3

CHAPTER 3

Energy-related challenges and aspects

3 Energy-related challenges and aspects

In the current energy situation we face two energy challenges resulting from the unsustainability of the existing model. Whether we are capable of meeting these challenges will depend on the development and involvement of the different aspects influencing energy.

3.1. Energy challenges

The existence of cheap and efficient energy has allowed constant economic development over the last few decades. This could be summarised in a formula:

> Efficient energy = Economic development

However, the present energy model is beginning to be unsustainable. We are faced with a situation which cannot continue for long: first, because of the almost exclusive reliance on finite energy sources and, secondly, because of the harmful effects it has on the environment.

Our efforts must therefore centre on maintaining our capacity to meet future energy needs by developing new forms of energy which will allow accessibility, availability and acceptability of energy; in other words, which will guarantee an energy supply that is compatible with respect for the environment. The formula could now be said to be as follows:

> Efficient energy + **Clean** energy = **Sustainable** economic development

Notes

In broad terms, therefore, we face two major energy challenges:

- Guaranteeing the energy supply.
- Respecting the environment.

Let us now take a closer look at these two challenges. The following section sets out the various aspects that need to be taken into account in tackle the critical energy situation and achieving a change towards a clean and sustainable model.

Guaranteeing the energy supply

Security of the energy supply is an issue that is now causing growing concern, in the light of the experts' supply and demand forecasts.

If governments continue with existing policies, the world's energy needs will be 60% greater in 2030 than they are now[17]. Fossil fuels will continue to dominate the energy scenario, and will be responsible for most of the increase in energy use; the contribution of nuclear energy and renewable energy sources will continue to be limited. In such a situation, it is reasonable to think that the energy supply cannot be assured.

As a result of this position of unsustainability, many countries have already begun to give great importance in their political agendas to energy assurance, in a scenario characterised by[18]:

- High and volatile oil prices which have a direct impact on national economic growth.
- Growing demand for non renewable sources intensified by the economic upsurge of new competitors with very large populations (China, India, etc.).
- Increase in reliance on energy imports to supply many countries.
- Political instability of large fossil fuel producers, natural disasters such as Hurricane Katrina and other threats.

The situation must therefore be tackled quickly if the energy needs of today are to be satisfied without jeopardising those of tomorrow. To do this a number of measures and changes in behaviour must be undertaken, affecting business, government and every member of the public to maintain the balance between energy supply and demand.

These measures consist[19], primarily and in the more short term, of ensuring international trade in energy, on the understanding that no country can achieve energy self-sufficiency, and that the aim is not therefore to minimise energy dependency, but to reduce the risks associated with that reliance. The political issues of energy assurance are going to be become highly relevant and international in nature.

Secondly, they seek the maximum diversification of the sources of supply and the infrastructure required to bring those sources to market through technological development and the combination of public support and private investment.

17. Information taken from World Energy Outlook 2004.

18. Global energy challenges identified by the G8 at their St. Petersburg meeting (16 July 2006).

19. Measures taken from the article "La seguridad del suministro energético: experiencias mediterráneas de una empresa global". Author: Luis Javier Navarro Vigil, Chairman of BP España.

Thirdly, they seek to reduce the current volatility and risk in the energy supply by adapting the direction of the International Energy Agency[20] - as an advisor on its members' energy policy-to the current situation, influenced by the entry of important consumer countries such as China and India.

Finally, governments need to encourage the general public and the private sector to be more energy efficient, and to innovate and develop technologies in the area of alternative energy sources to reduce fossil fuel consumption until a definitive transition is made.

Respecting the environment

The existing energy model, based on fossil fuels, has a negative environmental impact, among others reasons, because of the release into the atmosphere of large amounts of carbon dioxide (CO_2), which appears to be causing climate change. A new culture of energy sustainability needs to be propounded that makes it possible to assure the environmental wellbeing of future generations.

This new model must be based on three main pillars:

1. The "decarbonisation" of existing energy consumption with the awarding of new incentives to the use of renewable energy sources and the reinforcement of existing ones. Both the measures adopted at a political level and the development of new technologies (CO_2 capture and sequestration) must enable us to move towards a zero-emissions energy mix.

2. Encouragement of greater energy efficiency involving energy saving, translating into a reduction in emissions of greenhouse gases. The efficiency measures imposed by governments on business and consumers, together with technological improvements in efficiency, will foster environmental sustainability.

3. Global knowledge and awareness of the environmental problem and the consequences of not resolving it, so that society as a whole will exercise the necessary pressure on the political and economic sectors to take the necessary measures.

Facing up to the two energy challenges will therefore require, firstly, a profound commitment by the public sector through regulation and geo-political relations; secondly, private and public investment to achieve the technological development needed; and, thirdly support from society as a whole.

3.2. Various energy-related aspects

Addressing the energy challenges that now face us requires dedication and means addressing various energy-related aspects which are decisive in achieving sustainable economic development.

20. See http://www.iea.org/.

Energy is intrinsically related to **economic** aspects. On the one hand, the availability and cost of energy have a decisive influence on economic growth, due to the high level of dependency of different industries; at the same time, energy represents an opening to a new market in which public and private investment need to forge a transition towards clean and efficient energy, and an analysis of trends in energy is therefore a key factor in achieving economic sustainability.

Governments, through **political** action, will also play a decisive role in dealing with the energy shortage while at the same time respecting the environment. The public sector can impact energy in different ways: by establishing trading relations between governments in order to ensure supply and by introducing regulations to increase or reduce the consumption of a given energy type, and also by restricting environmentally-harmful emissions.

Another of the main agents in achieving energy sustainability is **society** as a whole. Enhancing an awareness among all members of the public of the existence of an environmental problem and of the possible exhaustion of traditional sources will help moves towards sustainable energy development.

As can be seen, addressing all aspects is the key to achieving the clean and efficient energy that will help resolve the **environmental** challenge. This chapter takes a closer look at the importance of energy-influenced environmental aspects and the reasons why these issues need to be addressed with all possible haste.

Finally, it will be technological aspects that mark the definitive step towards economic development, together with clean energy. Technology will enable greater energy efficiency with savings in consumption and thus a reduction in emissions, as well as the production of clean energy which allows all industries to continue in operation.

Illustration 22 shows the degree of importance that FTF experts have assigned to each of the aspects, viewed from the side of energy supply and demand.

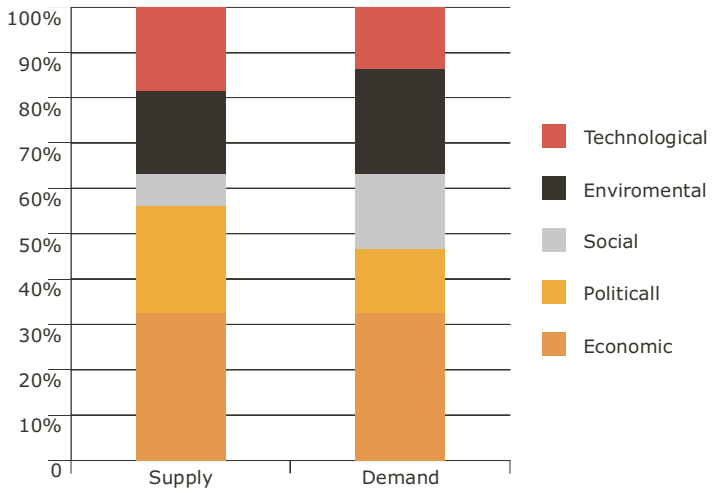


Illustration 22: Importance of different aspects on energy.
Source: Drawn from conclusions within the Future Trends Forum.

The most important aspect in both supply and demand is the economic aspect, since cost is a decisive factor in economic growth for both energy producers and consumers.

On the supply side, the political aspect is important, because of the clear repercussions for energy producers of any inter-governmental action or the establishment of incentives to production, and because of the contribution that can be made by technological aspects in achieving systems of clean and efficient production.

On the demand side, social and environmental aspects are more important, due to the fact that efficiency in energy use amongst the general public would lead to reductions in emissions and less energy consumption.

In the sections below, we will look at each of these aspects in greater depth.

3.2.1. Energy and economy

Since the Industrial Revolution, economic development has grown hand in hand with an increase in energy consumption, with factories, power stations, vehicles and homes increasingly consuming coal, oil and natural gas. These increases in demand are depleting traditional energy sources, causing economic strain on development, prices, currencies, investors and business.

The role of energy in economic growth

Energy is the cornerstone of the economy. It would be impossible to imagine a world without energy, since the whole gamut of industries from agriculture to commercial services depend on energy to operate.

The close relationship between energy demand and economic growth is measured in terms of growth in GDP. However, the fact that the economy is more efficient than before in terms of fuel usage, and the greater role played by the services sector, means that less energy is needed to produce each unit of GDP.

If we acknowledge society's reliance on fossil fuels, we need to bear in mind that the possible exhaustion of such fuels might cause an increase in the volatility of energy prices, which could lead to a downturn in global economic growth and an increase in inflation. Indeed, the high cost of crude oil and the volatility of this price, together with international imbalances, are causing concern among the most industrialised countries, given the possible risk to global economic development.

Prices of fossil fuels

Stabilising the price of fossil fuels is a very complex process, because of continuous changes in reserves and a constant increase in demand.

a) Oil

Oil markets have seen significant changes over recent years. A gradual upsurge in tension in the supply chain has been evident for some time, but it has only been in the last two years that most industry analysts have begun to accept that we are facing the most important structural change ever seen in the oil market.

Notes

Crude oil prices since 1861
US dollars per barrel
World events

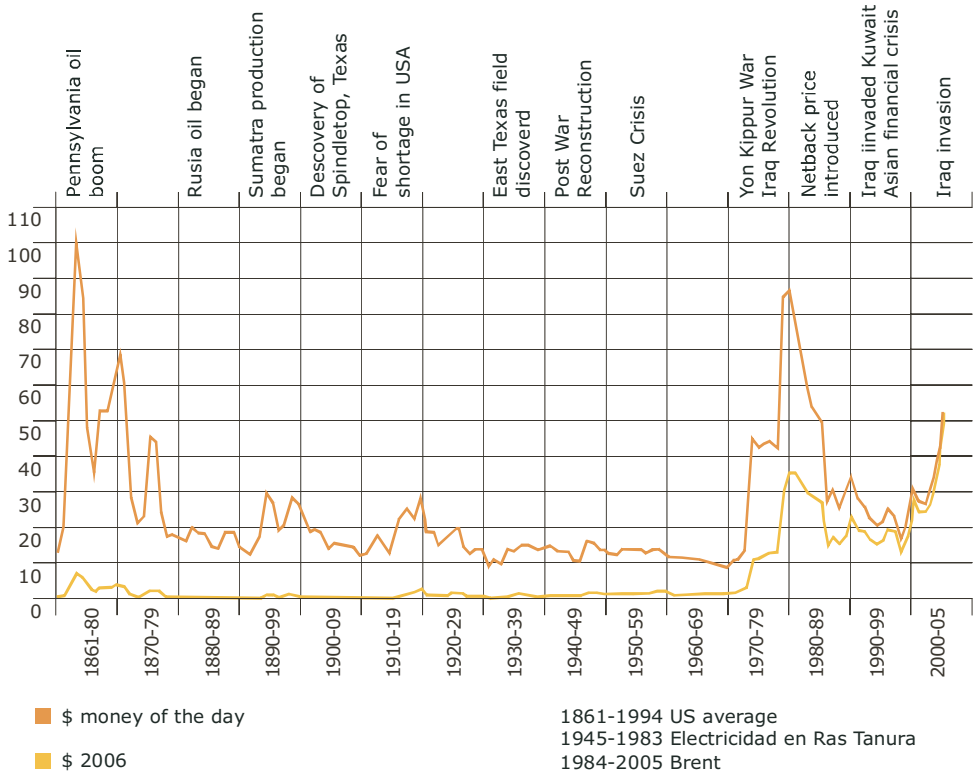


Illustration 23: Oil prices since 1861.
Source: BP Statistical Review of World Energy June 2006.

Throughout history, fluctuations in oil prices have been influenced by a range of socio-political and economic circumstances. If we look back over the last 36 years, we can see that the greatest peaks in the oil price have coincided with different wars affecting oil-producing countries (and more recently, the terrorist attack of 9/11, which led to a war whose repercussions are still being felt). The line showing the oil price in Illustration 23 has now rallied to reach 78 dollars a barrel.

The current increase in the price of crude oil differs from previous crises in one essential aspect: it is not the result of a restriction on supply masterminded by OPEC, nor is it the product of fear of a war in the Middle East affecting supply- although the Iranian nuclear crisis may be accentuating this increase in prices. The price of crude oil is rising for two widely-commented reasons:

1. The industry can only pump and refine a limited amount of oil.

2. Demand is experiencing a boom thanks to the growing oil needs of rapidly-growing countries such as China and India, and because of the economic recovery of the United States.

The sudden increase in oil prices may affect economies by acting as a tax on consumption, forcing people to spend less on other goods, pushing up their costs and hindering business profits. For the moment, economic growth does not appear to have been significantly slowed, since there are other economic forces that have offset the oil shock, such as global competition, for example, which has helped keep the inflation under control.

b) Natural gas

As an energy source, natural gas is very closely tied to oil. Supply of the two fuels is associated to a great degree and their prices are strongly correlated; as a result, variations in the price of natural gas are influenced by much the same factors as oil prices.

The international natural gas market is made up of a number of regional markets, meaning that there is no global market per se for this product. Although there has been a trend towards a certain degree of deregulation of the market worldwide, the market continues to be tightly regulated in many regions.

In North America, for example, where the market is highly deregulated, prices are very competitive and fluctuate depending on supply and demand. After the market was opened up to competition, prices fell significantly. In contrast, in Russia, where there is a monopoly, domestic prices have been kept artificially low and gas is sold on foreign markets at a higher rate to offset domestic losses. In Europe, the price of natural gas is most often influenced by competition with alternative fuel types.

Natural gas prices tend to be cyclical in nature. Upwards trends are a result of strong demand, which encourages further exploration and drilling. The current state of the market appears to suggest that in the future, natural gas prices will not fall to the low levels of recent years.

c) Coal

At a time when the international economy is getting used to higher prices for raw energy materials, the cost of coal is beginning to be a significant factor. As many economic experts say, the era of "cheap energy" is now drawing to a close.

Coal, like other fossil fuels, is being affected by all the international economic movements and in recent years international prices have risen sharply. The McCloskey index, for example, reached nearly $80 dollars a ton and, although the price was brought under control during 2005, the price of "futures" augured that it would rise again to $65, as is currently the case[21].

Currencies in energy trading

Another important influence on the economy is the currency used for oil trading.

Traditionally, oil prices have been quoted in US dollars. Although the merchandise can actually be paid for in any currency, the rate is always given in dollars. The result is that both sellers and buyers prefer transactions to be in dollars too, to avoid unnecessary expense. The US dollar owes its position as the global reserve currency precisely to this system of pricing and payments for oil (and most other energy sources too).

Nonetheless, fluctuations in the relative strength of the different agents on the oil market over recent years, together with an American budget and trade deficit and the growing importance of the euro, are leading to calls for this trading system to be revised; any such move would cause substantial changes in global politics[22].

In September 2000, Iraq announced that it would not accept more dollars-for-oil and ordered that the ten billion dollars transferred to the UN account should be converted into euro. This was a political move, aimed at profiting from the continued fall of the American currency. When Americans marines entered Baghdad, Iraqi oil once again began to be sold in dollars.

In 2006, Iran publicly declared its intention of opening a petroleum exchange on which hydrocarbons would be quoted in euro. The news has caused serious concern in petroleum circles, especially among the Americans, since Iran is the second largest producer in OPEC. The United States is concerned that the OPEC might transfer its international transactions from a dollar standard to a euro standard, this threatening its economic hegemony.

The exchange rate of the dollar would be affected by such a massive move in payments to another currency. Attempts such as those of Iraq and Iran, not to mention hints by Venezuela and Russia at a similar move, mark a growing trend to revise the present system for quotations and payments on the oil market. This trend could lead to the emergence of one or various contract currencies.

21. Information taken from the MCIS Index (dollars/ton), 30 June 2006. National Federation of Coal Mine Owners.

22. Information taken from the Centre for Energy Studies at the Institute of the World Economy and International Relations of the Russian Academy of Science.

The role of the large oil companies

During the 1990s, economic deregulation, reforms in the market economy and western-style corporate management have characterised the oil and gas industries of the largest energy-producing countries, and the energy industries of the developing countries that consume most. Today, the economy is going down the same road.

Among the most important players in the oil industry are the national oil companies (NOCs) and the private international oil companies (IOCs).

The NOCs[23], together with the remaining traditional oil and gas monopolies, control the great majority of the world's proven oil reserves; however, they do not control production to the same extent.

23. According to Petroleum Intelligence Weekly, NOCs such as Saudi Aramaco (Saudi Arabia), PDV (Venezuela), NIOC (Iran), PEMEX (Mexico) and Petrochina (China) are among the top ten in terms of both oil reserves and oil production. IOCs such as ExxonMobil, Royal Dutch/Shell, BP and ChevronTexaco also rank among the top ten, but in terms of reserves they stand in 10th and 20th position.

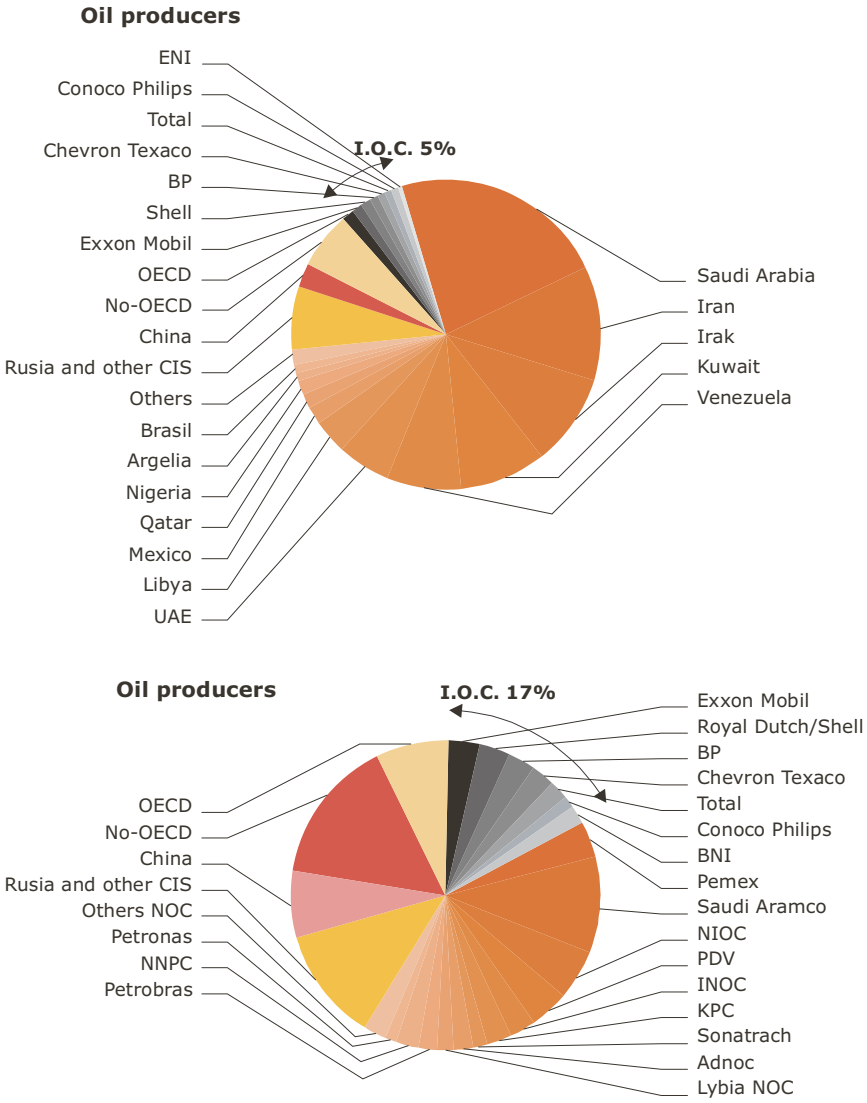


Illustration 24: Oil reserves and oil producers.
Source: BP Statistical Review of World Energy 2002.

Notes

Based on this control of reserves and new strategic initiatives in oil and gas investment and trade, the NOCs have gained such a level of influence that any overview of global energy would be incomplete without a mention of their goals, futures, strategies and behaviour.

In theory, their mission consists of increasing state profits and acting as the state's driving force behind national economic development. However, due to strong pressure from the public sector, they have diverted their attention from corporate interests to centre on more state-related aspects and have ended up holding social and political responsibilities. Thus, they have become a sort of highly bureaucratised macro-company, controlling the country's hydrocarbons monopoly and often fulfilling a regulatory function too.

As a result, although the need to reform NOCs and improve their operation, competitiveness and value-creation is widely recognised, little progress has been made. This all requires at least a clear separation of the tasks of defending national interests and of defending corporate interests. The NOCs should centre on the latter, whereas the state should be concerned with the former.

Going back to Illustration 24, let us focus on the IOCs. These play an important role as oil producers; however, if we look at reserves, we can see that their importance is considerably smaller. There appears therefore to be an alignment of interests between IOCs and NOCs. The IOCs offer technology, capacity to manage complex projects, efficiency and access to diversified markets. The NOCs, for their part, offer oil reserves, support for long term projects and potentially attractive returns on investment.

However, despite the clear alignment of interests, only limited advances have been achieved in conjoining them, and there is still a long way to go.

Transport

Transport has always been very important to the economy because of its impact on trade and its necessary participation in many other sectors (tourism, private travel, etc.). This importance has grown exponentially with a progressive increase in globalisation. We have witnessed an extraordinary advance in international economic relations, which have made transport one of the pillars of today's economy for both developed and underdeveloped countries.

Throughout the twentieth century, demand for the transport sector has increased exponentially in OECD Countries. The key factors areas of this growth have been overland transport and, more recently, air transport. As emerging countries continue to develop and the world faces the threat of climate change, this sector will come to represent a major long-term challenge. Its association with energy is undeniable: transport accounts for one third of all energy consumption.

The main source of energy consumed by the transport sector is oil, which made up more than half of the total consumed in the world (51.51%[24]). There has been a large increase in oil consumption in developed countries in recent years, as can be seen in Illustration 25.

24. Energy Consumption in the Transport Sector. IFP, Panorama 2005.

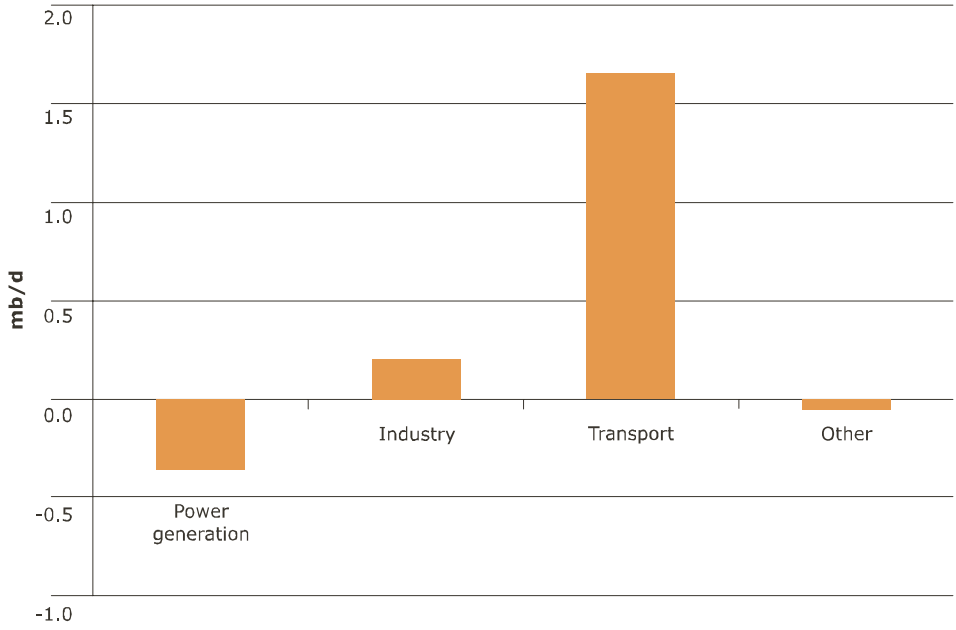


Illustration 25: Increase in the demand for oil in transport (1999-2004).
Source: World Energy Outlook 2005.

Overland transport is the largest sub-sector, representing 90% of passenger travel and 75% of freight traffic[25]. In the last 25 years, the fleet of vehicles has more than doubled in OECD countries, which contain 80% of the total fleet. In 2004 there were nearly 600 million private automobiles and 209 million lorries in the world.

In terms of energy consumption, overland transport is again the dominant sub-sector (accounting for 81% of energy demand in the sector) and, despite recent advances in energy efficiency, it is still the most energy-intensive form of transport.

25. Energy Consumption in the Transport Sector. IFP, Panorama 2005.

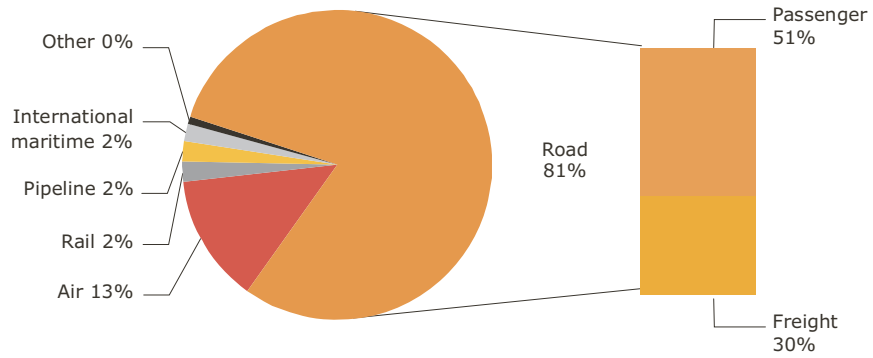


Illustration 26: Breakdown of energy consumption within the transport sector.
Source: Energy Consumption in the Transport Sector. IFP, Panorama 2005.

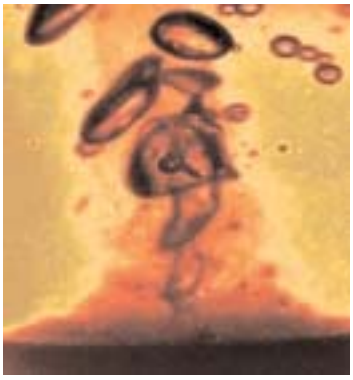
The strong growth rate in overland transport is limiting the impact of ongoing policies of energy conservation and environmental protection. A dominant factor in this paradoxical trend is that systems of transport that consume less energy or cleaner energy are not sufficiently competitive or lack the necessary infrastructure.

Although over the last thirty years it has been OECD countries that have spearheaded growth in road transport, emerging countries like China and India are soon expected to catch up. Indeed, this is already happening in China, where production of vehicles multiplied nearly nine-fold over the period 1997-2003 to around 4.4 million vehicles, equivalent to more than 20% of European production. The rate of vehicle ownership in China stands at just 10 vehicles per 1,000 inhabitants, so this is probably only the start of the trend.

Finally, the environmental impact of transport should not be ignored: it is the leading consumer of fossil fuels, which produce the most CO_2. This issue is dealt with at greater length in the section on energy and the environment.

3.2.2. Energy and politics

Political aspects are of key importance in energy, as they ensure a sustainable supply that is compatible with respect for the environment through regulation that encourages efficient use of non-renewable energy and at the same time promotes the development of renewable energy sources, all through stable geopolitical relations that ensure international trade in energy.



Regulation

In the current situation, marked as it is by high oil prices and forecast problems in supply, public bodies need to intervene to promote more efficient use of fossil fuels and a transition towards renewable energy.

The key to promoting energy efficiency is to give regions, the public and industry the incentives and instruments they need to perform the actions and the investments that will achieve a greater energy saving.

One of the functions of the public powers-at national or community level-is to compensate for deficiencies in the market. In this sense, governments can use state aid (grants or concessions), fiscal policy (variations in taxes) and awareness- heightening campaigns to guarantee greater energy efficiency.

In 2005, the European Commission launched its Green Paper on Energy Efficiency[26], which invited public authorities to encourage responsibility among all citizens and businesses and reward actions that encouraged saving. The green paper aims at "identifying options and at opening a wide-ranging discussion on how to realise the cost-effective savings and to start the process towards rapidly establishing a concrete action plan, involving action at Community, national, regional, local and international levels and at the level of industry and of individual consumers, to harness the identified potential energy-efficiency savings.".

Energy efficiency measures must go hand in hand with the promotion of renewable energy. Government policies must include targets on consumption of renewable energy.

As early as 1997, the European Commission published a White Paper on renewable energy sources (Energy for the future: renewable energy sources), in which it proposed a community strategy and action plan intended to double the contribution of renewable energy sources to meeting energy consumption in the EU by 2010[27]: from 6% to 12% of the energy mix. In 2005, renewable energy sources still accounted for just 6% of total EU consumption. Indeed, a new renewable energy plan 2005-2010 has been developed to try to meet the proposed target.

The promotion of electricity produced from renewable energy sources is another of the initiatives established in EU and national targets for power consumption (Directive 2001).

In view of the recent increase in the price of oil, governments are taking a greater interest in the development of biofuels for transport. In the EU, for example, the target is to increase the proportion of fuels obtained from biomass form the current figure of 1% to 5.75% by 2010.

26. See http://ec.europa.eu/energy/efficiency/doc/2005_06_green_paper_book_en.pdf.

27. See http://ec.europa.eu/energy/library/599fi_es.pdf.

Political support from public powers is vital in stimulating technological change and speeding up the introduction of technologies in renewable energy sources, and in deploying them on a broader scale[28].

Other issues relating to regulation turn around the influence climate change will have on the daily supply of energy to consumers. The Kyoto Protocol was the most important initiative in this area and is dealt with in greater depth in the chapter on the environment.

Geo-politics

As new measures are being taken to encourage the use of renewable energy sources, countries are taking steps to ensure that existing energy levels can be met through trading links to ensure the supply of hydrocarbons. Whether the world faces a panorama of tension and conflicts of interest or a scenario of global or regional cooperation (with the consequent impact these situations will have on prices) will depend on the intelligence of the political players and their international strategies.

Geo-politics plays a particularly important role in oil-addicted developed countries (primarily the US and EU), since they often import fuel from politically unstable regions.

For example, OPEC countries such as Nigeria, Iraq, Iran, etc. produce oil, but are politically unstable, and this causes fluctuations in the output on which many oil-consuming nations depend. Others, such as Venezuela, are threatening to review the supply contracts signed in the 1990s, in order to diversify supply and use oil to develop their own socialist interests.

Another aggravating factor is the thirst for growth among developing countries, such as *China* and *India*, which translates into a considerable increase in energy demand the international repercussion of which are putting a strain on energy supply.

China has already become the world's second-largest consumer of crude oil and Indian consumption will grow by 50% over the next eight years, following the major reforms made to the energy industry in the 1990s by New Delhi[29]. This increase in demand does not appear to be significantly altering forecast reserves, but it will unquestionably contribute to keeping prices up over coming years.

The fact that the two emerging giants obtain most of their oil from OPEC is also leading western economies to seek new supply sources that will enable them to allow reduce their massive dependency on the organisation. In recent years alternatives have been sought in the Gulf of Guinea, the Siberian fields and the Caspian basin-the new stars of petroleum geo-politics.

28. Information taken from the article "Energías Renovables en Europa: cifras, políticas, investigación y desarrollo tecnológico".

29. Información obtenida del artículo "Geopolítica del petróleo: ¿cambios existenciales?". Autor: Ángel Alonso Arroba. Marzo de 2005.

Nonetheless, the EU's reliance on OPEC does not seem likely to diminish dramatically in coming years. Europe currently imports nearly 80% of the oil it consumes, 45% of which comes from OPEC. The *United States*, for its part, relies on its energy trade with its geographical neighbours, Canada and Mexico, as well importing from OPEC countries.

Closer commercial ties with *Russia* may help increase the country's importance in EU oil supplies, as well as increasing the European presence in *Central Asia* and the *Caucasus*. However, studies indicate that the Caspian is not the new Persian Gulf that many anticipated in the mid 1990s. The reality is that production from the region will not exceed 4.7 million barrels a day in 2010, scarcely half of the oil currently produced by Saudi Arabia.

The same is true of *Western Africa*, whose contribution to European imports may have hit a ceiling of around 25%. Nigeria, the Congo, Gabon, Cameroon and Equatorial Guinea have a combined output of around 4.5 million barrels a day. To develop African energy resources, direct foreign investment is needed, since nearly all new reserves are in deep water off the coast and require advanced facilities and major capital investment.

All the indications are that the Middle East (OPEC members) will retain its leadership of oil. Saudi Arabia and Persian Gulf producers own around two thirds of the world's proven oil reserves. The size of these reserves, combined with low production costs, ensure that the Middle East will continue to play a crucial role on the world energy market.

Moreover, Saudi Arabia supports international energy security, by maintaining a considerable level of surplus production capacity, which can be called in quickly in the event of a serious disruption to supply elsewhere[30].

In view of the world's great reliance on oil from this region, consumer countries are tending to seek greater diversification of the world supply, without distancing themselves from these producers. Indeed, they are being encouraged to increase their supply by opening the way to greater foreign investment.

Gulf producers could earn greater profits if they opened up their economies to greater private investment, allowing oil and gas production capacity to grow and energy supplies to respond more fully to changes in demand. One industry in which this process has already begun is that of natural gas. Qatar is working with important international energy companies to become a major exporter of liquefied natural gas (LNG).

Illustration 27 shows the main commercial movements of oil between the various regions mentioned here.

30. Information taken from the article "La geopolítica del petróleo y el gas natural". Author: Alan Larson, Under Secretary for Economic, Business and Agricultural Affairs. U.S. Department of State.

This combination of commercial relations shows import/export flows between the different regions aimed at ensuring the energy supply of hydrocarbons. These flows today represent a major part of the energy required for economic development.

In the long term, the promotion of renewable energy sources and the development of new technologies such as the use of hydrogen or total carbon capture will enable economic progress with a minimal environmental impact without requiring most of the hydrocarbons consumed today. Till then, however, international energy policies will have to ensure a supply of hydrocarbons coming mostly from problematic regions of the globe.

Diversifying energy supply, improving investment opportunities and guaranteeing that market forces act with the greatest transparency and efficiency are just some of the political measures that could help sustain a stable energy market.

Major trade movements
Trade flows worldwide (million tonnes)

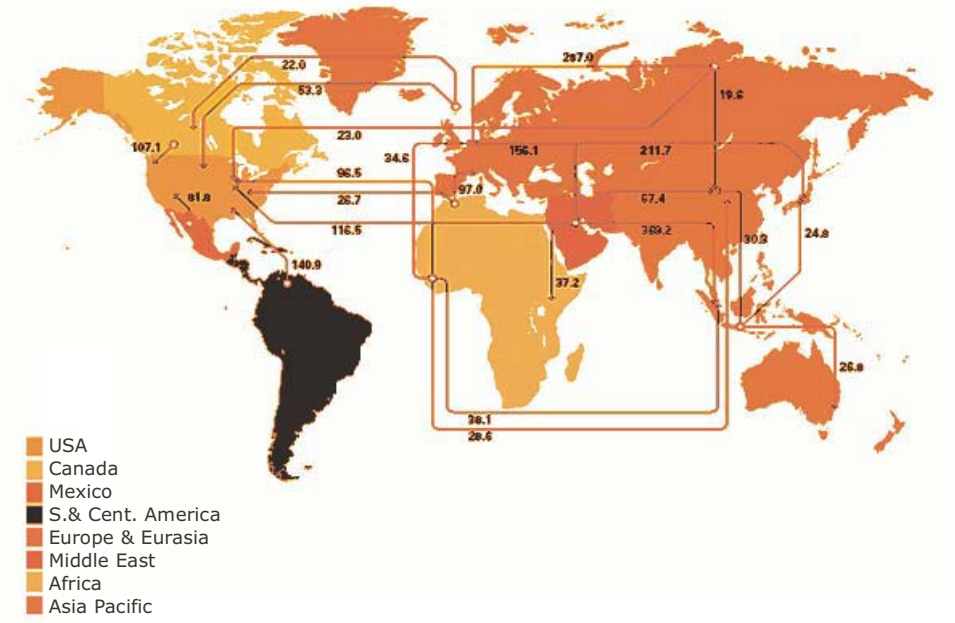


Illustration 27: Commercial movements of oil worldwide.
Source: BP Statistical Review of World Energy June 2006.

3.2.3. Energy and society

We start from the axiom that human society cannot survive without continuous use of energy and, therefore of energy sources. Throughout history, these have ranged from manpower to the sources we know now, but their importance has remained unchanged. Modern economies are so dependent on energy that per-capita energy consumption has become an indicator of a country's modernity and progress.

As we shall see, there are links between energy use and population growth, poverty, urbanisation and social awareness. These aspects influence energy consumption, just as energy systems influence them. Thus, energy is also in a position to solve global problems, particularly those related to the aforementioned factors.

In reality, the overall objective of energy can be summed up in a very short (and widely-used) expression: "sustainable development of the world".

Energy and population

Many current problems derive from the availability and use of natural resources, which are closely associated with the human population, which exercises pressure on them. The world's population has increased exponentially over the last hundred years. "It took a million years for the world population to reach one billion, 123 years to reach two billion, 33 years to reach 3 billion, 14 years to reach 4 billion and 13 years to reach 5 billion"[31].

The influence of the population on energy demand is evident: the greater the population, the more the energy that is required. This is, perhaps, the basis for the idea that a population increase in developing countries represents the most serious threat to growth and global warming.

However, statistics shows that intensive energy usage behaviour has an even greater impact: 49% of the increase in world energy demand between 1890 and 1990 was due to population growth and the remaining 51%, was due to the per capita increase in energy use. Population volume and habits, then, both have a direct impact on global energy consumption.

Energy and urbanization

A few centuries ago, not even the wildest visionaries could have imagined a city of over a million inhabitants. By 2010, it is forecast that over 500 cities in the world will have passed this mark, and that twenty-five-the "megacities"-will have over 10 million inhabitants. The availability of energy sources, combined with the phenomena of motorisation and industrialisation, have substantially altered the way in which people relate to their surroundings. Furthermore, the

31. Sen, 1994. We might add that the UN calculates that the world population hit six million on 13 October 1999. On that day a child born in a maternity ward in Sarajevo was designated as the six billionth person on the planet.

number of people living in cities will soon exceed the number living in the countryside[32].

According to the UN's 1996 conference on sustainable human settlements, "Habitat II"[33], the type and scale of urban development will have an enormous effect on future energy consumption. Urbanization has a very profound impact on the amount and type of energy consumed. Other factors such as economic development, industrialisation and socio-cultural features are also responsible for an overall increase in energy demand. While rural societies are mainly based on animal or human energy and on wood as a fuel, urban societies use electricity and fossil fuels.

However, despite the well-known negative environmental effects of urban areas, the reality is that a country's economic prosperity depends on the action of its cities.

In developing countries, per capita energy consumption remains low. As urbanisation spreads, the demand for energy increases and traditional fuels (wood and charcoal), food and other materials consumed in urban areas can be transported longer distances. In addition, urban industry and commerce require more energy and infrastructures than traditional agriculture. As a result, energy use increases quickly in developing countries as they become more industrialised.

Nonetheless, energy can act as an instrument for sustainable development if a stress is laid on more efficient use of energy and an increase in the use of renewable energy, among others measures.

There are many energy strategies related to urbanisation. For example, a suitable balance between mobility and accessibility based on demand management would result in a strategy of more energy-efficient transport. The purpose is to combine people's needs to move within the city with the city's real possibilities in terms of land and infrastructures.

Urban areas offer great potential for reducing the demand for energy-intensive materials and increase efficiency in the use of resources. The agglomeration of social networks encourages a milieu which is more accessible to public awareness- raising campaigns and creates a learning environment which is more favourable to a change in the patterns of consumer misspending. Moreover, new efficient energy technologies are being applied faster thanks to investments by private companies, forced by the competitiveness of the market.

Energy and poverty

Poverty might be defined as an individual's impossibility to gain access to basic human needs such as food, water, a home, clothes, health and education. It also includes a lack of opportunities and the possibility of choosing human develop-

32. World Energy Assessment: Energy and the challenge of sustainability. Chapter 2: Energy and social issues. Amulya K.N. Reddy (India). 2000 UNDP.

33. Report of the United Nations Conference on Human Settlements (Habitat II). United Nations. 7 August 1996.

ment (including a long, healthy and creative life, living standards, dignity, self-esteem and respect).

Energy services are a crucial input in the challenge of meeting people's basic needs, that is to say, in fostering primary development. Energy is one of the determining factors behind poverty and development. Per capita energy consumption is one of the most reliable indicators of the level of economic development and welfare of a given society. In a general sense, energy demand is thus associated with a country's Gross National Product (GNP), its industrial capacity and the living standards of its inhabitants.

Many examples could be given of the importance of energy; among other functions, it is used to cook food, ensure a comfortable temperature, for lighting, for pumping water, communication and transport. Lack of access to energy contributes to poverty and to deprivation, and can contribute to economic decline.

The energy dimension of poverty ("energy poverty") can be defined as an absence of sufficient opportunities to access the energy services that support human and economic development in a suitable, accessible, safe, reliable, environmentally-sound and quality way. The numbers speak for themselves: Two billion people do not have clean and safe fuel for cooking and depend on traditional biomass sources; in 2002, 1.6 billion people had no electricity, the great majority (as Illustration 28 shows) in developing countries; if measures are not taken, by 2030 1.4 billion people will still be living without electricity.

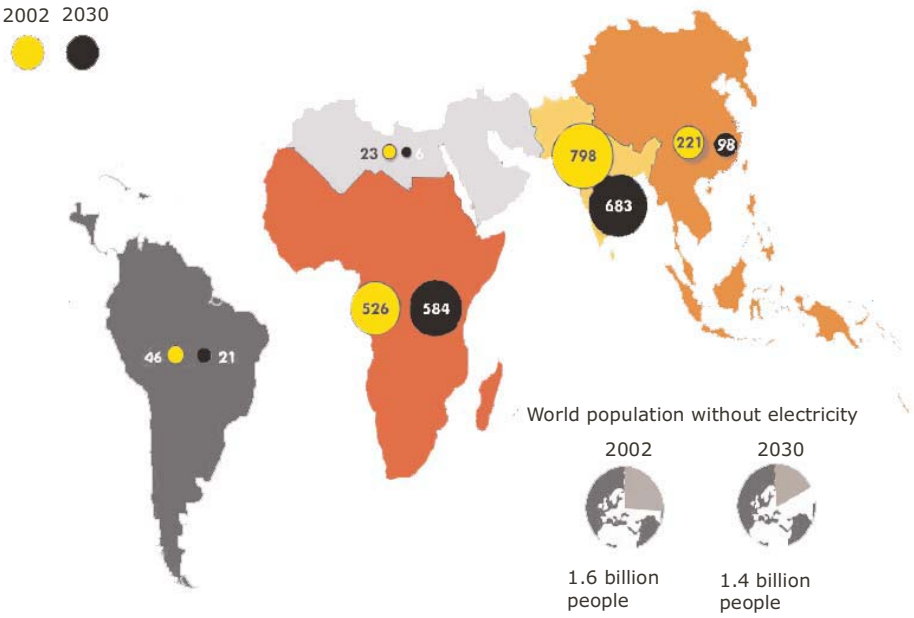


Illustration 28:Population without electricity.
Source: World Energy Outlook 2004: Key trends and strategic challenges. International Energy Agency.

All of this does not mean that simply increasing access to energy services will lead to economic or social development. However, the lack of suitable energy inputs could represent an important brake to development. Universal access to these services is therefore a necessary, but not sufficient, precondition for development.

It also needs to be remembered that all industrialised countries have a population on the poverty threshold, although the energy-related features of the poverty are very different to those of developing countries. Industrialised countries do not suffer from "energy poverty" in absolute terms.

The part of society below the poverty line in industrialised countries spends more of its income on energy than the average. In this case, the problem is not a lack of access to sufficient energy to meet their needs, but the fact that their individual circumstances mean that they consume too much energy and therefore spend an excessively high percentage of their income on it.

In industrialised countries an alternative strategy is required for energy poverty, consisting of ensuring that very low-income individuals or families are less vulnerable to high energy costs. In simple terms, this means that the main challenge in developing countries is to extend access to energy, whereas in developed countries the priority is to maintain access.

Energy and Social Conscience

Social conscience plays an essential role in the area of energy efficiency. According to the FTF experts, one of the most important instruments that a government can use to check energy demand is social awareness-raising (as well as regulation and promotion of clean energy).

Similarly, the impetus given over recent years to environmental issues, resulting from growing social concern, has translated into movements by different public and private bodies.

In the late 1960s, the seriousness of the environmental problems caused by toxic substances became clearer. Society also became aware of the phenomenon known as "acid rain". The problems of urban atmospheric pollution had been recognised for some time, and in the mid-1970s, debate intensified on the possibility of climate change. The oil crises of 1973 and 1979 helped enhance public awareness of the energy problem. Finally, the accumulation of greenhouse gases in the atmosphere resulting from energy consumption has opened people's eyes to this new issue of climate change.

If it is to serve the future of humankind optimally, the energy system must help achieve the targets set out at the UN's Conference on Environment and Development, held in Río de Janeiro in 1992 (the so-called "Earth Summit"). These objectives include the promotion of economically viable, socially harmo-

nious and environmental and strategically secure societies. Since this summit, many other measures have been taken to promote sustainable energy, such as increasing energy efficiency, supporting renewable energy sources and drawing up comprehensive energy resource plans.

Despite all this, people do not appear to be aware of the real dimension of the energy problem or do not afford it the importance it deserves. In a CIS poll taken in May 2006, Spaniards did not place energy among the 29 major problems facing the country. It is possible that energy is implicit in some other issues, but the fact that it was not specifically mentioned on its own is a significant indicator.

For another perspective on the important role that social awareness plays in energy, we need only look at nuclear power. At the latest G8 meeting (St. Petersburg, July 2006) there was a clear division amongst the world's most highly industrialised countries. The approved statement on energy concluded that countries that "have or are considering plans relating to the use and/or development of safe and secure nuclear energy believe that its development will contribute to global energy security, while simultaneously reducing harmful air pollution and addressing the climate change challenge". Countries such as France and the UK are clearly committed to this energy source.

However, despite all the data that appear to tip the scales towards the proliferation of nuclear energy, society is pushing in the opposite direction in countries like Germany, which has committed itself to progressively abandoning nuclear energy, and Italy, where nuclear development was rejected in a referendum.

3.2.4. Energy and environment

One of strategic objectives for sustainable energy development relates to the environment. This growing concern is being translated into actions that seek to prevent, tackle, control and reverse the problems derived from global warming and the degradation of natural ecosystems.

To do this, it is necessary to rationalise guidelines on energy production and consumption, define new approaches to mobility and conceive new methods for managing natural resources, based on a better understanding and capacity for predicting their impact and repercussions on the environment, especially on a global scale.

Political actions and research currently underway to address this problem of global impact centre on developing sustainable energy systems, managing CO_2 emissions from fossil fuels and disposing of nuclear waste.

CO_2 emissions from energy production

CO_2 emissions have a direct effect on global warming and the quality of air and water. Actions that limit emissions of greenhouse gases can alter the level and composition of energy-related CO_2 emissions.

CO_2 is one of the most common greenhouse gases in the atmosphere. Man-made CO_2 emissions are mainly the result of burning fossil fuels[34]. The debate on climate change has already begun, with the aim being to limit the consequences of a bleak panorama.

In 2005, emissions of CO_2 from fossil fuels increased by 2.6%. Though high, this rate is less than the 4.49% increase of 2004[35], but higher than the annual average of 1.69% during the period 1990-2004[36].

Obviously, not all regions and countries contribute equally to these emissions. Illustration 29 shows the carbon emissions of different fossil fuels and regions.

34. Burning one million of tonnes of oil equivalent (a unit of energy common to all energy sources) in fossil fuels produces: for oil, 19.9 million tonnes of carbon; for natural gas 13.8 million tonnes; and for coal, 24.1 million tonnes.

35. 2005 Carbon Dioxide Fact Sheet.

36. Energy Information Administration. World Carbon Dioxide Emissions from the Consumption and Flaring of Fossil Fuels, 1980-2004.

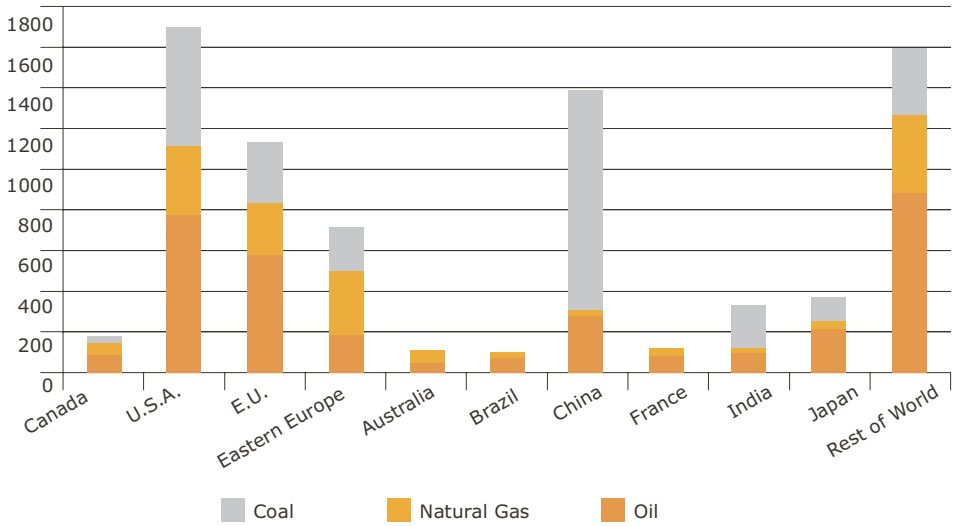


Illustration 29: Carbon emissions from fossil fuels by countries in million tonnes (2005). *Source: 2005 Carbon Dioxide Fact Sheet.*

Among *developed countries*, the US is the largest producer of CO_2 emissions from fossil fuels, accounting for 22.38% of the world total (in 2005), although there has been a downward trend in recent years. In Europe a distinction needs to be made between Eastern Europe, where emissions increased by 1.74% in 2005, and EU countries, where they fell slightly (by 0.10%). Countries like France and Canada produce smaller amounts of CO_2 from coal because most of their electricity is generated using nuclear and hydroelectric power, respectively.

Amongst *developing countries*, China increased its emissions by 9.1%, although the figure is less than the 14.96% figure seen in 2004, as a result of rapid economic growth. In India, the trend is similar, but on a smaller scale.

Global per-capita emissions in 2005 came to 1.18 tonnes of carbon per person. With a world population of 6.45 billion in 2005, emissions would have had to be cut by 0.43 tonnes per person (36%) to stabilise CO_2 levels in the atmosphere.

As we have seen, coal is the fossil fuel that produces most CO_2 emissions for the same amount of energy (million tonnes of oil equivalent); however, higher oil production means that the amount of CO_2 released by this fuel is practically the same as that that comes from coal burning.

Combustion of fossil fuels is responsible for practically all energy-related CO_2 emissions; only 0.4% of the total comes from other sources[37].

37. Key World Energy Statistics 2005. International Energy Agency.

Looking at the industries that release most CO_2 into the atmosphere, we see that power generation comes first, followed by transport, which is the largest consumer of fossil fuels.

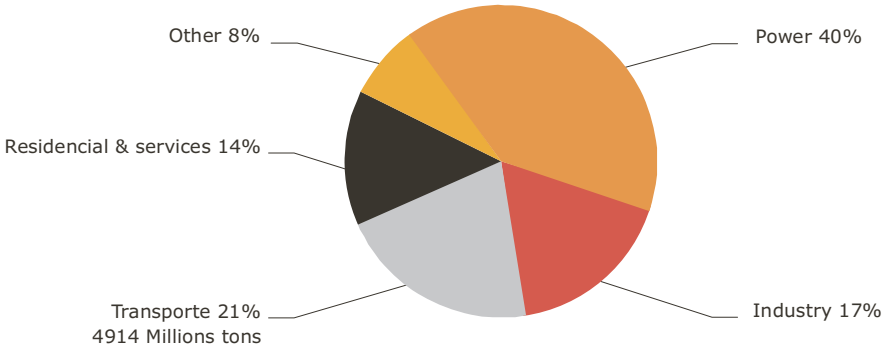


Illustration 30: Co_2 emissions by sector (2002).
Source: World Energy Outlook 2004. International Energy Agency.

It is precisely in the transport sector that the measures required to cut CO_2 emissions appear to be most complicated. It will take time before newly-developed emission-reducing technologies can be widely introduced. It generally takes 13 years to achieve a 50% level of penetration and 24 years to reach 95%[38]. There might be ways of speeding up the process, such as by imposing implementation standards so that vehicles using the new technology come into circulation earlier, but these measures would only succeed in accelerating penetration by three years.

Other complementary measures that encourage change (such as fiscal incentives or a mixture of alternative fuels from plant sources with conventional fuels) might also help to solve the problem. However, government backing is needed, given that oil continues to be the cheapest fuel despite its high CO_2 emissions.

38. Energy Consumption in the Transport Sector. IFP, Panorama 2005.

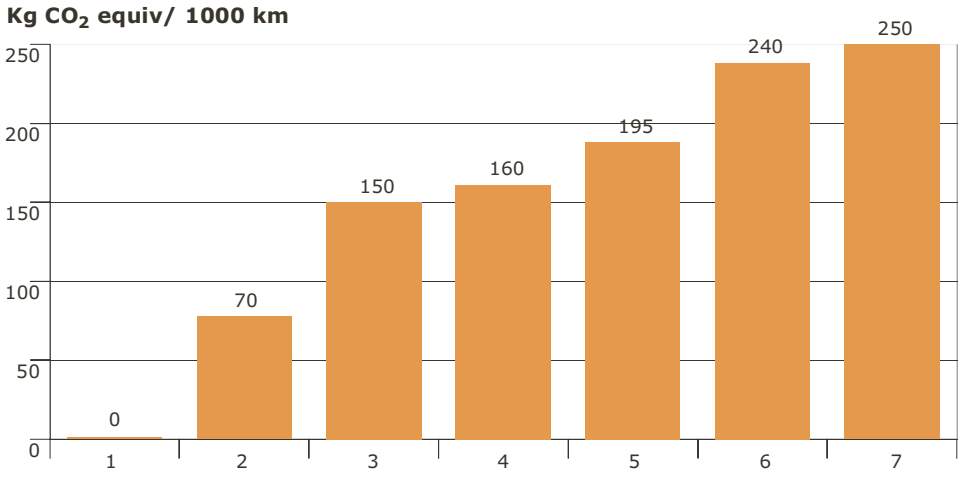


Illustration 31: Level of Co_2 emission by fuel per thousand kilometres.
Source: Methanol Research Institute.

In general terms, to successfully reduce CO_2 emissions into the atmosphere, the FTF experts propose a series of measures that would have a varying impact depending on whether they are applied in developed or developing countries.

An improvement in efficient energy use would lead to a greater reduction in CO_2 than other measures, in both developed and developing countries. In addition, the experts consider that a greater move towards nuclear energy could be an effective way of reducing CO_2 emissions in developed countries.

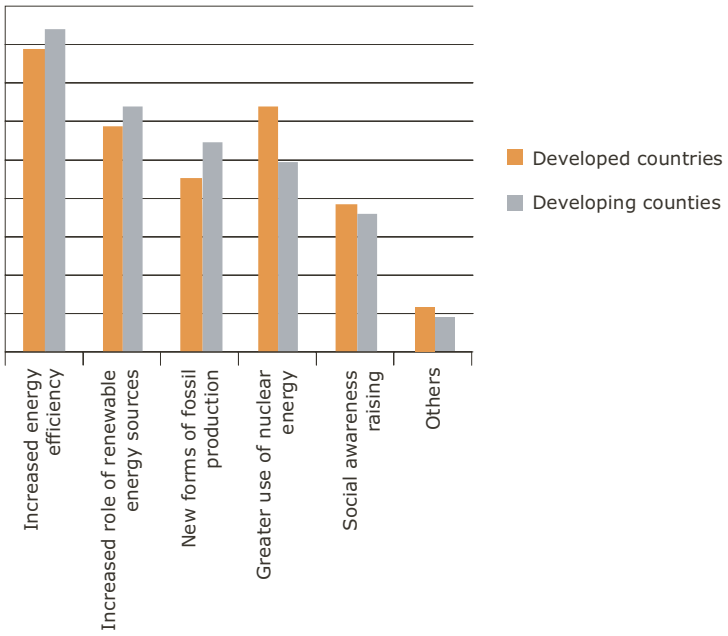


Illustration 32: Factors that currently contribute to reducing Co_2.
Source: Drawn from conclusions within the Future Trends Forum.

As well as the factors listed here, some experts suggest that the production of clean coal through sequestration and confinement is another measure that could contribute to reducing CO_2 emissions.

Disposal of nuclear waste

Nuclear or radioactive waste is waste material generated during the nuclear cycle, which starts with the extraction of the mineral used in nuclear power stations (uranium).

This waste has provoked great social controversy because of its high toxicity for human health. The possibility-low but real-of a nuclear accident caused by bad waste management has made the public wary of nuclear power. Nonetheless, nuclear energy prevents atmospheric emissions and should be recognised as such in any debate on climate change. The amount of CO_2 *not* produced each year thanks to nuclear energy in Europe comes to 800 million tonnes; closing down nuclear power stations is therefore incompatible with efforts to reduce greenhouse gas emissions[39].

39. United Nations Climate Change Conference, COP 6. 13-24 November 2000. The Hague.

The largest volume of radioactive waste is produced during the stages through which the nuclear fuel passes to produce electricity and in the decommissioning of nuclear power stations. This waste represents around 95% of the total produced; the rest is associated with non-energy applications.

There are currently a number of different methods for treating waste intended to minimise radioactive contamination:

- Open cycle: the spent fuels from the nuclear reactors, are considered as highly radioactive waste and stored definitively in deep geological repositories (DGRs); for example, in the desert between New Mexico and Nevada in the United States.

- Closed cycle: those spent fuels are treated (reprocessed) to recover the uranium and the plutonium, so that they can be used as energy materials.

- Advanced closed cycle: since the early 1990s, systems have been researched and developed for separating and transmuting certain long-life radioactive waste. The long-term toxic components of the highly radioactive waste are reduced.

These three options share two essential stages in common: the temporary storage of the spent fuels and their subsequent definitive storage.

Kyoto Protocol

The Kyoto Protocol is an agreement on climate change held under the aegis of the UN within the UN Framework Convention on Climate Change.

The Intergovernmental Panel on Climate Change (IPCC) estimates an average global increase in temperatures of between 1.4 and 5.8 degrees centigrade 1990 and 2100. The forecasts suggest that, if the Kyoto Protocol is properly implemented, this temperature increase will be reduced by between 0.02 and 0.28 degrees by 2050.

On 11 December 1997, in the Japanese city of Kyoto, the industrialised countries undertook to undertake a series of measures to reduce emissions of six greenhouse gases. The signatories pledged to reduce average emissions of pollutants by 5.2% between 2008 and 2012 (the European Union committed to an 8% reduction; the United States, to 7%; Japan, to 6%; etc.), taking as a reference the 1990 levels for all industrialised countries (without the protocol, the anticipated level of emissions by 2010 would be 29% greater than with it).

At this initial stage, the Kyoto Protocol does not place any requirements on developing countries, in view of their lower per-capita emission rates. It was established that the commitment would become binding once it had been ratified by

industrialised countries responsible for 55% of total CO_2 emissions. Russia ratified the protocol on 18 November 2004, after the European Union undertook to pay for the industrial restructuring and modernisation of its installations, particularly its oil facilities, and the Kyoto Protocol officially came into force on 16 February 2005.

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From the point of view of climate change, it is irrelevant where emissions are cut, because the effects of climate change occur -and its causes have to be combated -globally. However, from an economic point of view, it is more profitable to cut emissions where it is cheapest to do so. The cost to developed countries of bringing about changes in their national industry would be greater than that of helping introduce clean low energy efficiency technologies in Eastern countries or developing countries.

Based on this approach, as well as internal measures to contain emissions, the Kyoto Protocol also established three types of "flexibility mechanisms": Clean Development Mechanism, Joint Implementation and Emissions Trading.

The Clean Development Mechanism (CDM) consists of allowing Annex I countries (countries with an emission-reduction target) to invest in non-Annex I countries to meet the targets on emission reduction and limitation. The country receiving the investment achieves sustainable development through the transfer of clean technologies. At the same time, it contributes to meeting the ultimate aim of the climate change convention, while the investor receives emission certificates which can be used to supplement its internal reductions[40].

Under the Joint Implementation (JI) mechanism, an industrialised country can invest in another industrialised country to carry out a project geared towards reducing greenhouse gas emissions or increasing absorption using carbon sinks. The investing country receives certificates for reducing emissions at a lower rate than it would have cost it in its national area and the receiving country gains technology. This mechanism is similar to the CDM, except that the projects are carried out in industrialised countries with Kyoto reduction targets.

Finally, Emission Trading involves a transaction in greenhouse gas emissions between Annex I countries. Countries that reduce their emissions above target

40. The investor can trade these for emission rights, which it can use to meet its reduction targets or sell into the European emission rights trading market.

can sell surplus emissions certificates to others that are below target. Trading in emissions rights does not in itself reduce emissions, but it may help redistribute them among industrialised countries. The only way in which it can be environmentally beneficial is if a strict total quota of emission rights is established that guarantees compliance with the Kyoto Protocol. This trade in emissions will be fully implemented at an international level in 2008.

Illustration 33 shows a map of the world with each country's position on signature and ratification of the Kyoto Protocol.

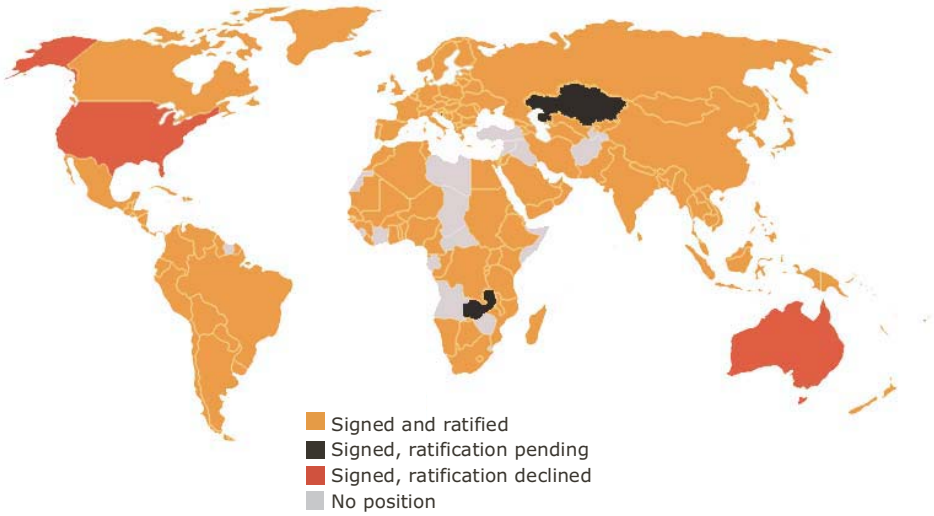

Illustration 33: Position of the different countries re the Kyoto Protocol (2005).
Source: Wikipedia.

Notes

The United States refuses to ratify the protocol, claiming that it would harm its economy to sign a protocol that does not affect developing countries such as China (the second largest producer of greenhouse gases) or India.

Many pro-nuclear delegates have boycotted the Kyoto Protocol summits, in protest against the fact that nuclear energy was not included in the list of measures under the Clean Development Mechanism. They want developed countries to be allowed to discount CO_2 emissions by investing in the building of nuclear power stations in developing countries, but nuclear energy has been excluded from the policies and measures proposed for fighting climate change.

Some lines of research or improvement for reducing CO_2 emissions

Renewable energy sources could solve many of the environmental problems caused by non-renewable energy sources, such as climate change, radioactive waste, acid rain and atmospheric pollution, as we have mentioned.

Renewable energy sources must be gradually integrated into the energy system with an increase in initiatives to promote innovation and investment in this type of technology. Energy policies must be oriented towards demonstrating that environmental challenges can be overcome with a massive contribution from renewable energy sources without a negative impact on social and economic development.

The European Union's target for 2010 is for 22% of electricity consumption to be met by renewable energy sources, with a subsequent reduction in environmentally-damaging emissions. Fourteen percent of the electricity produced in the EU already comes from renewable energy[41].

An energy saving of 20% would allow the European Union to meet its Kyoto commitments, reducing CO_2 emissions to conserve a healthy environment for citizens of today and tomorrow.

Technologies already exist (tested or under development) which could help improve the environmental impact of energy consumption. The next section will look in greater detail at the way in which technology can help to use biofuels in transport or develop combined-cycle power stations that harness the heat produced during power generation or, even, use fuel cells in the residential sector. All of these advances can help us reduce CO_2 emissions into the atmosphere.

41. "Promoción de Energías Renovables en la Unión Europea". Buenos Aires, 21-22 February 2005.

3.2.5. Energy and technology

Throughout history, technology has offered energy the key to accessing new higher-efficiency sources, allowing for economic development. Today, new technological advances have made it possible to extend the estimated lifetime of fossil fuel reserves, but this is only a temporary solution. The greatest challenge faced by technology lies in developing new sources that will enable energy sustainability, i.e., supplying the world with energy while respecting the environment.

One of the keys to achieving this sustainability lies in making new developments that give renewable energy sources an increased role, as well as increasing the efficiency of non renewable energy types, although the continued low cost of the latter still represents a considerable barrier to investment in renewable energy technology.

In the challenge of **ensuring the energy supply**, fossil fuels continue to be the most viable short term solution in terms of cost and efficiency. As a result, part of the technological research has centred on extending their lifetime in the energy mix.

The energy industry's capacity to identify hydrocarbon-bearing sediments under the sea bed at extreme depths is improving with new technologies. In recent years, the industry has centred on deep-water offshore operations, with new discoveries evaluated to justify the high cost of such projects.

There is considerable potential for deep-sea hydrocarbon drilling. It is estimated that possible reserves in the Caspian Sea alone could come to 210,000 million barrels of oil, approximately 20% of the world's proven reserves[42].

The development of these resources, together with improvements in the technologies for drilling unconventional oil deposits, would make it possible to extend the lifetime of oil and natural gas as energy sources. Technology is vitally important in achieving economic viability.

Another of the technological advances for identifying reserves are the "supercomputers", oil-searchers that use a 3-D seismic system to identify oil-bearing geological structures and locate them much more precisely. Another technology consists of drilling down and then out to the side, thus searching horizontally for the reserves. This reduces the number of drilling operations required, and thus the costs.

In order to assure the continued global energy supply, technological research is also centring on renewable energy sources, although they continue to account for only a small percentage of the energy mix. Some of these technologies are already at a mature stage (wind and hydro power, for instance), but there are

42. Information taken from "Reservas y transporte de petróleo en el Mar Caspio: El oleoducto Bakú-Tbilisi-Ceyhan". UNISCI Discussion Papers. October 2004.

Notes

others with great potential, such as photovoltaic solar power or biomass, for example, which will help chip away at the leadership of fossil fuels.

The other great challenge is to achieve new developments in the field of the **environment**.

Much of the technology related to combustion plants centres on reducing the level of emissions even further. The main technology consists of capturing CO_2 emissions which can then be transported and confined. Depending on the part of the process at which this capture occurs, the process is known as post-combustion capture or pre-combustion capture. In post-combustion, the CO_2 is isolated directly from the gas current after burning. In pre-combustion, the idea is to increase the concentration of CO_2 in the gases (from 4% to 14% in coal and natural gas technologies) in order to improve the capture process.

Once the CO_2 has been isolated from the gas flow, it has to be piped to the place where it is to be used in industrial processes-as has already been done before now in small quantities-or removed to the potential sinks currently being studied; transport is therefore another of the major steps in CO_2 sequestration. The latter process consists of disposing of the CO_2 in such a way that it is retained and isolated from the atmosphere for a long period of time.

Among the different technologies under development which are being used at this time, one of the most important is coal gasification[43]. Some hybrid combined-cycle technologies use the best characteristics of gasification and combustion technologies, achieving efficiency levels of over 50%. Most owners of combustion plants are not yet adopting these technologies, because they involve higher costs and there is no regulation obliging them to do so.

The transport sector is constantly looking for alternative fuels that will pollute less and be more economical. The motor industry has slowly joined in the development and large-scale production of environmentally-sound vehicles powered by biofuels, electricity or hydrogen.

The production and use of biofuels in transport offers a series of environmental advantages over fossil fuels. Burning bioethanol can reduce greenhouse gas emissions by between 40% and 80%44. Although biofuels generate CO_2 when burned, cereals that can be converted into alcohol or oil-bearing crops used to produce biodiesel are CO_2 sinks which balance out the emissions from automobiles.

Hybrid vehicles, which combine a petrol engine and an electric motor, consume 40% less fuel and are environmentally more friendly. For a city like Seville, with its 750,000 cars, if only 10% were hybrid, 30.4 million litres of fuel would be saved and 74,000 tonnes less CO_2[45] would be released into the atmosphere.

43. This system consists of transforming solid coal into a synthetic gas primarily composed of carbon monoxide and hydrogen. The coal is gasified by controlling the mix of coal, oxygen and steam in the gasifier.

44. Article "Energías renovables: los Biocarburantes" (http://www.publispain.com/revista/energias-renovables-los-biocarburantes.htm).

45. Information obtained from the Government of Andalusia (http://www.andaluciajunta.es/aj-not-.html?idNot=98801&idCanal=214411).

The fuel cell is another of the technologies that could play a significant role in the transport sector, given its high energy efficiency, its low level of noise and emissions, and the cogeneration of electricity and heat, primarily.

The environmental advantages of fuel cells are one of the main factors that have contributed to the great interest shown by public and private institutions in this technology. Fuel cells have enormous potential for reducing pollutant emissions and thus contributing to sustainable national development.

If fuel cells were used to generate power in the industrial and residential sectors, the reduction in emissions as compared to traditional thermal power stations could come to around 30% for CO_2 emissions and be two or threefold in the case of nitrogen oxides, sulphur, carbon monoxide and particles if hydrogen from natural gas[46] were used.

Its largest drawback today is its high cost: this is a new technology which has not been widely introduced and has not yet created enough of a market to lower prices. There are also certain technical problems in aspects that need to be improved upon, such as the weight of the cells.

Another area of research intended to replace fossil fuels focuses on the use of hydrogen in fuel cells. *Hydrogen* is cleaner than biofuels, but there are still a series of problems which need to be addressed, such as production, transport and storage.

Another of the technologies currently being developed to reduce emissions of pollutant gases is "combined production", which allows the heat generated from electricity to be re-used, rather than released. This would mean a considerable fuel saving and a subsequent positive impact on the environment. Efficiency in fuel consumption is increased and at the same time the production required is reduced.

Finally, we should mention *nuclear power*, given its environmental importance; as we saw in the previous chapter, it helps reduce the quantities of greenhouse gases released into the atmosphere. Research is centring on the technological development of new safer and more efficient reactors in order to produce an environmentally-compatible energy supply. Illustration 34 shows the principal reactors under construction and investigation.

46. According to data from the National Institute of Aerospace Technology.

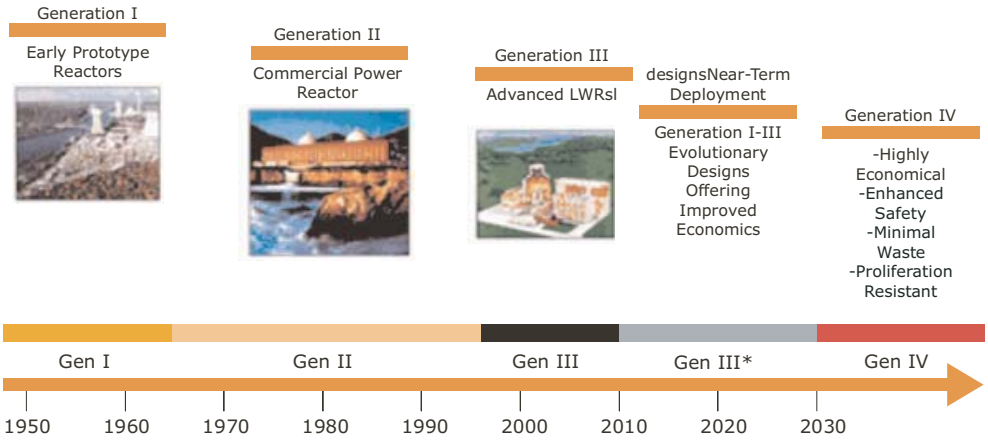

Illustration 34: Development of nuclear reactors.
Source: "Opciones de futuro y tecnologías en desarrollo". Emilio Mínguez Torres, Professor of Nuclear Technology. UPM.

France and Germany are developing construction of a new third-generation reactor known as the "European Pressurised Water Reactor" (EPR), which integrates the latest developments in safety, environmental protection, technical capacity and economic profitability.

By 2010 "Generation III+" reactors are expected to be developed, which will include passive safety designs and will mostly be based on gas reactors. Fourth-generation reactors, a longer term project, will be safer, will minimise waste and will cost less.

All of these technological developments for achieving a guaranteed energy supply and for reducing emissions of greenhouse gases, will appear on the market sooner or later, depending on public and private investment, on the solving of technical problems and on public pressure.

The new means of producing biofuels are seen as the advance that will be developed in the shortest term. Given its high dependency on oil, transport is one area in which innovations are needed, although oil seems set to maintain its hegemony here.

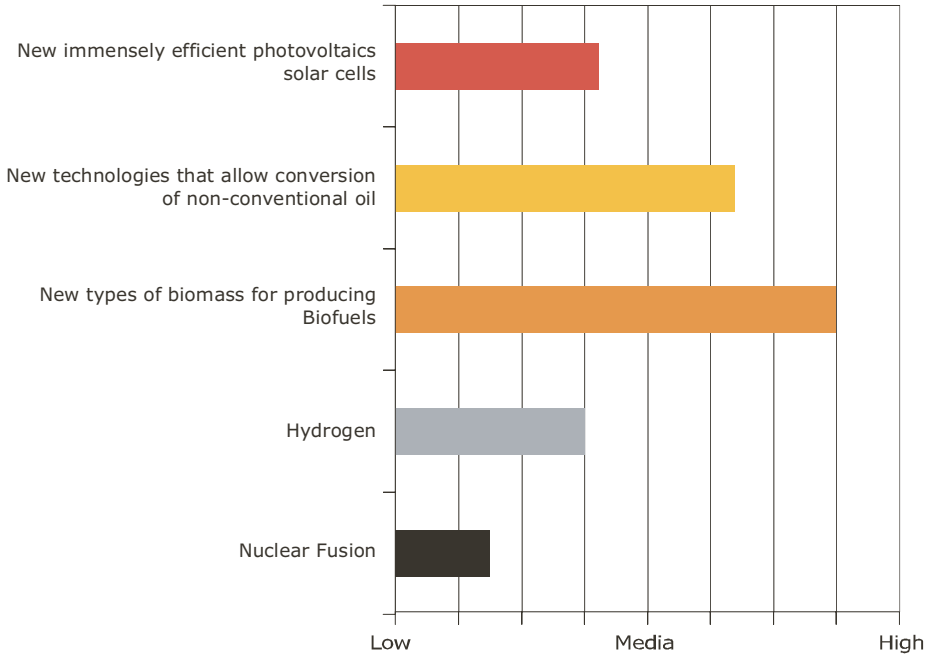

Illustration 35: Probability of technologies appearing in the short-medium term.
Source: Drawn from conclusions within the Future Trends Forum.

As for hydrogen or solar photovoltaic cells, the FTF experts consider that these will not be launched in the medium term future, since there are still certain technical problems that need to be overcome. The great hope may lie with nuclear fusion, but at present this seems more likely to be a solution for the twenty-second century.

It is possible that only when the exhaustion of fossil fuels becomes a real and tangible threat and, energy prices reach levels that cannot easily be borne by the world economy, will there be a radical change in investment in innovation and development of energy alternatives. In the meantime, the FTF experts consider that certain public and private measures or initiatives can be taken that will help make a smoother transition towards a new sustainable model of energy supply.