KEYNOTE ADDRESS

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TOWARD A POLICY AGENDA FOR CLIMATE CHANGE

Changing Technologies and Fuels against a Background of a Changing Value of Energy

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Given the vast and relevant experience of my audience, I am going to make the assumption that the need for action on climate change is accepted. I will share some trends, suggest some interpretations that arise from them and offer you some of my personal thinking towards future strategy for transportation energy and policy in the context of climate change. I am not going to make any startling corporate revelations; nor should what I say be taken as setting out a BP position, policy or strategy.

If more of my examples come from China than might seem warranted, I ask for your forbearance given that this country has been the focus of much of my work for the last year. Hopefully you will agree that the inferences that may be drawn from China can to a considerable extent be applied in a wider context of the non-OECD world and from that the implications that they have for Europe and North America.

Global Societal Trends

I will start by considering some global societal trends.

<u>Population:</u> (Fig 1) the UN forecasts that world population will rise from 6.5 billion today to 9.1 billion in 2050 (medium forecast). Today 95% of all population growth is absorbed by the developing world[1].

[1] UN Department of Economic and Social Affairs Population Division – World Population Prospects: The 2004 Revision (highlights)

Urbanisation: there is a widespread trend of urbanisation in the developing world. (Fig 2) In China it is forecast that between 2005 and 2030 the urban proportion of the population will rise from 36% to 60%[2]; to put this into further context that amounts to 10 million new urban dwellers per year or about 27,400 per day for the next 25 years.

Worldwide it is forecast that by 2015 there will be more than 368 cities with populations of more than 1 million[3]. And the growth of mega-cities (urban agglomerations of more that 10 million inhabitants) has gone from 5[4] in 1975 to 14[5] in 1995 and is projected to reach 26[6] by 2015[7]. A considerable majority of these mega-cities are in the developing world.

Incomes: associated with economic development, and arguably one of the causes of the trend of urbanisation, is the higher earnings potential of urban dwellers. (Fig 3) Again using a Chinese, example between 1997 and 2003 the per capita income ratio between rural and urban incomes rose from ca. 2.5 to ca. 3.7[8]. Thinking of the theme of our conference a frequent demonstration of new found wealth is in personal transportation leading to more (and often bigger) cars in cities; and that despite the traffic jams, and the 2.5 billion gallons of fuel that are wasted in them every year[9].

Energy: (Fig 4) while fossil fuels are far from running out they are a finite resource. Increasingly, conventional oil and gas is located in remote locations and/or in areas of political sensitivity. (Fig 5) There is also a distinct regional imbalance between consumption and reserves. (Fig 6) And on top of that it is very reasonable to forecast that as developing countries achieve their aspirations for economic development, growing personal affluence, coupled with the multiplying factors of population growth and urbanisation will lead to a huge increase in energy demand.

In the developed world for the last century we have increasingly taken energy for granted, and there has been a move away from dirty coal to cleaner oil and gas. (Fig 7) It is no secret that in energy as in so many other aspects of life there is a divide between the developed and the less developed worlds. (Fig 8) As we address poverty we have to confront the reality that in conventional

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[2] UN Department of Economic & Social Affairs
[3] C.K. Prahalad – the Fortune at the Bottom of the Pyramid, p12
[4] Tokyo, New York, Shanghai, Mexico, San Paolo
[5] as above plus Mumbai, Los Angeles, Calcutta, Buenos Aires, Soul, Beijing, Osaka, Lagos, Rio de Janiero
[6] as above plus Dhaka, Karachi, Delhi, Manila, Cairo, Jakarta, Tianjin, Istanbul, Hangzhou, Hyderabad, Tehran, Lahore
[7] Times Concise Atlas of the World 2000
[8] World Bank – China Survey
[9] Jerome Glenn, RSA Journal, August 2005, p21

terms a more prosperous world consumes more energy. (Fig 9) Indeed, the World Business Council for Sustainable Development (WBCSD) has forecast that if the UN goal to eliminate extreme poverty is to be met, global energy demand will increase over the period 2000 to 2050 by a factor of between 2 and 3, with the greater demand associated with the greater reduction in poverty[10]. As we consider how we should move on from the present position we should not forget the very considerable investment in energy infrastructure, replacement of which needs to be carefully considered in any plans for change.

<u>Transportation:</u> turning to the theme of this conference series, Transportation and Energy, a major element of this increase in energy demand will be driven by an increasing expectation for the access and mobility that the developed world takes for granted. (Fig 10) Work by the IEA has shown that in 2002 transport accounted for ca. 27% of world energy demand, with almost all of this being met by oil[11].

(Fig 11) Hidden in the wealth of data that was generated for the WBCSD Sustainable Mobility Project (SMP)[12] is a forecast that the total global vehicle stock will increase from 683 million to 2009 million over the period 2000 to 2050 and that the proportion of vehicles in the developing world will increase from 21% (146.1 million vehicles) to 61% (1216.9 million vehicles) - that is a 833% increase in non-OECD vehicles compared with a 147% increase in OECD countries. This raises some fairly significant questions regarding where vehicles will be made, the energy that will fuel them and the policies and technologies that will be adopted in their manufacture.

<u>Overall</u> these trends present an energy challenge that is quite stark and has three potential solutions;

- Increase the supply of energy – leave it to the technologists, with an increasing emphasis on unconventional fossil fuel derivatives and renewables, almost certainly including nuclear
- Decrease demand - through efficiencies and personal behaviours; I would argue that there are plenty of easy wins, but it is not something that many politicians find easy to tackle

[10] World Business Council for Sustainable Development, Facts and Trends to 2050, Energy and Climate Change, September 2004

[11] IEA World Energy Outlook 2004

[12] World Business Council for Sustainable Development, Sustainable Mobility Project report; Mobility 2030:
Executive Summary: www.wbcsd.org/web/publications/mobility/exec-summary.pdf
Overview: www.wbcsd.org/web/publications/mobility/overview.pdf
Full report: www.wbcsd.org/web/publications/mobility/mobility-full.pdf

- A combination of the two - obvious, but it is easy to be lulled into a false sense of security when each "side" assumes that the other is taking the lead

The lesson that I draw from this is that we need to be very clear on what is expected and from whom.

Present and Emerging Policy Trends

I will now consider, at a very broad level, some policy trends.

In most countries of the world we have seen the introduction of lead-free gasoline. (Fig 12) In many places there are currently step changes in the reduction of sulphur in transport fuels. Albeit there is still a lot of work to be done on the wider health impacts of transportation there is a general acceptance that emissions from automobiles (both LAQ and GHG) have health impacts and consequent costs. The resulting policy work in itself is an interesting example of integrated and holistic thinking leading to win-win solutions – e.g. low sulphur fuels enabling the use of improved catalytic exhaust after-treatment. How this translates into the developing world is another matter. Kuznet's curve[13] relating ambient sulphur dioxide levels to per capita income shows how environmental and sociological drivers of policy change through the phases of economic growth.

On GHG emissions and climate change we see Europe taking a lead; for example in creating the EU ETS. But this is not an easy lead. With a tendency toward short-termism, it is far more difficult for people on a personal basis to make the link between their individual actions and global climate change. I am sure that there is good intent, but the auto manufacturers find it difficult to keep to voluntary targets while there is a public appetite for ever larger, more powerful and more sophisticated vehicles – and not much policy incentive to restrict such indulgence for a relatively affluent population.

An exception to this has been in dieselisation in Europe. For many years in most European countries, especially France, diesel was cheaper than gasoline, albeit at the time this was not for reasons of GHG reduction. In some countries (e.g. UK) legislation has been introduced that penalises high CO_2 emitting cars. This has led to technology developments in both the mass- and luxury-car markets and also in fuels, that make diesel an attractive option. Indeed diesel now has approximately 50% of the LDV market and we are short on supply.

[13] USGS – after Shafik 1994

In BP we have developed a future fuels pathway towards a lower CO_2 world. (Fig 13). On the engine front this shows the move from internal combustion engine to hybrid to fuel cell. On the fuels side we show a path from dieselisation to conventional bio-components, GTL and on to advanced biomass conversion technologies and, perhaps in the long term, hydrogen. And, as an added incentive we are exploring ways of making an offsets offer, initially for the concerned motorist with the longer term aim of demonstrating a practical option for wider policy development.

Cleaner fuels with an increasing emphasis on reducing GHG emissions is fine in the short term and makes those of us who have the resources and political will-power to use them feel a little better. But it merely scratches the surface of the problems that I have outlined above for the developing world.

For many countries climate change features very low on their list of priorities. It doesn't mean to say that we should lose sight of climate change, but we have to approach it from a different angle and seek out different win-win solutions.

By way of example, in China we have found that the health impacts of poor air quality are appreciated; the mayors of major cities have annual air quality performance targets. The issues that are really concerning the Chinese are security of energy supply and urban planning for their rapidly urbanising population. (Fig 14) We mapped these two policy drivers on to the WBCSD SMP goals and found that by working to address them we would also be addressing the wider issues such as global climate change and social equity.

I mentioned earlier the imbalance of energy source and demand. (Fig 15). Concerns over security of supply are manifesting themselves in many ways; for example the recent attempt by CNOOC to purchase Unocal. Associated with this concern, the price of oil has increased dramatically and at the moment, while the pundits predict some reduction in 2006, there does not seem to be a reason to think that it will return to earlier levels. However, for every cloud there is a silver lining and this could provide the tipping point that is required for new low carbon technologies to break through.

Technology Trends

An example is cane-based ethanol; in Brazil the cost base is approximately $35 / boe. With oil at $60+ / bbl there is clearly a commercial market for ethanol and it will be interesting to see how other tropical countries pick up on this opportunity. We must hope that any policy decisions that are taken will be taken for the right reasons, reflect truly sustainable values and not jeopardise essential food production.

Staying with biofuels, the conventional forms (ethanol for gasoline and vegetable oils for diesel) have the disadvantage that they are not readily fungible in significant proportions with the fossil-fuel pool and thus require segregated facilities that are costly to provide. Nor, at higher concentrations, are they suitable for much of the current vehicle fleet. BP and others are actively researching advanced biofuels that will yield conventional fuel molecules. These fuels will have the advantage of being compatible for blending in any proportion and requiring no new infrastructure or engine technology; indeed there will be no discernable differences from fossil fuels. We see this as a very realisable technology.

A little earlier I alluded to the potential wider environmental and social downsides of biofuels. Naturally we are concerned that in solving one problem we do not create another. (Fig 16) We have conducted in-depth studies into the potential for biofuels and conclude that on a global basis there is a constrained land capacity (allowing for food production, water and land quality) to meet a minimum of 20% of the current demand for transport fuels (n.b. there is considerable regional variation in this figure and the figure that I have shown is for illustration only).

(Fig 17) Thinking back to the availability of fossil fuels, a fuel that is often forgotten but is still available in relative abundance is coal. The rise in oil prices begins to make coal-to-liquids technologies attractive, and with that other "to liquids" technologies – gas, and biomass to name two. In Shanxi province in China there is extensive research on coal to methanol technology and the development of associated technologies that will be required to realise the benefits. This is an interesting example of bucking convention to make use of what is available locally.

Fuels of themselves are of little use without vehicles to be powered. In recent years we have seen the advent of the hybrid car. The modularised design that is being adopted by some manufacturers enables several generations of development to be planned from the same platform and I envisage the hybrid becoming progressively more electrified. If the projected developments of battery technology are realised the plug-in hybrid vehicle with, say, a 150 km working range will be available for city use in the relatively near future. This will have significant benefits in improving urban air quality and noise. With good planning and optimised electricity generation it can also lead to more efficient use of energy and reduced GHG emissions.

In 2004 BP with Princeton proposed a "wedge and slices" approach to addressing the need to reduce carbon emissions[14]. In essence this involved reducing the seemingly inexorable growth of emissions and containing the 2050 emissions to the same level as in 2000. This would involve taking 7Gte p.a. of carbon out of the system. Our estimates showed that by breaking this into 7 or more slices of up to 1Gte the problem becomes rather more manageable and much can be done using technology available today. For example we have estimated that on a global basis the universal introduction of hybrid vehicles fuelled by biofuels, would contribute a 1Gte reduction.

Another practical example of this is BP's recently announced participation in the first power station to be fuelled by hydrogen derived from natural gas. The CO_2 that is stripped off will be re-injected into an oil reservoir, where it will be stored safely and also used to increase oil recovery. This is a significant step forward in developing "carbon free" energy technologies and will reduce the CO_2 emitted to the atmosphere from this 350MW generator by 90%.

However on the transportation side the energy and environmental costs of making, storing and transporting hydrogen will remain high until there are significant technical breakthroughs (e.g. fuel cell cost and life cycle, hydrogen storage, low cost carbon-free hydrogen production) – and even then there will be the question of whether transportation is the most effective use of the hydrogen generated. It is our view that hydrogen is unlikely to be of use for transportation in a significant commercial sense for at least 25 years.

Demand Side

Enough of the supply side – what about demand side and consumer behaviour? We and others can play our part in developing more efficient technology but that is of little use if the consumer does not also make a positive contribution. We believe that governments, whether national,

[14] John Browne, Beyond Kyoto - Foreign Affairs, July/August 2004, Volume 83, Number 4, pp 20-32
- see also articles by Socolow et al

regional or city can and indeed should formulate and implement policy that stimulates reduced consumer demand for energy. In the transportation field this can take many forms, including preferential taxation for low energy vehicles and more efficient fuels and lubricants, the provision of attractively routed and priced reliable public transport, the creation of private vehicle exclusion zones, and the provision of cycle paths and safe walkways for pedestrians (in this context I applaud the work that WRI is doing through the EMBARQ programme). Encouraging people to walk and cycle will also have long term benefits in terms of physical and mental health that can be translated into financial benefits and a general sense of public wellbeing. Provided they are implemented in a thoughtful and holistic way, actions to positively influence consumer behaviour will contribute to all of the SMP goals; lower LAQ emissions, lower GHG emissions, greater safety, reduced congestion, reduced noise, greater social equity and all the time maintaining the opportunity for mobility.

Total Energy

So far I have taken a relatively blinkered approach and considered transportation and it's energy requirements in isolation. I will not dwell long on this, but we should remember that the drivers of energy security and urban planning do not apply to mobility alone. We should consider the opportunities that this might present. Globally, transportation accounts for something less than 30% of total energy consumption. The demand from power generation, industry and domestic heat and light accounts for 70+%. With few exceptions there has been little attempt to take an integrated approach to the provision of these energy services.

Traditionally transportation has used liquid hydrocarbons for its energy source. What if technological advances could make alternative approaches possible? As referred to above there are indications that battery technology may be on the brink of a break through. If electricity can be generated, stored and transmitted cleanly and efficiently this will have significant benefits in terms of GHG and LAQ emissions, and will also lead to a much quieter environment.

The sources of energy for such a development can be many and chosen to suit the circumstances of the site; coal, gas, liquid hydrocarbons, hydrogen, wind, solar (PV and radiant thermal) can all be used in the right circumstances and combinations. I would happily expand further on my thoughts for the integrated supply of energy to cities, but that can wait for another occasion.

Conclusions

Where does all this lead? (Fig 18) I have outlined a business as usual case that shows that over the next 45 years:

a) the global population will grow by around 40%
b) the vast majority of that growth will be in the developing world
c) the number of mega-cities will grow considerably – again mainly in the developing world
d) the number of vehicles in the world will increase from 700 million to 2 billion – with most of the increase in developing countries
e) the global demand for energy will increase by a factor between 2 and 3
f) energy security will becoming an increasingly major issue
g) with increasing demand we can expect the cost of energy to remain high
h) we will have to find new ways of meeting energy demands,

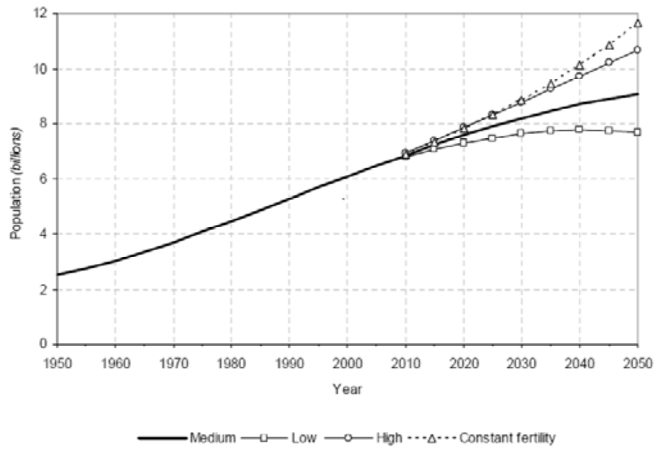
This leads me to suggest that the value that society puts on energy is going to change. Some will be alarmed by this. For me it opens up all sorts of opportunities. No longer will there be a "one size fits all" approach; what's right on the US West Coast won't necessarily be right in the Mid West, let alone China or India. Security of supply will become of increasing importance in energy discussions.

I am optimistic that the changing value that will be associated with energy will unleash a raft of technologies that are waiting in the wings, and that there will be others behind them. But to bring these forward politicians and bureaucrats will need to set goal-based, as opposed to prescriptive route-based policies, and global and regional providers will need to produce products that are adaptable to the various markets that they aim to serve.

To conclude, in meeting these changing and varied demands, Henry Ford's adage "you can have any colour you like - as long as it's black" just won't be good enough!

DGME
22nd August 2005

Population of the World, 1950-2050, by projection variants



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2005). *World Population Prospects: The 2004 Revision. Highlights*. New York: United Nations.

1 **Fig 1**

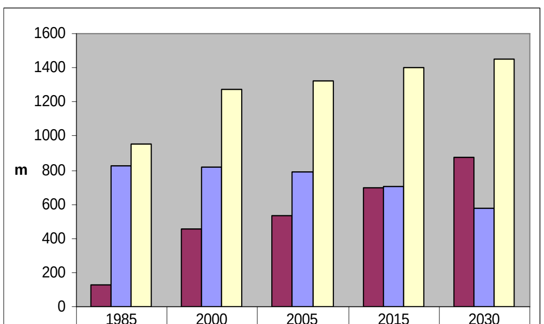
China: Urban/Rural Population Trend

China is undergoing a transformation that many western nations experienced in the mid / late 19th century during the industrial revolution. The result is a large scale urbanization, driven mainly by the policy of economic growth.

Forecast Population change 2005-2030

Overall: +10%
Rural: -27%
Urban: +64%

10 million new urban dwellers per year

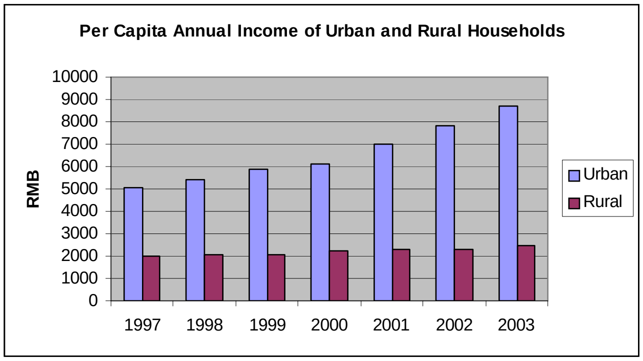


	1985	2000	2005	2015	2030
Urban	128	456	536	694	877
Rural	824	819	786	707	573
Total	952	1275	1322	1401	1450

Source: UN Department of Economic & Social Affairs

2 **Fig 2**

China: Urban/Rural annual income

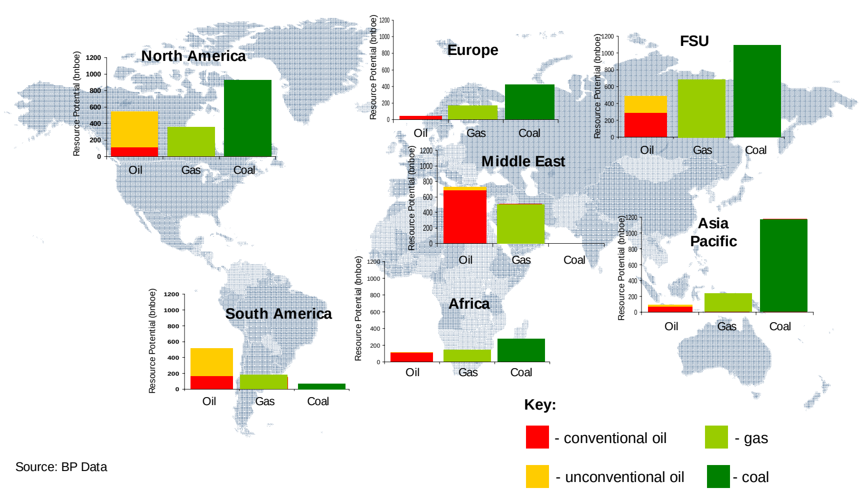


Source: World Bank – China Survey (current exchange rate is RMB 8.2/USD)

3 **Fig 3**

significant hydrocarbon resource potential

Oil, Gas and Coal Resources by Region (bnboe)

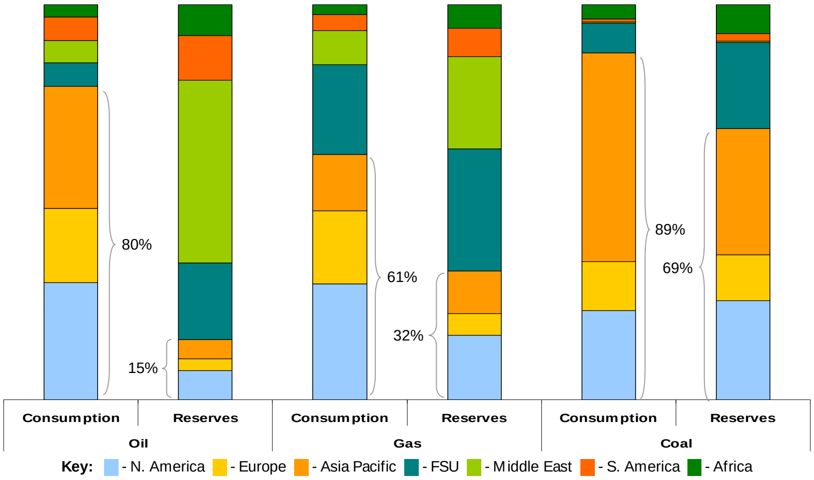


Source: BP Data

4 **Fig 4**

growing dislocation of supply & demand

Regional Share of Consumption v's Reserves for Oil, Gas & Coal



Note: oil reserve figures do not include unconventional reserves estimates

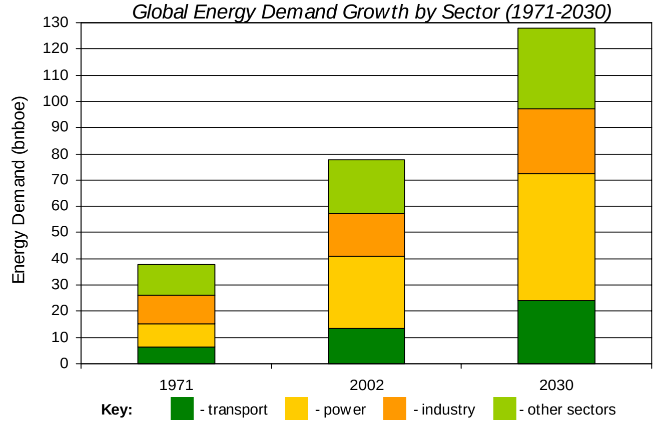
Source: BP Data, IEA WEO 2004

5 **Fig 5**

rapid demand growth projected for all sectors

- greater than 60% increase in energy demand projected out to 2030
- demand increasing across all sectors

Global Energy Demand Growth by Sector (1971-2030)



Notes: 1. Power includes heat generated at power plants
2. Other sectors includes residential, agricultural and service

Source: IEA WEO 2004

6 **Fig 6**

Regional Energy Intensities

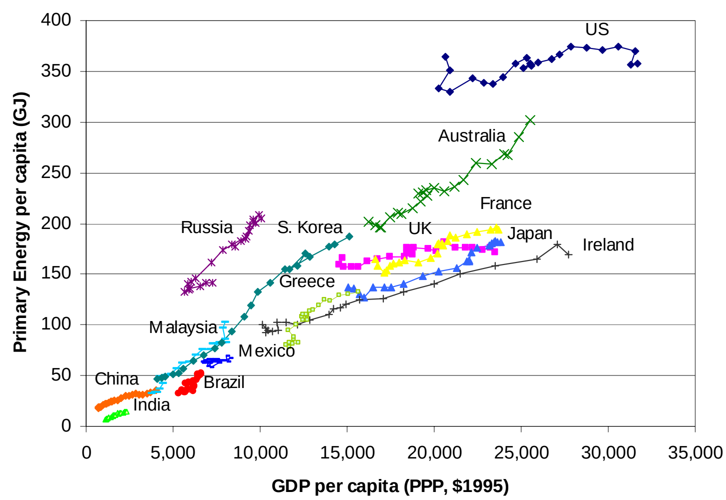
	Primary Energy[1] (million toe equiv)	Population[2] (million)	per capita energy usage (toe/cap)
OECD – Europe	1849.8	530.6	3.49
USA	2331.6	293.6	7.94
Japan	514.6	127.6	4.03
Brazil	187.7	179.1	1.05
Russia	668.6	144.1	4.64
India	375.8	1086.6	0.35
China	1386.2	1300.1	1.07

[1] BP Statistical Review of World Energy June 2005
[2] Population Reference Bureau, 2004 World Population Data Sheet

7 **Fig 7**

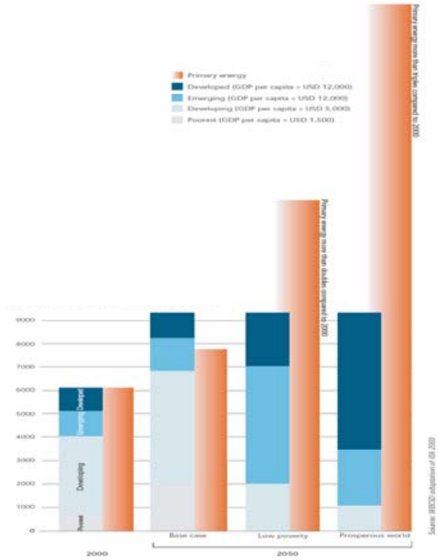
energy use grows as a function of GDP

Energy demand per capita and GDP per capita (1980 – 2002):



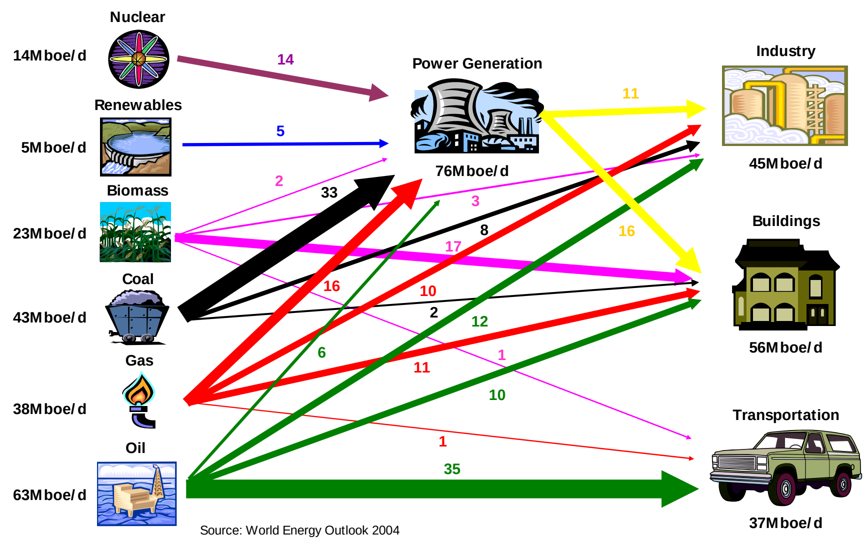
8 **Fig 8**

Energy demand of a rising population



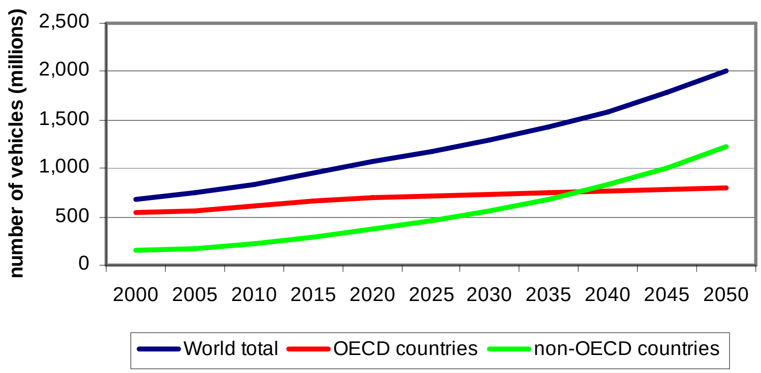
9 **Fig 9**

global energy supply & demand (2002)



10 **Fig 10**

Forecast global vehicle stocks

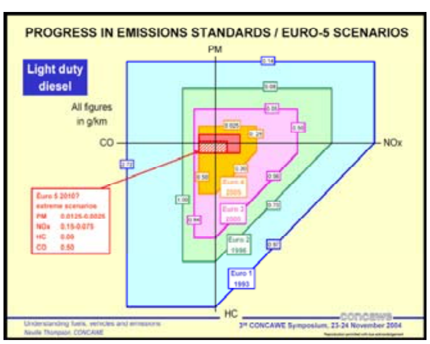


Source: WBCSD SMP 2004

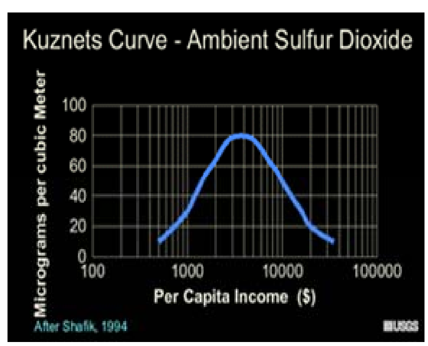
11 **Fig 11**

tightening regulations on local pollution

- Regulations on local pollutants will tighten in all OECD countries (e.g. Large Combustion Plant Directive, Clear Skies)
- Local pollution is becoming a key policy priority in many developing countries as impact on health is recognised
- Kuznets Curve describes the correlation of pollution levels to per capita income



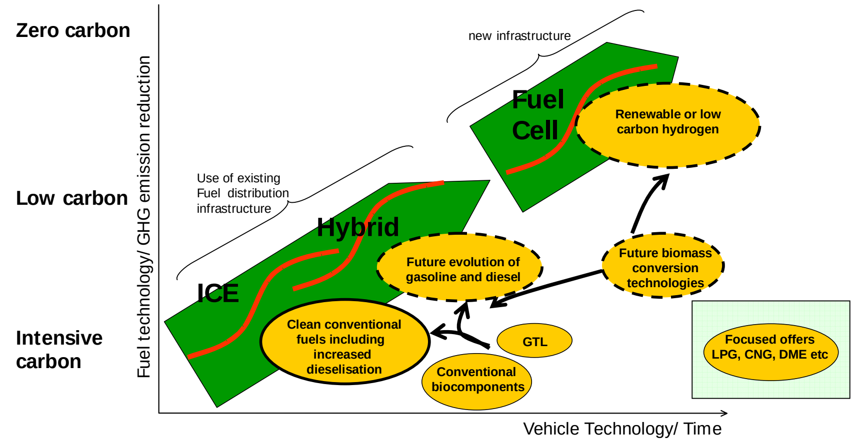
Source: Concawe



Source: USGS

12 **Fig 12**

Future fuels pathway



our world
our future

13 **Fig 13**

China: Sustainable Mobility : Meeting Needs

<u>WBCSD Goals</u>	<u>SECURITY OF SUPPLY</u>	<u>URBAN PLANNING</u>
GHG Emissions	*energy efficiency*	*total energy approach*
Local Air Quality	*alternative fuels*	*total energy approach*
Safety		*improved safety*
Noise	*alternative fuels*	*general planning*
Congestion	*modal shifts*	*modal shifts*
Social Equity	*modal shifts*	*central to planning*
Maintain Opportunity	*manage supply/ demand balance*	*opportunity to maintain/improve*

our world
our future

14 **Fig 14**

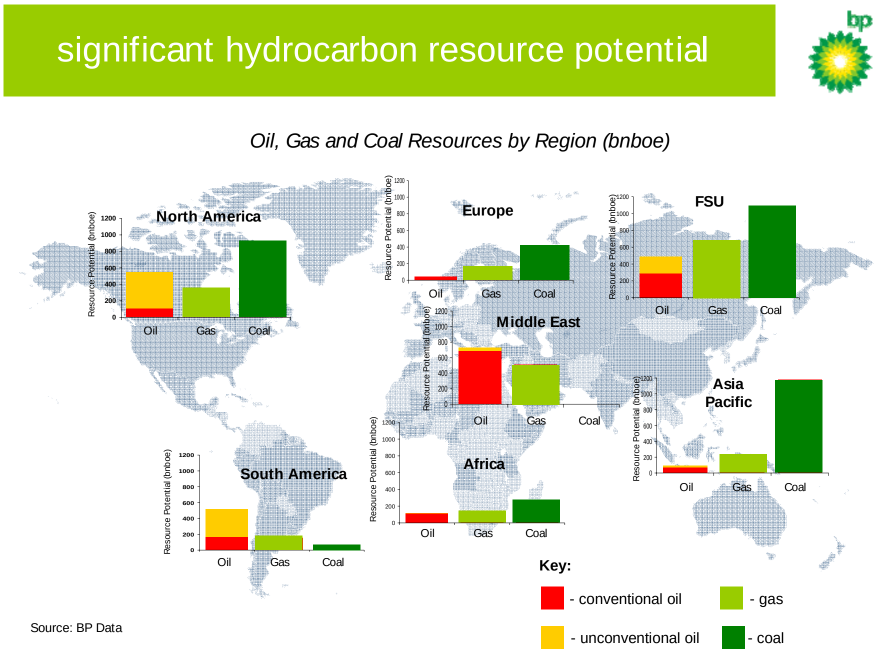

significant hydrocarbon resource potential
bp
Oil, Gas and Coal Resources by Region (bnboe)
North America
Europe
FSU
Middle East
Asia Pacific
South America
Africa
Oil
Gas
Coal
Resource Potential (bnboe)
Key:
- conventional oil
- unconventional oil
- gas
- coal
Source: BP Data
15

Fig 15

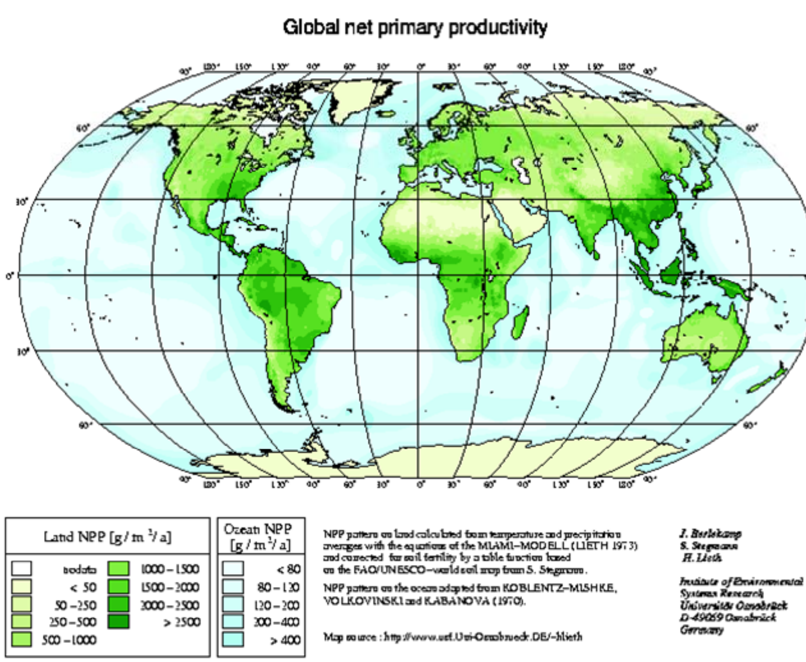
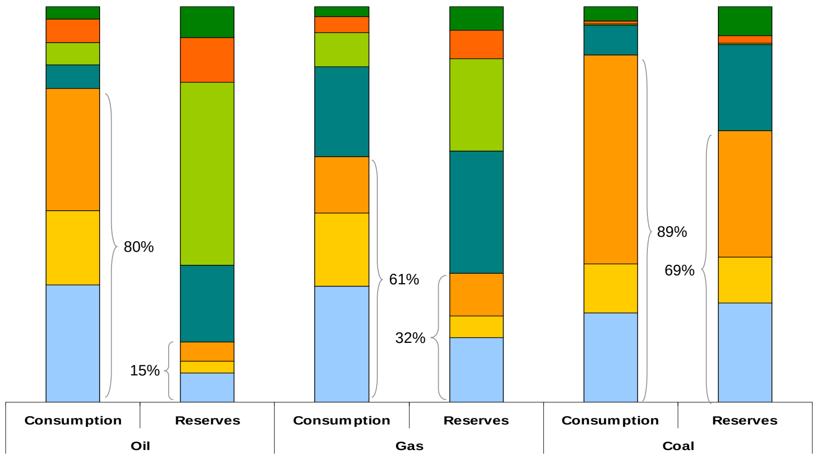

Global net primary productivity
Land NPP [g / m²/ a]
no data
< 50
50 – 250
250 – 500
500 – 1000
1000 – 1500
1500 – 2000
2000 – 2500
> 2500
Ozean NPP [g / m²/ a]
< 80
80 – 120
120 – 200
200 – 400
> 400
NPP pattern on land calculated from temperature and precipitation averages with the equations of the MIAMI–MODELL (LIETH 1973) and corrected for soil fertility by a table function based on the FAO/UNESCO–world soil map from S. Stegmann.
NPP pattern on the ocean adapted from KOBLENTZ–MISHKE, VOLKOVINSKI and KABANOVA (1970).
Map source : http://www.usf.Uni-Osnabrueck.DE/~hlieth
J. Berlekamp
S. Stegmann
H. Lieth
Institute of Environmental Systems Research
Universität Osnabrück
D-49069 Osnabrück
Germany

Fig 16

growing dislocation of supply & demand

Regional Share of Consumption v's Reserves for Oil, Gas & Coal



Key: - N. America - Europe - Asia Pacific - FSU - Middle East - S. America - Africa

Note: oil reserve figures do not include unconventional reserves estimates

Source: BP Data, IEA WEO 2004

17 **Fig 17**

Business as Usual to 2050

- global population will grow by around 40%
- vast majority of population growth will be in the developing world
- the number of mega-cities will grow considerably – mainly in the developing world
- the number of vehicles in the world will increase from 700 million to 2 billion – with most of the increase in developing countries
- demand for energy will increase by a factor between 2 and 3
- energy security will becoming an increasingly major issue
- we can expect the cost pf energy to remain high
- we will have to find new ways of meeting energy demands,

18 **Fig 18**