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# GLOBAL PATTERNS OF ENERGY SUPPLY

'America faces a major energy supply crisis over the next two decades. The failure to meet this challenge will threaten our nation's economic prosperity, compromise our national security and literally alter the way we lead our lives.'

US Secretary of Energy, March 19, 2001.

Following the 1973 Arab-Israeli war, the Arab nations reduced the supply of oil to the USA and Western Europe in an effort to lessen their support for Israel. This led to a serious energy shortage which became known as **'the Energy Crisis'**. Other less serious shortages of supply have occurred since then which have pushed energy prices up and reminded us that we cannot take energy for granted.

The key energy issues for individual countries are the three S's: Sustainability, Security and Strategy. Look at the World Energy Council's website for more information on these issues: www.worldenergy.org.

Global variations in energy supply occur for a number of reasons. These can be broadly subdivided into physical, economic and political factors. Figure 1 shows examples for each of these groupings.

*Figure 1: Constraints on energy supply*

| | |
|---|---|
| **PHYSICAL** | • Deposits of fossil fuels are only found in a limited number of locations.<br>• Large-scale hydroelectric development requires high precipitation, major steep-sided valleys and impermeable rock.<br>• Large power stations require flat land and geologically stable foundations.<br>• Solar power needs a large number of days a year with strong sunlight.<br>• Wind power needs high average wind speeds throughout the year.<br>• Tidal power stations require a very large tidal range.<br>• The availability of biomass varies widely due to climatic conditions. |
| **ECONOMIC** | • The most accessible, and lowest cost, deposits of fossil fuels are invariably developed first.<br>• Onshore deposits of oil and gas are usually cheaper to develop than offshore deposits.<br>• Potential hydroelectric sites close to major transport routes and existing electricity transmission corridors are more economical to develop than those in very inaccessible locations.<br>• In poor countries foreign direct investment is often essential for the development of energy resources.<br>• When energy prices rise significantly, companies increase spending on exploration and development. |
| **POLITICAL** | • Countries wanting to develop nuclear electricity require permission from the International Atomic Energy Agency.<br>• International agreements such as the Kyoto Protocol can have a considerable influence on the energy decisions of individual countries.<br>• Potential HEP schemes on 'international rivers' may require the agreement of other countries that share the river.<br>• Governments may insist on energy companies producing a certain proportion of their energy from renewable sources.<br>• Legislation regarding emissions from power stations will favour the use, for example, of low sulphur coal, as opposed to coal with a high sulphur content. |

Fossil fuels dominate the global energy situation. Their relative contributions are: oil 36%, coal 28%, natural gas 24%. In contrast, hydroelectricity and nuclear energy account for about 6% each. The source used for the data below is the *BP Statistical Review of World Energy*. It includes commercially traded fuels only. It excludes fuels such as wood, peat and animal waste which, though important in many countries, are unreliably documented in terms of production and consumption statistics. The *BP Review* is freely available to schools in printed format. It is available online at www.bp.com/statisticalreview.

## Oil

The pattern of regional oil production is shown in Figure 2. In 2007, the Middle East accounted for 30.8% of production, followed by Europe and Eurasia (22.0%), North America (16.5%), and Africa (12.5%). Within the Middle East, Saudi Arabia dominates production, alone accounting for 12.6% of the world total. The Russian Federation accounts for over half the total production of Europe and Eurasia.

The global distribution of oil consumption is markedly different, being led by Asia Pacific (30%), North America (28.7%), and Europe and Eurasia (24%). In contrast to its dominant production position the Middle East, accounted for only 7.4% of world oil consumption.

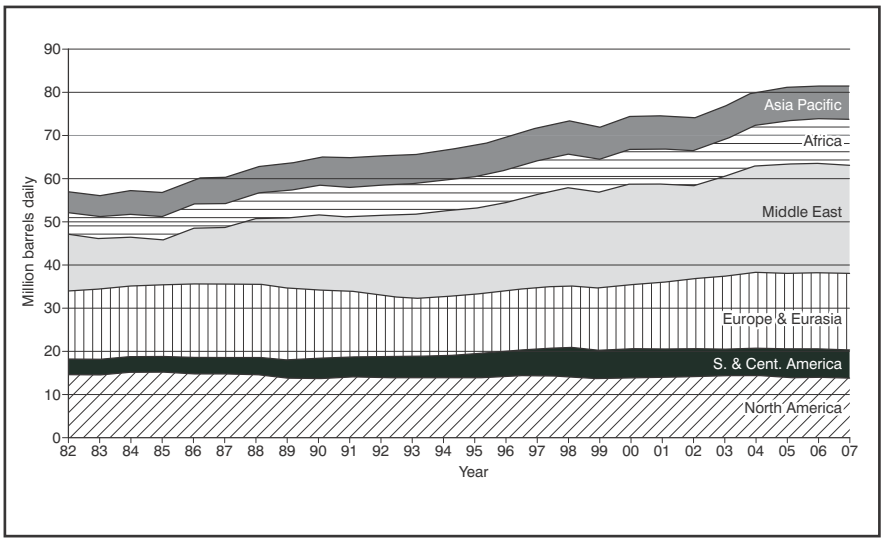
Figure 3 illustrates the spatial distribution of **proved oil reserves**. In the period 1987-2007, proved reserves rose considerably, but much more so

**Key terms**

*Proved reserves of oil:* quantities of oil that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions.

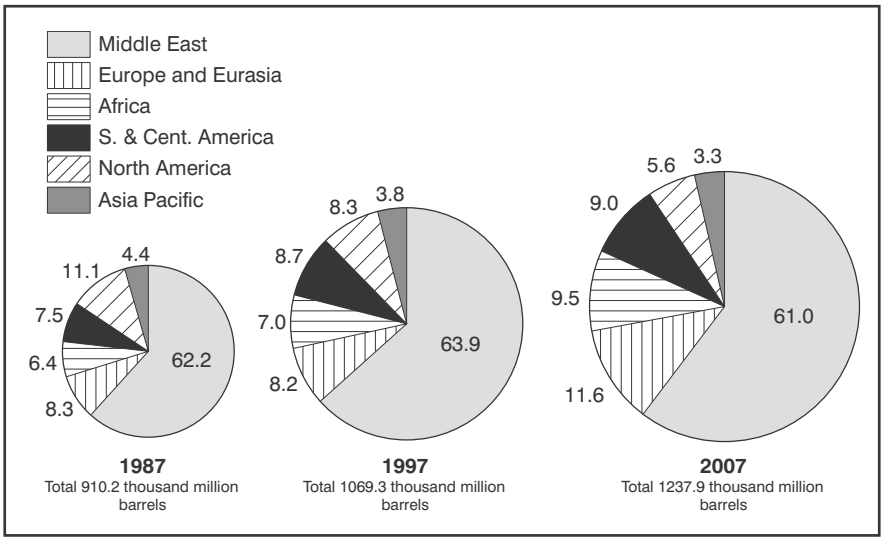
*Reserves-to-production (R/P) ratio:* The reserves remaining at the end of any year are divided by the production in that year. The result is the length of time that those remaining reserves would last if production were to continue at that level.

*Figure 2: Oil production by world region, 1982-2007*




Source: *BP Statistical Review of World Energy 2008*, p. 10

*Figure 3: Distribution of proved oil reserves, 1987, 1997, 2007*




Source: *BP Statistical Review of World Energy 2008*, p. 7

*Figure 4: Regional R/P ratios*

| Region | Reserves/production ratio (years) |
|---|---|
| North America | 13.9 |
| South and Central America | 45.9 |
| Europe and Eurasia | 22.1 |
| Middle East | 82.2 |
| Africa | 31.2 |
| Asia Pacific | 14.2 |
| World | 41.6 |

Source: *BP Statistical Review of World Energy 2008*

in the earlier part of the period than in the latter part. And here lies the problem, with demand increasing at a faster rate than proved reserves. In 2007, the Middle East accounted for 61% of global proved reserves. The main countries contributing to the latter figure are: Saudi Arabia 21.3%; Iran 11.2%; Iraq 9.3%; Kuwait 8.2% and the United Arab Emirates 7.9%. Europe and Eurasia held the second largest proved reserves, with 11.6% of the world total. The Russian Federation accounted for over half of the latter figure.

Figure 4 shows the **reserves-to-production ratio** for the world in 2007. While the R/P ratio is over 82 years in the Middle East, it is less than 14 years in North America. BP estimate that the world R/P ratio is 41.6 years. However, this figure is seen as wildly over-optimistic by some experts. The Association for the Study of Peak Oil and Gas (ASPO) predicts that the peak of global oil production could come as early as 2011, stating: 'Fifty years ago the world was consuming 4 billion barrels of oil per year and the average discovery was around 30 billion. Today we consume 30 billion barrels per year and the discovery rate is now approaching 4 billion barrels of crude oil per year'. If ASPO is correct and the oil peak is imminent, it will not allow time to shift energy use to alternative sources.

## Natural gas

Natural gas, composed mainly of methane, is the least polluting of all the fossil fuels. Production is dominated by Russia and the USA, together accounting for almost 40% of the world total (Figure 5). However, the distribution of proven reserves paints a different picture (Figure 6). The Middle East now holds the largest reserves (41.3%), a position held by Europe and Eurasia previously. Now Europe and Eurasia hold 38.5% of proved reserves.

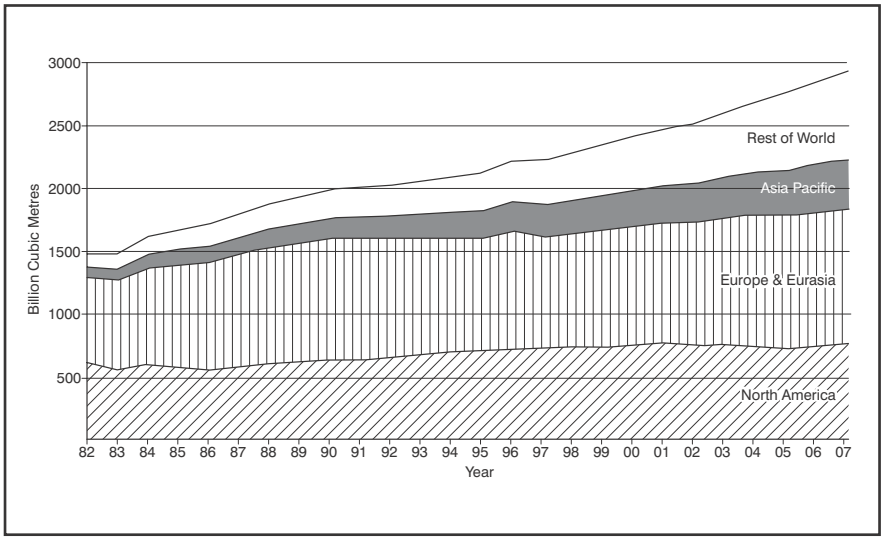
The relatively low production of natural gas in the Middle East is down to limited markets for the product in the region, where in the past the emphasis has been firmly on oil. Much of the natural gas that has been brought to the surface was 'flared off' because there were no pipeline networks to take the gas to consumers. However, this is beginning to change.

There is a much stronger correlation between consumption and production of natural gas than for oil, due mainly to the different ways these two energy products are transported. Global consumption of natural gas is led by Europe and Eurasia (39.4%), North America (27.6%) and Asia Pacific (15.3%).

'Conventional' natural gas , which is generally found within a few thousand metres or so below the surface, has accounted for most of the global supply to date. However, in recent years 'unconventional' deposits have begun to contribute more to supply. The main categories of **unconventional natural gas** are:

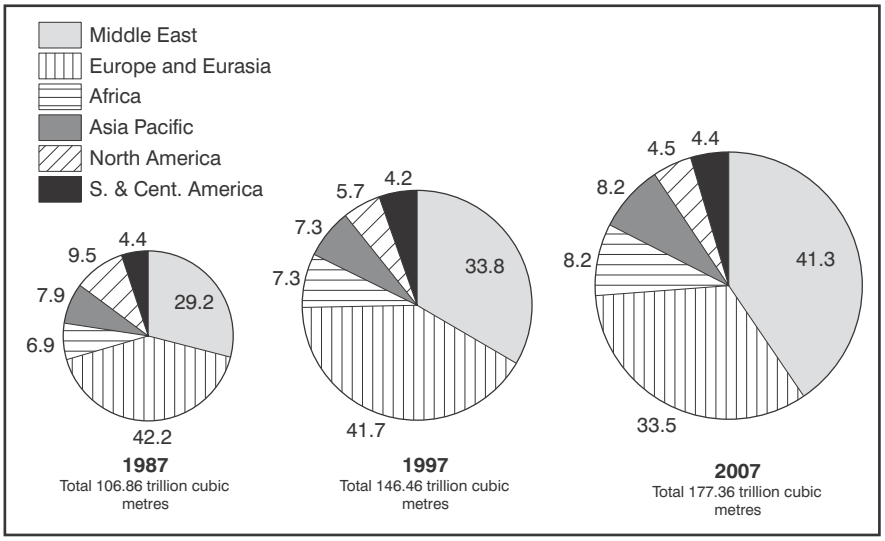
- deep gas
- tight gas
- gas-containing shales
- coalbed methane
- geopressurised zones

*Figure 5: Global distribution of natural gas production*




Source: *BP Statistical Review of World Energy 2008*, p. 26

*Figure 6: Distribution of proved natural gas reserves, 1987, 1997, 2007*

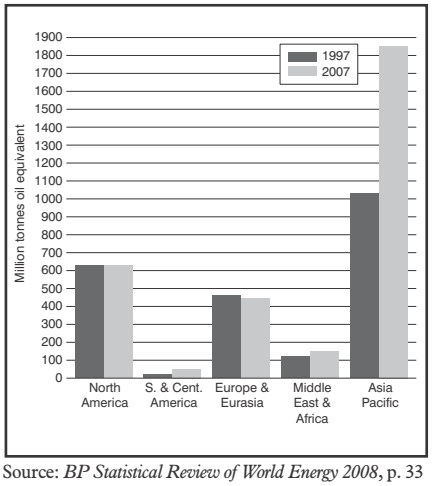



Source: *BP Statistical Review of World Energy 2008*, p. 23

- Arctic and sub-sea hydrates

Unconventional deposits are clearly more costly to extract, but as energy prices rise and technology advances, more and more of these deposits are attracting the interest of governments and energy companies.

*Figure 7: Coal production by region*




Source: *BP Statistical Review of World Energy 2008*, p. 33

## Coal

Coal production is dominated by the Asia Pacific region (Figure 7), with over two-thirds of the latter accounted for by China. China produced 41.1% of global coal in 2007. The next largest producing countries were the USA (18.7%), Australia (6.9%), India (5.8%) and the Russian Federation (4.7%).

The USA has the largest reserves of coal, enough to last 250 years at its present rate of consumption. Thus, it is not surprising that coal accounts for 50% of US electricity generation and 83% of power plant $CO_2$ emissions. However, China is by far the largest consumer of coal, and the gap between China and the rest of the world will steadily increase in the future. China is expected to need 3,242 million tons of coal a year by 2025. It is likely that China will build several hundred new coal-fired power stations to satisfy its demand for energy. This will have a huge impact on greenhouse gas emissions.

As with natural gas, there is a strong relationship between the production and consumption of coal by world region. Consumption is led by Asia Pacific (59.7%), North America (19.3%) and Europe and Eurasia (16.8%).

Coal is the most polluting source of energy. Environmental legislation in a number of countries has required coal-burning power plants to reduce pollutants such as nitrogen oxides and sulphur dioxide by installing building-size scrubbers and catalytic units. However, at present, all the carbon dioxide produced is still released into the atmosphere. This amounts to nearly two billion tons each year from US coal power plants alone.

*Figure 8: Proved reserves of coal*

| Region | % Share of proved reserves | Reserves/production ratio |
|---|---|---|
| North America | 29.6 | 224 |
| South and Central America | 1.9 | 188 |
| Europe and Eurasia | 32.1 | 224 |
| Middle East and Africa | 6.0 | 186 |
| Asia Pacific | 30.4 | 70 |
| World | 100.0 | 133 |

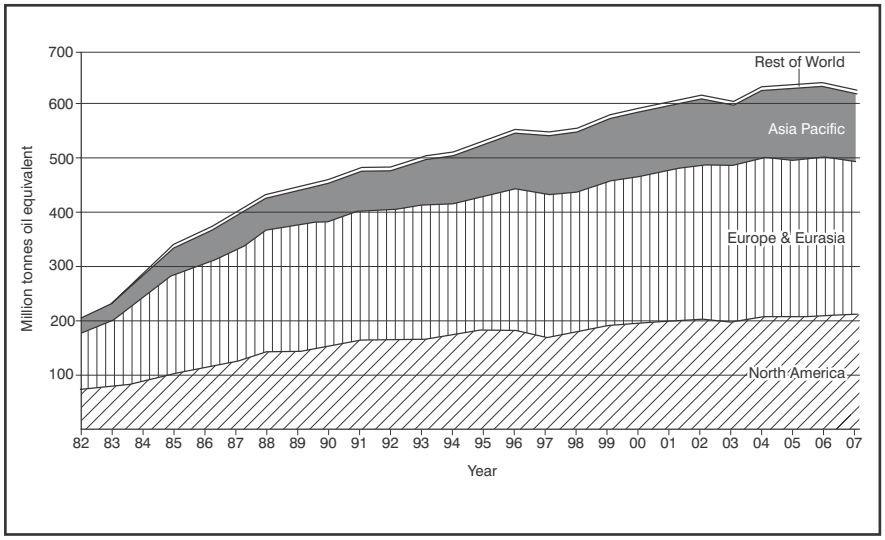
## Hydroelectric power: the largest renewable

The HEP figures produced by the *BP Statistical Review* (Figure 9) are for consumption rather than production, but trade in HEP between countries is extremely limited. The 'big four' HEP nations of China, Brazil, Canada, and the USA account for 47% of the global total.

*Figure 9: HEP consumption 2007*

| Region | % Share of consumption |
|---|---|
| North America | 20.6 |
| South and Central America | 21.6 |
| Europe and Eurasia | 26.6 |
| Middle East | 0.7 |
| Africa | 3.1 |
| Asia Pacific | 27.3 |
| World | 100.0 |

*Figure 10: Nuclear energy consumption 2007*




Source: *BP Statistical Review of World Energy 2008*, p. 37

Of the traditional five major sources of energy, HEP is the only one which is renewable. However, most of the best HEP locations are already in use, so the scope for further large-scale development is limited. However, in many countries there is scope for small-scale HEP plants to supply local communities.

## Nuclear power

Again, the statistics for nuclear energy in the *BP Statistical Review of World Energy* are for consumption. Like HEP there are only limited international transfers of nuclear energy. Figure 10 shows the regional pattern of consumption between 1982 and 2007. The world leaders in this form of energy are Europe and Eurasia (44.3%), North America (34.7%) and Asia Pacific (19.8%).

## New sources of energy

The new sources of energy which make the largest contribution to global energy supply are wind power and biofuels.

**1. Wind power**
Wind power is growing faster than any other form of renewable energy. The modern era of wind energy development started in Europe in the 1990s. Today wind energy is heavily concentrated in Europe, North America and Asia, with limited capacity elsewhere, although this situation will undoubtedly change in the future. Europe has achieved the highest totals for all of the five years shown, but in very recent years the rate of increase has been higher in North America and Asia.

Global wind power capacity increased from 6,000 MW in 1996 to 94,123 MW in 2007. However, wind power still only accounts for 0.8% of the world's electricity supply. Wind energy has reached the 'take-off' stage both as a source of energy and a manufacturing industry. As the cost of wind energy improves further against conventional energy sources, more and more countries will expand into this sector. However, projections regarding the industry still vary considerably because of the number of variables which will impact on its future.

**2. Biofuels**
Biofuels are fossil fuel substitutes that can be made from a range of agri-crop materials including oilseeds, wheat, corn and sugar. They can be blended with petrol and diesel. In recent years, increasing amounts of cropland have been used to produce biofuels.

Ethanol is the most common biofuel globally, particularly in Brazil and the USA. It accounts for over 90% of total biofuel production. Ethanol can be used in petrol engines when mixed with gasoline. Most existing petrol engines can run on blends of up to 15% ethanol. Global production of ethanol has risen rapidly in recent decades. For example, in the USA the amount of maize turned into ethanol increased from 15m tonnes in 2000 to 85 million tonnes in 2007. This amounts to about one-third of US maize production.

In contrast to the USA, Brazil uses sugar cane to produce ethanol. More than half of Brazil's sugar cane crop is now used for this purpose. Sugarcane-based ethanol can be produced in Brazil at about half the cost of maize-based ethanol in the USA. Global biodiesel production and capacity have risen significantly in recent years. Biodiesel is the most common biofuel produced in Europe, with the continent accounting for over 63% of global production. Germany and France are the leading producers within Europe.

**3. Other sources**
Alternative sources of energy such as solar, tidal and geothermal power remain at much lower levels of supply than the energy sources covered above.

## Focus Questions

1. To what extent do fossil fuels dominate global production and consumption of energy in the world today? Has the pattern changed over recent decades? (Use the data in the text and figures of this unit to illustrate your answer.)

2. In your opinion, what is likely to happen to global production and consumption of energy in the future? Will renewables dominate or not? (Do your own internet research and use trends discussed in this unit to assist in planning your answer.)