Such changes would have a wide ranging impact on all human activity. At present it is estimated that CO<sub>2</sub> contributes about 50 per cent to the anthropogenic greenhouse effect. GHGs are released by fossil fuel burning, combustion of fossil fuels and biomass, the production of ozone from the reactions involving pollutants from fossil fuel use and the production of methane from the fermentation of organic matter and distribution and use of natural gas.

It is more than apparent that the environmental consequences of economic growth and consequent rise in the use of energy has wide ranging and varied effects on human kind and the environment on a global scale. Thus, policy measures need to be devised and followed that incorporate a balance between the objectives of economic growth, poverty alleviation and environmental protection and conservation.

## Policy responses

Policy responses in the area of reconciling economic growth, energy use and environmental protection are largely determined by the following factors:

- Availability of technical options
  - Legislative and regulatory controls
  - The presence of policy instruments such as taxes and fiscal incentives
  - Improved information and public awareness
  - International harmonisation and co-ordination of environmental control efforts
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## Technical options<sup>3</sup>

The technical options available at present include pollution control based on the use of add on technologies, greater energy efficiency, fuel substitution, clean energy technologies. It should be noted that some or all of these technical options are available to nations in the Asia Pacific region. Add on pollution control technologies involve the use of treatment systems with little change in operating or production processes in order to reduce the environmental impact of an energy activity. Most though not all add on technologies involve end of line treatment. The use of add on technologies has been essentially induced by regulations based on emission standards.

Energy efficiency applies to actions applied across all fuel cycles. Thus it may occur not only in the conversion to final energy forms but also in the production of primary energy sources or the transformation to intermediate or final energy forms. Energy efficiency improvements can be implemented through hardware improvements such as technological enhancements or software actions such as improved energy management and better operational practices or by a combination of both approaches.

Efficiency enhancements have largely been undertaken in response to high energy prices or related competitive pressures in particular where technological innovations allowed such enhancements to be made. Thus the development of new technology supported by standards and regulations has an essential role to play in the continued growth of opportunities for greater energy efficiency.

Substituting fuels can involve permanent shifts to energy alternatives, temporary fuel switching to minimise short term environmental impacts and the use of higher quality (less polluting) forms of the same fuel. Such shifts have usually been brought about by the implementation of government policy that has been influenced by economic, technological and environmental factors.

Clean energy technologies are those that combine more energy efficient processes or operations and reduced pollutant production without necessarily entailing a change in the form of energy used. They are in addition specifically designed to limit emissions to air, water or waste production at the process stage and thus are primarily designed for new equipment or facilities though they can be applied to existing facilities in a limited number of situations. Environmental legislation, emission standards and financial support schemes have led to the introduction of clean energy programs.

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<sup>3</sup> This section is drawn mainly from the International Energy Agency (1989), pp. 86–93, 119–120, 139–141.

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## **Legislative and regulatory controls**

Environmental conservation laws are a necessary component of a nation's efforts to regulate energy consumption and prevent pollution. However, such legislation needs to be broad in scope and flexible in its operation so that it allows polluters to adopt a wide range of options/responses to meet the standards required. This ensures that such options are cost effective and in addition does not close the door on innovation and the introduction of new technology that is more efficient. The primary problem at least in the Asia Pacific region seems to be the actual implementation or enforcement of laws and regulations especially in the environmental sphere. Financial, administrative and manpower constraints act as a great hindrance to the effectiveness of legislative action.

## **Policy instruments**

Governments frequently use policy instruments to regulate the environmental sphere. Taxation especially differential taxation, charges, pricing schemes, tradable emission permits and non compliance fees are economic or market instruments which establish market prices and values for the use of the environment — in this case in the areas of energy conservation and pollution control. Some of these instruments have been applied in many Asian countries with some success. In addition subsidies in the areas of research and development or for the introduction of new, clean technology have also proved to be effective instruments.

## **Improved information and public awareness**

Creation of public awareness on environmental issues and the extent of environmental degradation together with an environmental rating for goods and services will not only succeed in informing and influencing public choice, but will also prompt industry to voluntarily comply with environmental laws and regulations. In addition programs that specifically address the industrial and business sector informing them of environmental objectives and assists them to comply with environmental regulations through access to training, technology and financial support will also ensure better compliance in this area.

## **International/regional harmonisation and co-ordination of environmental control efforts**

The harmonisation and co-ordination of international and regional environmental control efforts is essential in light of the environmental degradation that transcends national boundaries. Acid deposition, maritime pollution, ozone depletion, global warming and radioactive releases are on a growing list of environmental problems for which action can no longer be considered merely on a local scale. In addition, the absence of uniform environmental standards especially in relation to internationally traded goods and services

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could lead to restrictions in trade and competition. A warning note should be sounded at this point, when adopting uniform standards, the choice should not be that of the lowest common denominator as this would succeed in increasing environmental degradation rather than having the opposite effect.

The goals of harmonisation and co-ordination in the area of international/regional energy and environmental policy involve the exchange of information, the negotiation of agreements and the subsequent implementation at national level of commitments made to meet targets or requirements. This represents a growing challenge for national governments and relevant international/regional organisations as a balance has to be achieved between the performance criteria of environmental control on the one hand and of energy security on the other hand. It is imperative that concerns relating to economic growth, energy use and environmental conservation be incorporated in the process of international and regional development.

## Conclusion

Asian countries need to achieve an equitable balance, between the necessary goal of economic growth and the reduction of levels of absolute poverty, and the management of energy use so that environmental conservation goals are also met. This requires a fine tuned balancing act, which must be achieved by the judicious choice of policy options. Policy options are largely determined by the availability of technical options, legislative and regulatory controls, application of economic instruments, information and public awareness and international cooperation and actions.

As rapid growth of the Asian Pacific countries is likely to be sustained in the following decades, energy consumption will inevitably be substantially increased. This will certainly put a great pressure on the supply of energy, especially fossil fuels which will become increasingly scarce creating an energy gap. Alternative sources of energy can only fill some part of this potential gap. So dependence on primary fuel sources will continue. Therefore, the future overall energy picture looks rather uncertain. This may have an adverse effect on the sustainability of economic growth in the Asia and Pacific region.

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