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Will the world need increased production of nuclear electricity to meet in the long term a growing demand for energy? This is the question that three authors address in the first group of articles in this issue.

A second set comprised of two contributions raises questions about the current price regime for oil in international trade. This regime which largely relies on reference prices taken from futures exchanges is almost universally accepted, rather uncritically, as a good market-related price determination system. The authors analyse features of the regime that cast doubt about its ability to provide efficient signals to economic agents involved in the world energy scene.

On nuclear, Alain Bucaille believes that much progress ignored by the critics has been made in areas that cause concerns – safety, waste disposal and proliferation for example. His main argument, however, is that nuclear is necessary for both environmental objectives and the future energy supply/demand balance. The longer it may take for the realisation of the importance of nuclear to arise, the greater the problems that the world will face in 15 or 20 years time.

Pierre-René Bauquis begins by discussing the issue of 'peak oil', one of his arguments being that nuclear will be needed to compensate for a long-term scarcity of oil. He also points to the interesting fact that nuclear will be needed to increase petroleum supplies, particularly the very energy-intensive production of synthetic oil from tar sands.

An important and masterly article by Adnan Shihab-Eldin surveys the factors that may induce a renaissance of nuclear and those that may hinder it. In a sense, he covers the two sides of the debate.

The historical development of nuclear since the Second World War displayed two features. The first is a cycle comprised of an initial golden age (1950s to the 1970s) during which nuclear received strong support from several governments. This was followed, after accidents in Three Mile Island (1978) and Chernobyl (1986) by a decline in the rate of introduction of nuclear. In a number of countries public opinion became antagonistic. Concerns about the disposal of radioactive

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waste increased. The question raised by the author is whether we are near a resurgence inaugurating a new stage. The second feature is the huge differences among countries in the penetration of nuclear. In Italy no electricity is generated by nuclear, in France the share is 80 per cent.

The climate change issue combined with concerns about supply security are renewing interest in nuclear. The author, however, discusses difficulties: a public opinion that needs to be persuaded, the lack of a convincing solution to waste disposal and weaknesses of the non proliferation treaty.

In general, the three articles are favourable to nuclear. Readers may however worry legitimately about a number of issues. They may agree that there are no CO_2 emissions from the operations of the plants but what about their construction and the manufacturing of many pieces of equipment that do emit carbon. Furthermore, the proliferation issue is far from being solved. And radiations, because they relate to the big C disease and are perceived as an insidious invisible enemy to our health cause alarm. What is the trade-off between radiation and global climate change issues? In nuclear much depends on the safety issue – that is on future technological progress that is uncertain, and the risks of human error and misjudgments which are not always avoidable.

The articles in the second set – the oil price regime – point to a possible divorce on certain occasions between price movement and actual changes in fundamentals. This occurs when the term structure of futures prices is in contango; and when financial entities move funds in and out of the futures oil markets in response to changes in the relative profitable prospects of other financial markets.

Bassam Fattouh shows that the current regime poses serious challenges to OPEC. Robert Mabro argues that the nature of the futures contract – a financial instrument traded in a financial market where financial institutions appear to lead – disqualifies it as a provider of a reference price for physical oil in international trade.

Two contributors deal with separate issues, one with the important question of carbon emissions and the second with the interesting Brazilian ethanol story.

Peter Nicholls notes that the current price of carbon is low and that there is much uncertainty about governments' policies. This explains why the international oil and gas industry has no interest in acting to reduce atmospheric carbon. His suggestion, controversial as it may be, is for the industry to be obliged to purchase carbon permits for a proportion of its hydrocarbon production. This idea deserves discussion and we hope that readers will respond with rejoinders.

Eduardo Correia shows how technical progress in car engines, namely fuel flexibility, has caused a resurgence in the use of ethanol in Brazil. Ethanol no longer needs subsidies in a country that has become a world leader in both sugar and ethanol trade and production. The Brazilian experience is worth studying by those who wish to promote ethanol as a substitute for, or a complement to, gasoline and automotive diesel.

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Nuclear Energy

Alain Bucaille introduces the topic

We all accept today the significance of the energy question and the extent to which in the last few years economic, financial and political circles have rediscovered the main elements of this issue. The combined negative effects of demographics, climate change and access to resources cannot be ignored. At the same time we face a paradox: While it is hoped that the world economy will grow by 3 percent per annum the required growth in energy demand of 1.5 percent per annum is thought to be unsustainable.

It is surprising that for a long time a certain shortsightedness has delayed the recognition of this paradox. The strategies of the main actors on the energy scene, and the constraints on behaviour imposed by competition over long periods have put off a detailed analysis of the problem. Such an analysis would have provided valuable lessons, but that's how things are and it's no use regretting it now.

Among the most serious analytical mistakes that have been made is the longstanding taboo over nuclear energy. It is as though the accidents at Three Mile Island in the United States and Chernobyl in Russia were enough to condemn this form of energy for ever. It is also astonishing that most of the experts, the political decision makers, the circles regarded as competent, never produced a detailed analysis of what actually happened at Chernobyl. If they had done so, they would have found out that what happened was not an unfortunate accident, but a series of elementary mistakes and risky experiments that an authority in charge of safety should have legitimately prohibited. Everything carried on as though an accident had taken place in a high mountain pass and a car with no brakes had fallen over the edge.

Similarly many people have for a long time wanted to throw a veil over the huge progress made in the safety of nuclear power plants. As if this ignorance would help the progress of our societies. Thus, the fact that we are capable of constructing power stations which, even in the event of unexpected fusion of the core, would not present any danger to human life 5 kilometres away, has been considered to be of minor importance. In addition, we have been happy to consider nuclear waste as a quasi metaphysical question, although progress in the treatment of nuclear waste, in geological stockpiling, or future transformation in Fast Neutron Reactors (FNRs) was well known. Finally, although it is legitimate to raise the dangers of proliferation, it has not been mentioned that since 1975 the list of countries proliferating or suspected of it has been reduced to a very small number known by all the governments of the world. The Non Proliferation Treaty has thus functioned well for 30 years.

Currently, nuclear power is being re-examined or relaunched in the United States, the United Kingdom, China, India, Russia, Indonesia, Brazil and more widely in about 30 countries representing two-thirds of the world population. While the significance of this is clear, the strength of the movement is uncertain. Certainly it is hard to believe that all these countries, governed by forces and administrations that differ widely from each other, have the same illusions. They all understand increasingly clearly that failing major technological progress in stockpiling electricity, there are only two lasting possibilities for producing base load electricity – nuclear and coal with carbon sequestration.

Some people argue that the competitivity of power stations in construction must be judged on the evidence.

Although we need to wait for an exact assessment of projects currently under construction, there can be no doubt that the nuclear stations of the past proved to be competitive in ways that were very helpful to the electricity companies that used them. If transparency was as perfect as it should be, the numbers would speak for themselves.

That is certainly not the main point.

The later we start the movement, the greater will be the lack of engineers to respond to the demand. The more we appear to be unaware that beyond 150,000 tonnes of annual consumption of uranium we need to have treated enough used combustibles to calm the market and prepare for the arrival of the FNR, the less we will serve the long-term future of energy.

Of course it is to be hoped that the capture and sequestration of carbon will be as economical as possible; but can we believe that wherever there are CO_2 emissions there will be sites available to store them easily?

The real questions for tomorrow lie elsewhere: how to stabilise the price of energy while taking on the climate challenge at the least cost for humanity? We know that it is between 2012 and 2020 that this issue will arise. If we want the solution to be economically the most bearable for humanity, the development of nuclear will be a necessity. And it is this slow but inevitable realisation that we are witnessing at present.

We may even come to consider that nuclear energy is more indispensable than previously believed for the production of non-conventional fuels. And if the world has to become involved in the stabilisation of carbon emissions, the realisation that such a challenge entails a role for nuclear should not arise too late.

Adnan Shihab-Eldin looks at the prospect for a nuclear renaissance

The Promise of Nuclear Energy

The discovery and controlled use of nuclear energy was heralded as one of the greatest scientific and technological accomplishments of human civilisation in the twentieth century, notwithstanding the fact that the first demonstrable practical use of nuclear energy was in the form of the immensely destructive power of nuclear weapons. The successful conversion of nuclear energy to commercial electricity, demonstrated first in the USA in 1951, ushered nuclear to the forefront of the global energy scene.

In those early days, nuclear energy was considered to be a superior primary energy source for commercial power generation. The energy stored within each fissionable atomic nucleus is highly concentrated, as one gram of fissionable uranium could release vast quantities of thermal energy, equivalent to the consumption of around 13 barrels of oil. In addition, uranium and thorium (the fissionable nuclear fuel) resources appeared almost limitless, being widely distributed in the earth's crust and dissolved in the vast waters of the oceans, albeit at very low concentration. The generation cost of nuclear energy was thought to be relatively very low, giving rise to the slogan 'too cheap to meter' when describing the nuclear energy promise at the dawn of the nuclear age.

The Rise of Nuclear Power: the First Golden Age

Initially, the nuclear promise appeared fulfilled. With strong proactive support from governments in several industrial countries (USA, UK, Canada, France, and Russia) throughout the fifties, sixties and much of the seventies, several types of first and second generation nuclear reactor technologies were developed. These were mostly thermal reactors cooled with light water, heavy water or gas (CO_2). Prototype metal cooled fast reactors were built. One thermal and several fast breeder reactors were also developed and demonstrated commercially. These types of reactors allow burning of the more abundant uranium (^{238}U) isotope, as well as the thorium fuel, thus the potential of currently known uranium resources is multiplied by 50 (through the ^{238}U and another factor of 3 through the addition of Th as a fuel source), extending the lifetime of fission nuclear power into thousands of years.

These developments allowed the building and operation of an increasing number of large commercial nuclear power plants in the USA and other OECD countries as well as in the former Soviet Union, East European and a few developing countries. The role and share of nuclear power as an important source for the generation of electricity began to rise noticeably. Nuclear power looked set for a more prominent role in the wake of the first oil shock of 1973, when OECD and several developing countries looked for nuclear energy to reduce their dependence on imported oil, particularly for power generation. To a large extent this goal was realised as oil was phased out of the power generation sector, with nuclear, in addition to gas, leading the way as a replacement source in OECD countries.

The use of nuclear energy has been extended to the commercial production of desalinated water, mostly in conjunction with the production of electricity in dual purpose nuclear power plants. Desalination in a dual purpose nuclear power plant takes advantage of the availability at a relatively very low cost of minimal quality heat source (steam) as a byproduct. Demonstration and semi-commercial nuclear desalination projects have been built in Japan, South Korea, Russia, China, India and Argentina. Nevertheless, experience in nuclear desalination is very limited because the needs of the industrial countries for electricity generation have far exceeded their need for desalination so far. The situation is changing, especially with the introduction of nuclear desalination as an option in a number of large developing countries (e.g. China and India) where the need is high.

Today nuclear power contributes significantly to commercial global electricity generation. By the end of 2005, there were 442 nuclear power plants in operation in 31 countries with a total electricity generating capacity of about 370 GW(e), representing approximately 16 percent of the total commercial electricity generated worldwide in 2005, with six plants in long-term shutdown. In addition there are currently 29 nuclear power plants under construction, and nearly 120 reactors announced as part of energy planning in several countries. But the average nuclear share of electrical generating capacity hides huge differences even among OECD countries, ranging from zero (e.g. Italy, if one ignores what is imported from France in the north) to almost 80 percent in the case of France.

A Promise Unfulfilled

However, the pace of introducing nuclear power had began to decelerate noticeably following the 1978 accident at the Three Mile Island nuclear power plant in the USA and the slowdown became more dramatic after the Chernobyl accident in 1986. By then concerns about the lack of an assured solution for the disposal of high level radioactive waste, among other things, were also mounting. Costs were rising in many countries on account of construction delays stemming from changing regulations and licensing requirements. Public acceptability was shaken and support for nuclear energy in the USA and many European countries declined to a small minority. Many countries cancelled plans, with some cancelling the commissioning of completed plants (e.g. Austria and Italy), passed laws to outlaw the use of nuclear energy altogether (e.g. Ireland and Italy) or ordered the phasing out of operating nuclear plants (Germany, Sweden, the Netherlands, among others).

A few countries were more successful in managing their nuclear programmes and maintained good public support,

like France, Japan and South Korea. All, interestingly enough, are energy-resource poor countries. They had encountered no construction delays and were able to maintain their nuclear power programmes active, allowing nuclear to assume a major share of electricity generation. Large developing countries like China and India also maintained and pursued their plans to introduce nuclear power.

Potential for Resurgence of Nuclear Power

As a result, in most business-as-usual global energy scenarios performed prior to 2005, nuclear energy does not figure prominently over the next two decades, with its share in electricity generation declining slightly. Its contribution in absolute terms is expected to continue to increase but at a slow annual rate of around 0.7 percent, mainly due to plans for the expansion of nuclear power in large developing countries like China and India, in addition to OECD countries such as France, Japan and South Korea. This is in contrast to the robust growth in global demand for electricity, which is estimated to average over 2.5 percent per annum. Most of this growth will be coming from developing countries, with coal and gas expected to provide the bulk of the required fuel. And although renewable power will continue to grow at double digit figures, its share will remain small on account of a small starting base.

However, the prospect for nuclear power appears to be changing yet again. There is currently an unmistakable momentum of renewed interest in nuclear energy, covering both OECD as well as developing countries. This interest is broad, and includes the public and the media in addition to governments. Many in the industry are now talking about the 'Renaissance' of nuclear power. Over the last couple of years, several western governments have come out in favour of an increased role for nuclear power or have at least decided to bring the issue up for debate. The UK Energy Review report, *The Energy Challenge*, released in July 2006, favoured nuclear power and called on government to streamline the regulatory process. A White Paper to set out policy is expected in early 2007. But the clearest concrete action came from the USA with the enactment of the US Energy Policy Act 2005, giving incentives for new power plants and also calling for streamlining of the regulatory process. The phasing out of nuclear reactors that took place in Sweden, Germany and other European countries is now being debated openly.

"There is currently an unmistakable momentum of renewed interest in nuclear energy"

To be sure, for some countries like France or South Korea, there was no dark age to start with in order for there to be a Renaissance. In many places there was not even a slowing down. That was a luxury for the developed economies of Western Europe and North America. South Korea launched its economic miracle on the foundation of 20 new nuclear power plants. Japan pushed ahead, completing the building of each new advanced light water reactor in four to five years, not ten or fifteen years. China is implementing a plan to install 40 gigawatt reactors by 2020, with a grand plan to install 250 gigawatts of reactor capacity by mid-century. On the other hand the last time a US utility ordered a nuclear power plant was in 1979. Yet, even in the USA, upgrade work to improve performance and safety of existing nuclear power plants resulted in the equivalent of more than 2 GW of added capacity and higher capacity factors, producing some of the lowest cost electricity of any other options.

Three main factors lie behind the re-emergence of the nuclear option. They have been in the making for some time. Each has developed over a different timescale but they have converged recently to become a powerful force for attitude and policy change. They relate to the security of supply and fuel resources, economic competitiveness, and climate change policies. The importance of each factor plays differently within OECD countries as well as in developing countries.

Rising concerns about climate change from increased use of carbon-emitting fossil fuels has been the most compelling argument favouring reconsideration of the nuclear energy option among those OECD countries that have cancelled, stopped (or decided to phase out), or slowed down their nuclear power programmes. On economic grounds alone, a US$10 per tonne of emitted Carbon makes nuclear power compete favourably with coal power plants even under a high construction and high discount rate environment (and increases its advantage over gas when the gas price is already over $6 per MBTU). In the longer term, CO_2 capture and storage (sequestration) and renewables – in addition to improved efficiencies – offer alternative options to low carbon sources of electricity. But currently the costs of CO_2 sequestration technologies are high (above US$50/tonne of CO_2) and the costs of almost all renewable power technologies are even higher; only onshore wind and geothermal power in a few highly favourable locations can currently compete freely in the delivery of electricity at a cost in the range of US$5–7/MWh.

Having proactively opposed nuclear power for more than three decades on account of often exaggerated fears of a possible but highly unlikely catastrophic release of radioactivity (e.g. the fictional China syndrome), many prominent environmental activists and organisations are now turning around and rallying to support the re-launching of nuclear power in OECD and large developing countries as part of the response to the climate change challenge. These include among others, names like James Lovelock of the USA, Patrick Moore of the UK, a cofounder of Greenpeace, and Britain's Bishop Hugh Montefiore, a long-time board member of Friends of the Earth.

Recent developments in the oil and gas markets, particularly with prices

rising by more than a factor of two over less than three years, the increasing noise from 'Peak Oil' advocates of an imminent or looming decline of proven global oil and gas reserves and supplies as well as fears of possible extended supply disruptions on account of geopolitical considerations (e.g. Iraq or Iran) have combined to heighten concerns in OECD countries about energy security. This has prompted a consideration of alternatives to oil (for the transportation sector) and gas (for power generation). If coal is to be eliminated on account of its poor environmental credentials, nuclear is the only viable alternative to gas for large-scale central power plants for OECD and many developing countries.

The cost of nuclear-generated electricity is dominated by capital costs and therefore less vulnerable to volatile increases in fuel prices. Undoubtedly, this adds to the attractiveness of nuclear power. On the other hand, escalation in capital costs due to changing regulation or additional safety and licensing requirements that take time to develop carries on over the long term. Efforts to ameliorate the causes of such cost escalation through policy, management and technology are also a long-term proposition. This is exactly what happened through the late seventies and eighties and could conceivably happen again, though the nuclear industry and government regulators appear to have learned valuable lessons.

"The cost of nuclear-generated electricity is dominated by capital costs and therefore less vulnerable to volatile increases in fuel prices"

Over the last several decades, evolutionary but sustained improvements in management and operations as well as incremental upgrades to enhance safety and performance of existing nuclear power plants, particularly in the USA, have brought about a modest increase in capacities, and resulted in higher capacity factors and thus lower production costs. Across OECD countries the lifetimes of nuclear power plants are being extended, adding to the prospect for lower costs from existing plants.

These developments and the valuable experiences learned in the course of several decades are pointing to a brighter outlook for the cost of nuclear (based on evolutionary Generation III+ nuclear reactors) vs. other production options. Most recent studies point to electricity costs in the range of US$5/MWh and $US7/MWh for the low and high discount rate assumptions, respectively. This makes nuclear electricity very competitive in low inflation environments if gas and coal prices remain high enough (at or above US$5/MBtu for gas and US$60/tonne for coal) and provided construction and operating risks are kept reasonably low and well managed by all parties (the regulatory authority, the vendor and the operator).

It is realistic therefore to expect that nuclear power may indeed return to a more robust expansion phase. Under this scenario, construction of an increasing number of advanced and safer nuclear power plants (Generation III, and later Generation IV type reactors) is resumed in a number of important OECD countries like the USA and the UK, while countries with already active programmes maintain their plans. More large and medium size developing countries will also start introducing nuclear power as part of their future power generation portfolio, sometime around 2020. Instead of phasing out nuclear power plants, more will be upgraded with their lifetime extended up to 60 years. In such a scenario, nuclear power could grow at an average rate of 1.6 percent per year, with most of this additional growth starting towards the middle or later part of the next decade.

Conditions for Success

However, for such a 'rosy' scenario to materialise many conditions need to be met and several ongoing challenges must be addressed. First and foremost, public acceptability, while edging upwards in favour of nuclear, is still far from certain in most OECD countries. Another major accident with serious consequences could set back the re-emergence of nuclear power significantly, perhaps for a decade or more. This underlines the importance of maintaining the bright safety record of the nuclear industry since Chernobyl in 1986. Continued vigilance and discipline is a must and efforts to improve safety in existing as well as new plants need to be maintained. Many new plants are coming on line in countries with limited experience, for example China and India. This requires continued strong government support and enhanced international collaboration through the IAEA and other international and professional organisations like the World Association of Nuclear Operators.

"Public acceptance is central to future viability of nuclear as a significant option for clean energy"

The development and deployment of more-inherently safe Generation III and Generation IV reactor technologies is crucial for the long-term viability of nuclear power especially for developing countries. This requires long-term government commitment and support, stronger industry–government collaboration and enhanced international cooperation to share the risks as well as the benefits. Furthermore, streamlining the regulatory processes is another critical requirement in many nuclear countries, like the USA and the UK, as it is for countries that are introducing nuclear power for the first time. This is important to the future competitiveness of nuclear power as is the continued improvement of plant performance.

In addition to safety, an assured long-term permanent solution to the disposal of high level nuclear waste as well as safeguarding against the risk of proliferation remain two outstanding key challenges to a viable future of the

nuclear option and high on the agenda of public acceptability. Many technical solutions have been proposed for the safe and permanent disposal of nuclear waste, including isolation in stable geological sites as well as incineration in advanced reactors. But progress has been slow with no consensus on what constitutes an acceptable demonstration of a solution. Only intermediate remedies and temporary measures have been made available for now.

The recent experience of North Korea and the ongoing confrontation between Iran on the one hand and the IAEA's Board of Governors and, more recently, the UN Security Council on the other, are pointing to the need for changes in order to strengthen existing international frameworks, agreements and conventions to safeguard against the spread of nuclear weapons while continuing to provide interested developing countries with access to the nuclear power option. The call by the IAEA for universal adoption of the 'Additional Protocols' to allow more stringent inspection and verification has not worked well so far, with many countries declining to sign and ratify them.

One of the weaknesses of the Non Proliferation Treaty (and the associated IAEA Safeguards Agreements) is the absence of clear provisions on how to deal effectively with those who choose to withdraw from the treaty or violate their obligations under the related IAEA safeguards agreements. Another exposed weakness is the way in which the international community has responded to the development of nuclear weapons by a number of non-NPT signatory states, such as Israel, India and Pakistan. The lack of an effective and consistent response as well as the failure of the five nuclear weapon states to draw a road map and demonstrate progress towards the gradual dismantling of their own nuclear weapons (as stipulated by the NPT) have combined to undermine the credibility of the treaty and reduced the effectiveness of the associated Safeguards Agreements with the IAEA.

Finally, in response to the strong interests expressed by an increasing number of developing countries (including some oil-exporting countries) for access to nuclear energy to be included as part of their plans to meet their rising demand for electricity and fresh water, a number of international initiatives have been advanced recently. Most important among these are the US Global Nuclear Energy Partnership (GNEP), announced by President Bush in 2006, the Russian President's initiative on the International Nuclear Fuel Cycle (also announced in 2006), the IAEA mandated initiative as well as others from Germany, Japan and France.

"For nuclear to be truly a universal sustainable energy source, it must also be made available to many more developing countries who need it"

The general aim of these initiatives is to assist in the development of a global nuclear power infrastructure and provide access to nuclear technology for those interested developing countries while ensuring at the same time strict compliance with non-proliferation requirements. This is to be achieved by assuring unrestricted supply of nuclear fuel as well as removal of nuclear waste to major nuclear states for further processing, storage and final disposal, possibly under an IAEA or other international umbrella. The details and operationalisation of these initiatives are yet to be worked out, but many developing countries have expressed interest in pursuing cooperation within such frameworks. Others have expressed a strong preference to continue to cooperate within the existing framework of NPT and the IAEA without the need for additional restrictions or measures.

In this connection, several large countries with nuclear technology know-how, like Brazil, Argentina, Australia and South Africa, in addition to China and India, are moving quickly to position themselves among the recognised suppliers of assured nuclear fuel services, including enrichment and reprocessing, before additional international restrictions on access to these technologies are imposed.

Concluding Remarks

Nuclear energy has the potential to play a major and expanding role in meeting the growing global demand for energy, particularly power generation and desalination, and possibly hydrogen production in the very long term. The technical feasibility and economic competitiveness of nuclear power under certain conditions have been demonstrated on a large scale for a good part of the second half of the twentieth century, but so were its vulnerabilities and challenges. After decades of setbacks and decline in the perceptions of its long-term viability as an important option, nuclear energy appears to be heading for resurgence. Public acceptance is central to future viability of nuclear as a significant option for clean energy. It is anchored around continued improvement to safety, successful demonstration of acceptable technical and social solutions to the long-term disposal of high level nuclear waste as well as strengthening the international framework, conventions and institutions to safeguard against proliferation. For nuclear to be truly a universal sustainable energy source, it must also be made available to many more developing countries who need it. This requires new international initiatives that are transparent, simple and effective, but above all they must be fair and equitable, and perceived to be so.

Nuclear power may be re-emerging indeed, but the turn-around requires sustained efforts on all fronts by all parties. This will take time, measured in decades not years. This is a long time and a lot could happen meanwhile. For industrial countries with existing but currently stagnant or declining nuclear programmes, the earliest perceptible sign of a surge in the contribution of nuclear power above current base line scenarios is, at minimum, ten years away. For

developing countries with no prior nuclear experience, this will take longer, fifteen years or more. A worldwide nuclear 'Renaissance' may indeed be looming, but we will not know it has happened for sure before at least ten years.

Pierre-René Bauquis considers the path from peak oil to nuclear energy

The issue of peak world oil production is the subject of controversy between optimists and pessimists: will it occur in 2010 or 2050? That is the question for the general public. However, as regards the major disruptions that will ensue from the decline in oil production – 2010 or 2050, that's soon enough. In any case, this decline associated with the additional greenhouse effect linked to human activities will inevitably trigger a worldwide renewal of nuclear energy.

While the heading of this article may seem obscure, it is in fact only stating the obvious. Because oil, like natural gas and even coal, is a non-renewable resource found in discontinuous deposits underground, production cannot increase indefinitely since the reserves themselves are finite. Therefore when global production of fossil energy starts to decline, other forms of 'non-carbon emitting energies' will be needed to compensate for this. These can only be renewable energies and nuclear energies.

What is Peak Oil?

Everyone agrees that resources are limited, but disagreements arise when it comes to estimating the total amount of oil that can be recovered. The estimate of these ultimate reserves – the sum of everything that has already been produced (let's say 1,000 billion barrels or 1,000 Gbbl) and everything that will be produced in future (from 1,000 to 3,000 Gbbl, according to various experts) – is therefore the crux of the debate between optimists and pessimists.

Any discussion of 'oil peak' should include a definition of the term. 'Oil peak' refers to the maximum amount of world production of natural liquid hydrocarbons. These last two words are important. Liquids include conventional and non-conventional oil reserves (tar sand or shale oil) as well as condensates produced from natural gas. The adjective 'natural' excludes XTLs (GTLs, CTLs or BTLs), i.e. liquid hydrocarbons synthesised from natural gas, coal or biomass, such as biofuels.

For users, peak oil is not necessarily the most important concept. What interests them is the knowledge that they can fill up their car's petrol tank; they don't really care whether the fuel is synthetic or natural. For oil companies and contractors, however, the peak oil concept is crucial: it will be a key aspect of their business and the environment in which they will operate. As a result, it is important to gain a better understanding of why opinions differ so widely on this issue and in what way they diverge.

How can 'oil peak' be defined? The peak of world oil production is defined on the basis of three parameters. Two of these, which are essential and almost obvious, are the date (or approximate period of time) when the peak will be reached, and the level (or bracket of levels) of world production at that time. The third parameter is directly related to the first two: at what level would prices stabilise during the peak (not taking political fluctuations into account) and which level might become established after the peak? This is naturally a vital question for the oil industry and for world economies. The opinions of the opposing sides will be based on the values assigned to these three parameters.

The Pessimistic View

The pessimistic category includes organisations, companies and experts who believe peak world production will occur by or before 2020, around or below 100 million barrels per day (mb/d), whether this peak is described as a well-defined maximum or as an undulating plateau. In fact, the production-level criterion is more significant than the estimated date, which can vary somewhat depending on the rapid or slow growth of market demand. A prolonged recession could delay the peak by a dozen years, while only marginally changing its level, which is more affected by physical than economic or political constraints. However, to simplify matters, the date is generally given greater weight than the level. Differences exist within the pessimists' camp: there are various degrees of pessimism.

> "Without nuclear, major and prolonged regression to a more primitive state of material development would threaten the very existence of democratic systems"

Briefly, this school of thought encompasses a range of predictions, from ASPO (Association for the Study of Peak Oil and Gas), which projects a maximum peak of 90 mb/d between 2007 and 2015, to the 'French position' of a peak around 2020, give or take five years, at a level of 100 mb/d, give or take 5 mb/d. It is possible to talk about a French position – and France is probably the only country where there is a consensus – because this is the stance of Total, the IFP (Institut Français du Pétrole) and, last but not least, the author of this article. Of course, those who support this position don't consider themselves pessimists, but realists!

The Optimistic View

The optimists include everyone who

thinks that world oil production will peak well over 100 mb/d – at 120 or 130 mb/d or even higher. For this school of thought, or rather for this group of opinions (because their projections are rarely backed by hard figures but tend to rely on pessimists' past forecasting errors), the peak will definitely be arrived at after 2020 – here, too, the dates are rarely specified. Among the optimists are the majority of university economists, who focus on the law of supply and demand and thus believe that the higher the prices the better we'll be able to 'squeeze the sponge', i.e. increase oil recovery rates.

The fact that the tenfold rise in prices during the 1973–79 oil crisis proved that the price elasticity of recovery rates was very low does not seem to bother them, which is rather surprising. Their poor understanding of geology explains, if not excuses, their point of view. But what is more disconcerting and troubling is the fact that this optimistic position is shared by official national and international organisations, such as the United Nations, the World Bank and the OECD, even when their area of responsibility is energy and oil, particularly the U.S. Department of Energy, the U.S. Geological Survey and especially the International Energy Agency.

This position has clearly had a negative impact. It has encouraged an irresponsible lack of concern among governments of major consuming countries, even though this message is now tempered by strong warnings about the risks of production shortfalls related to geopolitics and insufficient investment. The ignorance or lack of understanding about geological factors delegitimises their position, which denies the increasing scarcity of oil while insisting on the urgent need to reduce consumption!

Lastly, and even more surprising, major oil groups share the optimists' position, particularly Exxon-Mobil, BP, Eni and Saudi Aramco. Some large consulting firms, such as CERA (Cambridge Energy Research Associates), hold similar views. Since it is not possible in these cases to blame a lack of competence, it is therefore up to each one of us to try to understand how such differences of opinion are possible – and to develop one's own opinion.

Geoscientists have an important role to play in this analysis because they are probably in the best position to evaluate the potential for discovering any remaining reserves in the planet's various oil basins as well as the potential for improving the average recovery rates from the oil accumulations. If the average rate of recovering oil in all active reservoirs (35 percent on average) were increased by 1 percent, the additional oil obtained would represent more than one year of world oil consumption.

The Paradox of the Golden Age

Paradoxically, the decline phase, which will last for more than a century and perhaps quite a bit longer, will be the golden age of the oil industry with high prices and major technological progress made possible by these prices.

This will be a golden age both for producing countries and their natural partners – oil companies – as well as for the national oil companies of producing countries (NOCs) and international oil companies (IOCs). This prosperous period should also lead to many cooperative ventures and alliances and maybe even mergers between NOCs and IOCs.

However, it will also be the golden age for non-carbon emitting energies, i.e. renewables and nuclear. These two energy sources represent today some 14 percent of world primary commercial energy production; and they will have to be able to compensate for the decline in the 86 percent share of fossil energies.

The Path to Sustainable Energy: from peak oil to nuclear

The difficult question concerns the capability of world economies to face the new situation of progressive oil production decline combined with high oil prices.

In fact, the oil and gas industries themselves will need to use nuclear energy directly or indirectly in order to slow down their production decline and in order to deliver clean energy to the various markets.

Upstream, the improvement in recovery rates, particularly for heavy and extra-heavy oils will require large quantities of heat or steam that only nuclear reactors could provide without emitting CO_2. Downstream, in order to upgrade these heavy oils and in order to extend the use of deep conversions in refineries, large quantities of heat and hydrogen will be necessary. Only nuclear would be able to satisfy such requirements.

Last but not least, production of synfuels, including biofuels, will also require large quantities of heat and hydrogen from outside sources in order to improve their productivities. This could be achieved on a large scale by combining nuclear and biomass. Such potential 'marriages' between fossil energies, renewable energies and nuclear will play a major role after peak oil occurs. This vision will largely depend upon a crucial choice: the acceptance of a very large development of nuclear power. Indeed, this would provide the only avenue open to humankind to achieve a sustainable long-term energy future. Without nuclear, major and prolonged regression to a more primitive state of material development would threaten the very existence of democratic systems and would exacerbate the risk of conflict for oil resources.

Close co-operation between the fossil fuel, renewable energy and nuclear industries, provides the only way to successfully face the radically new situation resulting from peak oil, combined with climate change risks. However, even this virtuous combination will not be sufficient to solve all problems: we will inevitably have to adjust our way of life by consuming less energy at least in the case of the most developed economies of our planet.

Climate Change, a Global Problem, is a Global Solution Possible?

Peter Nicholls

Climate change is gaining greater public and political attention in the developed world. In the UK and Europe governments are attempting to promote so-called green or renewable energy and to encourage, by non-obligatory means, economy in the use of energy. Energy or emissions taxation are seen as an acceptable source of governmental revenue. The European carbon trading scheme is in place and operating for the industrial organisations that have carbon limits placed on them. Unfortunately, as expected, the value of carbon emission under this scheme is low.

The approach to atmospheric carbon reduction is fragmented. Within the EU the obligatory reductions are those encompassed within the EU Carbon Trading Scheme plus some local schemes such as the renewable obligations in the UK. Of course carbon trading in itself will not bring about a reduction in carbon emissions; the reduction comes from lower carbon emission limits set by governments. Trading enables the reductions to be achieved with some economic efficiency. However, whilst major sectors of the global economy are excused from carbon limits, economic efficiency is not very significant. Even at a country level the requirement to reduce carbon is very selective. Politically sensitive sectors are excluded – transport fuels and domestic heating in the UK for example.

In reality the solution to emissions is in the hands of politicians who must understand that in order to control the level of atmospheric carbon key criteria must be satisfied. These are:

1. Every tonne of carbon emitted must have a permit.
2. Governments must define publicly the desired level of atmospheric carbon based on the best scientific research.
3. Finally an allowable level of carbon emissions must be set – at a level that will support long-term investment in atmospheric carbon reduction through all means:
   - Economising measures,
   - Carbon sequestration and
   - Cultivation of carbon absorbing vegetation.

These steps require political decisions, but there is little evidence that governments will act either individually or collectively in grasping the principles within the three requirements above whilst the changes required involve measures that are politically very unattractive.

Climate change is a global problem that requires global solutions. Serious scientific authorities suggest that the timescale required to embark on a global solution is very pressing. The urgent actions required imply major world-scale investment in the three areas mentioned above: cultivation of carbon absorbing crops, sequestration of carbon dioxide in, for example, depleted oil, gas and other geological structures and of course in the more efficient use of energy. The optimal mix of cultivation, sequestration and efficiency will vary from region to region and between applications, international carbon trading will ensure investments are economically efficient; this is an essential part of the solution. Without the rigour of the three steps above plus trading, local suboptimal schemes will be developed that will invariably waste money and probably increase emissions.

The case of the Dutch subsidising green electricity in their country demonstrates this. The local Dutch subsidy was such that traders bought from the rest of Europe as much electricity with green certificates as possible to sell into Holland to benefit from their subsidy. The majority of the green electricity purchased came from Germany, the country with most windmills. The effect was for the Dutch to shut down some gas-fired CCGT capacity (about 50 percent efficiency and low transmission loss) and for the Germans to start up old lignite power stations (30 percent efficiency and high transmission loss to Holland) to make good their loss of supplies. However well intended they may be, local subsidies will inevitably produce perverse results.

It is unlikely, within the current thinking, that global action on the scale and within the time required will occur. Politics will yield concerted and coordinated global action only when the process of climate change is well established, obvious and irreversible. The sheer industrial, financial and global scale of the potential solutions demands measures far beyond turning off television sets at night or building windmills in the UK. Rather than gaining a comfortable feeling from local suboptimal measures, UK and EU politicians should use their influence and energy to push internationally the key element required to arrive at a global solution to a global problem.

Only when all carbon emitted has to have a permit, is traded internationally and has sufficient value to encourage long-term investment will a global carbon recovery start. Under these conditions it is possible that countries sequestrating carbon or cultivating carbon absorbing crops could become the equivalent of the current oil rich nations of today. This must yield a physical equilibrium between the quantity of carbon produced, that is oil, gas and coal, and the quantity of carbon absorbed globally. This should lead to an economic equilibrium between the price of carbon and the price of oil, gas and coal.

The political reluctance to make unpopular moves and

the sheer industrial scale of solutions inhibits real action. What then can be done to start a serious programme of reduction in global atmospheric carbon quickly? The international oil industry has the necessary skills and requirements:

- Financial strength,
- International presence,
- Major projects are the norm,
- Geological expertise,
- Spare oil and gas infrastructure as fields deplete
- Trading expertise,
- Dealing with political risk.

The low value of carbon and the political uncertainty has quite understandably resulted in the international oil and gas industry having no interest in using its strengths to reduce atmospheric carbon. However, if the industry was obliged to purchase carbon permits for a proportion of the hydrocarbons it produced, this most important business sector would be brought into the carbon reduction market. It would be neither reasonable nor practical to make such a radical change to the industry in one step. The proportion of their production for which oil and gas producers would be required to have carbon permits would start at a low level, say five years notice of 5 percent, then be increased on an annual basis. The attraction of this model is that it allows the political expediency of sheltering some sectors to continue, but brings to the problem of atmospheric carbon the only major industry with the necessary technical, financial, operational and organisational wherewithal to implement a solution.

Without doubt such a change requires international agreements and controls. In realising this, it is essential that politicians develop a shared business model that will work within acceptable time limits and on the industrial scale required. It is certain that in developing and applying this model, the UK can through its international political influence have a far greater impact on this global problem than it can from the effects of eye-catching local measures. Involving the oil and gas industry in this solution should be politically very attractive. It will start a solution but the path forward must be clear and free from political horse-trading for confidence to help sustain long-term investment. The development should be attractive to the oil industry, for it gives it a future beyond petroleum.

The Oil Price Regime

Bassam Fattouh shows its challenges to OPEC

Many observers interpreted OPEC's decision in October 2006 to cut production by 1.2 million barrels per day (b/d) and the Organization's latest announcement of a production cut of 500,000 b/d to be implemented in February 2007 as signals that there is a new oil price floor that it would like to defend. The *Financial Times* interpreted OPEC cuts as a clear indication of a 'determination to defend $60 as its new minimum international price'.

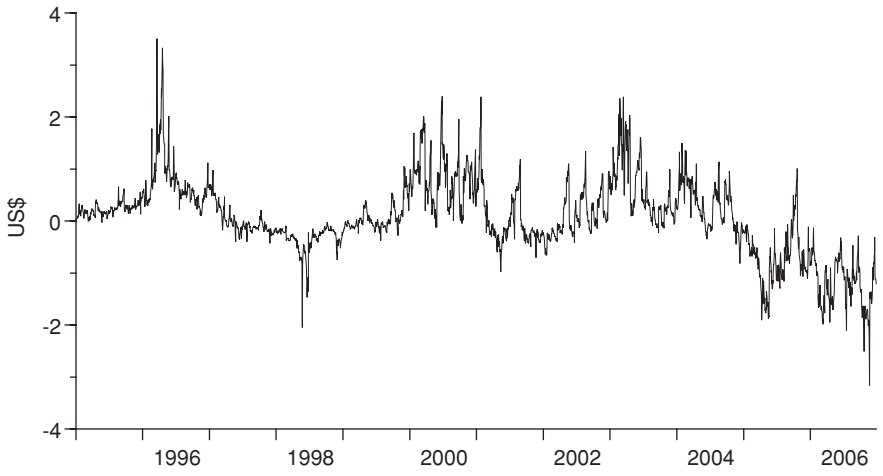
Although OPEC's president has announced that a price below $60 'is very low and it is not good for investors' and that 'something needs to be done to steady the price' and although price hawks Iran and Venezuela indicated more than once that OPEC would no longer tolerate prices below $60 a barrel, it is premature to jump to the conclusion that the Organization has adopted a new oil price floor as a matter of policy or any other price floor for that matter. It is also premature to assume that OPEC's latest decision in December is about protecting this price floor. The Saudi Oil Minister Ali Naimi declared during the OPEC conference in December 2006 that the price, whether above or below $60, did not figure in their latest decision. He argued that what the Organization is looking for is to re-balance the market claiming that 'there is a disequilibrium between supply and demand' and that OPEC is 'trying to get the market to the normal equilibrium and the price will take care of itself'. Many newspapers quoted Ali Naimi as saying that 100 million barrels of crude oil had to be trimmed from world stocks to balance supply and demand.

OPEC officials have been conveying recently their strong concerns about the high build-up of inventories in the USA and other OECD countries. By end of 2006, crude oil inventories in the USA stood at 321 million barrels which is 25 million barrels over the five-year average. OPEC is concerned that the release of large stocks of crude oil can flood the market with the effect of driving oil prices downwards to unacceptable levels. Furthermore, high levels of inventories are usually interpreted by oil analysts and traders as a sign of oversupply in the crude oil market.

OPEC's views about rising commercial inventories were made explicit in 2004 when Ali Naimi argued that 'a stock build always concerns us' and that 'whenever the stock level is high the price is low and vice versa'. He then raised the difficult question: 'do you wait until the build-up in inventory [occurs] and have a precipitous price fall or do you take a pre-emptive, proactive course of action?' The latest OPEC decision can be best understood within this complex dilemma.

The above raises the following questions: why have total commercial inventories risen so fast in recent years? Is there anything that OPEC can do to slow the process of

Figure 1: First Month Futures Contract minus Second Month Futures Contract for WTI



inventory accumulation? And if the answer to the latter question is yes, what are the costs associated with a policy that targets inventories?

Some have argued that the current build-up of inventories is the result of oversupply in the crude oil market. When supply exceeds (effective) demand at any point in time, the difference would be added to stock levels. This explanation however suffers from a major drawback: why would customers want to lift more crude oil than what they would effectively demand? Unless there is an incentive for them to hold inventories, customers are under no obligation to absorb the oversupply from the oil producers. Supply does not create its own demand!

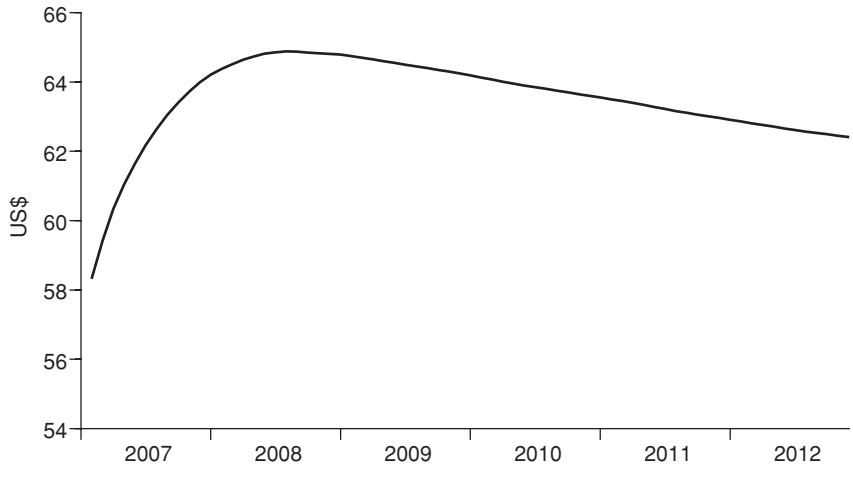
Others have suggested that the current build-up is driven by the demand for precautionary inventories in the face of tightness throughout the oil supply chain. For instance, *Petroleum Argus* (19 June 2006) argues that the market is signalling that 'just-in-time inventories are no longer appropriate as OPEC has lost the spare capacity that enabled it to act as a buffer, shifting stock risk management down the crude supply chain to refiners'. This explanation implies that private oil companies would build up their inventories even when it is costly for them to do so. It also implies a fundamental shift in the behaviour of oil companies and refineries towards a new inventory policy.

Since the mid-1980s and under pressure to maximise shareholder value, international oil companies have undergone major cost-cutting exercises including cutting inventories to their lowest possible level and shifting to a 'just in time' policy. In this new era, oil companies have relied on OPEC's large holdings and consuming countries' strategic petroleum reserves (SPR) and on a developed spot market for immediate deliveries. Thus, the shift back towards a new policy of holding precautionary inventories would imply a break in a strong behavioural trend. There is nothing to suggest that this has happened. Given that international oil companies are under pressure to maximise shareholder value, the proponents of structural shift in inventory policy must show how holding precautionary inventories would maximise shareholder value even when it is not commercially profitable to add to inventories.

A more plausible explanation is that the recent build-up of inventories is due to the price term structure of WTI or Brent. In an influential article, Litzenberger and Rabinowitz (*Journal of Finance*, 1995, no. 50) noted that 80–90 percent of the time the oil forward curve is in backwardation, i.e. futures prices are often observed to be below spot prices. One striking feature of the current market however has been the prolonged contango in the WTI/Brent forward curve. Figure 1 shows that during the last 20 months or so, the nearby (delivery) futures contracts have been trading at a discount to the second month futures contract. Figure 2 which plots the WTI forward price curve at the beginning of 2007 shows a very steep slope with the nearby contract trading at a discount of $6.5 to the August 2008 contract.

Given this oil price term structure, it is no surprise that commercial inventories have been rising fast. If the price of oil for future delivery is trading at a large premium over the price of oil for immediate delivery, this would cover the costs of carrying inventories prompting market

Figure 2: WTI Forward Price Curve (as of January 3, 2007)



participants with storage facilities to accumulate inventories, stock up their tanks, and lock a profit by selling contracts in the futures market. Finding a buyer to take the other side of the bet is not a problem in the current environment where many investors expect tighter crude oil market conditions in the future and where geopolitical uncertainties and a thin spare capacity cushion have made financial bets on potential supply shocks extremely attractive.

According to this explanation, a slowdown in the process of inventory accumulation requires either a change in the oil price term structure from contango to backwardation or for the scale of the contango to narrow to such levels that would make it unprofitable for investors to accumulate crude oil inventories. In effect, both of these cases require a sharp rise at the front side of the oil price curve. Thus, if OPEC wishes to trim the current level of inventories, it can achieve this by tightening crude oil supplies for immediate delivery pushing upwards the front side of the forward price curve.

"under pressure to maximise shareholder value, international oil companies have undergone major cost-cutting exercises including cutting inventories to their lowest possible level"

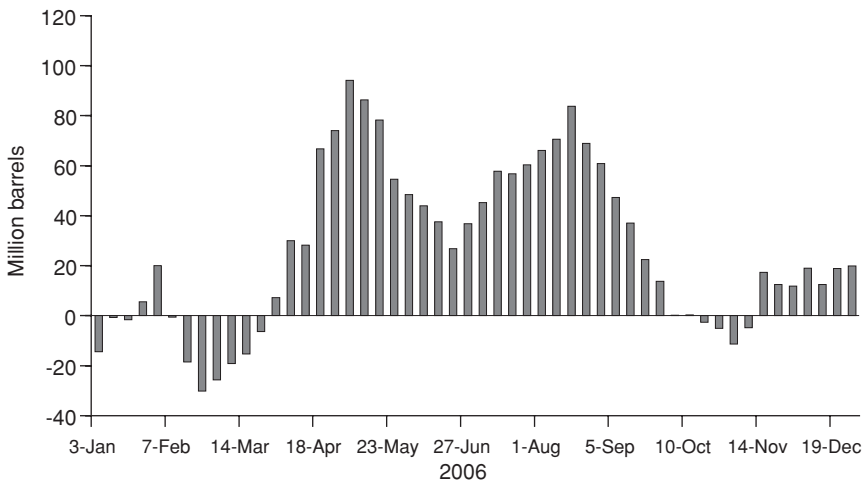
In the last two months or so, commercial inventories including crude oil have been declining in the OECD and the USA. Other things being equal, if this decline continues, then OPEC is unlikely to go ahead with the agreed production cut. If on the other hand, the current decline in commercial inventories is reversed and if commercial inventories begin to rise, then OPEC may be under pressure to take pre-emptive action to bring them to lower levels. Either way, OPEC is faced with very difficult options. The reduction in the scale of the contango would require large output cuts. If these are implemented, the Organization will be criticised on the ground that it has overreacted to current market trends and engaged in unnecessary excessive tightening. It will also be accused of stifling global demand and world growth by causing oil prices to rise. In addition, it may be accused that, by its deliberate policy to keep inventories at very low levels, OPEC is contributing to higher oil price volatility. On the other hand, if OPEC does nothing, then the build-up of inventories can continue, increasing the probability of a sharp downturn in oil prices in the next few months.

Although in the past few months rising inventories represented and still represent a major concern for OPEC, the strong bearish sentiment that has engulfed the oil market at the beginning of 2007 will certainly gain top priority in the Organization's agenda. At the time of writing (5/1/07), the price of an OPEC basket of eleven crudes stood at $51.25 a barrel, a decline from $59.06 over a month ago (8/12/06). The bearish sentiment also resulted in the shift of speculative funds from the long side to the short side of traders' positions which in turn contributed to the fall in oil prices. Although the futures net long positions of non-commercial traders have been slightly rising in the last months of 2006, the current crude oil futures net long position of 19.8 million barrels is only a fraction of the net long position witnessed in August 2006 when they reached close to 84 million barrels (see Figure 3). The sharp fall in oil prices at the beginning of 2007 and the downward swing in commercial traders' net long positions have occurred despite the fact that the fundamentals that have driven the oil market in the last year did not change so much as to explain such falls in oil prices.

"the recent build-up of inventories is due to the price term structure of WTI or Brent"

The main question is: can OPEC influence the bearish sentiment? In principle, they can send signals to the oil market through their quota decisions indicating that they are not happy with current prices or with the way prices are moving. However, this mechanism may or may not succeed, depending on how the market interprets the signals. Specifically, the effectiveness of the signal will depend on whether the market believes that OPEC is able to undertake the necessary output adjustment. If the

Figure 3: Crude Oil Futures Net Long Position of Non-Commercial Traders (million barrels)



market responds to OPEC's signals, then the Organization may not engage in excessive tightening. In the current market conditions, however, many traders are attaching little credibility to the Organization's announcements of production cuts. The bearish market is asking to see the cut before believing the announcement. If this view continues to dominate the market, then OPEC may resort to large production cuts to break the negative sentiment.

"An important consequence of the current price regime … is the wide range of factors that OPEC needs to consider in making its output decisions"

Alan Greenspan noted in 2004 that 'when in the last couple of years it became apparent that the world's industry was not investing enough to expand crude oil production capacity quickly enough to meet rising demand, increasing numbers of hedge funds and other institutional investors began bidding for oil'. Some argue that the current sharp fall in oil prices is caused by the reversal of these flows away from the oil market as other financial markets have become more attractive. If this hypothesis is correct and the oil market is indeed witnessing a large migration of funds which are driving prices downward, then there is little that OPEC can do to counter the effects of such outflow.

An important consequence of the current price regime which takes reference prices from the futures market is the wide range of factors that OPEC needs to consider in making its output decisions – including the level of inventories, the forward curve's shape, the size of speculative positions in the futures market, the traders' bearish or bullish sentiments, and funds flowing in and out of the paper market. This greatly complicates the decision-making process for the simple reason that OPEC has only one policy tool at its disposal (implementing production cuts) with which it would like to achieve a wide range of objectives. This may have undesired consequences on oil price fluctuations inducing volatility and causing sharp rises or falls in oil prices in some instances. But it seems that in the absence of any alternative, this is a cost or a risk that all market participants, including OPEC, are willing to bear and live with.

Robert Mabro questions the suitability of the current oil price regime

Bassam Fattouh's article focuses on two features of the oil futures markets that influence price movements in ways sometimes unrelated to changes in the supply/demand fundamentals. These are, first, the contango that characterises the term price structure at certain times and, secondly, the flow of monies from financial institutions, such as banks and hedge funds, in and out of a commodity market.

The contango has a perverse impact when the price differentials between successive contract months are sufficiently large to involve profits from buying physical oil up front and selling a futures contract. The additional oil so bought finds its way in commercial inventories. Other things being equal, the rise in inventories causes prices to fall.

The flow of funds in or out of a market need not be very significant on average (all that matters is what happens at the margin). The impact on prices can be considerable in response to what may seem to be a small change in the demand for futures contracts. Expectations about the *relative* profitability of investments in different financial markets (commodities, foreign exchange, equities, bonds and so on) is a determinant of the allocation of funds between them and therefore of their movements from this to that market.

In the past three years, commodities were considered to be more attractive than other financial markets. Money moved at the margin between these markets, adding to the fundamental forces that were pushing prices up. In the first days of 2007 the exit from commodity markets which had begun three or four months earlier on gained momentum. Oil prices went down in a way that some described as a free fall. Expectations about the future behaviour of economic fundamentals – mainly oil demand pessimism and over-optimism about increases in non-OPEC production – definitely played a role. So did expectations about the relative performance of other financial markets (for example equities) which did well in 2006.

All that raises a very crucial question: is the current regime for oil in international trade the best possible one for determining prices in response to changes in economic fundamentals without exaggerated volatility?

The current oil price regime, which came into existence after the 1986 counter-shock, involves price formulae including a reference or marker price and an adjustment factor that takes into account differences in quality and other properties between the marker and the traded crude.

For sales West of Suez most exporting countries now take marker prices from the futures exchanges for WTI (NYMEX) and Brent (ICE Futures). This was not always the case. Initially, reference prices were taken from spot markets (some exporting countries still do). Gradually, the realisation that these markets are beset with serious

problems grew and induced a preference for markers taken from futures exchanges. Alaska North Slope (ANS) was abandoned as a reference spot crude because of very limited physical liquidity. Manipulation, partly for tax optimisation reasons and partly for trading strategies, of Brent spot and forward physical (the famous 15-day Brent of yesteryears) gave rise to misgivings about the use of dated Brent prices as a reference. The fact that WTI is a pipeline, not a seaborne, crude also posed a problem because of vulnerability to squeezes.

In theory, a spot deal is a transaction at the margin of the market. It reveals the marginal price of the oil barrel, that is its 'economic' price. This is only true however if the transactions are not few and far between and the market is reasonably free from distortions and manipulations.

"True, futures oil markets cannot be easily squeezed but there is strong evidence of leadership by a small number of players"

At first sight, the futures markets seemed to offer a better alternative. First, liquidity, that is the volume of daily trades, is huge compared with the production of the chosen marker crude. Hence, the view that a futures oil market cannot be squeezed. Secondly, prices are published instantaneously for everyone to see. They are the actual prices of futures contracts. Hence the view that futures markets are transparent. True, futures oil markets cannot be easily squeezed but there is strong evidence of leadership by a small number of players – mainly but not exclusively financial institutions – who are considered by other traders as having superior knowledge, sophisticated strategies or significant weight at the margin.

True, futures markets are transparent insofar as prices are concerned but no data are provided on the volume traded by participants. This affects the ability to interpret price movements in a correct way and opens the door to rumours and pseudo-explanations which in turn may affect behaviour.

The most important qualification, however, is that the futures price that arises on the NYMEX or ICE Futures is that of a *financial instrument* which in the NYMEX involves a claim on oil by the buyer who still holds a contract on its expiry date and an obligation to supply by the counterpart. In ICE Futures, contracts held on the expiry day are settled in cash on the basis of a price index.

NYMEX traders who buy or sell futures contracts rarely intend at the outset to obtain or supply physical oil. Their objective is to make a profit from price movements. Many positions are closed on the same day as they are opened. Some are carried over a number of days (the open interest) but very few are held over a long period. And this is probably true of long-dated futures contracts.

All the talk about risk management, hedging and speculation, although not without some analytical usefulness and elements of truth, also serves to obscure an important reality. Essentially, all participants are taking bets on oil price movements in the futures and other derivative markets, often covering the position by another related trade. The objective is to make, if lucky, competent or powerful, trading profits.

The hedger transfers risks onto the speculator but inevitably bets on a hedging price that will hopefully minimise her risks. The speculator takes the other side of the transaction, betting in turn on the price involved, hoping that the actual outcome will involve profits. She will probably hedge the deal entering with another party in another transaction.

People making different bets have different perceptions of the likely evolution of the market over the relevant time horizon of the contract. If everybody had the same opinion there would be no transaction. The relative weight of different views moves prices in one, or the opposite, direction. And in this sense we say that the betting leads to 'price discovery' which in reality means the discovery of the *ex ante* majority view of the market.

The discovery, however, is that of the price of a financial instrument with an oil label; still a financial instrument traded in a financial market.

"the futures price that arises on the NYMEX or ICE Futures is that of a *financial instrument*"

As a financial instrument of interest to investors, the futures oil contract belongs to a wide set of such tools. This explains the predominance of financial institutions among participants in the oil futures markets and the leading role they play in influencing the direction of price movements. Econometric models show that the net position of the so-called 'non-commercial' traders is correlated with the subsequent direction of price changes. In other words, when the non-commercial entities hold net long positions (they are betting on a price rise) prices often do rise. And the opposite impact occurs when these entities hold net short positions. Is it not odd that the non-commercial players (meaning very broadly the non-oil companies) should lead and the commercial entities (broadly speaking oil or energy companies, oil users and oil-related agents) should follow in what is supposed to be an oil market?

One could infer that the financial institutions lead because the futures oil contracts are traded in a financial market, that is on familiar territory.

Because the futures oil contract belongs to a set of similar instruments of interest to investors, the influence of expected relative profitability of different markets in the set is bound to be significant as mentioned at the beginning of this article. The investor seeks to optimise the portfolio of instruments she may be holding. Available funds to an investor are not unlimited so shifts at the margin are bound to occur to achieve the

optimisation. This implies a non-oil influence, at times strong, at times weak, on oil price movements.

This does not mean that the price of a futures oil contract is not influenced by oil news – data about current developments and events and, more importantly, traders' views about the future impact of possible geo-political, climatic or economic events on tomorrow's supply and demand conditions. After all, the futures market, by definition, is about the future.

The inference is that the futures oil contract is about oil and other things, not one hundred per cent about oil. This would have been of little significance if the price movements caused by the non-oil factors (more precisely the shift of funds in and out of the oil market) were always small. We have recently witnessed very significant rises in oil prices from 2002 to 2006 and a precipitous fall towards the end of 2006 and, more dramatically, at the beginning of 2007. The oil fundamentals – a huge increase in oil demand in both China and the USA and tight supplies – explain the 2004 price rises. The US Gulf hurricanes were partly responsible for price rises in 2005. By then, however, both the demand and supply situation had eased. The first question is why did oil prices continue to rise so much, and the second is why did they then fall as they did in late 2006 and early 2007? It is difficult to believe that the fundamentals of supply and demand cause on their own an increase from say $30 per barrel to a peak (albeit short-lived) of $78 per barrel, and then a fall from this peak to some $50 per barrel (and perhaps less by the time the ink dries up on this paper).

To apportion price changes between different factors is an impossible exercise that should not be attempted. The fact remains that there are non-oil determinants to the price which oil producers cannot control and which sometimes cause de-stabilising and economically disturbing fluctuations. These determinants are inherent to the nature of the current price regime, embedded, as it is, in the futures market.

All that suggests that we should not consider the current oil price regime as appropriate to the purposes it is intended to serve; these being to provide signals that reflect the true supply/demand situation, to allocate resources efficiently, particularly for investment in capacity, and to avoid disruptive volatility due to factors other than economic fundamentals.

"The inference is that the futures oil contract is about oil and other things, not one hundred per cent about oil"

There are problems other than those arising from the characteristics of futures markets that have an impact on price movements. To mention but a few, there is the poor quality of oil information; the prejudices, self pleading, attempts at manipulations that disturb the interpretation signals by OPEC and other relevant players. The fact that a large proportion of trades in the futures (and other derivatives) oil markets are about spreads etc., not the flat price, suggests that price formation does not result from the apparent huge liquidity that characterises the markets. The liquidity that has a bearing on prices seems to be small.

The main problem, however, is that oil prices can move over a fairly long period over a wide range between a low cost floor and a high economic ceiling. Low oil prices do not immediately impact on supplies. Producers do not shut in fields when oil prices fall toward operational costs, or even lower. Before shutting in a well or a field a producer will wait for as long as possible for a reversal in the price trend. Shutting down a producer's asset is often expensive and in the case of small stripper wells irreversible. The impact of low oil prices on supplies is thus delayed. A low price may stick close to the cost floor for a year or even longer.

My guess-estimate is that the world petroleum system can deliver for a while the current demand requirements (say 85 million barrels per day) at a price of $15/barrel because of this delay. When supplies begin to decline some idle capacity in the Gulf will be brought back into production thus compensating for the lost supplies. Low prices have a negative impact on investments needed to meet future growth in demand, not on current supplies, as is evidenced by events in 1986 and 1998.

Do high oil prices affect demand? They do, of course, but the negative impact seems to be initially small. Here again there are mitigating factors and delays. The price effect of demand is mitigated by the excise tax cushion on petroleum products imposed by many countries (except the USA), the very low elasticity of demand for automotive fuels and other factors. Surprisingly, the rate of growth of the world economy was not apparently affected by the oil price rises of 2004–6. Prices could therefore rise to $60 or $70 without causing a reduction in demand.

The $15–70 price range is thus wide open for the market to roam up and down before hard economic factors provide anchors to the fluctuations. There is a clear need for a stabilising influence.

Today nobody is seriously questioning the merits of the current price regime. All the relevant parties have an interest, albeit different in each case, in maintaining it. The OECD countries, having always argued that oil prices must be determined by a market, are not now going to reject a system of 'market-related' prices. One is tempted to say 'by a market, yes, but which market?' OPEC does not want to carry the burden of administering prices, so why question the current system? And the big international banks, and many big oil companies, make huge profits from their trading activities. Their powerful lobbies support the current system.

We shall never know if there is a workable alternative, unless serious research is undertaken. The answer may or may not be that all other conceivable systems have worse characteristics. To refuse to investigate the issue is a sin of omission.

The Re-emergence of Ethanol Fuel in Brazil

Eduardo Luiz Correia

The development of the ethanol agro-industry generated complex relationships within Brazilian society, an understanding of which requires analyses from a political, economic, anthropological and especially historical perspective. ProAlcool (National Ethanol Programme) induced changes in labour relationships and rural migration, while reinforcing technological development and economic and political capacities. It is important to mention, moreover, that the cultivation of sugarcane is closely related to the formation of the Brazilian economy and society since colonial times (i.e. since the beginning of the sixteenth century), having been the first economic activity developed by the Portuguese colonists.

The objective of this article is more modest: to analyse the resurgence of the automotive use of ethanol in Brazil with the introduction of flexible fuel vehicles, and to briefly describe the history and use of ethanol as a fuel in Brazil.

Ethanol has been used as a fuel in Brazil for almost a century. We can segment this history into five distinct periods:

1. Experimentation (1923–1974)
2. The first phase of ProAlcool (1975–1979)
3. The second phase of ProAlcool (1980–1988)
4. Crisis (1989–2003)
5. Resurgence (2004 –)

Historical Antecedents of ProAlcool

In 1923, Brazil's National Institute of Technology began an experimental programme to test the use of pure ethanol as a fuel in Otto cycle engines. In August 1923, as a consequence of these experiments, a Ford vehicle using hydrous ethanol took part in an automobile race in Brazil.

For the owners of the sugar factories, ethanol was still a by-product, produced only in small hydrous ethanol distilleries. After 1930, the new government stimulated industrial modernisation and financed the establishment of distilleries to produce anhydrous ethanol. The desire to intensify the ethanol production had a double purpose: to use it as a fuel and to make possible the transformation of the sugar surpluses. Thus, in 1931 a decree was issued requiring that 5 percent of the total volume of gasoline imports be supplemented by domestically-produced ethanol. Also in 1931, the Brazilian government created the Commission of Studies on Ethanol Fuel and the Institute of Sugar and Alcohol (IAA). When gasoline production started in Brazil, a law of 1938 obliged the national producers to add anhydrous ethanol to the gasoline produced in the country as well as imports, in a proportion determined by the National Council of Oil (CNP) in agreement with the IAA.

Until 1975, the addition of ethanol to gasoline was made in a disorderly way, by satisfying only the desires of the agro-sugar industry, since there was a very close relation between the price of sugar and ethanol in the external market and their production in the domestic market. A consequence of the chaotic changes in the ethanol content of fuel was the variable efficiency of the engines and then the dissatisfaction of consumers and the automobile industry.

The Oil Crisis and the Creation of ProAlcool

After the first oil prices shock of October 1973, the Brazilian strategy in this new context was, initially, to seek to maintain the high growth rates which had been observed since the end of the sixties. In 1973, Brazil imported 78 percent of its oil requirements. The road transport sector used 42 percent of the total consumption of oil products. It was clear that, should the country adopt a policy of substitution of oil, this sector would have to be a priority.

ProAlcool was created by decree only in November 1975. The government described the programme as an essential instrument of Brazilian energy policy. With the creation of ProAlcool, ethanol fuel not only provided the sugar industry with a new source of demand, but became a means of reducing the impact of the oil crisis on the trade balance and of reducing foreign energy dependence.

It must be observed, moreover, that ProAlcool was a great victory for the groups related to the production of sugarcane. The country had a surplus of sugar production, difficult to put on the international market, and the owners of the factories had a significant ability to put pressure on the government. ProAlcool provided subsidised financing to the industrialists willing to install new distilleries. With this policy, the government met the needs of the ethanol and sugar producers and justified its action by social and economic arguments related to the balance of payments.

During this first phase of ProAlcool there was a strong increase at the national level in the use of anhydrous ethanol added to gasoline. However, by 1979 this phase of the programme had allowed for a substitution of only 14 percent of gasoline consumption, suggesting that, at this stage of the game, the programme reflected more the needs of sugar factory owners than a determined policy of energy substitution. The priority of economic policy at this time was, above all, the growth of the national product.

The Second Oil Crisis and the New Phase of ProAlcool

After the second oil price shock of 1979, a new phase of

economic and energy policy took hold in Brazil. Combined with the rise in oil prices, 1979 was marked by a strong upward movement of international interest rates. For Brazil, which imported 86 percent of its domestic needs for oil and was burdened by a high level of foreign debt, these upward movements caused a serious imbalance in its balance of payments. In this context of adversity, economic policy gave priority to rebalancing the country's external accounts.

Programmes of oil product substitution were set up. ProAlcool, which already existed, received special attention. The government established an ethanol production target of 10.7 million m^3 for 1985 and increased subsidies and credit for investment in new ethanol distilleries. This helped to create a market for hydrous ethanol for a fleet of cars that ran exclusively on this fuel (the automotive industry began the sale of these vehicles at the end of 1979). The government stimulated ethanol sales with subsidies that reduced the retail price and by setting lower value-added taxes (VAT) for ethanol vehicles. The ethanol market received a further boost from subsidies for the cost of ethanol transport from distilleries to the service stations, the revenues for which were generated by taxes on gasoline consumption.

"When sugar prices on the international market started to rise in 1989, Brazilian sugar-cane growers diverted their harvests towards sugar exports, thus reducing ethanol production"

By creating an exclusive market for pure ethanol, this second phase of the programme gave a strong impulse to ProAlcool. Ethanol fuel consumption, which was 2.5 million m^3 in 1981, reached 12.7 million m^3 in 1989 (60.5 percent of total automotive fuel consumption in Brazil for Otto cycle).

The Crisis of ProAlcool

After the oil counter shock of 1986 gasoline and ethanol prices declined on the domestic market, reducing in turn the profitability of ethanol production in Brazil. Due to an unfavourable pricing policy, ethanol and sugar production had stabilised, at the time when the demand for ethanol was growing quickly. This structural difference between the two growth rates indicated that a serious supply crisis would inevitably arise in the near future.

When sugar prices on the international market started to rise in 1989, Brazilian sugar-cane growers diverted their harvests towards sugar exports, thus reducing ethanol production and causing the demise of ProAlcool. The reduction of ethanol supply created a serious problem for owners of vehicles running exclusively on this fuel, immobilising them for several days and forcing the government to import ethanol and methanol. Consequently, ProAlcool's credibility was destroyed, causing a sharp fall in ethanol vehicles sales. This fall ultimately modified the profile of the vehicle fleet and thus the structure of the fuel market.

With the recovery of oil prices since 1999, ethanol has once again become an attractive option, boosting, though only marginally, ethanol vehicles sales. The credibility of the ethanol supplies being always available at competitive prices had been destroyed by the 1989 crisis.

The Resurgence of the Use of Ethanol Fuel

The substantial increases in oil prices and the introduction of flexible-fuel technology brought to an end the ethanol fuel crisis. Research on flexible-fuel technology began in the 1980s. Since 1988, such vehicles have been produced in the United States with a practically fixed blend of ethanol or methanol (85 percent) and gasoline (15 percent). The research continued in the 1990s and into the present decade. In May 2003, Volkswagen produced for the first time a flexible-fuel car in Brazil and was followed shortly after by other manufacturers. These cars can run with variable combinations of gasoline and ethanol (up to 100 percent of ethanol), but current engines cannot use pure gasoline (they are designed to run on gasoline mixed with 20–25 percent of ethanol, which is obligatory in Brazil). For the final consumers, who acquire the ability to engage in arbitrage when choosing the fuel for their vehicle, the ghost of a possible ethanol supply interruption and/or an extreme increase in price disappears. The vehicle therefore is not, as in the early 1980s, captive to the use of only one fuel and consumers have a flexibility they never enjoyed before. For the ethanol producers, focused on the growing external market (for ethanol to be blended with gasoline, and for sugar, because the end of the European subsidies brightens the prospects for an increase in exports), it means the continuing existence of a domestic ethanol market.

The production of vehicles for exclusive use of ethanol must end this year. Next year only FFV, gasoline and diesel vehicles will be produced in Brazil. The FFV option, whose share of light vehicles sales in Brazil has already exceeded 70 percent, is likely to reach a 90 percent share in at most two years time. The light vehicles fleet in Brazil, which at the end of 2005 reached 21 million units including 5 percent FFV, would reach more than 35 million units in 2020, two-thirds of which will be FFVs.

The FFV was designed according to the gasoline vehicle model, and is generally optimised for the use of gasoline type C. Thus, the efficiency of the FFV is similar to the gasoline equivalent car, when this makes exclusive use of gasoline type C. According to the automobile manufacturers, the use of ethanol as fuel in the FFV will enable the consumer to cover 70 percent of the distance achieved with the same quantity of gasoline. In other words, if the

retail price ratio between ethanol and gasoline is equal to or greater than 70 percent, the consumer will use gasoline in his FFV.

The relative use of ethanol and gasoline in FFVs depends on a series of factors, the most important of which is the regional ethanol balance, as this is critical in determining the relative ethanol/gasoline price. In general we must consider the following variables to assess possible developments of the ethanol fuel market in Brazil: the forecasted and potential investments in distilleries and sugar plants and the rate of expansion of sugar cane cultivation; the logistical structure and the costs of transport for ethanol and gasoline in the country; the regional tax policy for automotive fuels; the trends of Brazilian sugar and ethanol exports; the evolution of the national demand for sugar; potential regional ethanol requirements for addition to gasoline and to supply vehicles; market trends for alcohol for non-energy uses; international oil prices and their effect on gasoline prices in Brazil.

"With regard to the domestic ethanol market, the growth in the use of flexible-fuel vehicles brings new dimensions to this market"

In synthesis, there are several factors that define the relative competitiveness of ethanol at the regional level and thus, the amounts of gasoline and hydrous ethanol consumed by FFVs. The main problem brought about by the FFV, given the rapid increase of its share of the national fleet in recent years, is the risk of increasing volatility in the gasoline market, due to uncertainties concerning levels of ethanol and sugar exports. What is certain is that they will be much higher than at present and more volatile.

Another important aspect concerns the sensitivity of demand to fuel prices. The renewal of the vehicle fleet, focused more and more on the FFV, implies a strong change in the average profile of the owners of these vehicles. The new fleet is associated to consumers with higher incomes whose price elasticity of demand tends to be lower than average. On the other hand, the average age of the gasoline fleet will increase over time, implying greater price elasticity for gasoline and less use of gasoline vehicles. The gradual increase in the price elasticity of gasoline demand can thus be taken as given for two reasons: a higher substitution effect (more options for the FFV owner) and lower average income of the owners of gasoline vehicles.

Conclusion

After almost a century of experience using ethanol as an automotive fuel, Brazil seems to have reached a degree of maturity in this field. Depending in the first phase of implementation on a structured programme of subsidies, the ethanol from sugar cane in Brazil has now reached self-sufficiency and is no longer dependent on governmental subsidies. It has uncontested competitive advantages on the international market. The production costs of sugar and ethanol in Brazil are lower than those of other international players, and Brazil is now the largest world exporter and a market-maker of sugar and ethanol.

With the worldwide emergence of programmes for the use of ethanol as a fuel, brought about by the Kyoto Treaty and higher oil prices, Brazil assumes a leadership role in ethanol supply on the international market. Higher prices translate into higher profitability, which attracts various international companies to Brazil. The availability of vast cultivable lands will allow Brazil to maintain its leadership in this market for some time.

With regard to the domestic ethanol market, the growth in the use of flexible-fuel vehicles brings new dimensions to this market. These vehicles have allowed greater flexibility in the use of fuel and have allowed consumers to overcome the fear of a possible shortage of ethanol supplies. However, the introduction of the FFV affects gasoline demand in several ways: higher price elasticity, greater market volatility and greater market uncertainty in the long term.

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Asinus Muses

CO_2 Wars: Episode IV – a new hype?

To judge from a torrent of recent statements from the rich, mighty and influential, only 17 years after communism was supposedly laid to rest and before even the end of the beginning of the war on terrorism, the world is haunted by a new spectre – that ubiquitous and unprepossessing gas, carbon dioxide. While those of us who live in stables have a slightly different point of view on global warming, we recognise that for many humans and most polar bears it is a serious threat. Inter-species solidarity makes Asinus welcome such weighty denunciations of the CO_2 menace.

The oil majors vs. CO_2?

Take, for example, the major oil companies. Apparently, according to their recent advertising, they have completely stopped exploring for, producing and distributing fuel products, cause of such a large part of our excess CO_2 emissions. Defining their new role Chevron says that 'saving energy is like finding it' and BP (whose PR name is now 'beyond petroleum') asks us to 'learn how to reduce [your carbon footprint] and see how we're reducing ours'; even ExxonMobil, sometimes accused of making real money while its rivals make false promises, is sponsoring university research about 'dramatically reducing greenhouse gas emissions', while Shell ostentatiously sponsors environmentalist TV programmes. Why, then, was the latter so upset by being squeezed out of the Sakhalin II project by the born-again environmentalist Russian government? Should it not have been relieved to have been prevented from damaging the environment?

The CO_2 World War

Russia's green conversion is not an isolated phenomenon. In the last few weeks strong condemnations of CO_2 have been uttered by most major world leaders. Even the Chinese government – tired of being pilloried as the world's fastest growing source of global pollution – is busy trying to arrange that the crowds at the 2008 Olympic Games will be able to see the athletes, as well as doing a cleanup of the coal industry. The EU Commission has called for a 30 percent fall in CO_2 emissions by 2020 – unless other governments fail to follow suit, in which case they will heed the Industry Commissioner, who is opposed to doing anything faster than the rest of the world and so raise relative costs for European industries. Not really so different from George Bush when you come to think about it.

The Royal Family vs. CO_2 – the battle on the ice.

Celebrities are joining in, too. One senior member of the British royal family recently went to see for herself how global warming was affecting the Antarctic ice cap. She sped around in one of those notorious gas-guzzling motor sleighs before addressing the cameras of the TV crew which had made the 12,000 mile journey with her. How she actually knew how much of the ice cap had melted away was puzzling, since she had not, as far as I know, been there before. But she was commendably emphatic that things were bad and that it was all because of the fact that 'we are filthy', a phrase which she repeated several times. Clever, thought Asinus, to use this arresting and simple phrase whose meaning was not immediately obvious, so that the viewers were forced to think for themselves a little. It can safely be ruled out that she was referring to the bodily cleanliness of the royal family, who I would imagine are kept spotless by their many bathers, scrubbers and tooth-paste squeezers. Nor, surely, was she reiterating the old cliché about the very rich in general. No, I think it became clear that 'we' was neither a class nor a royal 'we' but referred to the whole human race; and that the term 'filthy' was yet one more, slightly vulgar and ear-catching, way of persuading the viewers that humans were producing too much carbon dioxide. She offered no general solution to the general filth but said that she was trying to take the train more frequently.

The war moves from the High Street to the shelves

In the High Street 'carbon neutrality' is suddenly in fashion. The HSBC has become a carbon neutral bank and has recently been followed by Marks and Spencer, BSkyB and others. Tesco (perhaps soon to be renamed 'tesCO_2') even proposes to print on all the goods it sells an index of their carbon footprint. So the green shopper will know not only where the product was made, whether it was sold under fair exchange conditions, manufactured under fair labour conditions, produced by organic methods, its percentage of recommended daily allowances of nutrients, whether it contains sugar, fat, allergens and other undesirables and, now, exactly how much CO_2 emission has resulted from its production and distribution. Oh yes, also the price and basic ingredients, if that still interests anyone. Shoppers face such a nightmare array of ethical, political, health-related and arithmetical choices for every single purchase that they may end up thinking more about carbon monoxide than carbon dioxide.

All in all, however, Asinus has to express admiration for the moral courage of so many important people and companies battling the cause of the common good against the evil gas, knowing that, since much of what they say and do will incidentally help them to get votes, profits and prestige at the expense of their rivals, they will only incur accusations of window-dressing and hypocrisy.

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