Energy Balance, Carbon Emissions and Climate Change – Some Hard Choices for Asia

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Introduction

Access to plentiful supplies of affordable energy is a key requirement for sustainable economic and social development in all emerging nations, and nowhere more so than in Asia. Global primary energy demand is expected in the reference scenario of the International Energy Agency (IEA) to increase by 1.6% per annum from 2004 to 2030, growing from 11.2 billion tones of oil equivalent (btoe) to 17.1 btoe in 2030, more than a 50% increase in total (IEA World Energy Outlook-WEO, 2006). 70% of this increase in energy demand is forecast to come from developing countries with 48.9% coming from developing nations in Asia (including China 30% and India 9.0%) with populations and economies growing much faster than OECD nations, shifting the focus of global energy demand to Asia (Figure 1). About 50% of the increase in global primary energy use is for electricity generation and one-fifth to meet transportation mainly in form of oil-based fuels.

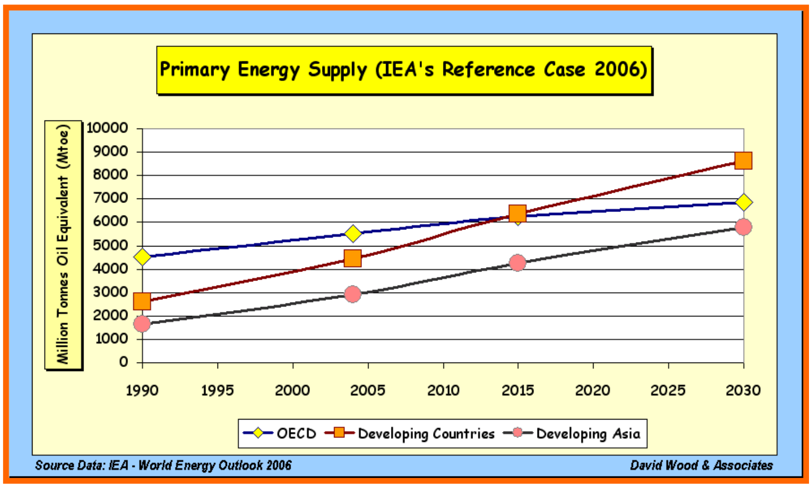

Figure 1. *Developing countries, particularly in Asia, will dominate future energy demand. Average annual growth rates in energy supply from 2004 to 2030 forecast by IEA in 2006 were 0.9% for OECD, 2.6% for Developing Countries and 2.7% for Developing Asia, with a World average of 1.6%.*

The fossil fuels (oil, gas and coal) in the IEA's reference scenario continue to dominate primary energy supply over the next 25 years. Available fossil fuel reserves are just about adequate to meet that demand growth, but many doubt that they will be adequate to sustain energy demand growth much beyond 2030.

Such projections raise several concerns, including:

- sufficient long-term energy supply, because of the finite nature of fossil fuel reserves;
- investment strategies to develop suitable and sustainable future energy infrastructure;
- environmental and climatic issues associated with the resulting carbon and other greenhouse gas (GHG) emissions from fossil fuel usage;
- increased competition for diminishing fossil fuel reserves;
- unequal access of the world's population to adequate energy supplies.

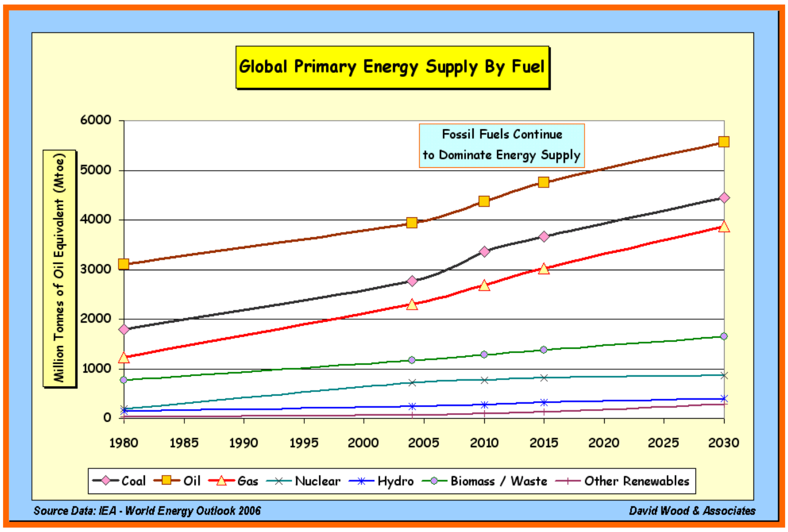

Figure 2. *Global increase in energy demand continues to be dominated by fossil fuels.*

Global Population & Levels of Economic Development Impact Future Energy Requirements

The world population is expected to increase from about 6.5 billion in 2007 to between 9 and 10 billion by 2050 (US Census Bureau, 2004). According to U.S. Census Bureau estimates, world population reached 6 billion in June 1999 – a figure more than 3.5 times the size of the earth's population at the beginning of the 20th century and about double its size in 1960. The time required for global population to grow from 5 to 6 billion — 12 years from 1987 to 1999 —was shorter than the time interval required for the growth of any of the previous billions. The growth in global population is thought to have peaked during that period. Adding each additional billion to increase global population to 10 billion are expected to take between 14 and 20 years. OECD countries have populations expected to grow at rates substantially less than 1% / year whereas developing countries have populations expected to grow at rates for the most part greater than 1% / year, resulting in a global average growth rate of about 1% / year (IEA-WEO, 2006). This sustained and preferentially distributed global population growth will create significant and changing demands for additional energy supplies from:

- ***Developing Economies***, as they industrialize and become more affluent will dominate world population growth, additional energy demand and GHG emissions. There is a direct correlation between primary energy consumption and economic prosperity measured crudely in terms of gross domestic product (GDP). The observations of the World Energy Council suggest that broader measures of prosperity and community welfare, including access to adequate health care, water, food, and education cannot be improved unless modern energy becomes readily available and affordable to all.

- ***Industrialized Countries***, as they continue to develop their skills base are expected to sustain economic growth through service sectors that are less energy intensive. In addition their ability to introduce energy efficiencies and conservation efforts more quickly than the developing world should have a mitigating impact on their energy demand growth. Nevertheless, business–as–usual projections for such countries will contribute to the sustained increase in worldwide demand for energy over the coming decades.

The world is therefore confronted by multiple energy-related threats associated with not having adequate and secure future supplies of energy at affordable prices, the environmental harm caused by consuming too much of it and the uneven distribution of and access to available energy resources. Tackling the multiple needs to constrain growth in fossil fuel demand, to increase geographically diverse supplies of cheap energy and to mitigate the negative climatic impacts of GHG emissions to the atmosphere are considered by many scientists, politicians and governments to be the overriding challenges for the human race to secure its future development beyond the twenty-first century.

Industrialized countries have recognized the problem (e.g. recent G8 leaders meetings at Gleneagles July 2005 and St Petersburg July 2006) and in order to focus their actions have sought advise on alternative energy scenarios and strategies aimed at a clean, clever and competitive energy future". The IEA's Reference Scenario (RS, IEA WEO, 2006) assumes no such government action and confirms that fossil fuel demand and trade flows, GHG emissions would follow their current unsustainable paths through to 2030 in the absence of government action. The IEA's Alternative Policy Scenario (APS) identifies a package of policies that could, if implemented reduce the rate of increase in energy demand and emissions with economic costs of such measures outweighed by economic benefits of using and producing energy more efficiently.

Kyoto's Clean Development Mechanism (CDM) – A way Forward?

The Clean Development Mechanism (CDM) is a provision of the Kyoto Protocol to The United Nations Framework Convention on Climate Change (UNCCC) that offers a new pathway to encourage technology transfer, promote sustainable development in host countries, reduce greenhouse gases (GHG) emissions and assist Annex B countries (developed countries listed in Annex B of the Kyoto Protocol – see Table 1) to cost-effectively meet their commitments under the Kyoto Protocol.

Emissions Targets of Countries Included in Annex B to the Kyoto Protocol (Dec 1997)

Adjustments Permitted to 1990 Emissions Baseline	For Period 2008 to 2012
EU-15, Bulgaria, Czech Republic, Estonia, Latvia, Liechtenstein, Lithuania, Monaco, Romania, Slovakia, Slovenia, Switzerland	-8%
US (Elected not to Ratify Kyoto Agreement)	(-7%)
Canada, Hungary, Japan, Poland	-6%
Croatia	-5%
New Zealand, Russian Federation, Ukraine	0%
Norway	+1%
Australia	+8%
Iceland	+10%

Source: UNFCC website *David Wood & Associates*

Table 1. *Developed countries listed in Annex B of the Kyoto Protocol and their assigned emissions targets relative to 1990 levels during the first commitment period (2008 – 2012) of the Kyoto Protocol.*

The CDM arrangement allows these Annex 1 industrialized countries with GHG reduction commitments to invest in emission reducing projects in developing countries as an alternative to what is generally considered more costly emission reductions in their own countries. In theory, the CDM allows for a drastic reduction of costs for the industrialized countries, while achieving the same amount of emission reductions as without the CDM. Critics argue the emission reductions may be less with CDM than without it as they may encourage unsustainable practices difficult to monitor lead to some manipulation of the data and corrupt practices. Those in favour of CDM say third party checking of monitored emission reductions ameliorates this problem. The CDM is supervised by the CDM Executive Board (CDM EB) and is under the guidance of the Conference of the Parties (COP/MOP) of the UNFCCC.

The emissions targets cover the six main greenhouse gases, namely:
• Carbon dioxide (CO2);
• Methane (CH4);
• Nitrous oxide (N2O);
• Hydrofluorocarbons (HFCs);
• Perfluorocarbons (PFCs); and
• Sulphur hexafluoride (SF6)

The maximum amount of emissions (measured as the equivalent in carbon dioxide) that a developed countries listed in Annex B of the Kyoto Protocol may emit over the commitment period in order to comply with its emissions target is known as a it's assigned amount.

Global energy related emissions of carbon dioxide (CO_2) are projected in the IEA Reference Scenario (IEA –WEO, 2006) to grow at a rate slightly higher than primary energy demand, i.e. at around 1.7 % per year from 2004 to 2030. Energy CO_2 emissions will reach some 40 giga-tonnes (GT) in 2030, an increase of 14Gt on 2004 levels. This creates a long term energy and environmental policy challenges to be formulated to provide affordable energy for economic and social development, on one hand, whilst, on the other hand, limiting the long-term growth in GHG emissions to the atmosphere.

The development and deployment of efficient and economic technologies offer a variety of potential solutions, including efficiency improvements, CO_2 capture and storage, use of biological sinks and development of commercially viable non-fossil fuel energy systems. The focus of climate change policies in most Annex B countries has to-date been on commitments to emission reduction targets (e.g. Table 1). Improving energy efficiency and switching, where possible, to less-polluting fuels are often the most cost-effective ways to reduce emissions substantially in the short-term. Systems for emissions' trading and other market based mechanisms have also been developed in the recent past to facilitate cost-effective emission reductions. As part of these efforts there have been attempts to identify CDM projects in Asian nations, particularly in the oil and gas industry.

Energy, Economic Development and Climate Related Asian Issues in CDM Context

Reflecting a rapid growth in demand fossil fuel consumption in developing countries, mainly in India and China on account of their sustained robust economic growth, are expected to surpass that of industrialized / OECD nations by about 2012 (IEA-WEO, 2006). Tables 2, 3 and 4 (data from IEA-WEO, 2006) summarize the energy supply, power generation and emissions status for developing Asia in relation to the total world and the developing world as a whole for 2004 (actual figures) and for 2030 (IEA-WEO reference case forecast). These figures explain why developing Asia is at the center of energy and carbon emissions issues.

Energy Supply, Power Generation & Emissions Forecast

	IEA - WEO 2004 (Actual)					IEA - WEO 2030 (Reference Case Forecast)				
Primary Energy Supply (Mtoe)	**Coal**	**Oil**	**Gas**	**Other**	**Total**	**Coal**	**Oil**	**Gas**	**Other**	**Total**
Total World	2773	3940	2302	2189	11204	4441	5575	3869	3210	17095
Developing World	1442	1317	567	1134	4460	2936	2490	1475	1718	8619
Developing Asia	1309	713	203	691	2916	2750	1482	522	1042	5796
China	999	319	44	264	1626	2065	758	157	415	3395
India	196	127	23	227	573	450	268	68	318	1104

Power Generation (TWh)	**Coal**	**Oil**	**Gas**	**Other**	**Total**	**Coal**	**Oil**	**Gas**	**Other**	**Total**
Total World	6917	1161	3412	5918	17408	14703	940	7790	10317	33750
Developing World	2753	580	983	1438	5754	8979	616	3389	4017	17001
Developing Asia	2442	222	406	688	3758	8423	211	1113	2418	12165
China	1739	72	19	407	2237	5980	54	169	1421	7624
India	461	36	63	108	668	1631	46	163	474	2314

CO_2 Emissions (Mt)	**Coal**	**Oil**	**Gas**	**Other**	**Total**	**Coal**	**Oil**	**Gas**	**Other**	**Total**
Total World	10625	10199	5254	0	26079	17293	14334	8793	0	40420
Developing World	5508	3392	1271	0	10171	11453	6349	3310	0	21111
Developing Asia	5071	1746	448	0	7265	10819	3694	1140	0	15653
China	3897	779	93	0	4769	8167	1924	334	0	10425
India	734	314	54	0	1103	1741	645	157	0	2544

Power Generation Component of CO_2 Emissions (Mt)	**Coal**	**Oil**	**Gas**	**Other**	**Total**	**Coal**	**Oil**	**Gas**	**Other**	**Total**
Total World	7600	934	2054	0	10587	12946	762	3972	0	17680
Developing World	3378	472	545	0	4395	7944	496	1713	0	10153
Developing Asia	3083	178	200	0	3462	7484	166	506	0	8156
China	2269	72	14	0	2355	5450	56	97	0	5603
India	572	26	30	0	629	1382	33	75	0	1490

Source Data: IEA - World Energy Outlook 2006 — *David Wood & Associates*

***Table 2**. Energy supply, power generation and emissions in absolute terms for 2004 and 2030 (IEA reference case forecast). The magnitude of developing Asia's contribution, China and India particularly, to energy consumption and emissions is clear.*

The World's primary energy supply is forecast to grow by 5891 million tones of oil equivalent (Mtoe) from 2004 to 2030 (IEA-WEO 2006). 83% of that global growth is expected to come from fossil fuels (coal, oil and gas) with 71% of the growth expected to occur in the Developing World. 49% of the World's primary energy supply growth is expected to come from Developing Asia (dominated by 30% from China and 9% from India). Some 88% of the energy supply growth in Developing Asia is forecast to come from fossil fuels – in China that figure is 91% whereas in India it is in line with the global average of 83%. For all the talk at political and senior scientific levels of weaning the planet off fossil fuels these figures emphasize the stark reality that for the next 25 years fossil fuels are expected to dominate energy supply growth unless drastic measures are taken.

Energy Supply, Power Generation & Emissions Forecast (%)

	IEA - WEO 2004 (Actual)					IEA - WEO 2030 (Reference Case Forecast)				
Primary Energy Supply (% of Total World)	**Coal**	**Oil**	**Gas**	**Other**	**Total**	**Coal**	**Oil**	**Gas**	**Other**	**Total**
Total World	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Developing World	52.0%	33.4%	24.6%	51.8%	39.8%	66.1%	44.7%	38.1%	53.5%	50.4%
Developing Asia	47.2%	18.1%	8.8%	31.6%	26.0%	61.9%	26.6%	13.5%	32.5%	33.9%
China	36.0%	8.1%	1.9%	12.1%	14.5%	46.5%	13.6%	4.1%	12.9%	19.9%
India	7.1%	3.2%	1.0%	10.4%	5.1%	10.1%	4.8%	1.8%	9.9%	6.5%
Power Generation (% of Total World)	**Coal**	**Oil**	**Gas**	**Other**	**Total**	**Coal**	**Oil**	**Gas**	**Other**	**Total**
Total World	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Developing World	39.8%	50.0%	28.8%	24.3%	33.1%	61.1%	65.5%	43.5%	38.9%	50.4%
Developing Asia	35.3%	19.1%	11.9%	11.6%	21.6%	57.3%	22.4%	14.3%	23.4%	36.0%
China	25.1%	6.2%	0.6%	6.9%	12.9%	40.7%	5.7%	2.2%	13.8%	22.6%
India	6.7%	3.1%	1.8%	1.8%	3.8%	11.1%	4.9%	2.1%	4.6%	6.9%
CO_2 Emissions (% of Total World)	**Coal**	**Oil**	**Gas**	**Other**	**Total**	**Coal**	**Oil**	**Gas**	**Other**	**Total**
Total World	100%	100%	100%	0%	100%	100%	100%	100%	0%	100%
Developing World	51.8%	33.3%	24.2%	0%	39.0%	66.2%	44.3%	37.6%	0%	52.2%
Developing Asia	47.7%	17.1%	8.5%	0%	27.9%	62.6%	25.8%	13.0%	0%	38.7%
China	36.7%	7.6%	1.8%	0%	18.3%	47.2%	13.4%	3.8%	0%	25.8%
India	6.9%	3.1%	1.0%	0%	4.2%	10.1%	4.5%	1.8%	0%	6.3%
Power Generation Component of CO_2 Emissions (% of Total World)	**Coal**	**Oil**	**Gas**	**Other**	**Total**	**Coal**	**Oil**	**Gas**	**Other**	**Total**
Total World	100%	100%	100%	0%	100%	100%	100%	100%	0%	100%
Developing World	44.4%	50.5%	26.5%	0%	41.5%	61.4%	65.1%	43.1%	0%	57.4%
Developing Asia	40.6%	19.1%	9.7%	0%	32.7%	57.8%	21.8%	12.7%	0%	46.1%
China	29.9%	7.7%	0.7%	0%	22.2%	42.1%	7.3%	2.4%	0%	31.7%
India	7.5%	2.8%	1.5%	0%	5.9%	10.7%	4.3%	1.9%	0%	8.4%

Source Data: IEA - World Energy Outlook 2006 — *David Wood & Associates*

***Table 3**. Energy supply, power generation and emissions in percentage terms for 2004 and 2030 (IEA reference case forecast). The magnitude of developing Asia's contribution, China and India particularly, to energy consumption and emissions is clear.*

Developing countries are forecast to account for some 76% of CO_2 emissions increase (rising from 39% in 2004 to some 52% of global emissions by 2030) due to their more carbon-intensive energy consumption. China's emission, according to the IEA forecasts (2006), is expected to more than double from 2004 to 2030 (with strong economic growth driven mainly by coal). China is therefore forecast to overtake the US as the biggest CO_2 emitter before 2010. Developing Asia is expected to contribute some 58% of CO_2 emissions from 2004 to 2030. China and India, on their own, are forecast to be responsible for some 39% and 10%, respectively, of the rise in global emissions from 2004 to 2030.

Energy Supply, Power Generation & Emissions Growth Forecast

	IEA - WEO Reference Case Growth 2004 to 2030 (Forecast)					IEA - WEO Reference Case Growth (% of Total World Growth)				
Primary Energy Supply (Mtoe)	**Coal**	**Oil**	**Gas**	**Other**	**Total**	**Coal**	**Oil**	**Gas**	**Other**	**Total**
Total World	1668	1635	1567	1021	5891	100%	100%	100%	100%	100%
Developing World	1494	1173	908	584	4159	90%	72%	58%	57%	71%
Developing Asia	1441	769	319	351	2880	86%	47%	20%	34%	49%
China	1066	439	113	151	1769	64%	27%	7%	15%	30%
India	254	141	45	91	531	15%	9%	3%	9%	9%
Power Generation (TWh)	**Coal**	**Oil**	**Gas**	**Other**	**Total**	**Coal**	**Oil**	**Gas**	**Other**	**Total**
Total World	7786	-221	4378	4399	16342	100%	100%	100%	100%	100%
Developing World	6226	36	2406	2579	11247	80%	-16%	55%	59%	69%
Developing Asia	5981	-11	707	1730	8407	77%	5%	16%	39%	51%
China	4241	-18	150	1014	5387	54%	8%	3%	23%	33%
India	1170	10	100	366	1646	15%	-5%	2%	8%	10%
CO2 Emissions (Mt)	**Coal**	**Oil**	**Gas**	**Other**	**Total**	**Coal**	**Oil**	**Gas**	**Other**	**Total**
Total World	6668	4135	3539	0	14341	100%	100%	100%	0%	100%
Developing World	5945	2957	2039	0	10940	89%	72%	58%	0%	76%
Developing Asia	5748	1948	692	0	8388	86%	47%	20%	0%	58%
China	4270	1145	241	0	5656	64%	28%	7%	0%	39%
India	1007	331	103	0	1441	15%	8%	3%	0%	10%
Power Generation Component of CO2 Emissions (Mt)	**Coal**	**Oil**	**Gas**	**Other**	**Total**	**Coal**	**Oil**	**Gas**	**Other**	**Total**
Total World	5346	-172	1918	0	7093	100%	100%	100%	0%	100%
Developing World	4566	24	1168	0	5758	85%	-14%	61%	0%	81%
Developing Asia	4401	-12	306	0	4694	82%	7%	16%	0%	66%
China	3181	-16	83	0	3248	60%	9%	4%	0%	46%
India	810	7	45	0	861	15%	-4%	2%	0%	12%

Source Data: IEA - World Energy Outlook 2006 — *David Wood & Associates*

Table 4*. Energy supply, power generation and emissions growth in absolute and percentage terms for 2004 and 2030 (IEA reference case forecast). Developing Asia's growing contribution, China and India particularly, to energy consumption and emissions is clear.*

In spite of substantial increases in energy consumption per capita emissions from the Developing World are expected to continue to remain low during the 2004 to 2030 period. Nevertheless, in

Developing Asia CO_2 emissions are expected to increase from some 28% to 39% of the global total. China's contribution to CO_2 emissions is set to increase from some18% to 26% of the global total (an increase of some 5.7 billion tones). In percentage terms India's projected emissions increase at 131% from 2004 to 2030 is the greatest of any country (China 119%, Developing Asia 115%; Total World 55%) and is due mostly to growing electricity demand and continued heavy reliance on coal for power generation. China and India are projected to be responsible for 46% and 12%, respectively, of the World's CO_2 emissions from power generation from 2004 to 2030.

In spite of its growing thirst for energy, the World Economic Forum has noted that more than 500 million people in Southern Asia still live on less than US $ 1 per day, and that the provision of affordable and reliable energy to communities currently without access to electricity remains the key requirement for regional development. For this reason climate change mitigation is understandably not a short-term priority for Southern Asia or most of the Developing World. Rather the provision of primary education, medical facilities, regular employment, clean water supplies and proper sanitation are understandably taking priority on national development agendas in most of the Asian, African and Latin American countries. Climate change strategies therefore have to be considered within the context of these broader identified and pressing national sustainable development priorities.

Potential CDM Objectives in the Asian Context

CDM project objectives are focused to: encourage technology transfer; promote sustainable development, reduce GHGs and assist Annex – B parties to cost effectively meet their Kyoto Protocol obligations. The CDM potential among Asian Nations is considerable. In terms of carbon accounting, the emission reduction potential among Asian Nations, and India and China in particular, is on the order of hundreds of million of tones of CO_2, with large scale CDM Projects including:

- Fuel switching from coal to oil and gas;
- CO_2 capture and geological sequestration;
- Exploiting Liquefied and Compressed Natural Gas (LNG or CNG) technologies for importing natural gas;
- Exploitation of CNG to replace refined products for vehicular transportation;
- Reduction of flaring and venting of associated gas during oil production;
- Building facilities to produce biofuels and research to develop more efficient biofuel sources and processes

The establishment of Designated National Authorities (DNAs), responsible for reviewing, recommending and submitting projects for approval to the CDM Executive Board, which are registered to the UNFCC Secretariat, are being created among Asian nations (e.g. India). Current activity, however, seems to remain focused on small-scale emission reduction projects, particularly renewable energy (i.e., hydro, solar, wind, biomass, and geothermal) and energy efficiency projects. While such projects are clearly worthwhile some 90% of the problem lies within the realms of fossil fuel production and consumption. A diverse range of candidate CDM projects may be identified. The salient features in the Asian context are as below:

- Under the domain of Hydrocarbon Energy Business, most of the CDM Projects are being identified across the continent, under petroleum exploration and production operations.
- Project identification emphasizes the environmental and emissions reduction benefits of CDM.
- As CDM projects progress through to implementation, more emphasis is required on the need for sustainable development and poverty elimination, under national developmental agenda.
- The emphasis is being evolved to develop sustainable energy portfolios by incorporating increasing proportion of renewable energy mix. Such a strategy is aimed at providing energy security and energy independency in the longer term, reducing dependence on fossil fuels and, in environmental and climatic dimensions, promoting the use of carbon free fuel.
- There is an urgent need to develop local capacity and expertise to facilitate CDM implementation.
- Future CDM investments are expected to come from a variety of sources, including Annex B Governments (e.g. The Netherlands, Norway, and Canada), multinational corporations, International Financial institutions (e.g. World Bank Prototype Carbon Fund – PCF), Development Agencies (e.g. UNDP), and local and national companies.
- Further clarity on procedural and project related CDM issues will be required before significant levels of investment, trading in Certified Emissions Reduction Credits (CERs), or technology transfer occur.
- Projects must be based on sound economies, as the generation of CERs will in most cases affect economic returns only at the margins.

CDM Issues Requiring Further Clarification

These include:

- Clearer guidance on project eligibility criteria
- Acceptable methodologies for calculating emissions baselines
- Criteria for determining whether projects meet additionality criteria
- Timeframe for processing and approving projects
- Project information requirements
- Level of transaction costs
- Future price of Certified Emissions Reductions (CERs) in Emissions Trading Schemes

Oil and Gas Industry Considerations for CDM Activities at Carbon Energy Business

It has been emphasized world-wide that large scale CDM projects have substantial emission reduction and technology transfer potential, but these are currently receiving little attention at the international negotiating level, resulting in a lack of focus at national levels. The oil and gas industry is particularly well suited to developing large-scale projects with significant emissions reduction potentials. The examples include:

- Energy efficiency improvements along the supply chain
- Utilization of associated gas that has been previously flared or vented
- Large scale fuel switching projects (e.g. from coal to oil and natural gas)
- Carbon dioxide capture and geological (or other) storage
- Applications of modern efficient technologies

However, it is noted that these types of projects currently face technical challenges (e.g. defining baselines and determining additionality) and that their political acceptability / priority remains uncertain (e.g., CDM eligibility, technical and economic analysis and approval processes). Tables 2, 3 and 4 illustrate the opportunity offered by the gas industry, in which global supply is projected to grow more rapidly (i.e. 68% versus 41% for oil and 60% for coal) than any other fossil fuel sector in the period 2004 to 2030. In Developing Asia gas supply is forecast to grow at 157% in that period (China 257% and India 196%, both from a low base in 2004). Encouraging more gas-fired power generation projects to replace coal-fired capacity in developing Asia under the CDM scheme could make a real impact on emissions and energy efficiency.

Key Messages

1. The alleviation of poverty and the provision of clean water, health services, sanitation facilities and primary education are key priorities in the developing Asian nations, including India and China. With 1.60 billion people worldwide lacking access to electricity, the provision of affordable energy is a key requirement for economic and social development among Asian Nations. Actions to mitigate the long-term risk of climate change must be considered within the context of such developmental priorities.

2. Reflecting increasing developments, among Asian nations in general, and India and China in particular, energy demand is forecast to grow rapidly over the period of 2004 to 2030. Projections show that this increased demand will met primarily by increased consumption of oil, natural gas and coal. The result is a fundamental challenge to meet developmental goals, whilst at the same time addressing greenhouse gas (GHG) emissions. The global deployment of existing technologies that result in the low GHG emissions, and the development of the improved technologies are the key elements in addressing these challenges.

3. The Clean Development Mechanisms (CDM) of the Kyoto Protocol provides one pathway to encourage technology transfer, promote sustainable development, and reduce GHG emissions. Through the transfer of CDM – Certified Emissions Reductions Credits (CERs), it also aims to assist developed countries to cost effectively meet their obligations under Kyoto Protocol. There is considerable emissions reduction potential for CDM Projects in Asia as a whole, and India and China in particular. The current focus, however, remains on small-scale energy efficiency improvement and renewable energy schemes. This focus needs to shift to large-scale fossil fuel projects, particularly those power generation projects replacing coal with gas.

4. Whilst capacity for governments and companies among Asian Nations to address the CDM and the development of CDM projects have increased over the past few years, individual nations still vary in their capacity to review CDM Projects. Some of the Asian countries, including India and China have clearly developed greater capacity to facilitate the development and review of such projects. Such countries have established or are planning the establishment of, Designated National Authorities (DNAs), which serve to ensure that the identified projects serve national sustainable development priorities. A way government can play a key role in CDM project development is by facilitating agreements between multilateral funding agencies, such as UNDP, UNEP, Asian Development Bank or World Bank, and the private sector, which satisfy national sustainable development objectives.

5. There currently remain economic, methodological and institutional barriers to private sector investment in CDM Projects. Uncertainties about the rules surrounding the CDM have progressed from the more hypothetical concerns about additionality and baselines, or more

practical concerns about institutional capacity to process project applications in a timely and cost-effective manner. While concerns and detailed issues about additionality and baselines have not disappeared, the development of more projects, and the series of international negotiations and clarification of proposed rules and processes have led to an improved understanding of the CDM since recent past. However, the range of CDM Projects that might be awarded CERs in the future still remains unclear.

6. Future CDM investment, among Asian Nations is expected to come from a variety of sources, including Annex B Governments, Multinational Corporations, International Financial Institutions (World Bank, Asian Development Bank), Developmental Agencies (e.g. UNDP), and local and national energy companies. Investments in CDM Projects will however be dwarfed by the overall investment in energy, especially in Asia, through to the end of the Kyoto Protocol's first commitment period in 2012. Over the next decade, the petroleum industry will make investments leading to development, the transfer of technology, and emissions reductions or avoidance that will go far beyond those that are likely to be granted credits under the Kyoto Protocol. In this regard the petroleum industry should be recognized and politically embraced as a key part of the emissions reduction solution not just a punitive taxation target for being part of the problem.

7. Emission Reduction Targets and timetables specified by the Kyoto Protocol are for the first commitment period from 2008 – 2012. It remains unclear what International Framework may evolve after that and what future obligations might be undertaken by the developing countries. The development and deployment of technologies that result in significant emissions reductions need to be key part of any future energy strategy for Developing Asia, but it remains unclear whether an effective of International Framework will be universally ratified.

Convergence of Global Strategies for Energy, Environmental and Carbon Emissions Required

Growing efforts to restrict carbon emissions to limit climate change impacts are leading to the recognition of the need for more integrated energy and environmental policy approaches trying to achieve long-term sustainable energy supply beyond the first half of the 21st century. Continuation of the 20th century carbon-dominated economy without measures to mitigate rising carbon emissions and replacement of depleting fossil fuel resources increasingly seems to be an unrealistic option.

A consensus has emerged among scientists regarding the potential impacts of emissions on the climate. In pre-industrial times CO_2 concentration was about 280 ppm. This has risen, rapidly since 1960 to greater than 380ppm (by volume). Concentrations of methane (CH_4) have risen 750 ppb (by volume) to >1750 ppb. These increases in CO_2 and CH_4 are the main cause of the anthropogenic (human induced) global greenhouse effect on the atmosphere. Many scientists believe that if CO_2 concentrations rise above ~550 ppmv the associated temperature rise will lead to irreversible melting of the Greenland ice sheet and some 7-metre rise in sea level will become unpreventable. Some take a more negative view (e.g. Pierce, 2006) that humankind has already injected about 200 billion tonnes of CO_2 into the atmosphere since the industrial revolution. The atmosphere now holds some 800 billion tonnes CO_2 and will probably exceed a critical threshold of 850 billion tonnes CO_2 by 2020 and an almost certain tipping point of 1 trillion tones CO_2 by 2050.

Earth has existed for most of its geological history in two contrasting but relatively stable states: 1) icy cold; 2) scorching hot and has periodically switched between the two rapidly. A wobble in the planets orbit around the sun and/or volcanic activity (i.e., sudden changes in solar radiation levels reaching the Earth) may have triggered the state change switch periodically in the past. It seems to have involved a shift of some 200 billion tonnes of CO_2 between oceans, land and atmosphere. Through anthropogenic emissions we are stimulating the current wobble between states. A warming Earth and retreating permafrost could then release frozen methane from Siberian peat bogs. Warmer more acidic oceans could regasify and release methane clathrate (hydrates) from the currently cool deep ocean. Both events will then push the Earth into a hot state from, which it cannot be easily returned.

Such Doomsday scenarios explain why long-term energy and environmental policy and emissions control regulations are so high on the agenda of many governments. Many believe that in the 21st century it will necessary to limit cumulative anthropogenic carbon emissions in the form of CO_2 (largely from fossil fuel combustion) from 1991 to 2100 to some 1,000 giga-tonnes in order to stabilize atmospheric CO_2 concentrations at 550 ppmv. Table 5 outlines the remaining fossil fuel reserves and their associated carbon contents. There is much uncertainty in these figures with most confidence in the proved reserves, which for oil gas and coal collectively, amount to some 950 billion tones of oil equivalent (Gtoe) that contain some 900 million tones of carbon (MtC).

Remaining Recoverable Fossil Fuel Reserves & Their Carbon Contents

Hydrocarbon Resource Type	Proved Reserves	Units	Proved (Gtoe)	3P Lowside Estimate	Units	3P Lowside (Gtoe)	3P Highside Estimate	Units	3P Highside (Gtoe)	Carbon Content Proved Reserves	Carbon Content 3P Lowside (Mt)	Carbon Content 3P Highside (Mt)
Natural Gas	6348	tcf	165	15000	tcf	390	25000	tcf	650	102	240	400
Natural Gas Liquids (NGL)	200	Gbarrels	20	500	Gbarrels	50	1000	Gbarrels	100	15	38	75
Conventional Oil	1000	Gbarrels	140	1750	Gbarrels	245	2900	Gbarrels	406	120	211	349
Heavy Oil	400	Gbarrels	69	1000	Gbarrels	172	1950	Gbarrels	336	61	153	299
Extra-Heavy Oil	200	Gbarrels	34	1500	Gbarrels	259	3250	Gbarrels	560	31	230	499
Oil Sand & Bitumen	400	Gbarrels	69	2000	Gbarrels	345	3900	Gbarrels	672	61	307	598
Total Commercial Oil	**2200**	**Gbarrels**	**332**	**6750**	**Gbarrels**	**1071**	**13000**	**Gbarrels**	**2075**	**289**	**939**	**1821**
Total Commercial Oil + Gas			**498**			**1461**			**2725**	**390**	**1179**	**2220**
Oil Shales (not commercial)				2000	Gbarrels	345	4000	Gbarrels	690	0	307	614
Hard Coal	479	Gtonnes	239	750	Gtonnes	375	1500	Gtonnes	750	263	413	825
Brown Coal	430	Gtonnes	215	750	Gtonnes	375	1500	Gtonnes	750	237	413	825
Total Coal	**909**	**Gtonnes**	**455**	**1500**	**Gtonnes**	**750**	**3000**	**Gtonnes**	**1500**	**500**	**825**	**1650**
Total Hydrocarbons			**952**			**2556**			**4915**	**890**	**2311**	**4484**

Unit Conversions:	3P = Proved + Probable + Possible
1 tonne (average) crude oil	7.14 barrels (Average~ 29 degree API)
1 bcf natural gas	0.026 million tonne of oil equivalent (toe)
1 tonne of NGL	10 barrels
1 tonne bitumen	5.8 barrels
1 tonne coal	0.5 toe G = billion

Approximate Carbon Contents million tonnes carbon (Mt) / Mtoe:		
Natural Gas	0.62	Mt/Mtoe
NGL / LPG	0.75	Mt/Mtoe
Crude Oil	0.86	Mt/Mtoe
Bitumen	0.89	Mt/Mtoe
Coal	1.10	Mt/Mtoe

Data Sources: Various (including BP, EIA, Schlumberger) *David Wood & Associates*

Table 5. *Remaining reserves of fossil fuels and their carbon contents. It is important to consider the potential impact of the non-proven (i.e. probable and possible) components of reserves in addition to the proven values and these will in the longer term, at least in part contribute to carbon emissions. Natural gas reserves ignore naturally occurring gas hydrates (clathrate deposits).*

However, potential emissions from hydrocarbon reserves go far beyond the proved component. Table 5 shows high-side and low-side estimates for the 3P (proved plus probable plus possible) fossil fuel reserves that may become technically recoverable of the course of the 21st century. The estimates range from approximately 2500 to 5000 Gtoe of reserves involving up to 4500 MtC. Unconventional heavy oil, tar sand, bitumen and oil shale account for some 25% of these resources. Indeed by including these unconventional oil resources in the remaining oil reserves it becomes apparent that the imminent decline in conventional oil resources might possibly be offset in resource volume terms. At face value the reserves to production ratios using 3P reserves estimates for all the fossil fuels approach 200 years implying that there are probably more than enough fossil fuels to meet medium-term energy demands. However, such a conclusion is somewhat misleading. It is necessary to consider the net energy available from a specific type of fossil fuel resource and the emissions it will generate. To do this it is necessary to take account of the energy used and emissions generated to find, extract, process and deliver that resource to energy consumers and then subtract that amount from the amount of energy the resource contains.

It takes some two barrels of oil equivalent to obtain three barrels of usable oil from oil sands. This compares with one barrel of oil equivalent consumed to deliver 20 barrels of conventional oil from a developed oil field and 8 barrels of conventional oil from a yet to be developed oil field. Hence it is going to become more costly, time-consuming and generate more emissions per energy unit supplied to use these more difficult to access fossil fuel reserves. This implies that we are less likely to run out of fossil fuels in volumetric terms before the economic and environmental cases for continuing to extract them become prohibitively expensive. The need to find cheap, low-emissions alternative energy sources to replace the planets dependence on fossil fuels during the 21st century remains compelling.

Moreover, there are practical solutions with emerging technologies that might make it possible to initially cap and then progressively reduce CO_2 emissions, while we continue to rely on fossil fuels. Even if major political initiatives are made now (e.g. to promote hydrogen and nuclear power driven economies) there is a considerable lead-time for a substantial conversion of the global energy system to sustainable and carbon-free sources of power. Therefore, it seems essential that while reliance on the conventional hydrocarbon resources persists the application of technologies that eliminate carbon emissions from coal and capture emissions from large-scale fossil fuel burning sites should be promoted by energy policy. The environmentally prudent emissions policy is to follow the IPCC recommendations attempting to limit cumulative emissions of carbon in the form of CO_2 between 1991 to 2100 to 1,000 giga-tonnes. To do this requires major technology changes, particularly in developing Asia, which is heavily dependent on coal for power generation.

Carbon capture technologies offer possibilities, but these involve substantial cost. In such schemes fossil fuels are first converted to hydrogen and CO_2. The CO_2 is sequestered in suitable geological formations, coal beds, or in the deep ocean. The vision is to then use the hydrogen for extremely efficient power generation and as a regional source of surface transport fuel. This is route to a carbon emission free "Hydrogen Economy" is itself unsustainable in the long-term because of the finite nature and increasing cost of extracting and handling fossil fuels and their emissions. However, such an approach would increase the lead-time to achieve such an economy by many decades during which new technologies, such as energy-efficient extraction of hydrogen from water and nuclear fusion, obviating the need for fossil fuels, could be developed. The energy supply mix of the future must strive to promote carbon emission free and sustainable sources of energy integrating wind, photovoltaic and thermal-solar, hydro, nuclear, biomass in addition to reducing emissions from remaining fossil fuel resources.

Natural gas is the most attractive fossil fuel to exploit as a transition fuel to a lower carbon – emission energy mix on account of its low carbon intensity and abundant reserves (Table 5). It offers the most energy efficient fuel for power generation combined with low particulate, acid gas and CO_2 emissions. As the most hydrogen-rich fossil fuel it is the most energy-efficient source of hydrogen available. A sensible transition strategy for next few decades at least involves optimizing the contribution of natural gas to global energy supply. To do this a substantial amount of the 15,000 tcf or so (Table 5) of probable and possible reserves, much of this currently stranded in remote locations, must be upgraded to the proved category. This will involve investment in long distance pipelines, gas liquefaction (LNG) supply chains, gas-to-liquid plants, compressed natural gas (CNG) marine transportation and research and development into potentially transporting and storing natural gas in hydrate form.

Energy Supply Forecasts to 2030 Only Tell Part of the Story

Table 6 summarizes global energy dependence on fossil fuels and highlights how Developing Asia is more dependent on coal than the rest of the World – by 2030 global average energy supply is forecast to be 26% coal and 23% gas, whereas for Developing Asia supply is forecast to be 47% coal and 9% gas. Average annual growth rates for energy supply to 2030 are forecast to be substantially higher (2.7%) in Developing Asia than for the World as a whole (1.6%). Therefore there is plenty of scope in Asia to further develop natural gas supply chains to substitute for coal and make a significant positive impact on global CO_2 emissions.

Primary Energy Supply Status & Forecast

	2004 Actual		2030 Forecast		Annual Growth (%) from 2004 to 2030
Total World	**Mtoe**	**%**	**Mtoe**	**%**	**% / Year**
Coal	2773	25%	4441	26%	1.8%
Oil	3940	35%	5575	33%	1.3%
Gas	2302	21%	3869	23%	2.0%
Nuclear	714	6%	861	5%	0.7%
Hydro	242	2%	408	2%	2.0%
Biomass / Waste	1176	10%	1645	10%	1.3%
Other Renewables	57	1%	296	2%	6.6%
Total	**11204**	**100%**	**17095**	**100%**	**1.6%**
Developing Asia	**Mtoe**	**%**	**Mtoe**	**%**	**% / Year**
Coal	1309	45%	2750	47%	2.9%
Oil	713	24%	1482	26%	2.9%
Gas	203	7%	522	9%	3.7%
Nuclear	29	1%	122	2%	5.7%
Hydro	47	2%	126	2%	3.9%
Biomass / Waste	600	21%	717	12%	0.7%
Other Renewables	15	1%	78	1%	6.6%
Total	**2916**	**100%**	**5797**	**100%**	**2.7%**

Source Data: IEA - World Energy Outlook 2006 — *David Wood & Associates*

Table 6. *Energy supply status and forecast to 2030 for the World and Developing Asia by IEA suggest fossil fuels will continue to dominate (>80%). Such forecasts provide little indication of the massive changes in energy supply that must follow in the mid to late 21st Century if emissions related environmental damage and high cost energy are to be avoided.*

A key priority should be given to projects in Developing Asia that confirm and exploit CO_2 storage capacity in geological formations and verify the economic viability of carbon capture from natural gas and clean coal power generation projects. Realistically coal and natural gas with higher remaining reserves than oil, that can be exploited at lower cost than heavy oil and tar sands, should become the focus of sustainable medium-term energy policies, combining their exploitation with carbon emission mitigation technologies.

Sharing the Burden of Emissions Reduction

It is very difficult to establish an effective, popular and fair continent-wide emissions cap and trade system. The EU-wide emissions' trading scheme so far focuses on energy - intensive sectors, although it frequently gets side-tracked by political issues that have only marginal bearing on the overall emissions problems (e.g. in 2006 the Aviation contributed about 1.6% of global CO_2 emissions, yet EU governments have become pre-occupied with trying to tax easy targets, such as the aviation sector, rather than concentrating on promoting energy efficiency in power generation, domestic and road transportation sectors). It is important to understand how energy consumption is distributed across industry sectors. Table 7 provides a breakdown of energy use by sector globally and for Developing Asia using IEA figures for 2004 and their forecast for 2030. Developing Asia burns more energy in industry and less in transportation that the rest of the world. Power generation and industrial energy consumers would seem to be the obvious prime target for emissions trading in Developing Asia. However, forecasts of a rapid growth in personal motor vehicles across the Developing World suggest that transportation sector cannot be ignored. Transportation emissions pose more difficult emissions problems to mitigate. It is impossible to sequester emissions from millions of small moving vehicles. High engine efficiency, flexi-fuelled and hybrid vehicles, and clean low-emissions fuels such as biofuels, CNG, LPG and GTL derived fuels offer the most scope for emissions reduction in the transportation sector.

Final Energy Consumption By Sector

	2004 Actual		2030 Forecast		Annual Growth (%) from 2004 to 2030
Total World	**Mtoe**	**%**	**Mtoe**	**%**	**% / Year**
Industry	2511	33%	3932	34%	1.7%
Transport	1969	26%	3111	27%	1.8%
Other Energy	2905	38%	4221	36%	1.4%
Non-Energy Use	254	3%	400	3%	1.8%
Total	**7639**	**100%**	**11664**	**100%**	**1.6%**
Developing Asia	**Mtoe**	**%**	**Mtoe**	**%**	**% / Year**
Industry	756	38%	1551	40%	2.8%
Transport	265	13%	741	19%	4.0%
Other Energy	857	43%	1363	36%	1.8%
Non-Energy Use	96	5%	178	5%	2.4%
Total	**1974**	**100%**	**3833**	**100%**	**2.6%**

Source Data: IEA - World Energy Outlook 2006 *David Wood & Associates*

Table 7. *Final energy consumption by sector. IEA's status and forecast to 2030 for the World and Developing Asia. "Other energy" consuming sector combines residential, service and agriculture sectors. The figures suggest that there is substantial potential for the transport sector in Developing Asia to expand its energy consumption as economies grow and more affluent populations own personal road transportation vehicles.*

The key objective of evolving emissions' regulations and cap and trade schemes should be to promote cost-efficiency in reaching emissions reductions targets and international commitments. Emissions reduction is likely to take place where it can be achieved at the lowest unit cost. Regulation needs to recognize this or risk making its industry uncompetitive globally. Schemes also need to motivate the entire population to save energy and promote energy efficiency and emissions reduction, albeit on a smaller scale, if the achievements of emissions reductions are to be widely valued and appreciated. This implies that while energy intensive sectors need to be the major contributors to the emissions reduction schemes, partial contributions are also required by all segments of economies, including residential energy consumers that should be ultimately incorporated in domestic emissions' regulations. Promoting the construction of energy-efficient residential, office and industrial buildings and other schemes to reduce energy waste have to be progressed in conjunction with cap and tax emissions trading schemes in order to have maximum impact on energy emissions.

The tables and figures in this study provide the details of why Developing Asia is so important in global efforts to mitigate carbon emissions and establish a sustainable energy balance. The Clean Development Mechanism (CDM) of the Kyoto Protocol to The United Nations Framework Convention on Climate Change (UNCCC) offers a pathway, through Certified Emissions Reductions (CERs) in emissions trading schemes, to promote sustainable developments in Developing Asia and to assist developed nations to cost-effectively meet their commitments under the Kyoto Protocol. These mechanisms should be embraced and offer opportunity for both public and private sector organizations to shape economic growth in an environmentally responsible manner.

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