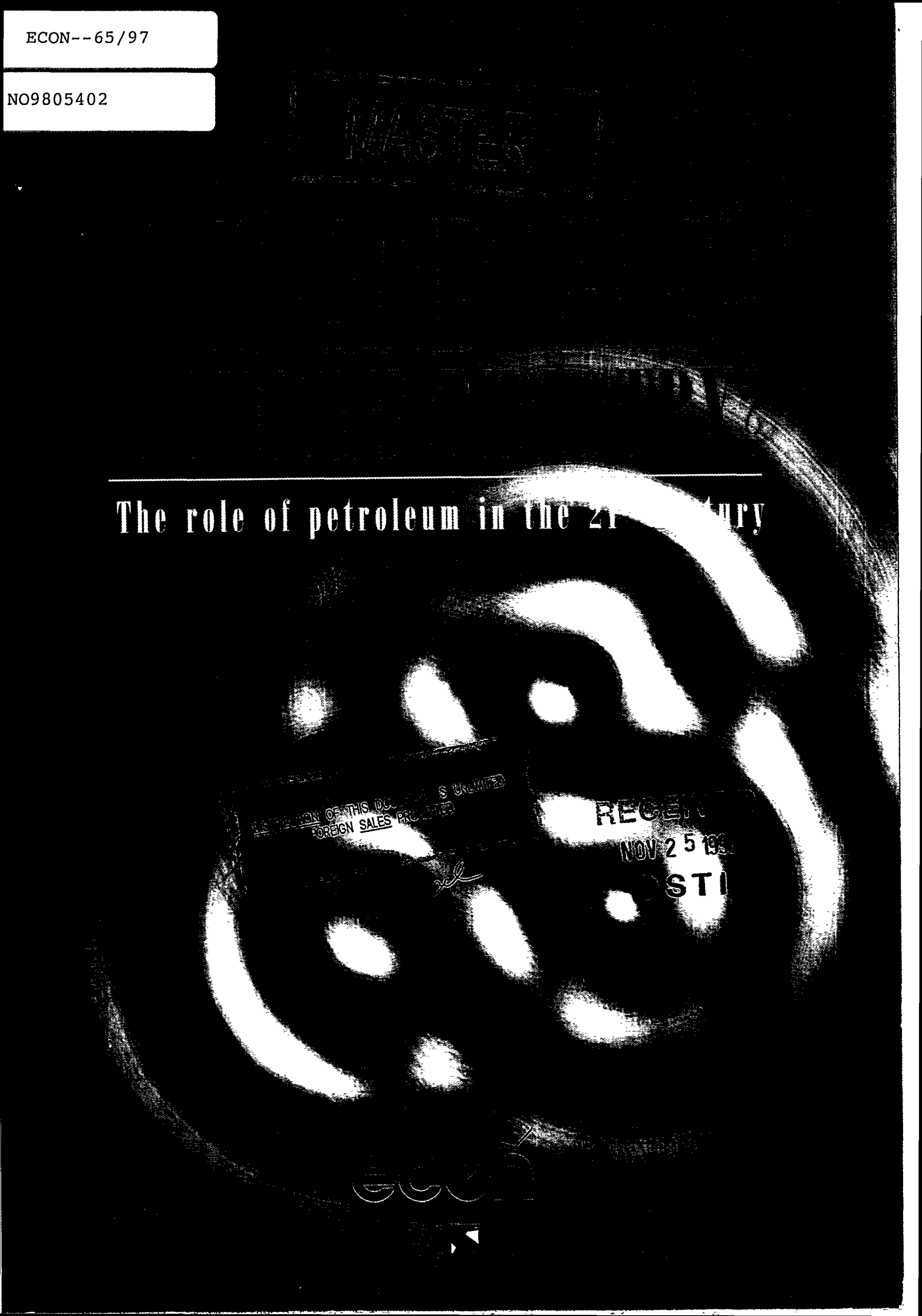

The role of petroleum in the 21st century

25 år NORSK PETROLEUMS-FORENING/NPF
NORWEGIAN PETROLEUM SOCIETY

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Oil and gas - a sunset industry?

The role of petroleum in the 21st century

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Foreword

In 1972, the development of the Norwegian petroleum resources led to the establishment of Statoil, Saga, The Norwegian Petroleum Directorate and Norwegian Petroleum Society. Consequently all these key institutions can celebrate their 25th anniversaries in 1997.

During this period the four institutions have played different roles. Norwegian Petroleum Society has developed into a forum for contact, information and networking. Our most important role is to arrange seminars and conferences for the petroleum industry.

It is therefore appropriate to celebrate our 25th anniversary with a unique and forward-looking conference. NPF has engaged ECON Centre for Economic Analysis to analyse the role of oil and gas in the 21st century, and to present this report as the first speech at our 25th anniversary conference.

Kjell Roland has been principal author of this report. Valuable contributions have been made by Torleif Haugland, Paul Parks, Bjørn P. Saga, Jan Arild Snoen and Knut Vrålstad, while May Brith Håkonsen has provided clerical assistance.

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Happy 25th anniversary to NPF and its members!

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1 Experiences of the past and perceptions of the future

Introduction

Policies and long term commercial commitments build on passed experience and on our present perception of the future. *This report explores our understanding of the petroleum industry after more than 25 years of petroleum activity in the North Sea and review the current perceptions commonly shared by industry and analysts regarding future developments.*

During the last 25 years, *North Sea has become a major new petroleum province* and Norway the worlds 8th (soon to be 7th) biggest oil producer. The country is the second largest oil exporter and soon will become the most important supplier to the Continental gas market.

Past achievements (or investments) in the North Sea are the accumulated results of concerns and expectations of policy makers and oil industry executives over the last 3 decades. Yet during this period both the world and our views of it and the energy business have changed radically and often. One of the messages that history teaches us in this business is the one of *being humble as to our ability to understand and predict what the future may bring.* A few examples may illustrate the point.

Limited ability to understand and predict the future

Energy to important to be left with the market

In the 70s, oil, gas and other natural resources were regarded to be too important to be left to market uncertainties. In large parts of the world, direct government ownership of energy was the preferred option. At that time it seemed that *government ownership in the oil and gas industry was on an forever upward trend and private ownership, represented by the Majors, was on the defensive.* Indeed the stewardship of energy resources properly belonged in the public domain. Nationalisation in the OPEC countries together with the establishment of national oil companies in many consuming countries was the result of this belief. Our own Statoil was born very much in the mood of the day.

Government ownership the preferred remedy

The market better than governments to provide energy

However, today the opposite view prevails. The last decade has seen the re-emergence of market forces and private capital as the determinant factors in the energy industry and thus these factors are now viewed as the primary determinants of the future. *The view is increasingly that, given a proper regulatory framework, markets and private companies are in fact in a better position to service our need for energy than are governments.*

Domestically, again Statoil illustrates and manifest this new trend. Supported by the government as well as the Storting, Statoil is increasingly being exposed to competition at home and the company is actively pursuing a strategy of expansion, primarily outside the North Sea. The corporate aims are to become an international, may be in the long term even a multinational oil company. Furthermore, even the ownership structure is not sacred anymore. Over the next decade, the company will most likely move away from the present 100 per cent government ownership towards a private-government mix.

Overly optimistic oil prices expectations.....

Oil prices doomed to increase

Much have been said and written about oil prices. *In the 70s, the physical fact that oil (and gas) are exhaustible and that prices would trend forever upward* was viewed as the base reality facing the energy industry - and indeed the world. The question then was only when and how fast, not if, such price rises would happen.

In the North Sea, huge commitments in the late 70s and first half of the 80s were based on oil prices being double or triple of what they turned out to be. Even at those price expectations a number of field developments were only marginally profitable.

Since the mid 70s, pundit's oil price expectations have bumped up and down, from a high of more that 100 $/b at the turn of the century around 1980 to a low 8-12 $/b after the 1986 price crash. Despite the volatility however, the overall trend of price forecasts is much lower than that of the 1970s.

..... and conservative production projections.

More oil found and more oil produced than expected

It was not only that we struggled to understand the dynamics of the market forces. *The interplay between geology and technology proved equally difficult to anticipate.* For example, recoverable reserves in a geological structure have tended to increase substantially beyond initial estimates, as has been the case in the North Sea as elsewhere in the world. Enhanced oil recovery, horizontal drilling, 3D seismic and subsea production systems have made it possible to drain the reservoirs better than before and to find more oil and gas in the same area - and at significant lower costs.

Projections of production to low

Thus projections of oil production consistently turned out to be lower than what were realised. Production once expected to peak early in a field's life or for geological provinces, and then decline quickly, has instead shown longer and more stable production. This is Norway's experience, but also that of future production outside OPEC and the former communist countries.

What was not on the agenda but proved important

The examples above illustrate how limited our ability to foresee and to predict even the most salient future developments have been. With the benefit of hindsight, we can now recognise our limitations in terms of understanding important factors that dramatically changed the future, but were not on the agenda two decades ago. A couple of examples may again be useful.

In the early 70s, nobody foresaw how Information Technology (IT) would transform modern society. Production of hard and soft wares have developed into industries surpassing the petroleum industry in size in most industrialised countries. To illustrates how IT have changed our daily life as professionals and also impacted on our private life, remember that *when the first gas from the Continental shelf reached the west coast of Norway, we all used pencils and calculators.* Pocket size cellular phones and PC were not invented.

When first gas was landed in Norway, cellular phones and PCs not invented

The petroleum industry in itself, as most other major industries, have significantly changed its way of operating not to speak of its organisational mode. *Modern IT have allowed the industry to change from the huge, centrally controlled and vertically integrated machinery's that before was so typical for the multinational oil companies, to decentralised systems of co-operating but autonomous entities.* From long lines of command like spider webs from a far away HQ possessing ultimate power, to a system of commercial interactions between partners co-operating in their own self interest. In the words of business consultants, reengineering has changed companies from large, integrated and self-contained giants to slim, decentralised service and knowledge based entities. Important management strategies in this regards recommend outsourcing of non-core business like accounting, transportation, legal services etc.

IT has fundamentally changed oil industry

An other example of what was not but should have been on the agenda 25 years ago, was the environment. The fundamental changes in the energy sector that have taken place (and even more, which may take place in the future) due to environmental concerns, were not at all understood in the mid 70s (more on this later, see Ch. 3.3 and 4.3).

The importance of environment not understood

A healthy industry

Despite the fact that price expectations consistently turned out to be wrong, projections of crude production were far too pessimistic, and that we seriously underestimated our own ability to improve on technology and at the same time lower costs, *the Norwegian oil and gas industry today is in very good shape. Costs are coming down, production is increasing, most companies collect handsome profits, and rents are pouring into government coffers.* In fact, even with the very significant government take, only modest complaints are voiced against the present system of taxes and levies.

Norwegian oil and gas industry in a very good shape

With the benefit of hindsight, it is fair to say that a lot of good things happened by accident or as unexpected by-products of decisions. Some of the good that we sought to achieve turned out to be less of a virtue. Also,

great triumphs have been made by visionary decision makers guided by insights and strategic goals.

Limited ability to foresee future

The belief in number crunching seriously questioned

The experience of the past gives ample reason to be humble when we today celebrates NPF's 25 years anniversary, and from this platform turn around and reflect upon what is to be expected over the next 25 years of petroleum history in Norway. *The belief in number crunching and projections of prices, production, costs and revenues more than a few years into the future is seriously questioned and are for good reasons not in high esteem.* The feeling that framework conditions and political priorities are highly unpredictable and may easily change is also shared by many in this industry. Yet our actions today will always be guided by our expectations of the future. Thus despite our past misperceptions, we need to try, in a humble way, to analyse what the future may bring.

The unpredictable and changing energy world

As will soon be obvious to the reader, this report addresses and discuss a large number of complicated and often inter-linked issues. No attempts are made to cover all of these issues in depth or otherwise make full justice to the issues involved. Rather, *the aim is to remind us all of how unpredictable and changing the energy world has been and is likely to remain, and to discuss and possibly also influence how we today perceive the energy futures.*

Structure of report

This report is essentially divided into three parts. In Chapter 2 we focus on issues where insights and perceptions have changed and hopefully improved over the last 25 years. In the subsequent chapter (Chapter 3), we summarise some of the most important changes or trends which have shaped energy industries and which are expected to impact developments in the decades to come. In the end, in Chapter 4, we discuss issues that ought be part of the agenda when exploring what the future may bring to the Norwegian petroleum industry as well as energy industries in general.

2 Fallacies of the past 25 years

2.1 Introduction

«Learn from history»

Looking back on the past 25 years of oil and gas history, it is useful to revisit areas where our perceptions proved wrong. In such areas, we may either have changed our mind and base our present decisions on other assumptions about the world. Or we may simply have come to the conclusion that our knowledge of the world is less perfect than we thought it to be, and accepted to live with the uncertainty involved.

Moving back a couple of decades, *energy policy debates centred around the following beliefs*:

Important premises for energy policy

- *The fact that physical resources of petroleum are finite* and that this impending shortage is of primary importance to policy makers and markets.
- *The fear that the industrialised world was doomed to be overly reliant on OPEC* and unstable supplies of crude, and that serious actions were needed to address this.
- *The fundamental mistrust that existed in large parts of the world toward multinational oil* (and other) *companies* (and their parent governments), to their motives and actions, and that state owned companies was the remedy.

2.2 Exhaustible resources - the nonproblem

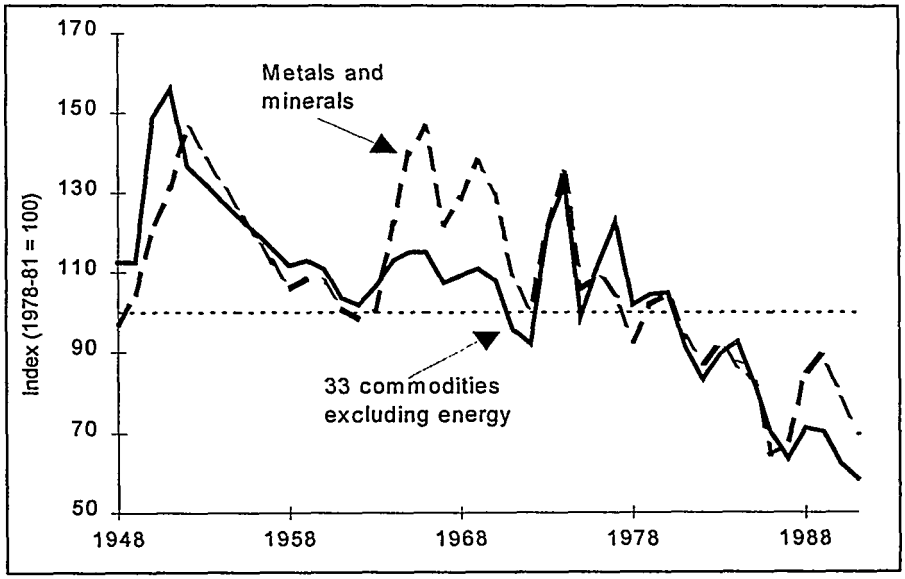
The origin of the "hockey stick" price projection

Spurred by the first oil price hike in 1973, the notion that the world would soon run out of oil made it to the top of newspapers headlines and soon became conventional wisdom. In the public debate, this perception was precisely articulated but Paul Ehrlich in his question: *«What will we do when the pumps run dry?»*. In the academic world, economists rediscovered a seminal article from 1931 (Hotelling, 1931). In this article, Hotelling started out from the assumption of a fixed stock of a mineral

«What will we do when the pumps run dry?»

asset, and discussed how prices and depletion would take place in a competitive market. The logic and aesthetics of his theory were attractive from an academic perspective and well suited for sophisticated mathematical analysis within the neo-classical paradigm. *Given Hotelling's fixed and known stock assumptions, the "hockey stick" forecast of oil prices became a logical conclusion and a commonly shared perception of the future.* This perception became the accepted paradigm despite the fact that commodity prices historically have tended to be on the decline.

Figure 2.1: Commodity prices in constant dollars



Source: World Bank (1993)

Insufficient oil in ground to meet demand unless oil price escalated

The belief was that there was not sufficient oil in the ground to meet demand unless costs of extraction escalated. The question was not if, but when the real price of oil would have to start climbing to balance demand and the limited resources of gradually more costly and hence expensive oil to be produced. Hardly any other perception of the future have been so persistent and survived in the industry despite the lack of support in historical data (except for the very peculiar hick ups in the oil prices in the 70s) and its poor performance in terms of predicting future prices.

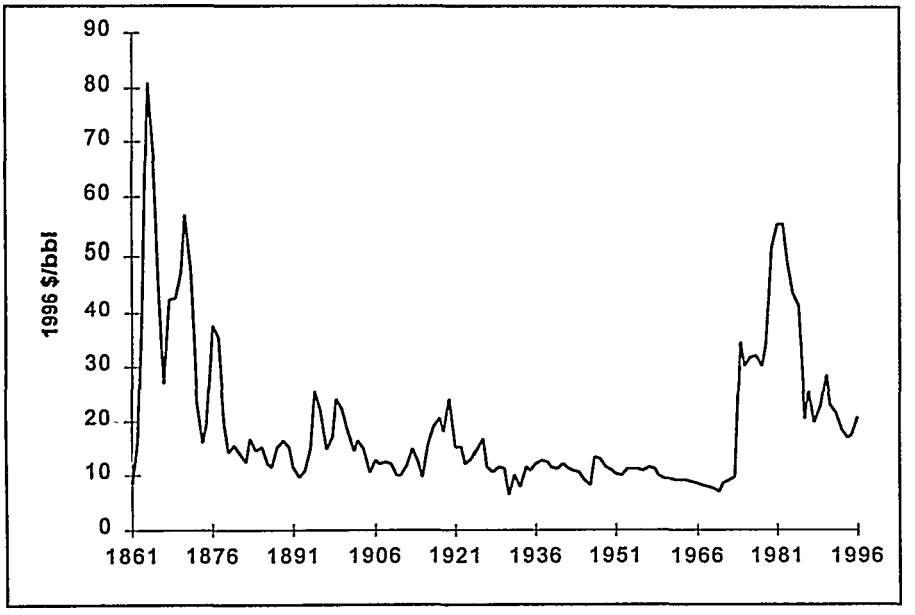


Figure 2.2: Real price of oil

Source:BP (1997)

However, our modern fear of a doomsday has long historical roots. Malthus (1798) argued that an increasing population would force agriculture into more and more infertile land, and in the end push standard of living down to a subsistence level where population stopped expanding. This argument has later been called *the Malthusian error.* Later, in 1865, W. Stanley Jevons (1965) wrote a comprehensive study to explain why England's economic growth would grind to a halt due to exhaustion of the country's coal resources.

The Malthusian error

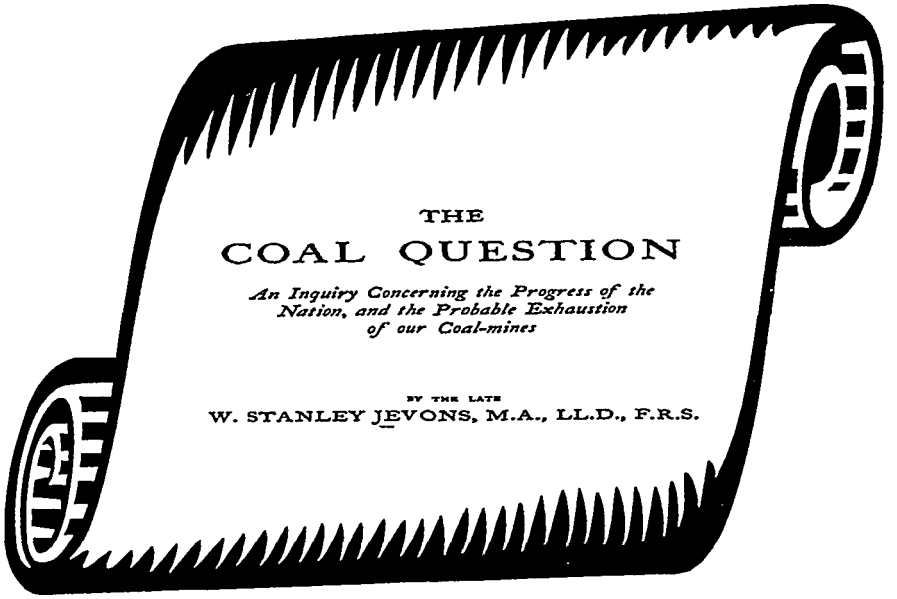

THE
COAL QUESTION
An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of our Coal-mines
BY THE LATE
W. STANLEY JEVONS, M.A., LL.D., F.R.S.

Figure 2.3: Jevon's study of coal resources in England

Unconventional but wise?

Among modern energy analysts, two important exceptions to the "hockey price" curve perception needs to be pointed out. Both Morris Adelman and Peter Odell revolted against conventional wisdom. In Adelman's word, "*the world's reserves are unknown, probably unknowable, but above all unimportant*". All that really matters is costs - like in all other industries.

«World's reserves are unknown, probably unknowable, but above all unimportant»

The notion of a fixed stock is misleading and should be dismissed. (See Adelman, 1995 or Odell, 1986)

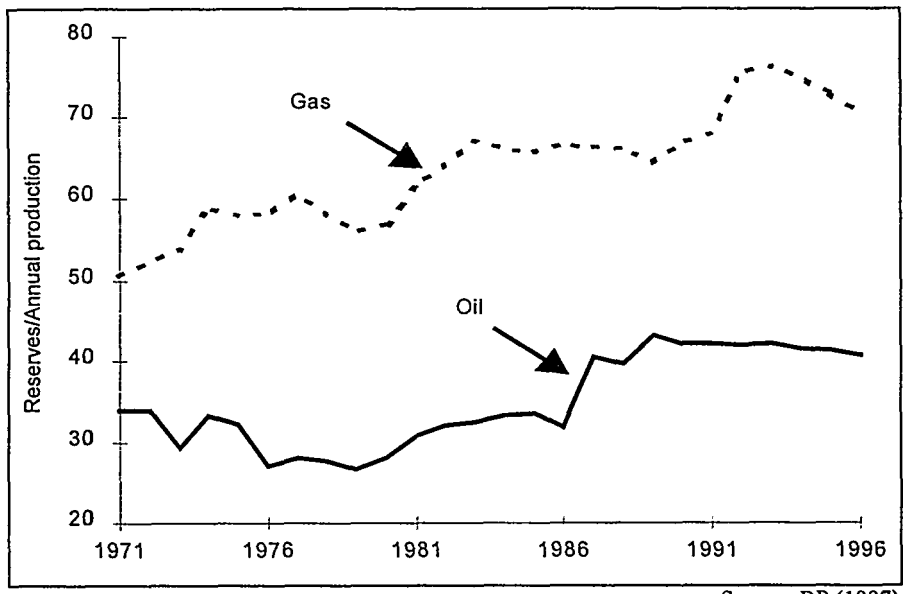
The only limited resource: human imagination and spirit

The same kind of argument is extended by Simon (1996) to the discussion of natural resources in general, not only petroleum. He argues that there is only one resource that is ultimate, and that we need to be seriously concerned about in the long term. The ultimate resource is «*human imagination coupled with the human spirit*».

Among the natural resources, energy is indeed special

Many argues that energy is special in the sense that it is hard to do without, and that the resource base in this case is in fact likely to be limited relative to human needs. *Among the natural resources, energy is indeed special in the sense that it is required to exploit all other natural resources, and in the sense that when used, it is gone and may not be recycled.* Thus, we can not do without energy. What is said about energy in general also goes for fossil fuels given today's dependence on oil, gas and coal. Thus, how and when energy resources are depleted is something that we need to understand and reflect upon.

Figure 2.4: Global Reserves-to-Production (R/P) ratios



Source: BP (1997)

No indication that world is running out of fossil fuels

However, empirical studies does not indicate that the world is running out of fossil fuels. There is *plentiful coal, increasing proven reserves of gas and more oil today than in the mid 70s* when «scarcity» as measured in terms of number of years that the present reserves (i.e. inventories) may sustain present production was assumed to be on a declining path.

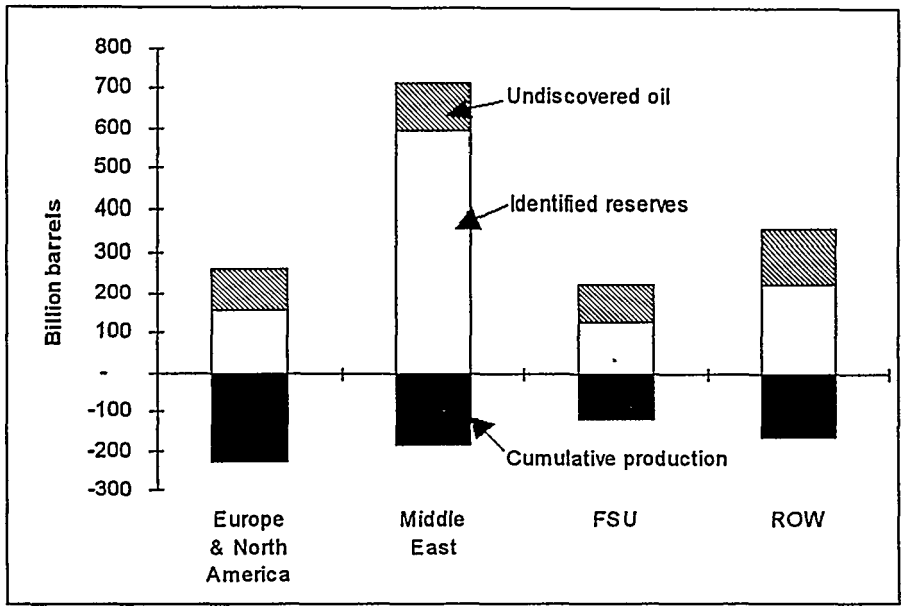


Figure 2.5: Identified reserves, undiscovered resources and accumulated production of crude oil

Source: Masters et. al. (1994)

More specifically, one intuitive illustration of the «scarcity» of oil is the size of accumulated production to date relative to identified reserves plus undiscovered resources. *On a global level, accumulated production in modern time is close to 700 billions of barrels which compares to 1600 billions of barrels of estimated remaining discovered and undiscovered resources.* Thus, if this estimate is largely right, we have produced around 44 per cent of our conventional resources.

Still 56 per cent of oil resources in the ground

In addition comes unconventional resources, such as extra heavy oils and tar sands. Estimates of these resources suggests that heavy oils in the Orinoco province in Venezuela and tar sands in Western Canada, both located in the Western Hemisphere, approximately equals world identified reserves of conventional crude in Middle East. Thus, it is possible to conclude that the world at one point in time may deplete conventional and also other sources of oil. When this may happen, we do not know. However, *within the time frame considered in this study - 25 years ahead and even far beyond - there is no reason to believe that limitations in the resource base will require prices to raise to balance supply and demand even at a much higher level of consumption than today.*

Resource constraints does not require higher oil prices next 25 years

All that matters is cost

Our limited resource, human imagination and spirit, will be challenged over the next decades to see to that our energy needs are met at acceptable costs. *The concern that should occupy policy makers as well as industry executives, is not the volumes of resources that do exist in the crust of the earth, but the amount of human effort needed to bring these resources to the consumers.*

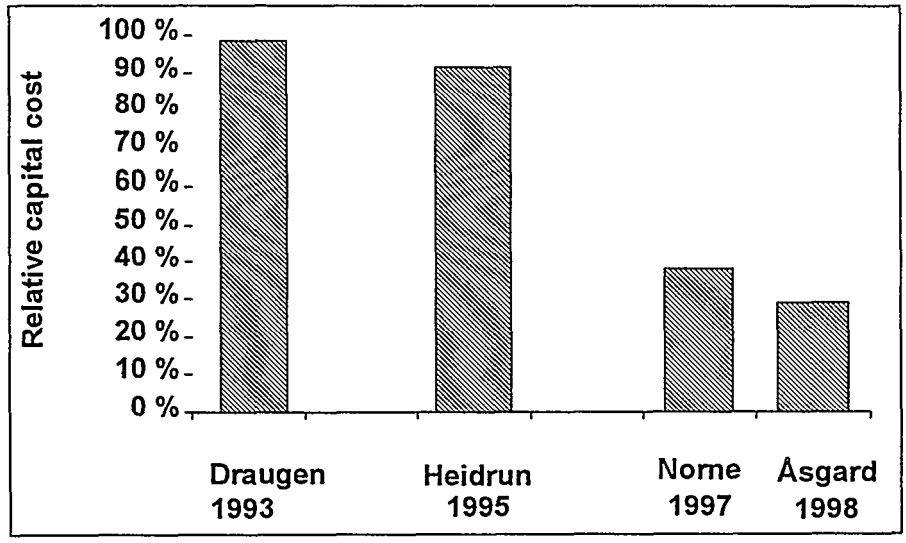
Enough resources, but how to bring them to consumers

The North Sea experience in terms of the costs of extraction over the last few years is a telling one, and gives hope for the future for our own industry. *NORSOK, a joint initiative by industry, government and contractors was established to improve the competitive standing of the Norwegian offshore*

sector in the international oil and gas industry. The aim was to review all phases of offshore development to reduce costs. Through this joint effort, very significant reductions in costs in all parts of the offshore development were achieved over a short period of time. The Government critically reviewed its licensing procedures to reduce time spent from Plan for Development and Operation (PDO) was submitted, to development could be initiated. Contractors and oil and gas companies significantly reduced costs through effective co-operation, standardisation, less bureaucracy and uniform information management. As the Figures below illustrate, *costs came down more than most people expected to be possible in most offshore activities.*

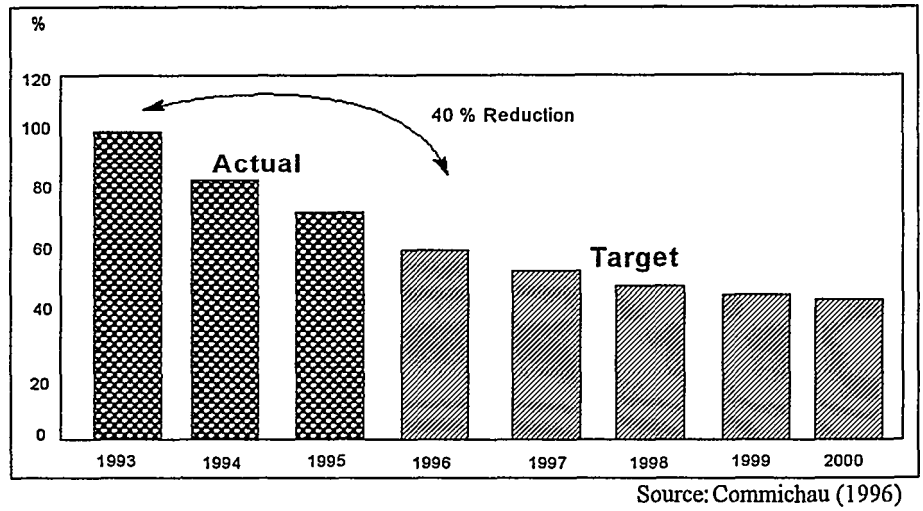
Costs came down more than expected possible

Figure 2.6: Capital cost per unit of production



Source: NORSOK

Figure 2.7: Operating cost per unit of production



Source: Commichau (1996)

Similar industry - government initiatives and results were made in the UK. Thus, the evidence does not support the idea that petroleum is in short supply and costs are edging upwards due to the fact that we are pushed into marginal and increasingly expensive resource deposits. Rather on the contrary, *the petroleum industry so far has been able to develop more sophisticated technology that allows costs to be reduced even at increasing production in more remote areas.*

The Malthusian error in gas policies

In addition to the errors that were made in the Malthusian direction on future oil prices, the notion of fixed and rather limited stocks of oil and gas in the ground also strongly affected gas policies in the last part of the 70s. *To preserve resources for the future beyond what the market would presumably bring about, the idea emerged that natural gas was a premium fuel to precious for bulk use.* In fact, natural gas should be reserved for «premium» use in households and the commercial sector.

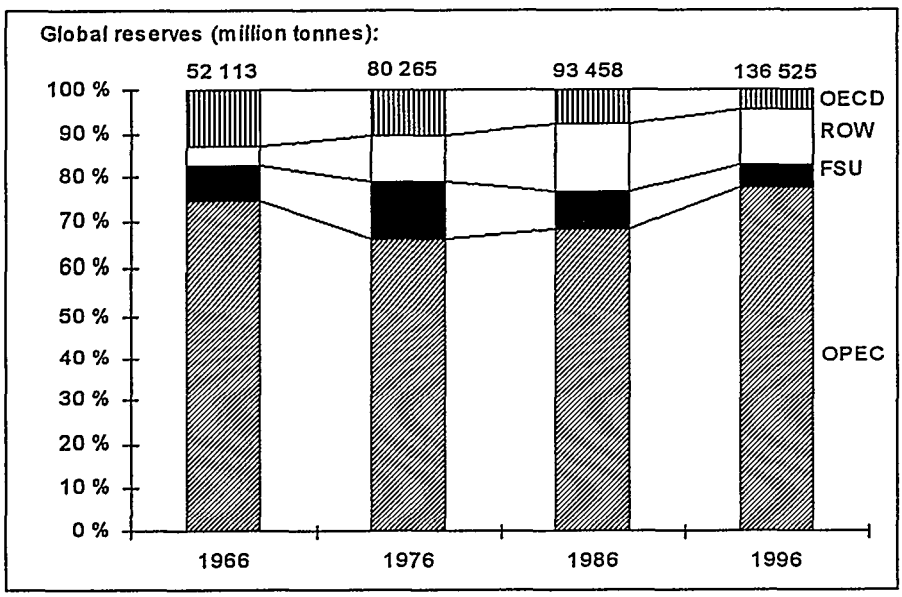
Natural gas -a premium fuel to precious for bulk use

In Europe, the European Union in fact took this literally and introduced a directive with the aim to curb growth of new power stations fuelled by gas. As we all know, today gas used in Combined Cycle Gas Turbines (CCGT) in large parts of OECD as well as in many developing countries, is the preferred alternative in power generation both for financial and environmental reasons. In some countries, gas fired power generating capacity is actively promoted by environmentalists.

Geopolitics matters - not depletion

The geopolitical distribution of conventional oil reserves are, however, rather skewed. The dominance of Middle East is significant and does not change if comparing identified reserves or if possible, undiscovered resources are included. Thus, geopolitical concerns impact on our views as to how much oil "should" be consumed, and raises the issue of supplies.

The skewed geopolitical distribution of reserves



Source: BP (1997)

Figure 2.8: Regional distribution of proven reserves of oil

However, even if the notion of depletable resources does not impact on gas policies today, the notion of a basic upwards tilt of real prices is still in the head of some analysts and policy makers. This report does not share this view, nor the belief that prices need to increase over the next couple of decades due to limited physical availability of resources and related costs. However, *the fact remains that an disproportional share of the world's proven oil reserves are located in a limited number of countries situated in an unstable part of the world dominated by a political and cultural*

Future prices remain heavily dependent on the geopolitics of oil

environment not always friendly to the West, nor particularly friendly to their upcoming dominant customer; the rapidly growing countries in Asia. Thus, the issue of future prices is likely to remain heavily dependent on the geopolitics of oil.

Table 2.1: Oil reserves and production by region

	Identified bn bbls	Possible total bn bbls	R/P ratio identified	R/P ratio possible total
CIS/FSU	125,1	225,1	43	78
OPEC outside Middle East	123,4	158,5	42	54
Middle East	597,2	714,6	89	106
Rest of the World	257,5	475,7	23	42
World	1 103,2	1573,9	46	66

Source:Mitchel (1996)

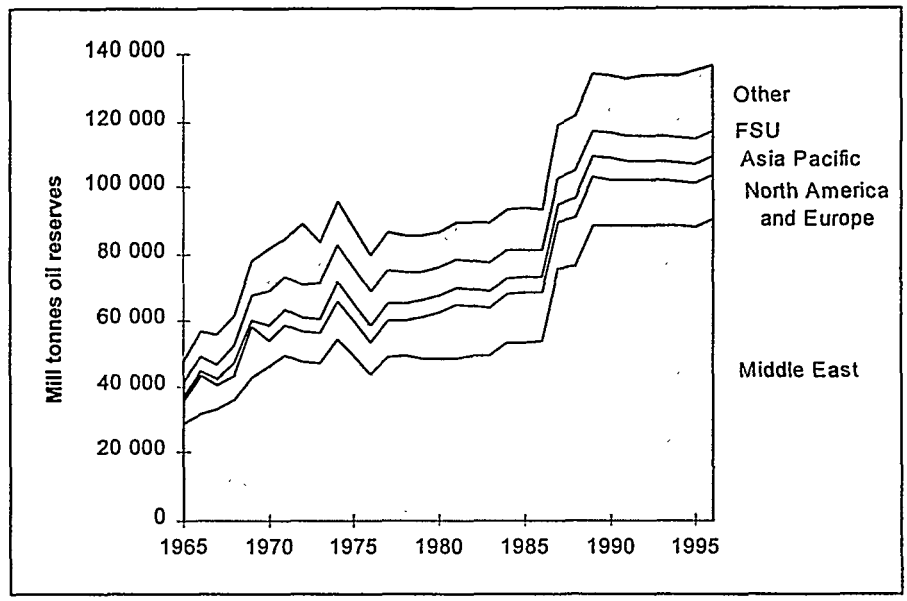
2.3 OECD living on OPEC mercy

Security of oil supplies

The Yom Kippur war made oil the centre of Western power politics

The boycott of Israel, of US and the Netherlands by oil exporters in the Gulf subsequent to *the Yom Kippur war in 1973 moved oil to the centre of Western power politics.* Escalation of Muslim fundamentalism in the region and the downfall of the Shah of Iran, the West's closest ally, kept attention on security of supplies of oil. In US and other OECD countries, consumption of oil was projected to increase while production from domestic sources and «friendly» producers was on the decline. Nobody doubted that net imports was increasing, the question was from where the oil would come. *The fear was that the West increasingly would have to rely on supplies of oil from a region hostile to our values and culture, and unstable due to domestic and regional political tensions.*

Figure 2.9: Regional distribution of oil reserves



Source:BP (1997)

The perception that the West was doomed to be overly reliant on the Middle East is explained by the regional distribution of reserves. From 1965 to the end of the 1980s, the share of global oil reserves in the Middle East varied between 55 to 60 percent. In the 1990s the share has shifted upwards to 65-67 percent.

Increasing reliance on Middle East oil in the long term

Yet despite the continuing dominance of Middle East reserves and the continuing instability in the region, no longer does the West (or the East) appear to be preoccupied with the security of supply issue.

The Non-OPEC miracle

One reason why dependence of OPEC oil is less prominent as a political concern in the West today, is that far more oil has been discovered and is being produced in countries outside OPEC and the FSU/CIS than was expected. *Production in the Rest of the World (ROW) have been increasing steadily over the last three decades, on the average by 600 000 b/d per year.* As share of world production, oil from ROW increased substantially in the decade starting in 1975, from 32 to 49 per cent. Later, the share has stayed around 47 per cent. Reviewing past projections of ROW, just as price expectations systematically were to high, projections of ROW production were consistently expected to peak within a few years and then be on the decline. History proved otherwise.

Production in ROW increased steadily over three decades

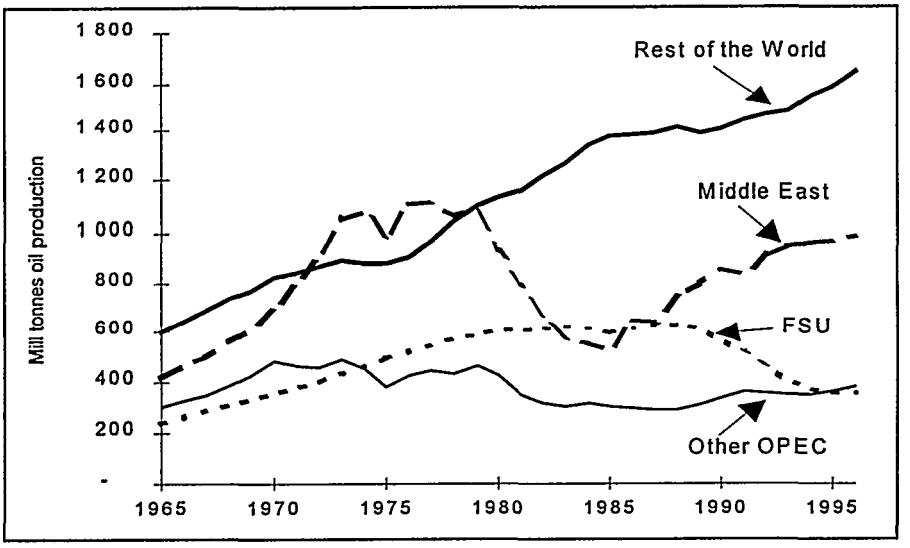
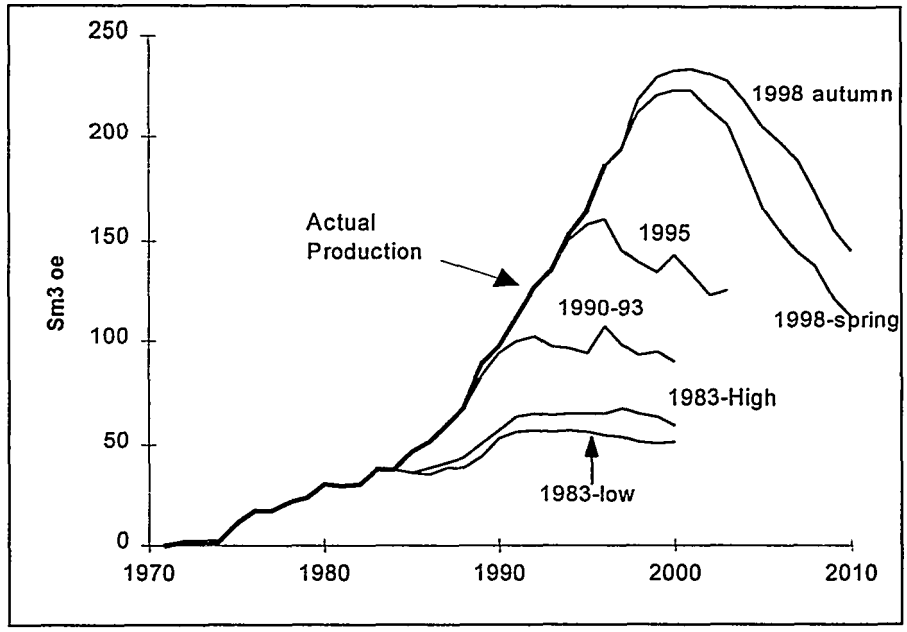


Figure 2.10: Oil production by region

Source: BP (1997)

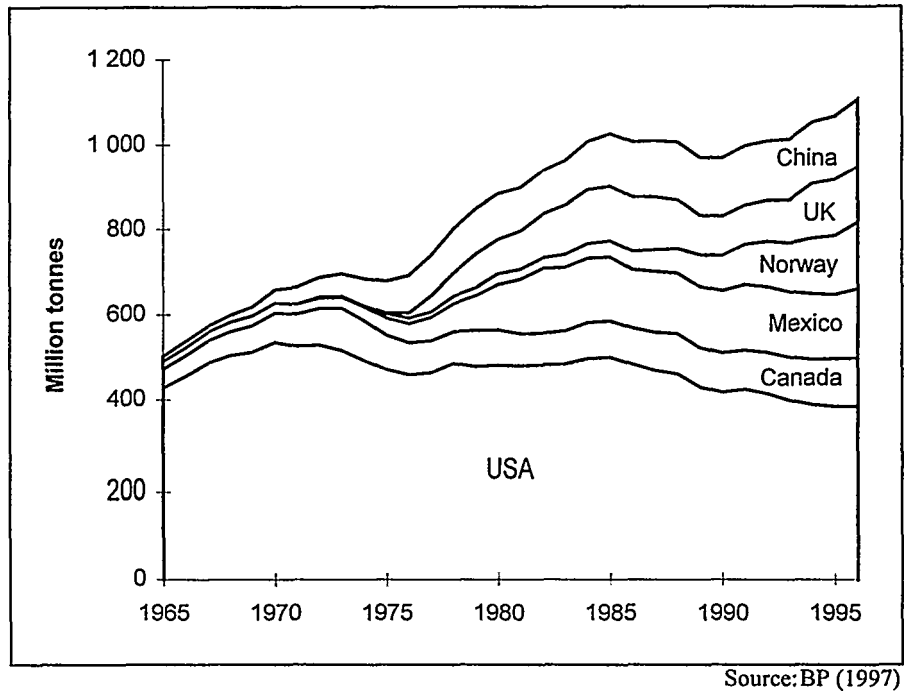
Figure 2.11: Official projections of oil production in Norway



Source:ECON

Our inability to project production in the ROW area is perfectly illustrated by Norwegian projections of North Sea production, which have been systematically biased on the low side. The success of exploration and development has far outpaced expectations both in new petroleum provinces like the North Sea and existing producers like China, the US and Mexico.

Figure 2.12: Oil production in selected Non-OPEC countries



Source:BP (1997)

Competitive and transparent markets

Markets de-couple physical and financial risks of interruptions

A third reason why security of supplies is perceived as less of a problem today than in the 70s and first part of the 80s, is the fact *that world crude and product markets today are much better instruments to fend of disturbances in the physical supplies of oil.* In the 70s, most oil traded internationally was moving along the physical supply chains owned by the seven sisters (Exxon, BP, Shell, Gulf Oil, Standard Oil of Texas, Texaco, and Mobil) and a few other major oil companies.

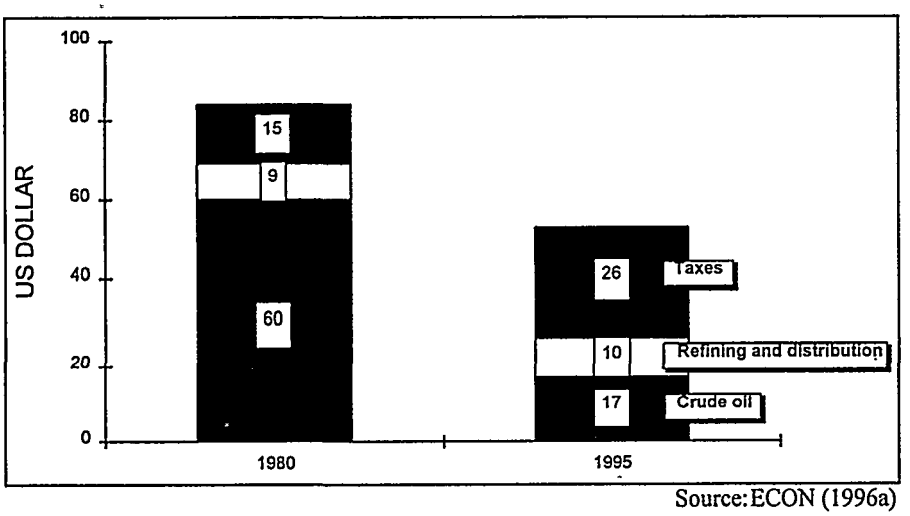
All countries share in the risk of supply interruptions

Interruptions in upstream activities in one part of the world would in those days end up as curtailment of supplies to particular customers at the end of a particular chain of supplies. Today, interruptions of supplies affect prices globally, but do not end up as curtailment of supplies to particular customers. Liquid, transparent and well functioning markets for crude as well as most products de-couple the physical and the financial risks of interruptions. *Global markets have put all of the consuming nations on a more equal footing - they all have a share in the risk of a financial burden due to temporally high prices.*

Who gained from the price hikes?

Consuming nations gained from oil price hikes

OPEC's position in terms of resources and production of course raise the issue of cartel power. Many fear that heavy reliance on OPEC oil may tempt the Arabic world to raise prices by curtailing production. *The lesson learned from the price hikes in the 70s is that they did not actually serve the interests of the big oil exporters. In the longer term, governments in consuming countries proved to be the big winners.* This is apparent when studying how revenues from a barrel of oil have changed after the last decades. While the producing end of the system (company plus host government) in 1980 received 60 USD/b, this was reduced to only 17 USD/b 15 years later. On the other hand, governments in consuming nations increased their take from 15 to 26 USD/b. Thus, today *governments in importing nations earn more than the double of what governments in oil exporting nations earn per barrel produced and consumed.*



Source: ECON (1996a)

Figure 2.13: The split of the barrel

Volatility in prices bad for producers

Increases in taxes in particular seem to accelerate in periods where the price of oil is on the decline, like 1986-87. More detailed studies suggest that volatility in prices in itself is bad for the exporters due to the existence of a ratchet effect. *When the oil price increase, the blame is on OPEC. When they decline, consuming nations are soon to increase taxes to «stabilise» price to consumers.* Consumers do not react with the same hostility to increased taxes when the price at the gas station is stable or declining. From OPEC (and Norway's) point of view, history proves that what initially tastes sweet (high prices) may easily turn sour when time goes by.

Oil supplies - less of a problem?

To summarise, dependence of OPEC oil have proved to be less of a problem than foreseen in the 70s and 80s. Even if reliance on Middle East is still an issue in Washington, it attracts far less attention today. Several reasons explain why.

OPEC overly dependent on oil exports

Over the last couple of decades, what we learned was not only that the West was dependent on continuous supplies of oil from the Middle East, it also proved to be the case that the countries in this region were overly dependent on exporting oil to the West. Also, we learned that high prices set in motion very strong forces in the market place. At prices above 25 USD/b, demand for conventional crude oil tapers of. Consumers switch to other sources of energy wherever possible. On the supply side, oil from tar sands in places like Canada and heavy oils in the Orinoco belt in Venezuela becomes profitable on a large scale. Similarly, middle distillates could profitable be produced from natural gas or even from coal. Thus, *even if the Middle East producers would like to take advantage of their substantial production capacity to rise prices, there are limits to how far they could move, and they may easily hurt themselves in the medium to long term.*

High oil prices may hurt OPEC

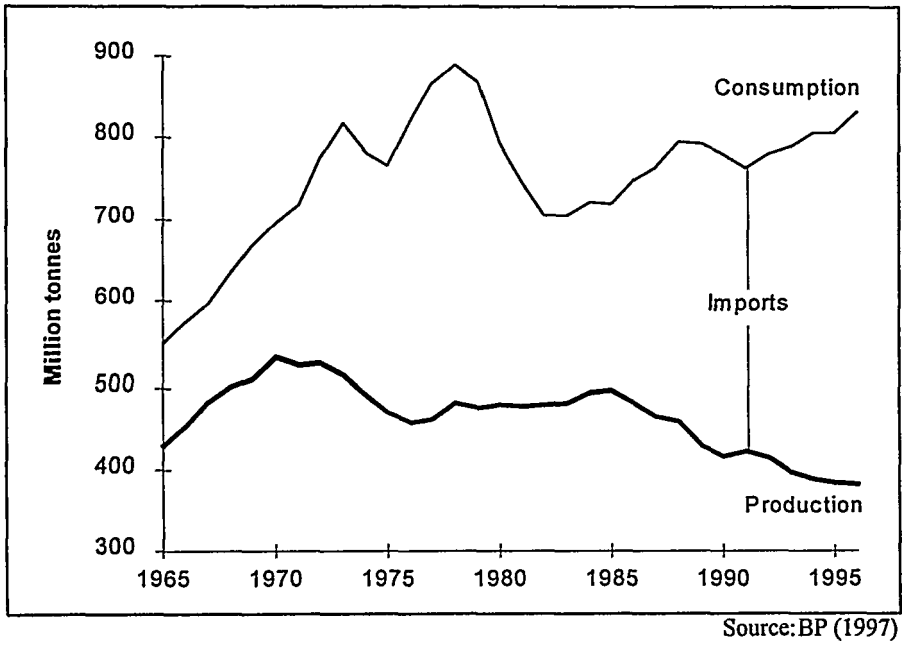
Political turmoil in Middle East likely to spill over to oil market

The arguments outlined above assume the rational responses by decision makers who maximises revenues. An entirely other matter is the fact that *the Middle East is likely to remain highly unstable. Revolutions, wars and political turmoil in the region are likely to spill over to the oil market.* If or when stability is challenged in the region, oil prices are likely to be affected in the short to medium term. Thus, security of supplies may still turn out to be important in energy policy.

A new logic to security of supplies?

Security of supplies have in the past been a concern for OECD

The geopolitics of oil may change in the future when the centre of gravity in international economics are shifting to the Asia-Pacific region. *Security of supplies has in the past been related to OECD, in particular US import dependence.* To address the nation's strategic dependence of imported oil, the US at different times developed strong ties to one or more of the big Middle East oil producers. Billions of dollars have been and still are spent on armaments and personnel to support this policy.



Source: BP (1997)

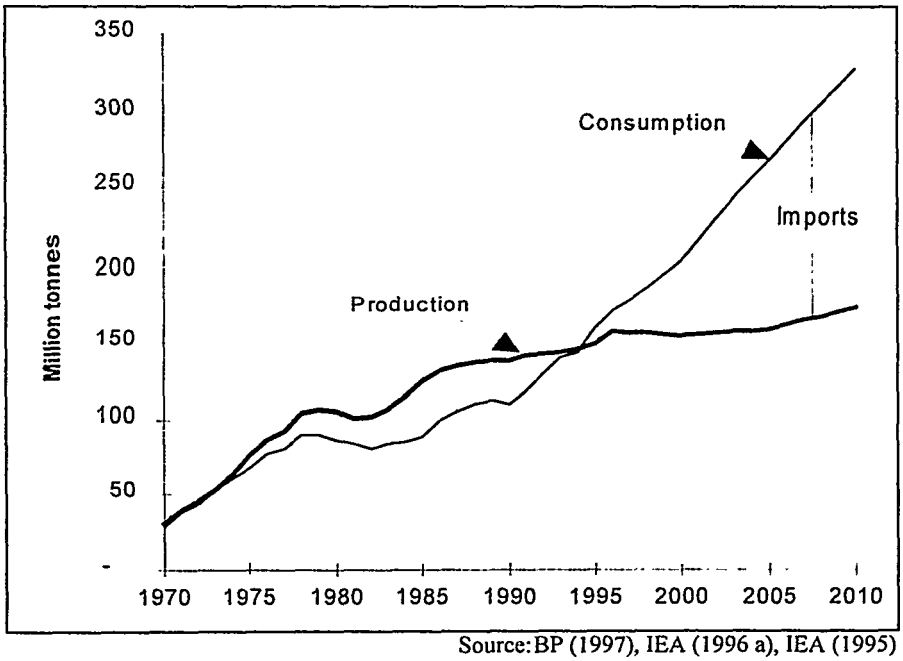
Figure 2.14: US oil import requirements

In the future, we may see similar strategies pursued for similar reasons but most likely with other means from countries in South East Asia. China, as an example, is expected to rapidly develop a hefty import dependence in the oil market. Production in China is stagnant and consumption has for the last 5 years been increasing by 8 per cent annually. If China sees its national interests at stake, one should not doubt that the country is able and willing to undertake whatever action perceived to be necessary. *Thus, the perception of security of supplies may very well resurface as an important energy policy issue, but involving new actors and geopolitical interests.*

Security of supplies may involve new actors and geopolitical interests

The means likely to be used to pursue these policies, should be sought in areas where common interests exists or mutually beneficial deals would be made between the countries involved. China does not command the military force that allows it to engage in direct military actions in the Gulf. However, it may be willing to export - or rather barter - modern armaments. In addition to armaments, nuclear technology could make such an alliance very attractive to several of the regional or would-be regional powers in the Gulf.

Figure 2.15: Production and consumption of oil in China



Source: BP (1997), IEA (1996 a), IEA (1995)

2.4 Multinational corporations as vehicles of neo-colonialism

By 1970, prospects for the eight Western Majors (Exxon, Shell, British Petroleum, Mobil, Texaco, Gulf, Chevron and Total) *looked troubled.* Indeed. Gadaffi's rise to power in Libya the year before was definitely a harbinger of things to come. *Supplying 25 percent of Western Europe's oil imports, Gadaffi started out with a strong bargaining position.* And he used it: one year after coming to power. He forced Occidental Petroleum, totally dependent on Libyan oil for its downstream markets, to accept income taxes on oil and significant production reductions. This move had an important demonstration impact. It set off a domino effect in terms of changed power relations between OPEC and Western oil Majors; which culminates in the quadrupling of oil prices at the outbreak of the Israeli-Arab War in October 1973. Even if the longer term financial burden of high oil prices was largely pushed forwards to oil importing countries, the oil Majors were never again to resume the leading role in the global political economy of oil.

Gadaffi started out with a strong bargaining position

Power of Middle East had ramifications far beyond oil industry

This display of the importance of the countries in the Middle East had ramifications far beyond the oil industry. *At the time of OPEC's stand-off with the Oil Majors, political aspirations born out of decolonisation were already being translated into demands from countries all over the developing world for economic independence.* They had won political independence, but remained humbly dependent on former colonial powers and Multi National Corporations (MNC) in terms of economic power. Blends of nationalism and socialism went well together to form a dominating strategy for new and vulnerable nation states. The OPEC 'earthquake' demonstrated a promising way to translate abstract 'dependency theory' into practice. Encouraged by and aiming to capitalise on OPEC's unprecedented achievement, poor country governments adopted various blends of approaches in open defiance against established

rules of the game: from total de-coupling from the world economy in the most extreme cases, to the more moderate but still radical (and, in hindsight often self-defeating) strategies of self reliance, import substitution and widespread nationalisation in strategic economic sectors.

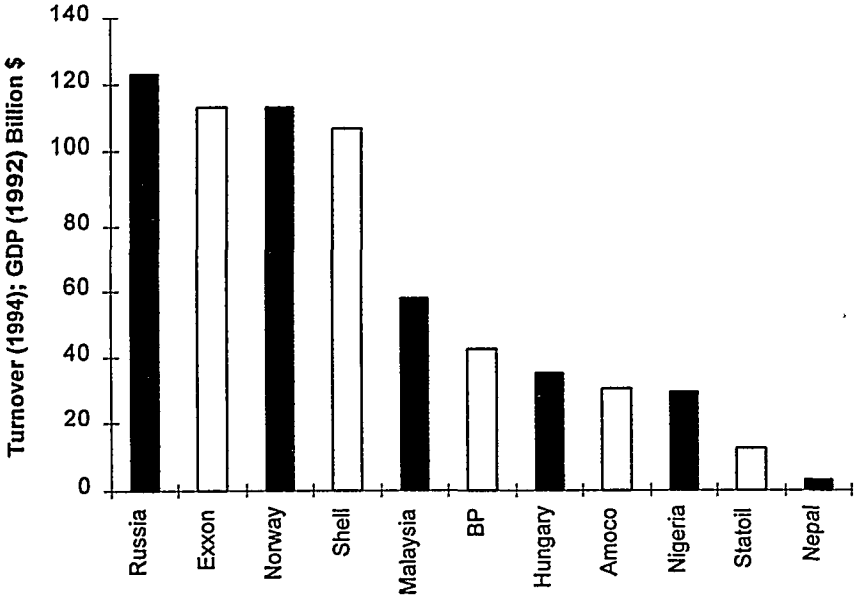


Figure 2.16: Turnover and GDP of selected MNC and nation states

Source: Estrada et. al. (1998)

The image of immoral and cynical MNC

In this upsurge of economic radicalism, *MNCs were the main culprits.* They came out as spiders in the web of dependence that threatened to strangle lofty political aspirations in quagmires of economic misery. The oil majors had, in this mould of thinking, set bad precedents, but others were following suit. Examples such as ITT's flagrant violation of Chilean political integrity in the early 1970s served to galvanise *the image of immoral and cynical multinationals.* In more general terms, to quote a representative textbook criticism of MNCs:

> 'In sum, argue critics, multinational corporations create a distorted and undesirable form of growth. *Multinational corporations often create highly developed enclaves which do not contribute to the development of the larger economy.* These enclaves use capital-intensive technology which employs few local citizens; acquire supplies from abroad, not locally; use transfer prices and technology agreements to avoid taxes; and send earnings back home. In welfare terms the benefits of the enclave accrue to the home country and to a small part of the host population allied with the corporation.' (Spero, 1981).

MNC's create enclaves but not development

MNC's are socially irresponsible

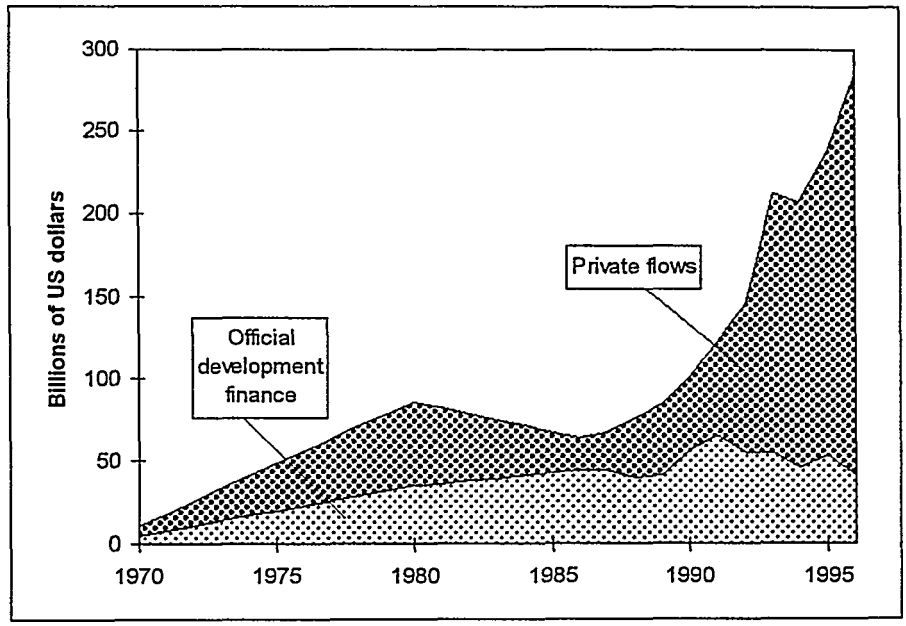
Whatever the mix of reasons; *a robust image was created throughout the 1970s and into the 1980s of multinational companies as socially irresponsible and largely detrimental to the interests of developing country economies.* The wave of nationalisations and other policies that constrained MNC scope of action mattered as much to oil companies as to any other multinational corporation. The number of oil groups affected by these third world policies were also increasing, as internationalisation

rapidly emerged as a serious business option for national companies such as Statoil.

A complete U-turn in attitudes

It is striking, therefore, to note the contrast between this negative image and the present scramble by third world governments for the attention of prospective investment by multinational companies. The change is no less than a complete U-turn, which has been made over less than a decade. While a live and real image with important and largely negative policy implications for the international oil industry only 15 years back, today it falls squarely into the category of fallacies of the past.

Figure 2.17: Financial flows to developing countries



Source: World Bank (1994, 1995, 1996, 1997)

Poor suffer because rich fail to invest'

To the extent the interface of MNCs with developing country governments is criticised today, it is not the investment or investment performance that is in focus, but the fact that many are hesitant to invest in the poorer parts of the developing world. Note, for instance, the presentation of UNCTAD's 1997 Trade and Development (Financial Times 15.9.97): *'Poor suffer because rich fail to invest'*. UNCTAD, for long the stronghold of OPEC-type challenging of multinational corporations, has changed its key mission into that of assessing how developing countries best can be integrated in and benefit from economic and financial globalisation. Even communist countries like China are today inviting majority bids from multinational companies into key strategic infrastructure investments, and use the volume of FDI (largely by MNCs) as a key economic success indicator.

A number of factors serve to explain the U-turn in third world conceptions of MNCs and foreign direct investment:

A harsh policy climate was shaped by the debt crisis

- Mexico's default on its mounting burden of foreign debt in 1982 set of a debt crisis with severe consequences for developing countries throughout the 1980s. *In the harsh policy climate that was shaped by the debt crisis, any hope of collective third world action against anybody, dissipated.* It proved impossible to copy OPEC, and cracks

were already growing wide in the OPEC wall. Also, *the majority of developing countries were, and are, net oil importers, and thus came out as major victims of OPEC's price hike strategy.*

- Throughout the 1980s, mounting debt burdens and related hardships led large parts of African and Latin American countries into a deep and sustained economic crisis. Many experienced a vicious cycle of rising debt payments and decreasing inflow of capital. Private banks had had their fingers burnt and virtually stopped lending to debt-ridden countries. In such a situation, *to continue keeping foreign investment at bay was a luxury only North Korea and Cuba could afford.* The debt crisis literally forced upon poor countries a radically changed attitude to multinational companies.

To continue keeping foreign investment at bay was a luxury

- Finally, the end of the cold war around 1990 and the ensuing victory of 'market economics' over 'socialism' or 'planned economy' approaches served to stamp out what was left of support for anti-MNC policies in developing countries. No superpower existed any longer to legitimise such attitudes. *In less than two decades, MNCs went from pariah status to that of potential saviours.*

MNCs went from pariah status to that of potential saviours

All this is not to say that MNCs will not run into difficult investment situations in developing countries. Shell's experience in Nigeria, Total's controversial entry into Iran and Unocal's troubles in Burma are but a few of recent controversies specifically involving oil companies. A major difference, though, is *that it is no longer developing country governments, but Western NGOs and sometimes Western governments (e.g. USA) that place conditions on MNC involvement in particular countries.* With continuing oil industry internationalisation, environmental, social and political demands on global petroleum investments are bound to intensify. Such demands, however, takes place squarely within the paradigm of market-oriented development and growth. The notion of multinational companies as vehicles of neo-colonialism is definitely a fallacy of the past.

Not host countries, but Western NGOs place conditions on MNC involvement

3 Megatrends in the energy industry

Few things should be taken for granted when we try to grasp and understand the future of energy. However, the degree and kind of uncertainty differs depending on the issue at hand. In this chapter, we shall *discuss topics that most people in the energy business would agree are trends and developments likely to remain with us even in the long term.*

Megatrends: development patterns likely to remain with us even in the long term

We argue that the *trend towards open markets and competition* started more than 25 years ago and will, the argument goes, most likely be extended far into the future.

Competition and marketisation

Secondly, we review past trends in terms of technology improvements that have significantly reduced costs and increased efficiency of extracting, converting and end use. There are solid reasons to believe that continuous improvements, if not in parallel between energy carriers, will go on also in the years to come and significantly will affect energy systems as well as the environment.

Technology will change energy sectors

Finally, environmental concerns have been high on the energy policy agenda for a long time. The issues at centre of attention have changed over time and priorities differs between countries. This is likely to remain so in the future. However, *environment is likely the remain one, possibly the most important force shaping the future of energy industries and markets.*

Environment likely to shape the future of energy industries

3.1 Liberalisation and competition

Introduction

Over the last decades, energy has increasingly become a commodity traded in competitive markets. This development has not moved along smoothly all the time and changes have jeen made at different pace for different energy carriers or parts of the energy industry, *yet the direction of change is indisputable. While the changes in the 70s and 80s were concentrated on the upstream segments of the industry, oil and coal production and trade in particular, the momentum started to move downstream to distribution to final consumers and grid based industries (electricity and gas).* Most analysts share the view that what we have seen so far is only the beginning.

The direction of change is indisputable

From vertical chains to markets

De-verticalisation initiated by OPEC

The movement away from vertically structured and self contained systems controlling physical flows to market based system where trade is conducted between independent actors in different segments in the vertical chain, was initiated when OPEC started to nationalise oil production. National oil companies with access to huge crude production facilities and resources, limited refinery capacity and practically no downstream outlet desperately started to look for trading partners.

Nationalised crude producers and national downstream companies were a perfect match

In a number of importing countries, state owned oil companies were established to gain national control of distribution and to squeeze margins that once went to multinational oil companies. *Nationalised crude producers and national downstream companies appeared a perfect match.* Competitive trading practices was the obvious way to balance the need of both parties.

Box 3.1: New partners in oil industry

Establishment of major upstream national oil companies

Kuwait	KNPC	1962
Venezuela	CVP	1962
Saudi-Arabia	Petromin	1962
Algeria	Sonatrach	1963
Iraq	INOC	1964
France	Elf	1967
Indonesia	Pertamina	1968
Norway	Norsk Hydro	1970
Abu Dhabi	ADNOC	1971
Libya	NOC	1971
Nigeria	NNOC	1971
Qatar	QNPC	1972
Norway	Statoil	1972
Malaysia	Petronas	1974
Canada	PetroCanada	1975
United Kingdom	BNOC	1975
Saudi Arabia	Saudi Aramco	1982
Malaysia	Petronas	1974

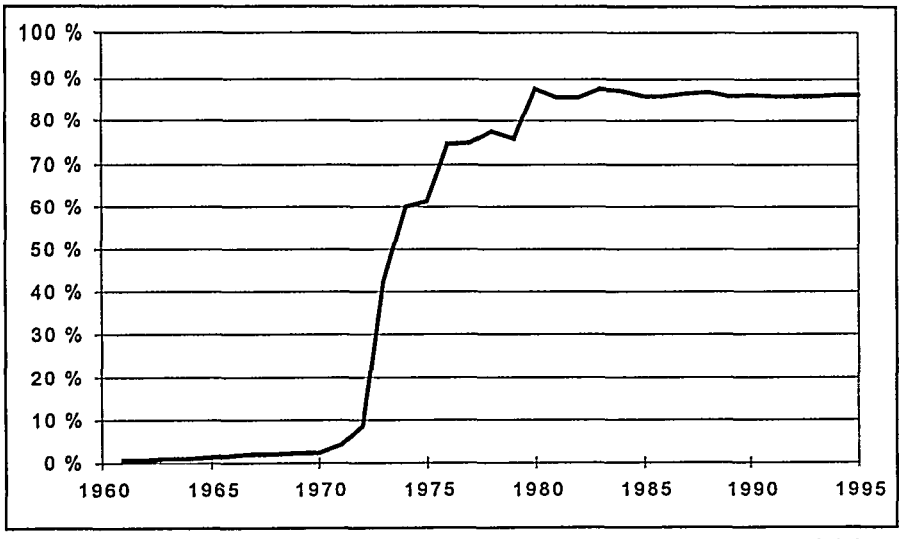
Source: Ø. Noreng

Liquid spot and futures market instruments developed rapidly

Liquid spot and futures market instruments for all major crude oils developed rapidly in the latter part of the 70s. This development was in response to the price volatility risks experienced by market actors, and to the serious imbalance that all major oil companies were experiencing in terms of access to crude production relative to downstream market outlets. In the outset, the Majors were hostile to new financial instruments and used to think in terms of vertical chains and physical control. However, most of the major oil companies were short of equity crude after being pushed out of the OPEC countries and most other oil producing regions outside the US. OPEC, Mexican, Venezuelan and other national companies were looking for

downstream outlets and national oil companies in importing countries needed crude. *Well organised markets for crude as well as for all major products gradually did away with the perception that to be well balanced, one needed to control the whole physical chain from wellhead to gas stations.*

No need to control the physical chain from wellhead to gas stations



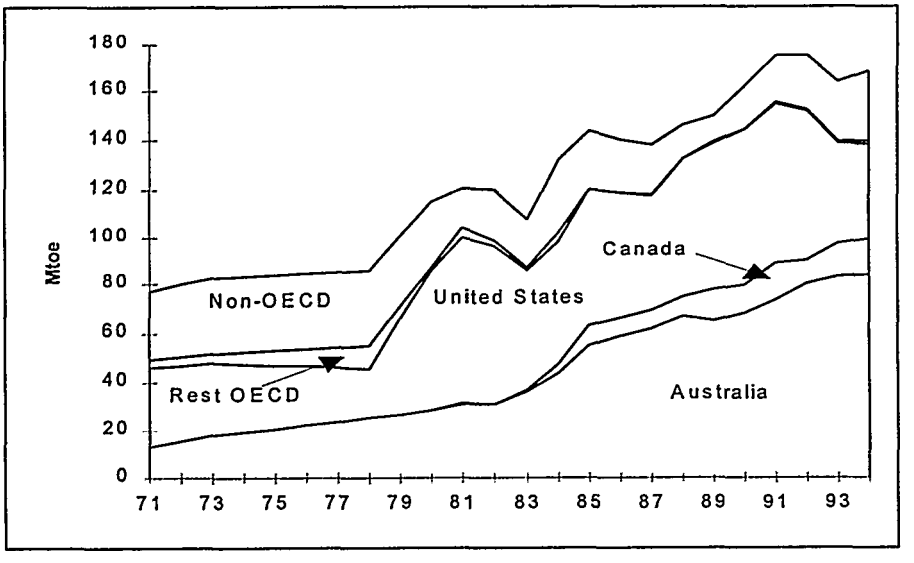
Source: OPEC (1995)

Figure 3.1: Share of OPEC crude controlled by national companies

A world market for low cost coal

The world market for coal did get a major push forwards as a response to the first oil price hike. Large stationary consumers wanted to reduce their dependence on oil and started to move to coal. In response to increasing demand in a number of industrialised countries, the supply side started to respond in a number of low cost areas of the world. Increasing demand gradually pushed prices upwards and moved international coal trade away from trade on the margin to balance supply and demand for specific qualities in different regions of the world, to long term relationships between export oriented producers and consumers reliant on the international market.

International coal market developed in response to oil price hikes



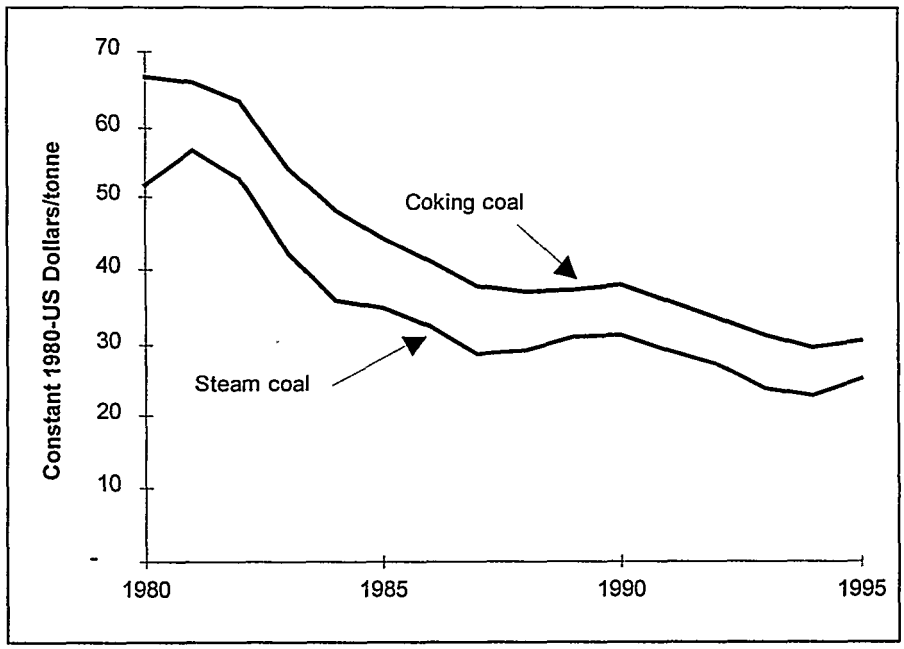
Source: IEA (1997)

Figure 3.2: Coal exports to OECD countries

New low cost capacity developed

Excess production capacity in the Appalachian region of the US East coast was used for export, *new low cost capacity was developed in countries such as Australia, Canada, Bolivia and South Africa.* Increasing volume facilitated a liquid market, increasing supply gradually lowered prices.

Figure 3.3: Price on imported coal to OECD



Source:IEA (1996 b)

Uneconomic domestic coal production in Europe came under increasing pressure

Uneconomic domestic coal production in Europe came under increasing scrutiny. Even if the European Coal and Steel Community in 1951 was put in place to create a European wide market, the effect was rather to establish the institutional framework for government subsidies and maintain national confinements of coal markets. *However, public debt problems surfacing in the 80s, growth in nuclear power, reduced attention paid to security of supplies and, last but not least, well functioning international markets all together eroded the political will to continue and even increase subsidies to production of domestic coal.* Thus, during the 1980s, the gap between production and consumption of coal in Europe widened. In parallel, the price for international traded coal observed in Rotterdam gradually turned out to determine the value of coal even if produced domestically.

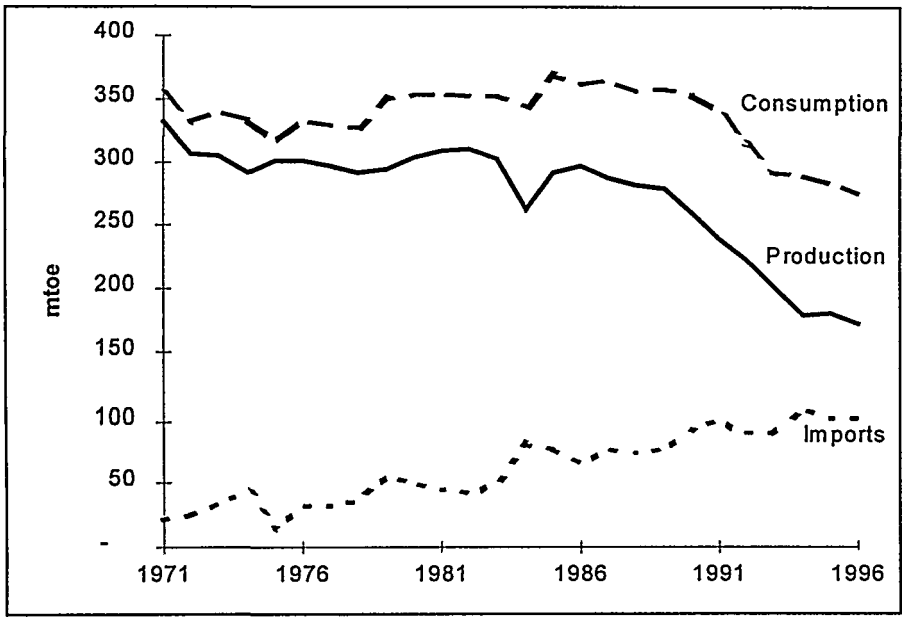


Figure 3.4: Production, consumption and imports of coal to Western Europe

Source: IEA (1997)

Thus, to summarise, the oil crisis in the 70s spilt over to the coal market by significantly increasing demand. This gave a strong impetus to development of an international coal market which became highly competitive. Prices noted on the international coal market in the next phase contributed to undermine the willingness to continue to subsidise domestic coal in Europe, and enforces the trend towards liberalisation and competition.

Natural gas - deregulation in the US

US gas market illustrates a general trend

In the natural gas area, deregulation and restructuring of the industry started in the US. Today, Europe is starting to move in the same direction. Below the US experience is used to illustrate what seem to be a general trend.

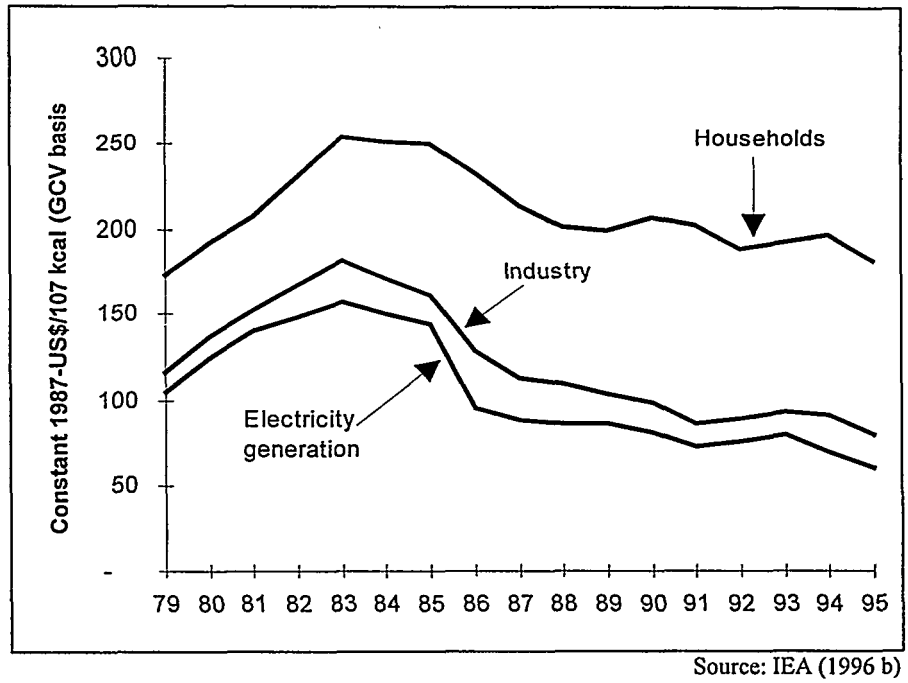
Deregulation in the US was initiated in 1978 by the adoption of the Natural Gas Policy Act (NGPA). NGPA was made necessary by the failure of an inflexible and bureaucratic regulatory system which hampered normal operations of the gas industry. In the winter of 1977, schools and factories in New England had to close because gas was not available. However, surplus production capacity existed in the Gulf and the Mid West as well as in the transportation system, but *the burden of regulation, not the market, effectively hindered available gas to reach consumers in the North East.*

The burden of regulation hindered gas to reach consumers

NGPA started a ten year process of decontrol of wellhead prices and loosening of the detailed and cumbersome bureaucratic grip that regulators had in particular on interstate pipeline companies. Gradually, the services that transmissions companies provide were debundled (transportation separated from gas merchant function) and transmission were opened for Third Party Access (TPA) and allowed for more smooth and effective use of existing pipelines. In the old regulatory system, long term secure access to gas resources was high on the policy agenda. Thus, despite complicated

wellhead price regulations, gas pipeline and distribution companies in the 70s were competing for long term take-or-pay (TOP) contracts, and accepted price clauses and indexation on the premises that the cost could be pushed forwards to consumers in closed vertical chains.

Figure 3.5: Natural Gas Prices in the US



Source: IEA (1996 b)

The US «gas bubble»

Long-term contracts with strict Take-or-Pay (TOP) conditions made companies unable to either take, or pay for the gas when the recession came in 1981 and gas demand declined sharply. The «gas bubble» was a fact. In 1984, FERC (Federal Energy Regulatory Commission) issued Order 380 which started the deregulation era and exacerbated the take-or-pay problem. After a peak of around 600 bcm, gas demand had come down to 473 bcm in 1986. In a situation of surplus capacity, pipelines desperately struggling with their TOP problems were persuaded to introduce open access to their facilities by new by new regulations.

«The final restructuring rule»

More important in this context, however, is *the «final restructuring rule»* (Order 636) issued in 1992. This order *finalised the process begun in 1986* and required pipelines to separate their merchant function from their transportation service, and had the effect of taking interstate pipelines out of the business of selling gas and making them transporters of gas without owning it. End users and distributors now buy gas directly from producers, aggregators or marketers. The impact of wellhead price decontrol together with the «final restructuring rule» has been to greatly increase the level of competition for most industry participants. *An entirely new and competitive industry still based on a blend of commercial principles and a remodelled but still (by European standard) heavy-handed government regulation emerged.*

Competitive market but still heavy-handed government regulation

Competition even in electricity

Electricity industry - the archetype of utility industry

Until only ten years ago, the electricity industry was the archetype of a utility industry. Electricity was completely monopolised and the industry structure was designed to mirror the physical chain: vertically integrated

from generation to end consumers. Financially, it was a low risk, cost plus kind of operation, investments were made according to an engineering approach and a long term planning horizon in a highly politicised environment.

Our understanding of what is natural and possible in terms of organising the power sector has completely changed since reform of the power sector in UK, Chile and New Zealand was initiated in the late 1980s. Debundling of the product consumed by end users and separate accounts between production, transmission, distribution and trading activities have been introduced in a number of countries. Regulatory systems that opens up for *Third Party Access (TPA) to the grid allows for competition between generators.* Pools for electricity trading and innovative financial instruments for hedging and price settings have opened for new trading practices. *In countries like Norway, even individual households have access to the market and shop around between suppliers.*

Our understanding of what is natural and possible has completely changed

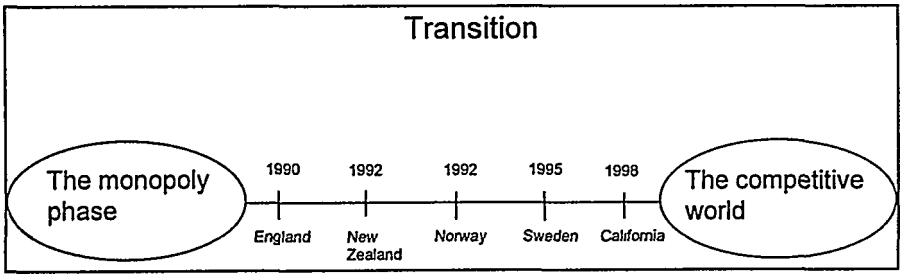


Figure 3.6: Competition in electricity

Policy driven structural change is not limited to industrialised countries, even though the forms are different in the developing world. *Restructuring electricity industries in developing countries have largely centred on mobilising private capital to facilitate expansions of the system.* Regulatory reform has opened up for Independent Power Producers (IPPs) in countries as diverse as China, Philippines, Tanzania, and Nicaragua.

Mobilising private capital in DC

Expectations for the future: transparency and competition

It is hard to see how the present well organised markets for crude oil, petroleum products and coal could be undone. Rather, we should expect volumes traded to increase and institutions handling the trade to mature. With regards to oil, *what was labelled commoditization of oil in the mid 80s, and was regarded by oil producers as a big treat, is today a fact. Oil is traded like other commodities.* The international coal market is, and will remain, a highly competitive market which simply due to its pure existence gradually will undermine domestic protection and subsidies.

Commoditization of oil today a fact

Fundamental changes have started and should be expected to deepen in grid based energy industries; electricity and gas. Some analysts maintain that even in the power sector the present monopolised and vertically integrated company structures will disappear. Debundling of services along the lines seen today in Scandinavia will fundamentally change the rules of the game. Independent actors will appear in all parts of the industry and small scale environment friendly technologies close to or even controlled by the consumer are favoured in many countries.

Competition even in grid based energy industries

In the gas industry, the direction of change is very much the same. Contrary to what we see in the power sector, in the gas market the US is ahead. However, competition in Europe is likely to follow suit, and a competitive market for LNG in Asia seems likely in the future.

A global trend towards competition and transparency

As in all other industries, there are front runners and laggards. Some countries are already advanced, others have not yet started to change. However, *the global trend that we see today towards increasing competition, new and often private actors plus regulatory systems that establish transparency and introduce incentives to lower cost, will stay with us in the decades to come.*

Globalisation

Globalisation of all economic relationships

What we see in the energy industries falls well in line with what we see in the economy in general - a trend towards globalisation of economic relationships. Economies in different parts of the world are increasingly becoming inter-linked and interdependent. Globalisation of economic relations in general as well as in energy takes the same forms; trade has been growing at twice the rate of the global economy over the last 10 years, the volume of foreign direct investment grew four times faster than trade, financial markets even faster. Other common features are the rapid integration of economies in transition into world energy and other markets at the same time as they familiarise themselves with existing international economical and political institutions. *In energy as in the economy, the centre of gravity is gradually being shifted from industrialised countries to East Asia.*

The centre of gravity shifting to Asia

Also markets for electricity may merge across countries

The oil industry has for decades been a part of the global economy, cf. the label multinational oil company. Above we described how the international coal market developed. Over the last decade, even companies involved in electricity generation are developing into global corporations with activities in a large number of countries. *Tomorrow, also markets for electricity may merge across countries, which is what is happening in Scandinavia for the first time ever.*

Energy to be traded and to compete like manufacturing products

To summarise, globalisation is likely to go on in energy markets. 25 years ahead, a much larger share of total energy consumed is likely to be traded internationally or exposed to international competition. Energy companies, including power and gas companies, are likely to become multinational undertakings. Energy and energy companies will increasingly be regarded as a «normal» industry with no particular reason to be protected, subsidised or controlled by governments; i.e. *where energy is heading in the next decades compares to what happened to manufacturing industries in the 60s and 70s.* For this to be the case, institutions and common rules and regulations are needed to see that competition across borders are possible on a level playing field, i.e. to be regulated by institutions like the World Trade Organisation (WTO), the European Energy Charter and alike.

The demand for change moving to down-stream segments

Among the energy industries, the demand for change is moving to the downstream segments. While world oil, gas and coal industries have experienced dramatic changes in the past, the challenges and the need for change in the future will be in the utility sectors and in the relation

between companies and consumers. *The market changes that to such an extent has altered the upstream energy sector will soon make their way through the utility sector as well.*

3.2 Technology and costs

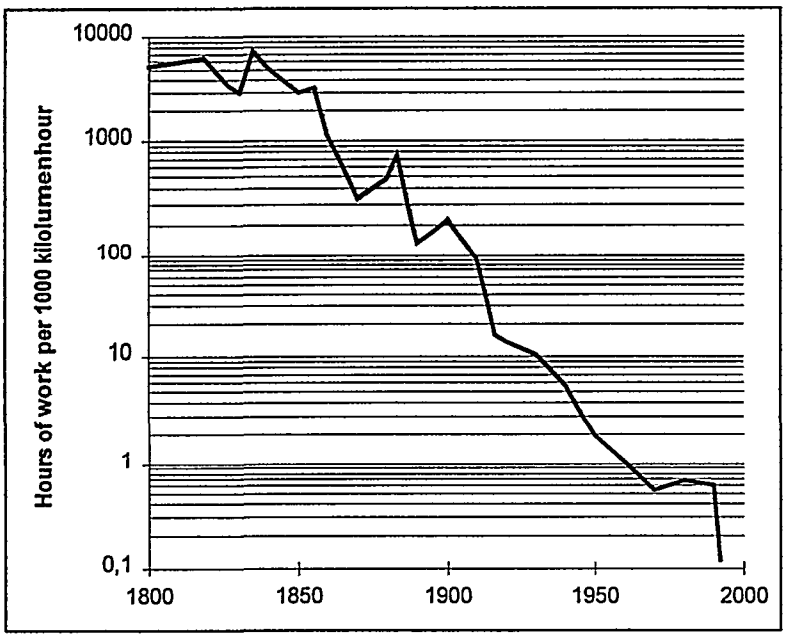
3.2.1 Forces shaping energy developments

Technology crucial in shaping energy futures

For decades, technological progress has contributed to major productivity gains in energy supplies and improved efficiency in energy use. *Any study on future energy developments needs to bear in mind the crucial role of technology.* Technological trends are important not only for technical efficiency in supply and consumption, but also for industrial structures and for the design of regulatory regimes and policy.

The impact of technology on energy markets has profoundly affected costs and quality of supplying energy services. One kilowatt-hour of electricity can today be delivered to individual households at a much lower price, with greater regularity, with less variance in frequency and - importantly - often with less harm to the environment than only two or three decades ago. Technological progress has enhanced the use of electricity in end uses previously served by direct use of coal, wood or petroleum due to its superior qualities in terms of comfort and reliability.

Figure 3.7:
The true price of light



Source: Nordhaus (1994)

Technologies have brought to the market new forms of energy

New technologies have brought to the market *new forms of energy* such as nuclear power and solar energy. To judge by current R&D efforts, *future energy options may include hydrogen, fuel cells, improved nuclear power designs and, not least, improvements in conventional technologies that can drastically alter their operational characteristics.*

3.2.2 Technology and structure of industries

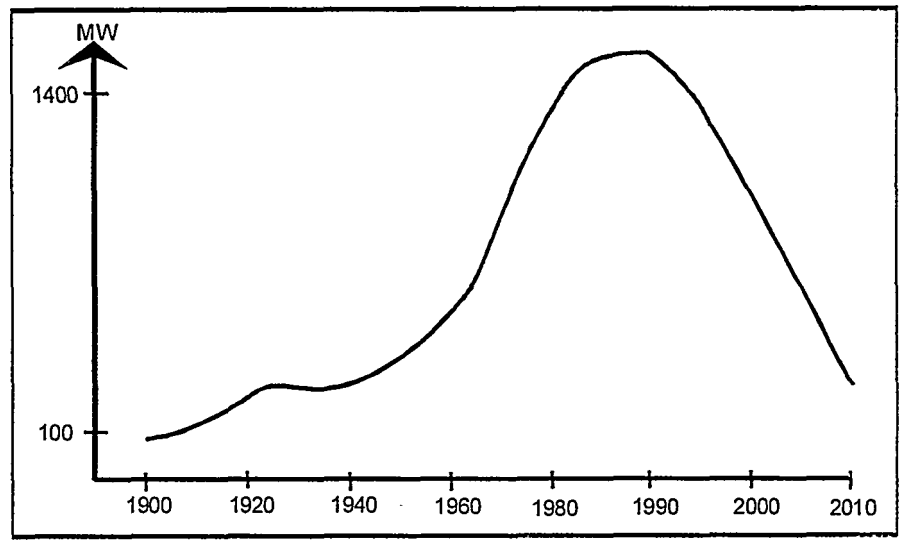
The long term trend towards increasing scale.....

As technology progressed in the post-war period, there was an increase in the optimal size of units in energy production, particularly in electricity generation. The organisational and structural counterpart to *economies of scale* was the growth of large integrated companies which were granted de facto or de jure monopoly in markets for electricity and gas. This in turn was paired with tight public control. The capital intensity of production and monopolistic structures in the vertical chains acted to deter new entrants.

..... is challenged and may have turned around

Recent technological developments have begun to challenge this pattern. Gas fired technologies in power production (for example, the Combined-Cycle Gas Turbines, CCGT) capture economies of scale in comparatively small units. Both capital costs and environmental attractiveness (including reduced siting difficulties) make them competitive with, for example, larger coal fired plants. Co-generation of heat and power in modular small scale energy systems in the hands of consumers may in the near future gain in economic attractiveness. Solar and wind power owned and operated by consumers or small scale independent producers can also come to challenge the power of electric utilities.

Figure 3.8: Optimal scale in power generation



Source: ECON (1996b)

IT technology has made unbundling of services possible

Modern Information Technology (IT) reduces *economies of scope* (i.e. cost advantage of producing a bundle versus a single service) in grid-operated energy systems. Before, economies of scope was important in utilities selling a bundle of services - electricity, transmission, distribution, measuring and billing. Before, this could be done more cheaply by one company, compared to the same services being offered by separate entities. This is no longer the case: *computer technology has made unbundling of services possible by allowing co-ordination between independent commercial actors in closely interconnected systems.* Co-ordination between competitors requires that large volumes of information can be shifted around at low cost. In practical terms, even individual households can now shop around the market for the cheapest electricity supplies which was inconceivable only a few years ago.

A trend towards smaller units in energy supply will undermine the dominant position of large and often vertically integrated energy enterprises. Increases in co-generation with surplus energy available to the grid will in many countries call for regulatory changes that will affect the interface between grid owners and independent producers. *If the trend towards "clean and cheap" small-scale technologies continues at today's rapid pace, this would represent a major force for radical changes to the structure of the energy sector.*

Towards «clean and cheap» small-scale technologies

Further development and improvement of existing technologies is also likely to change their relative attractiveness in terms of both costs and environmental impacts. *Clean-coal technology is within reach,* and widespread use is likely over the next decade without adding to the cost of electricity generation. The costs of solar power and other renewables are coming down rapidly, which could make such technologies commercially attractive in many end uses at a large scale early in the next century. *The most far-reaching perspective on the horizon today is the possibility that the menu of technologies available in the future could undermine the firmly-held tenet in energy industries that big is beautiful - and cheap.*

Clean-coal technology within reach, costs of renewables coming down

No longer big, beautiful and cheap?

3.2.3 The scope for improvement - the gas sector

Competitive pressure

Technological improvements may radically alter the competitive position of the different energy carriers, reduce environmental damages from energy use and reduce the cost of supplying energy and in particular energy services. *The natural gas industry is used in this section to illustrate the general trend in energy industries.* Gas is chosen because this industry provides a lot of good examples in this respect.

Gas industry used to illustrate general trend in energy industries

In industries with competitive markets, there is an incentive to reduce costs in order to maximise profits. Declining prices gives an extra impetus to reduce costs. When the European gas industry was developed in the 1950s and 60s, it was based on domestic resources that were relatively cheap to produce. Imports of gas from more remote sources received a boost from the oil price hikes in the 1970s and the first half of the 1980s, but new projects all of a sudden were severely threatened by the oil price crunch in 1986. The Troll project is a good example of this: the first gas sales agreements were negotiated before 1986. At this point in time, the sellers expected a healthy return on the investment. All of a sudden the project looked more dubious.

Competition and low prices strong incentives for cost reductions

Figure 3.9: Costs for natural gas imports to EU

Source: IEA (1996b)

Reductions in gas price mandated lower cost in the whole gas chain

Thanks to long lead times, however, modifications of project design to shave costs were still possible. *Reductions in the gas price in fact spawned a new drive to reduce cost in the whole gas chain all over the world.* This event combined with the prospect of having to take gas from more hostile and remote locations, which normally imply higher costs, has forced the gas industry to focus on costs reduction to a much higher degree than before. So when the gas companies in Norway are still keen to develop new gas fields despite a gas price (in constant dollars) only half of what it used to be only ten years ago, it is due to the fact that better management and improved technology has reduced costs to a level which can justify such developments.

Cost reduction in the gas chain

Figure 3.10 gives a stylised picture of the gas chain from the exploration phase to the burner tip, and indicates areas where substantial cost reductions have been obtained thanks to technological innovations and technological improvements.

The exploration phase

Increased R/P ratio due to technology and management

Judged by development of reserve/production (R/P) ratios for gas, exploration over the last decades has been a success. The global R/P ratio has increased from 35 in 1960 to 45 years in 1980, and further to 70 currently. *Increased exploration for gas is one explanation for this, more important however is application of improved technology and management practises.* An example of improved technology, is that exploration now is done more efficiently and cheaply thanks to 3-Dimensional seismic. 3-D seismic in itself is more expensive than traditional 2-D seismic but has a higher success ratio. Experience from the Gulf of Mexico suggests an increase in the success ratio from 42 to 70 per cent when 3-D seismic is employed. Similar success stories are told elsewhere in the world. The applicability of 3-D seismic is not confined to exploration, it also contributes to addition of new reserves and increased production in existing fields.

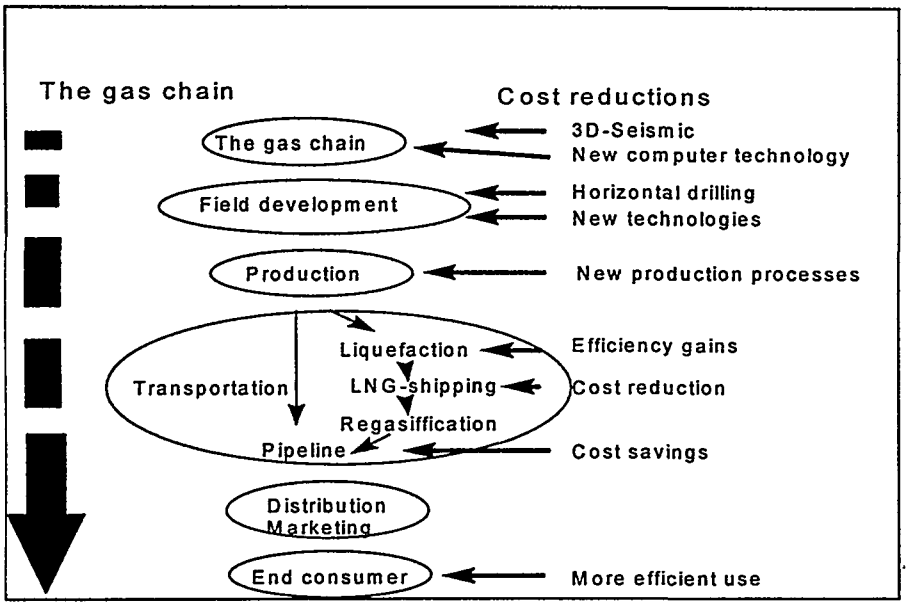


Figure 3.10: Cost reduction in the gas chain

Source: Commichau (1996)

The race between depletion and the finding costs

A study of crude oil finding cost (Fragan, 1997) *illustrate the importance of technology to understand the race between depletion and the cost of finding more oil.* The US is the most well explored and mature geological region of the world. Even in this region, reduction in finding costs outpace the increase in efforts that are required to find oil due to depletion. Depletion costs relates to the fact that extraction is moving into marginal resources, smaller fields in more remote areas etc. In the period 1977 to 1994, average onshore finding costs decreased by 15 per cent while resource depletion increased costs by 7 per cent. Similar figures applies to gas exploration.

The development phase

This part of upstream business engages the highest cost and involves long lead times. Cost reductions and shortening of the development cycle are therefore of major economic importance. Extensive efforts have been undertaken in this area. A good example is a number of offshore gas fields in the UK North Sea, where *development costs for gas fields of comparable size, location and production rates were reduced by more than 50 per cent over a period of four years.* Similar figures have been realised in the Norwegian part of the North Sea as well.

50% lower drilling cost within ten years

Such cost reductions are achieved through various measures, some of them representing introduction of technical breakthroughs. One interesting example is directional drilling technology and its further refinements into horizontal drilling and horizontal drilling with multiple fracing. This technology extends significantly the area that can be drilled from one single platform and may even reduce the number of platforms required. Development of satellite fields close to existing installation can also be facilitated by this technology. The National Petroleum Council of the US estimates that *ongoing drilling technology developments will allow future*

savings of about 4 per cent per year compared to the cost of using present-day methods. This would cut drilling cost in half within ten years.

The production phase

Unit costs in production down by 40 %

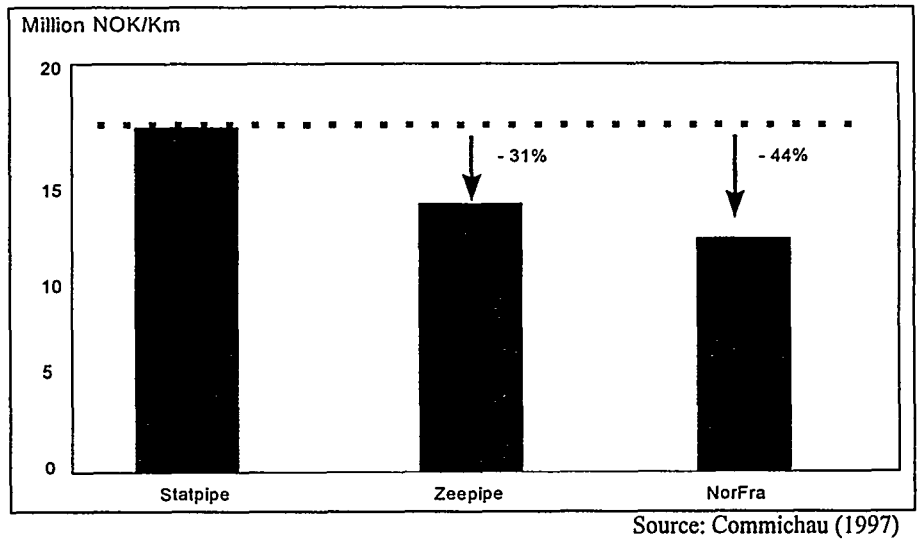
The experience on the Norwegian shelf offers a good example of what it has been possible to achieve in terms of cost reductions in this phase: between 1993 and 1996, cost were reduced by some 40 per cent for oil as well as gas. (see section 2.2 above)

Transportation of gas

Pipeline installation cost down by 44 %

The pipeline transportation part of the gas chain has not been characterised by major technological breakthroughs over the last few decades. Still gradual cost reductions have been made possible. One example is the pipeline installation cost in the Norwegian part of the North Sea. *Cost of installing the NorFra pipeline to France* (to be commissioned in 1998*) per kilometre is some 44 per cent lower than the corresponding cost for Statpipe*, which was commissioned in 1985.

Figure 3.11: Pipeline installation costs in North Sea



Source: Commichau (1997)

LNG shipping costs down by 40 %, liquefaction costs by 60 %

Substantial progress has also been made in terms of reducing cost involved in transporting gas as LNG. Over the last 25 years, a steady decrease in gas liquefaction costs has taken place due to improved technology and improved scale economics. *Compared to 1969, liquefaction costs in 1995 were reduced by about 60 per cent.* Cost reductions are also taking place in the transportation part of the LNG chain. It has been estimated that during the *decade from 1990 to 2000, LNG shipping costs will decrease by about 40 per cent,* mainly through larger vessels, new tank design and more efficient use of space.

Distribution, marketing and end use

As is the case of gas transportation in general, gas distribution to end consumers does not feature any spectacular breakthroughs in the basic technology over the last twenty five years. However, improved technologies for pipe laying, line inspection, welding, etc., have been introduced and contributed to lower costs. Marketing and meter reading

have been vastly improved by more advanced computer technology. Progress in efficiency in end use is, however, perhaps even more spectacular. In less than 25 years, private consumers using natural gas boilers have seen the efficiency in new boilers increasing substantially. *Today consumers are now able to squeeze more than 50 per cent more useful energy out of the same volume of natural gas.*

More useful energy per m^3 of natural gas

The improvements that have taken place in combined cycle technology over the last two decades have led to drastically changed prospects for gas in power generation. From an efficiency of less than 40 per cent in traditional gas fired thermal power plants, Combined Cycle Gas Turbine (CCGT) fired plants now obtain an efficiency close to 60 per cent. Conversion efficiency may improve further to more than 90 per cent in combined heat and power facilities. *This technological development has made CCGT facilities the preferred solution for new power generation capacity in many countries.*

CCGT - the preferred technology for power generation

The need for change moving downstream

Looking at the cost components of the price to end user, one will in most markets find that value added in transportation and distribution constitutes a higher share than the revenue to the producer. For this reason one may say that the absolute potential for cost reductions and therefore the need for technological improvements, is more urgent in transportation and distribution than in production. *The fact that upstream operators in most countries up to now have been more exposed to competition than operators further downstream indicate that also the relative potential for cost reductions is bigger in transportation and distribution than in production.*

More competition upstream than downstream

Two important factors driving the need for technological innovations and cost reductions, are the geographical mismatch between gas reserves and consumption, and the regulatory reform process in the gas sector of most countries:

- *Logistical challenges*

  As gas consumption increases, the need to transport gas from more remote areas to the main consumption centres increase even more. *Europe's dependence on imports from extra-European sources will increase considerably over the next twenty five years.* Further expansion of gas use in Asia is to a large extent dependent on further LNG developments in the Middle East. As transportation of natural gas still is very expensive in comparison with oil, there will be a tremendous pressure to reduce those costs in the future.

  Long haul gas transportation increase rapidly

  Both pipeline and LNG costs will certainly come down gradually, but the industry is also looking for technological breakthroughs that could bring cost down more radically. One interesting concept in this context, transportation of gas in hydrate form by specially built vessels, has been proposed by a group of researchers at the Norwegian University of Science and Technology. The transportation cost under this concept is

claimed to be some 25 per cent lower than for traditional LNG and its optimum size is smaller than for LNG.

- *Unbundling and competition*

Corporatisation, demonopolisation, unbundling of services and privatisation

The global trend towards competition and privatisation extends to all energy sectors, and will no doubt also influence the gas sector profoundly over the next twenty five years. The major policy objective behind this process is a more efficient energy sector and lower prices to end consumers. *Corporatisation, demonopolisation, unbundling of services and privatisation are key words in this context. Added to this should be a development towards tougher and more efficient regulatory regimes.* For energy companies, this often combines with tightened environmental standards and requirements to increased customer orientation.

This in its turn will give an impetus to improve the hardware part of the industry in general, and distribution in particular will require widespread application of advanced information technology. The restructuring measures undertaken in the US and the UK illustrate this. In the US, introduction of third party access and release of spare capacity in interstate pipelines led to the creation of markets for such capacity. Their functioning turned out to be dependent on the introduction of electronic bulletin boards with online monitoring of spare capacity. The creation of such markets would not have been possible without technology that did not exist just a few years ago. It is also interesting to note that one of the major obstacles to the recent introduction of competition in the residential sector in the UK, was availability of software to facilitate enforcement of the network code.

New technology - more tailor made energy services

Development in information technology will enable companies to tailor make energy services to customers need and respond to demand for more sophisticated services. Future progress in metering technology will determine what kind of service energy companies may offer. On-line metering will for example allow for sophisticated tariff systems.

More and cheaper storage - a major challenge

As gas markets mature, the need for storage increases. Total world gas working storage amount to some 11 per cent of total consumption, in mature gas markets this figure is around 20 per cent. *Unbundling and introduction of competition will probably increase the need for storage* even further. Storage, however, is expensive to build and many countries do not possess good natural conditions for underground gas storage. The natural gas industry is therefore faced with major challenges in this area both in terms of new technology and lower costs.

New applications for gas

It would take us too far to discuss all the areas where new technology will make new uses of gas possible or where widespread use is feasible over the next 25 years. Already today, however, some areas can be identified where the technology exists but where there are still obstacles to large scale commercial breakthrough of those technologies. Some of them are *the use of natural gas :*

- *as a vehicle fuel,*
- *in fuel cells for decentralised production of heat and power,*
- *for production of synthetic fuels, and*
- *to produce food (proteins) for animals as well as mankind.*

In future - gas may find new large volume uses

Intensive research in order to improve technology is undertaken in all of these areas and will certainly materialise in some way or an other in the decades to come. Similar developments may be observed for other sources of energy.

Intensified competition between energy technologies

The race to reduce cost, improve convenience and environmental performance

The general conclusions to be drawn is that energy, and energy services in particular, most likely will be offered consumers at lower prices, that new applications will surface and that the competitive position of fuels and technology are changing continuously. *Competition between different sources of energy in a 25 years perspective is very much a moving target, where the winners are those who leads in reducing costs and improving convenience, reliability and environmental standards.* To illustrate the point, many people pay much attention to the fact that some of the renewable technologies have improved substantially in terms of costs over the last decade. However, so have traditional technologies and they are likely to go on doing so. Who will take the lead in this race over the next couple of decades remains to be seen. *Today and most likely in the near future, gas is an aggressive competitor increasing market shares for environmental and economic reasons in large parts of the world.*

Increasing market shares for gas

3.3 The environment

The first generation of environmental concerns

The environment first developed into an oil industry business variable in the 1950s, when people died from smog caused by vehicles and industrial plants in large cities. Smog was identified as the cause of health problems, mainly pulmonary diseases. This acknowledgement prompted the adoption of emission controls to reduce air pollution. Los Angeles pioneered this legislative process, which culminated with the US federal government promulgation of the Clean Air Act in 1963 and the Motor Vehicle Air Pollution Control Act in 1965. Within this early period of environmental awareness, however, concern was not directed towards the oil industry as such but to oil consumption through combustion processes (in transport and industry). Growing pressures led to the 1970 Amendments to the Clean Air Act, which introduced ambitious measures to abate CO, NO_x and VOC emissions. In 1970 the Environmental Protection Agency also made catalytic converters mandatory for all new cars built after 1975, and lead in petrol became a regulatory concern from 1973 and onwards.

In the 50s - people died from smog caused by combustion processes

Broadening of perspectives in second generation

Environmental ministries set up in OECD countries

Estrada et al (1998) label the period leading up to the early seventies *the first generation of environmental concern.* The 1972 UN environmental conference in Stockholm in many ways represents the launching of *a second generation or wave of such concern.* It was duly acknowledged that regulations introduced to date had no chance of tackling pollution stemming from the solid economic growth throughout the Western world. Environmental ministries were set up in most OECD countries, with environmental regulations widened and intensified. *Oil was singled out as one of the major culprits,* as it was suggested that petrol and diesel were responsible for about half of all pollutant-related human exposure to airborne carcinogens.

Oil singled out as major culprit

Priorities differed between the US and Europe. While environmental regulation affecting the oil industry in the US was driven by local air quality concerns, acid rain was the main European impetus for enhanced environmental regulation. Already in the early 1970s, the Nordic countries started to pass legislation to curb SO_2 emissions. Increasing evidence of harm to large European forest areas made countries like Germany follow suit, and in 1988 the European Community adopted its first set of directives specifically aimed at regulating the sulphur content of oil products and NO_X emission levels from large combustion plants.

Increasing conflicts between environmental groups and energy sector

Overall, environmental concern in Europe and the USA were on a downward trend in the late 1970s. Due to factors such as acid rain and nuclear accidents (1979, 1986), however, it was soon to resume again. It became clear, within the framework of what we called the second wave of environmental concern, that public anxieties about oil-related (and other) pollution was not an isolated event. *From being mainly an individual health concern during the first 'environmental wave', it was now developing into a broader mobilisation of social groups seeking to address prime causes and effects of environmental degradation.* This meant increasing levels of conflicts between environmental groups and institutions and interests linked to production and use of energy.

All the same, few oil companies at the time perceived the effects of environmental policies as an important emerging trend.

Global commons on the agenda

The Brundtland commission - a major catalyst

A variety of developments combined to change this and catapult environmental concerns to the top of government and corporate agendas alike. The report of the Brundtland commission in 1987 and the Toronto climate conference in 1988 came to represent major catalysts for increasing concern about transboundary and global environmental problems, and intensify tensions between these concerns and modern consumption patterns and lifestyles. 'Sustainable development' became the catchword of the day, a concept which epitomises the content of what we might call *the third wave of environmental concern.*

«Sustainable development»

From the late 1980s, the environmental agenda has grown ever wider (the greenhouse effect), become genuinely global, opened up for NGOs (Non-

Governmental Organisations) and the media as import political actors. Also, we have seen the level of political attention and conflict grow significantly. Not least thanks to the increasing influence of environmental NGOs on government policies, *the environment has developed over the last decade into a serious business variable that no one can afford to ignore, and definitely not the oil industry.*

Environment - a serious business variable that no one can afford to ignore

The following aspects make the issues raised by the third environmental wave particularly challenging for the oil and gas industry:

- *The growing power of NGOs and modern mass media*

  Extensive media coverage of local and global environmental issues are reinforcing the political potency of environmental NGOs. Political pressures have spilled over to governments who in turn support the scientific research needed in order to understand and propose solutions to complex environmental threats. Moreover, the media now tend to treat local environmental problems, such as oil spills, as issues that concern the international audience. NGOs capitalise on such images; translating global threats into salient local political challenges, and bringing local violations of environmental codes of conduct firmly into the international spotlight.

Media and green NGOs - a potent alliance

  Shell's heated controversies with NGOs over what to do with the Brent Spar platform and its presence and political responsibilities in Nigeria are just two examples of the changes in global influence patterns brought about by the third environmental wave. *The Nigeria example also demonstrates the extent to which environmental concerns on the one hand, and social and political concerns on the other, are mutually reinforcing* - bringing a growing number of complex cases to the attention of corporate boards.

Mutually reinforcing: environment, social and political concerns

- *The global nature of present environmental threats and treaties*

  Globalisation means promising opportunities as well as demanding challenges to the oil and gas industry. And globalisation of environmental concerns is no longer a prospect, but a fact. Suffice it to mention Statoil, formerly a squarely 'national' company created to extract North Sea petroleum resources, whose list of international engagements now counts 25 countries. This global coverage, however, serves to expose companies to an ever toughening political agenda as just described above.

Globalisation of environment concerns - challenging to industry

  At the same time, the globalisation of environmental concerns means that domestic regulations are no longer the only rules to play by for oil and gas companies. With regard to global warming, for instance, this means that investments in any part of the world may have to take into account future provisions under the Climate Convention. This may fundamentally impact on corporate strategies. However, global warming may also bring new opportunities for forward-looking energy companies, with increased marked shares for lower carbon fuels and technologies and involvement in joint implementation and emissions trading as examples to this effect.

- *The overall sustainability of fossil fuel-based energy futures*

'No more oil exploration'

The adoption by Greenpeace of the '*no more oil exploration*' slogan in 1997 is but one expression of *the present fundamental questioning of fossil fuel-based energy futures*. Radical fractions of the environmental NGO community mobilise in order to question and block any further search for and exploration of petroleum resources. Even if not representative of the overall environmental movement, *the perceived need to plan today for a rapid transfer from fossil fuels to renewable alternatives, is gaining hold in broad segments of international political opinion*. We will explores these issues in more detail in the next Chapter.

A fundamental questioning of fossil fuel

4 The future of energy

4.1 Today's consensus in number crunching

Economic growth and energy demand - historical facts

Energy is vital for economic development and social progress. Without an increase in the supply of energy services - lighting, heating, motive power etc.- economic growth and improvement in the quality of life for a growing world population will come to a halt. Growth in the demand for energy services does not necessarily mean that the consumption of energy needs to grow at the same rate. Improvement in energy efficiency implies that energy services can be provided with less energy.

Energy . vital for development

In addition growth in consumption of energy is sensitive to structural changes in the economy, for example a shift from industrial goods to production of services tends to lower growth in energy demand.

Energy intensities - energy consumption per unit of GDP - is a measure which combines these two effects; i.e. both improvements in energy efficiency and structural change towards less energy intensive sectors.

Historical evidence has shown that countries follow a «normal path» in energy use: rising energy intensity at the an early stage of development followed by a decline. The rise and fall in energy intensity have the following causes :

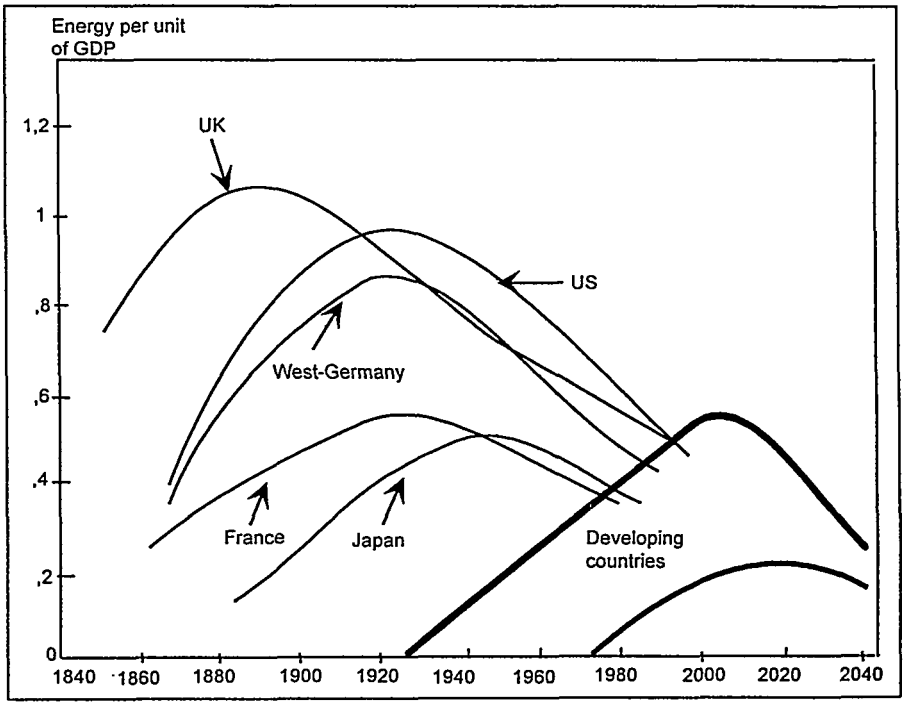
- **Rising.** Commercial energy products replace non-commercial fuels in the household sector. Industrialisation and large investments in infrastructure give strong growth in high energy consuming industries.
- **Falling.** Production patterns change towards less energy intensive activities. Access to modern technologies improve energy efficiency. Saturation is observed for some energy services.

Rise and fall of energy intensity

Another typical feature is that energy intensity peaks at a substantially lower level than it did some decades ago. This is because more energy efficient technology is available now, and that the quality of materials have improved, so that for example one unit of infrastructure can be provided with less use of steel, cement etc.

The stylised development of energy intensity does not apply uniformly to all countries, but in a longer historical perspective, this path helps explain the underlying determinants of energy use, and in particular why energy consumption increase over the last century and most likely will continue to increase in the future.

Figure 4.1: Evolution of Energy Intensity



Source: ECON

Transportation and electricity closely linked to GDP

De- coupling of stationary use

Some parts of energy consumption growth tend to be more stable than others. Energy used in transportation and for electricity generation follows very closely the growth in world economic output. By contrast, fossil fuels used for stationary purposes show an average growth below that of GDP. *Over the last 25 years, a de-coupling of stationary energy consumption growth and economic growth has taken place in the OECD.* But also in many developing countries the growth in stationary energy consumption (excluding electricity) has been below economic growth. In China, for example, the growth in energy demand has been less that half of the economic growth since 1980. The development in China is to a large extent a result of economic reforms and modernisation from an extremely backwards and wasteful economic structure. In Central and Eastern Europe and FSU on the other hand energy intensity has not fallen much despite a decisive departure from the system of central planning. Energy consumption has declined but generally less that the fall in economic output.

Decades of growth

Global energy consumption increased from 3,7 to 8,1 million tonnes of oil equivalent (mtoe) over the three decades since 1965, equivalent to 2,6 per cent annually. Over the period, oil use grew approximately in line with the total, and contributed 40 per cent of total despite the substantial impacts that oil price had on consumption. Gas, on the other hand, increased its share from 17 to 24 per cent, while coal decreased from 40 to 27 per cent.

Nuclear and hydro power made up the rest of global commercial energy consumption.

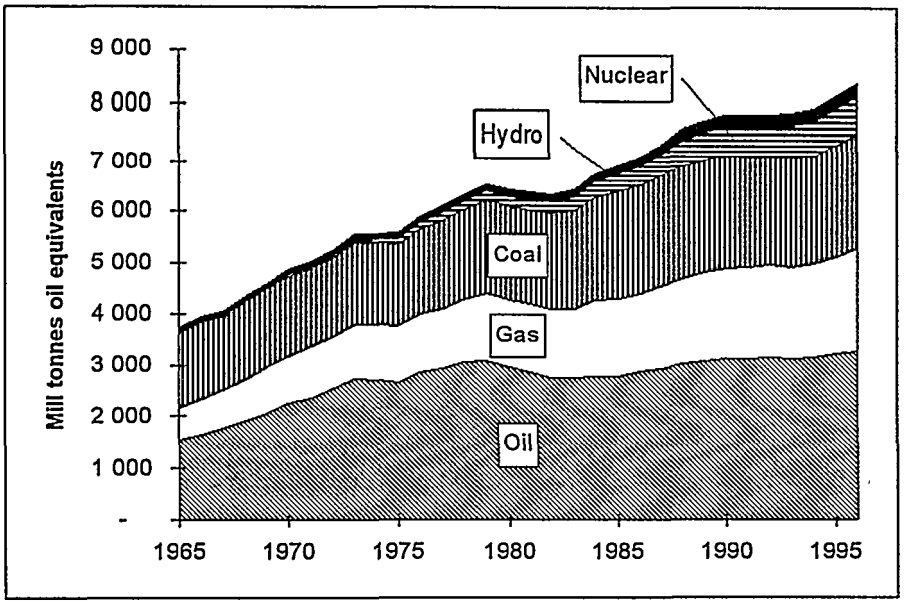


Figure 4.2: Global energy consumption by fuel

Source: BP (1997)

On a regional level, patterns differ somewhat. Growth in consumption declined for a few years subsequent to the oil price hikes, but began increasing again from the early 80s. In FSU/CEE, the downfall of the communist systems in the late 80s initiated a period of decline. However, in ROW, growth have been fairly stable, but at a somewhat increased pace in the 90s.

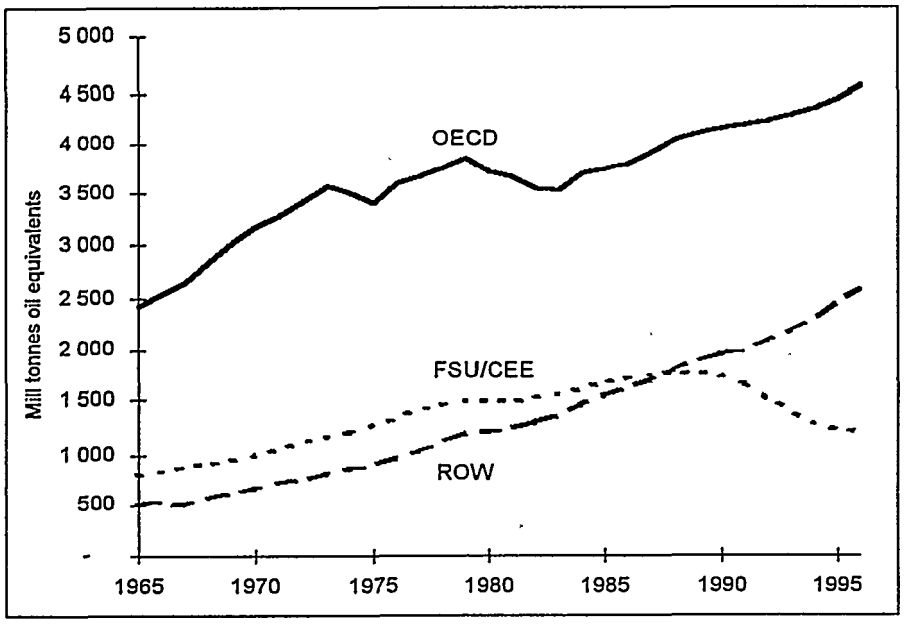


Figure 4.3: Global energy consumption by region

Source: BP (1997)

What do number crunchers expect for the coming decades?

Historically, much efforts have been devoted to predict the future of energy, in particular for oil. Despite an impressive amount of intellectual efforts and sophisticated computer methodologies, the reputation of energy forecasting has been in decline. Clearly humbleness is warranted with respect to the ability of foreseeing and estimating in quantitative terms where energy markets are heading decades into the future.

Resilience in underlying structures

However, as was explained above, *the long term trends in energy consumption display some remarkable resilience in the underlying structures that determine energy growth.* The havoc that oil price hikes created in the 70s and 80s, and the collapse of communist regimes of the early 90s, were admittedly more than blips in the curves, but they did hardly caused fundamental changes to the relationship between economic activity and energy use. The role of oil relative to other energy sources has not changed in any permanent and fundamental way. However, climate policy may eventually call for a change in historical trends, and this is currently reflected in forecasts of energy futures.

A collection of energy projections

To illustrate this, *we have collected projections or scenarios from a number of respected and well known institutions involved in analysis of future energy developments.* We do not maintain that what follows is an authoritative view or the «best-guess» of future energy developments. Rather, it illustrates some basic features and trends in present perceptions of tomorrow's energy scene.

Because of the potential importance and impacts that the environment, in particular global warming, may have on energy markets, we have made a distinction between projections dominated by environmental concerns, called «Green Scenarios» and other projections, which we have labelled «Conventional Futures».

Box 4.1: Two classes of projections of future energy

Conventional Futures

- International Energy Agency (1996), Capital constraints case
- World Energy Council /International Institute for Applied System Analysis (1995), Case B
- World Energy Council (1993), Case B
- Europeen Union (1992), Reference case

Green Scenarios

- International Energy Agency (1996), Energy savings case
- World Energy Council /International Institute for Applied System Analysis(1995), Case C
- World Energy Council (1993), Case C

Global energy use expected to increase

Starting with overall energy consumption, *most scenarios, even most Green Scenarios predict a continued energy growth.* In Conventional Futures, energy consumption increases from 7 850 mtoe in 1990 to 12 550 mtoe in 2020, by 1,5 per cent annually. This compares with 1,0 per cent per year to a total of 10 550 mtoe in Green Scenarios. Relative to historical trends, both projections are low. In the last 3 decades, global TPE increased more than 2,5 per cent annually. (1965 - 1996 = 2,6%, 1970-1996 = 2,1%)

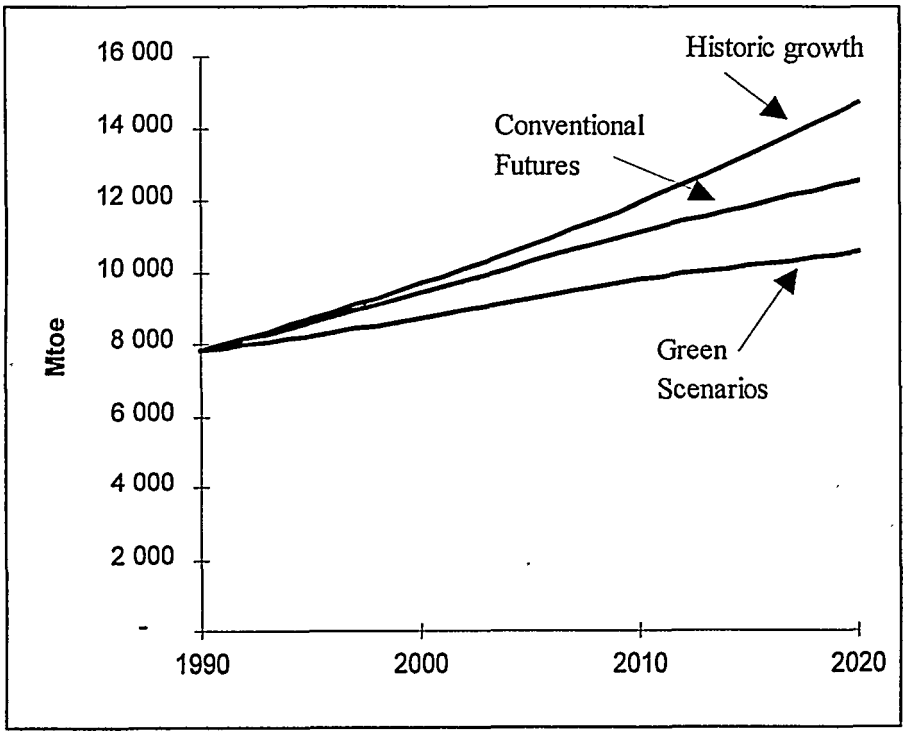


Figure 4.4: Scenarios for global energy consumption

Source: Various publications (see box)

The difference between Green Scenarios and Conventional Futures is 2022 mtoe in 2020. If, by contrast, energy consumption from 1990 to 2020 stays at the historical of 2,1 per cent per annum, the consumption level would be 2155 mtoe above the Conventional Futures.

Significant improvements in energy intensities

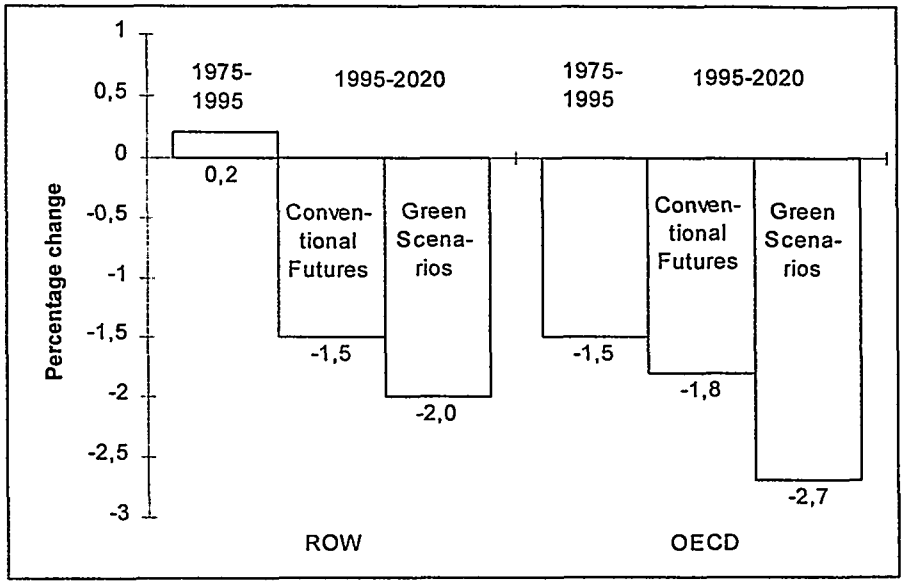
Rapid diffusion of new technology

It is interesting to note that the implied development in energy intensity in Conventional Futures and Green Scenarios are considerably higher than from 1970 to 1995, despite large actual and expected price increases during that period. *The assumption of an increased speed by which new technology and management practises are spread across the globe seem to be shared by all forecasts that we have reviewed.* However, why this is a reasonable assumption is often not well argued.

In particular assumptions regarding future developments in the world outside OECD, where energy intensities have been increasing due to industrialisation and modernisation in the past, implies a break with observed historical trends. From an environmental point of view, this portrays a desirable change that significantly lowers growth in energy use below historical trends. However, it should be pointed out that if this does

not materialise, we may observe very significant upwards revisions of projections of energy demand in the future.

Figure 4.5: Changes in energy intensity in OECD and ROW



Source: ECON

Moderate growth assumptions

Moderate GDP growth assumed

In addition to the development of energy intensity, the level of growth is of course extremely important for overall energy consumption. Also in terms of economic growth, *many of the projections reviewed are based on the premise of a certain slow down compared to what has been observed over the last decades.*

The growth rate assumptions may in particular be low for China. Economic growth in China since 1978 has on average been 10,1 per cent and it is perfectly feasible that it will remain at this level for the next couple of decades. As a comparison, South Korea had an economic growth rate from 1960 to 1990 of 9,1 per cent, and Singapore and Thailand grew by 8,2 and 7,3 per cent respectively. It appears that only a political setback can prevent China to copy this. On the other hand, there are indications that growth in some of the Asian tigers is slowing down.

Energy use may be higher than forecasted

The Conventional Futures energy growth of China (IEA, 1996a) is set at 4,2 per cent per annum to 2010 based on a GDP growth rate of 7,8. Keeping the same energy intensity decline as in the IEA forecast, an economic growth of 10,1 per cent would imply an energy consumption level in 2010 of 1800 mtoe, 23 per cent higher that in the IEA forecast and 176 per cent above the 1990 level. *This illustrates that if China, and other developing countries for that matter, succeed in their striving for modernisation and economic development, energy demand growth may turn out to be notably higher than forecasts shown in Conventional Futures.*

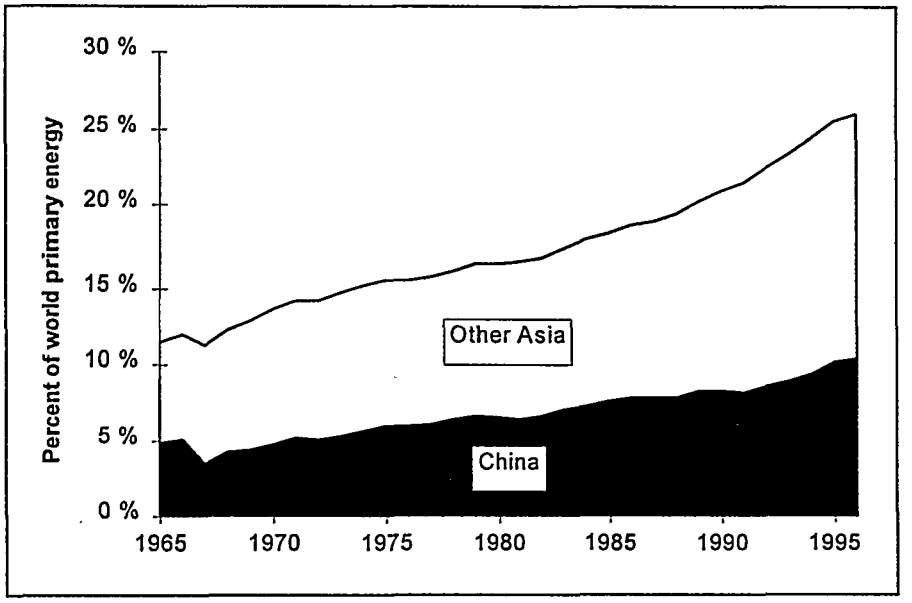


Figure 4.6: Share of energy used in Asia

Source: BP (1997)

Exit fossil fuels?

Green Scenarios show lower overall growth in energy consumption than Conventional Future, albeit not radically lower. But do Green Scenarios predict substantial shifts in the fuel mix? *Are fossil fuels, and the main target of recent energy policy - oil, on their way out? The answer is no, judged by the studies reviewed. In the Green Scenarios, global oil consumption grows by 0,5 per cent per annum from 3180 mtoe in 1990 to 3714 mtoe in 2020.* At the end of the forecasting period oil demand approaches a plateau and further growth in developing countries is offset by a decline in consumption in industrialised countries

Many seem to believe that the oil age will soon be over

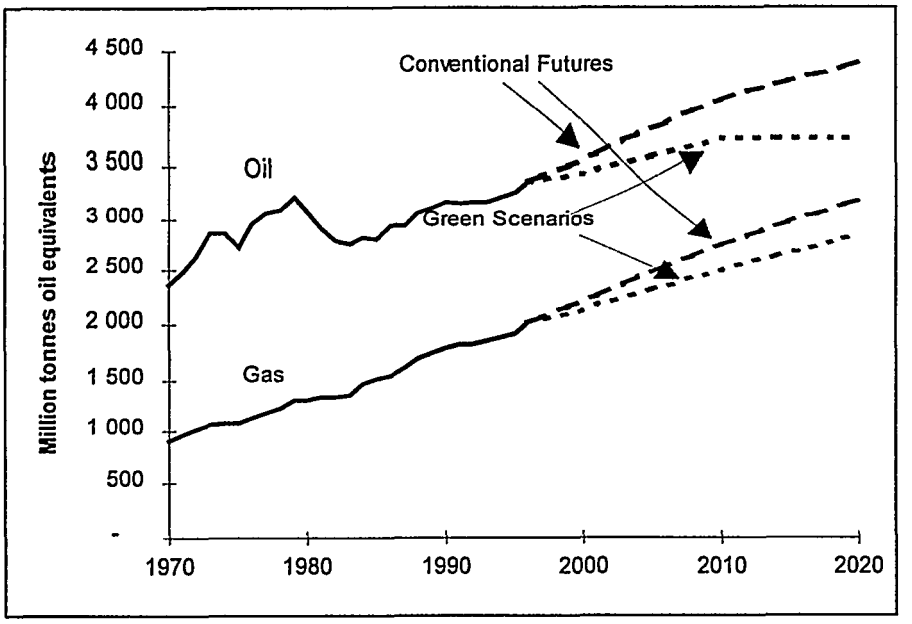


Figure 4.7: Consumption of oil and gas

For gas the situation appears to be even less dramatic. Global consumption grows by an annual rate of 1,5 per cent to 2020 in Green Scenarios compared to 1,9 per cent in Conventional Future. Gas is less vulnerable to

environmental measures than oil and coal due to the fact that a number of environmental policies may result in a change in the fuel mix in its favour.

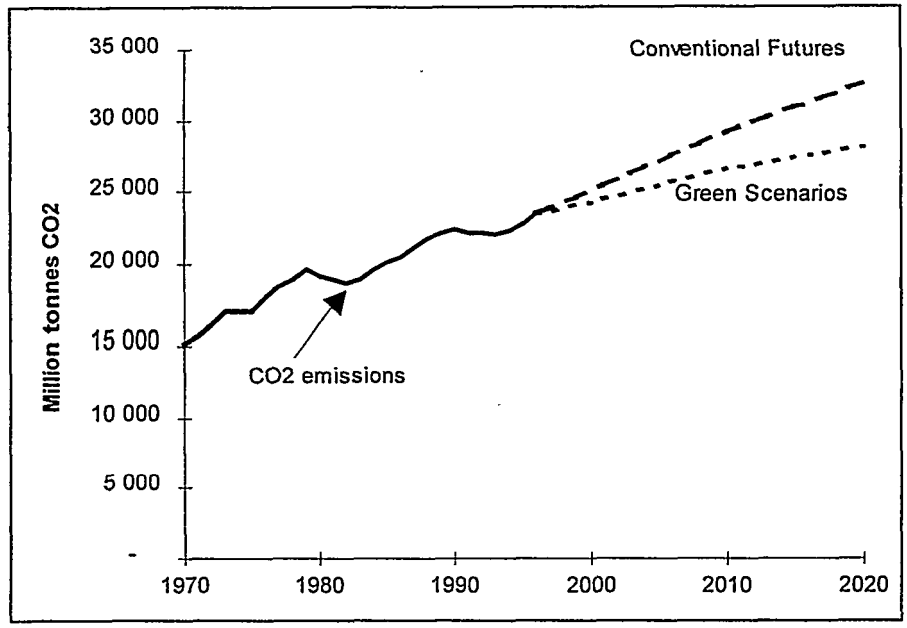
CO_2-emissions

Green Scenarios - less radical and less alarming than hoped/or feared

Green Scenarios contain vigorous environmental policy efforts, and as such, by and large stretch our imagination compared to what has been observed in energy/environmental policies. Still they are less radical than many environmentalist would like to see, and less alarming than some industrialists would fear. This is largely because of relatively cautious environmental measures assumed to be imposed in developing countries.

Globally, carbon emissions increase from 23471 billion tonnes of CO_2 in 1996 to 32625 billion by 2020 in Conventional Futures. Compared to historical trends, annual growth is 1,4 per cent while in the period from 1970 to 1996, growth was 1,7 per annum. In the Green Scenarios, emission grow to 28171 billion tonnes by 2020, or 0,8 per cent annually. Thus, CO_2 emissions are only reduced by 14 per cent compared to Conventional Futures, and emissions still some 26 per cent above the 1990 level.

Figure 4.8: Global carbon emission



Reduced emissions in OECD, strong increase in ROW

On a regional level, some very interesting differences appear. *In OECD, emissions are significantly lower in the Green Scenarios, and are also declining in absolute terms.* The difference between the two scenarios is 4,2 billion tonnes by 2020, and the level is then 9 per cent below the 1990 level. *In the FSU/CEE area, emissions stabilise at around the present level.* Also the differences between the scenarios are significant, with emissions declining in Green Scenarios. However, *growth in the Rest of the World, which is strongly influenced by China, India and Brazil, is paramount and dominate the outcome at the global level.* In Conventional Futures, emissions in ROW increase from 8,0 in 1996 to 15,9 billion tonnes in 2020, 2,9 per cent annually. In Green Scenarios, annual growth is reduced to 2,4 per cent, and the level in 2020 to 14,0 billion tonnes. However, this is still 7,8 billion tonnes above the 1990 - level.

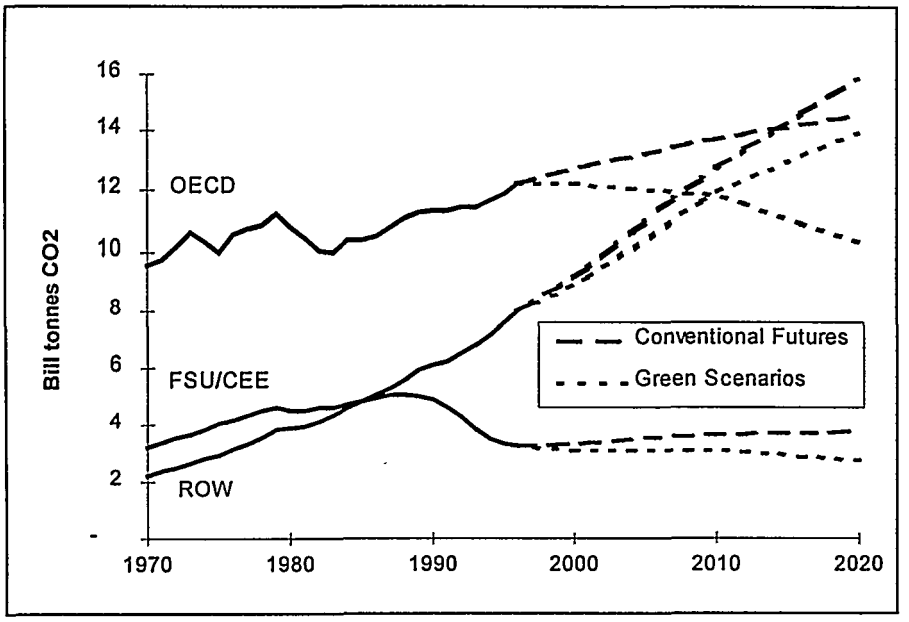


Figure 4.9: Carbon emission by region

4.2 A shifting and complex policy agenda

Shifting priorities in energy policy

Concern with energy supplies dates at least back to the 18th century, when Jevons (1865) predicted the end of the Industrial Revolution as England would run out of coal. In most societies, access to cheap and reliable sources of energy has been and still is a major public concern. But governments also have other interests in energy, as we can see from the evolution of the energy policy agenda over that last fifty years. Since World War II, three major issues have shaped the direction of energy development in Western Europe (See Haugland et. al., 1998).

Reconstruction, industrialisation and economic growth

The immediate post-war period was characterised by government planning and control of most economic activities. The pivotal role played by the energy sector in reconstruction and industrialisation made energy policy a major priority.

How to provide energy to fuel rapid economic growth

In the 1950s and 1960s, the predominant issue in energy policy was how to provide sufficient energy to fuel rapid economic growth. The technological and financial challenges in building adequate energy supply capacity were immense. This period saw the emergence of large and often vertically integrated energy enterprises able to master modern capital intensive, large-scale technologies.

Security of supply

In the late 1960s and in the 1970s, the geopolitical aspects of energy supplies came to the forefront. Growing trade in oil and natural gas called for national control of the supply chain for energy traded internationally. The oil sector became a target of governmental intervention, as explained earlier. *The oil crises of the 1970s established an entire generation of policy makers with a world-view centred around energy security.* Both balance of payment and security of supply considerations led to a strengthening of governmental control over imports and exports, storage, distribution and pricing of oil and natural gas.

The oil crisis developed a generation of policy makers obsessed with security of supplies

Significant shift in fuel mix away from oil

Furthermore, the oil price shocks combined with public R&D initiatives and political influence over the electricity sector led *to a significant shift in fuel mix, away from oil.*

Environmental concerns

Environmental issues have gradually grown in influence on energy policy. The rise in popular pressures for preserving the natural environment is a strong indication of this trend. Smog and acid rain were early concerns. Other issues were concern over the effects on marine life of oil spills in open waters as well as in coastal areas. Controversies over the siting of thermal power plants and transmission lines also became widespread, creating major complications for investment programmes in the power sector. Health and safety risks related to *nuclear power* became a top-priority after the Three Mile Island accident in 1979. Today, the major new issue on the agenda is global warming (see Chapter 4.3 below).

Environment priorities shifting

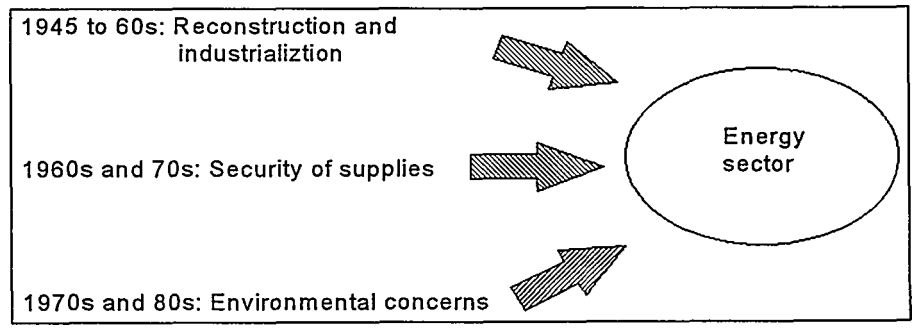
New priorities emerge in a sequential manner

From this brief historical sketch we can see that *policies and priorities directed towards the energy sector have changed substantially in recent decades*. In some cases, political shifts have occurred abruptly, with little warning and with profound effects on energy markets.

Important to note is the sequential manner in which the main political priorities surfaced and succeeded each others. In most countries, the energy sector was exposed to a relatively coherent set of policy priorities at a time. Thus, the direction in which to move and the thrust of the measures to be undertaken were, if not obvious, at least clearly discernible to most of the actors involved.

Priorities shifting in a sequential manner

Figure 4.10: The post-war energy policy agenda in OECD



A complex and conflicting agenda

More complex and onerous policy agenda

Since the mid-1980s, the *strategic challenges facing the energy sector have gradually become more complex and onerous.* Mention has already been made of the major unresolved environmental problems related to energy supply and consumption. The threat of global warming has now moved to the top of the agenda in both international and national politics. In addition, several other political and economic high-priority issues with potentially large impacts for the energy sector have surfaced. *All of these new challenges call into question today's national confinement of energy markets and energy/environmental policies.* Despite a free flow of technology, extensive trade in energy and shifting political priorities in the post-war period, the energy sector still, by and large, is in the hands of nation-states.

National confinement of energy markets questioned

A need to move beyond nation states in energy policy

In many respects, differences in industrial structure, fuel mix and technology are more easily explained by reference to the country of location than by the particular energy industry in question. *This strong national bent in policies and industries has come under severe strain from several angles.* The need to move beyond the nation state in energy policy for environmental and economic reasons falls well in line with the general trend towards globalisation of the economy.

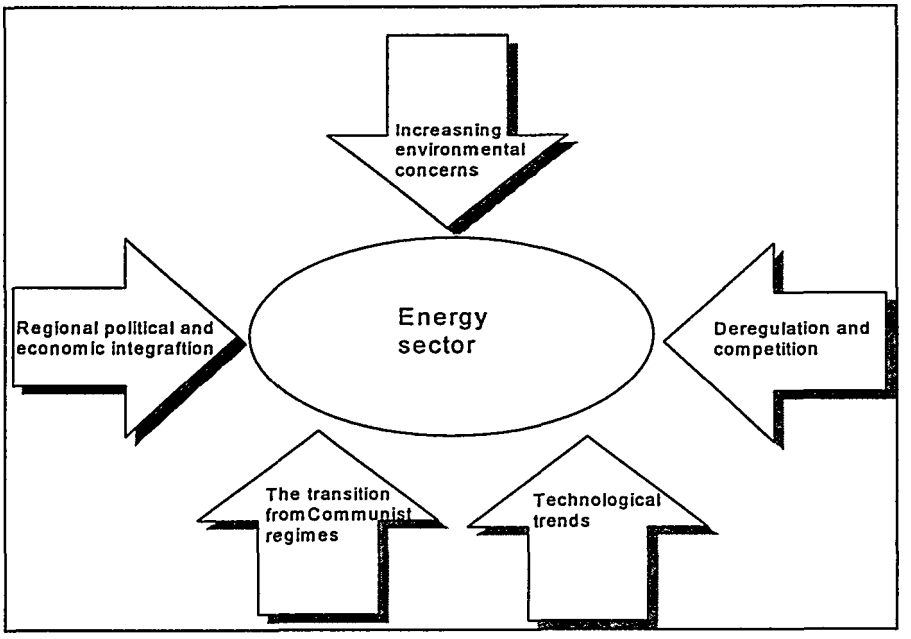


Figure 4.11: The new agenda

A complex and inconsistent policy agenda

To understand the complex and often inconsistent policies that the energy industry is confronted with today and in the years to come, it is important to keep in mind at least *five major challenges that could easily be transformed into forces capable of undermining the current structure of the energy sector:*

- *Increasing environmental concerns, in particular climate change*
- *Regional economic integration, in EU, NAFTA and APEC*
- *The transition from planned to market economies in the former communist countries*

- *New technological options which will open up for new competitors and challenge the present industry structure*
- *Deregulation and competition*

Reliable supplies - a prerequisite

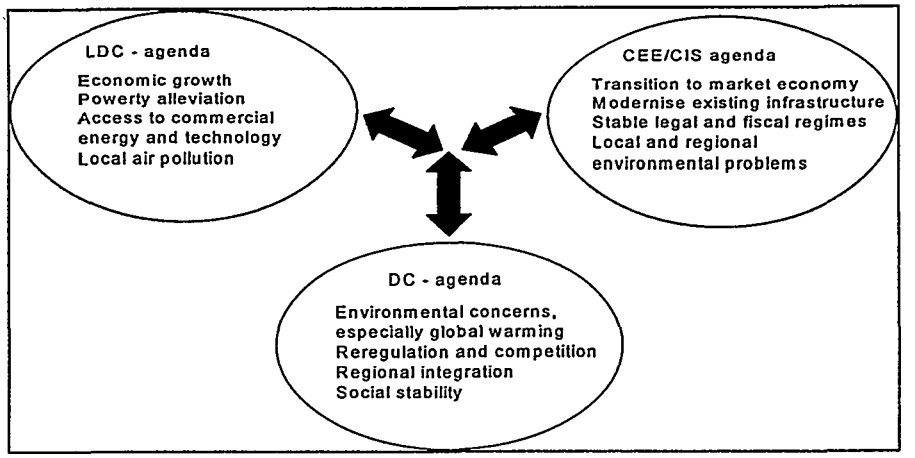
This new agenda does not imply that the old one has disappeared. *Reliable and predictable supplies will remain a prerequisite for all governments.* An energy sector that neglects this objective will not be acceptable in the long term, regardless of ownership structure or whatever policy issue may be high on the agenda. Security of supply remain a prerequisite for stability and acceptability.

More complex and diverse

Strikingly different agendas in different parts of world

Important to note is the fact that trends in energy policy priorities outlined above are very much a reflection of the mind sets in the OECD. *The agendas are strikingly different in the less developed parts of the world.* In developing countries, economic growth and reduction of incidence of poverty, access to commercial energy and the finance needed to achieve this, access to technology and finally reduction in local environmental problems are the priorities.

Figure 4.12: Conflicting and diverse policy priorities



In the CEE/CIS countries, priorities are more on modernisation of existing supply infrastructure, promotion of more rational use of energy, transition to a market based a environment, development of stable legal and fiscal regimes that promote private sector involvement and abatement of local and regional pollution.

Tomorrow's policy agenda

Prepare for a complex and rapidly changing environment

Corporate planners and public policy makers should prepare mentally for an energy scene where single minded strategies or one dimensional solutions based on passed experience will not survive.

Energy companies

- needs to keep an eye on *technological developments that may change own business opportunities* or opens up for low cost (often small scale) competitors in home markets,

- have to pay far more attention to *service customer needs* than before,

Focus on customers

- should *move internationally* (if they are not there already) but respect differing policy priorities in different countries and in particular in different parts of the world,

Move internationally

- ask and hope for consistency in energy/environment policies *but plan for inconsistency*, and

Plan for inconsistency

- *prepare for a broader policy agenda* not only encompassing energy and environment objects, but broadened to include human rights and social aspects as well.

Prepare for broad agenda

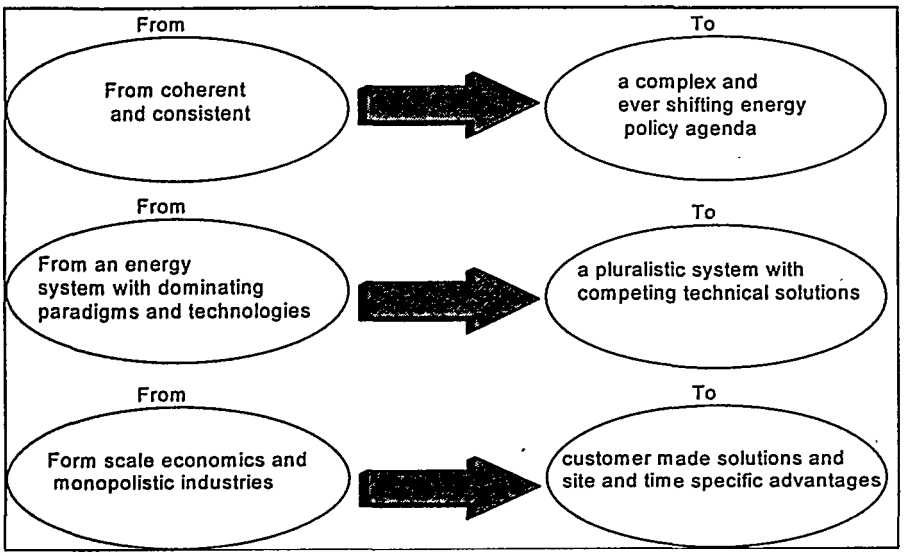


Figure 4.13: Tomorrow's policy agenda

4.3 Global warming - the final stumbling block

4.3.1 Understanding the nature of the problem

Problem before: too little resources, problem now: too much resources

The tittle of this section - the final stumbling block - alludes to the fact that many people are of the opinion that a serious and effective CO_2 abatement strategy could put an end to fossil fuel use, in particular coal and oil in the foreseeable future, long before the resource base is exhausted. In a sense, *compared to our prior concern that we ought to limit the use of non-renewable resources (i.e. oil and gas) and thereby preserve resources for coming generations, the problem is now the opposite.* We have more fossil fuels than we what like to see put in use.

Scientists agree to problem

Climate change caused by emissions of Green House Gases (GHG), first of all carbon released by combustion of fossil fuels, may fundamentally change energy industries and markets over the next two or three decades. Much intellectual efforts have over the last decade been devoted to understanding how the global climate will be affected by changes in the chemical composition of the atmosphere. Even if scientific knowledge still

is far from perfect and serious uncertainties remain in terms of the scale and effects of climate change in the future, *the large majority of scientists agree that a continuation of the present trends in anthropogenic emissions will significantly warm the globe by the middle of the next century.*

The big uncertainty are how to solve, not so much if there is a problem

Much attention in the international debate has so far been on our scientific knowledge of the problem. *From the petroleum industry's point of view, the focus should shift from the scientific debate and toward the possible means by with the international community might act on the issue.* The complexity and difficulties of negotiating international agreements and later, how they may be implemented on a national level, are vital to understanding the implications for the petroleum industry.

Prepare for a long ride

The process from Rio to Kyoto should be regarded as only the first step of a several decade long strive to develop international institutions and agreements to limit man made emissions of GHGs. While economic growth is closely correlated to energy use, the kind of energy carrier used in different countries and at different levels of economic development is not the same. GHG growth ties directly to this economic grouth via the energy use. A major curb on global emissions of GHGs, in particular CO_2, will affect the global economy and have ramifications for the energy industry. *In scope and complexity, it resembles the process toward international co-operation in areas like free trade, where the present WTO trading regime is negotiated over fifty years.*

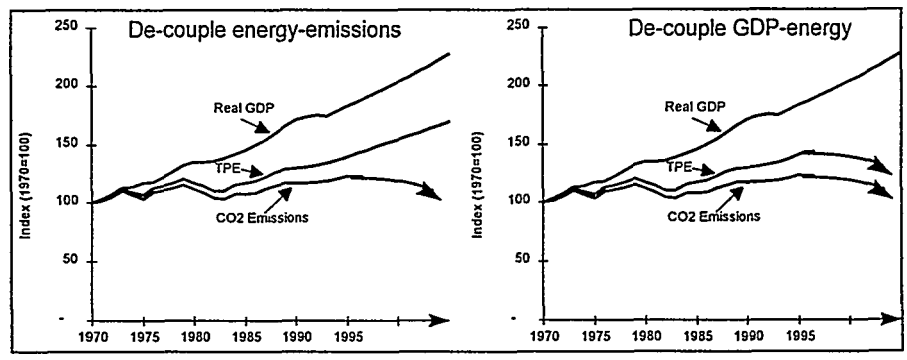
GHG regime resembles WTO in complexity and scope

4.3.2 De-couple energy use and carbon emissions

The overall task in energy/environment policy will be to de-couple economic growth and CO_2 emissions. This could either be done by de-coupling of energy use from economic growth, or de-linking emissions of CO_2 from energy use. Neither seem possible for political and economic reasons with today's technical and economic options. Rather, if the world in the near term (next decade or more) has to severely limit emissions, the policies needed to be implemented would significantly impact on economic growth and particularly on the distribution of wealth between nations.

Only two options: de-couple economy - energy, or energy - emissions

Figure 4.14: De-coupling emissions



The latter is the case for several reasons. Of course, *if demand for energy is changed significantly by depressing demand for fossil fuels, energy prices will be affected and fossil fuel prices depressed.*

Fossil fuel prices to be depressed

Countries heavily dependent on export of these commodities would be hurt, importing nations would gain. The price gains could be significant for importing countries, in particular countries which have not accepted to take up commitments to reduce their own GHG emissions, which is likely to be the case for most developing countries. However, *changes in economic growth and trading patterns for all other goods and services may be significant.* Even if actions to curb emissions in the first phase are limited to industrialised countries, studies indicate that reduced economic growth and thus imports in the OECD area will reduce demand for developing countries exports and thus their export revenues.

Economic growth effected

Due to the strong and conflicting interests that are involved in any kind of co-operative international effort to limit emissions of GHGs, one should expect that progress towards a workable and efficient international regime will be slow and very time consuming. Nothing like the success of the negotiations over ozone depletion (the Montreal Protocol) is likely, at least not unless major technological breakthroughs are made. *The more global warming moves up the policy agenda in the OECD countries, the more attention will be paid to R&D.* At least, this seem highly plausible judged on past experience. When energy policy (for different reasons at different times) have been regarded as important, budget allocations for R&D always seem to increase.

Strong and conflicting interests involved

4.3.3 Real world abatement policies

Many wonder why progress to limit man-made emissions of GHGs have been so slow. *After the Rio Conference in 1992, governments and green NGOs returned home with clear commitments to act on the issue, but by the end of 1997, not much has been achieved.* Emissions in a few industrialised countries have declined, most other countries are on an increasing trend. By 2000, probably only England and Germany among the OECD nations will have reduced carbon emissions compared to the 1990 base year. *The reason why Germany and England achieve the target, are however due to factors outside any specific climate measures.* In Germany, emissions were reduced as a result of the reunion of East and West Germany, the concurrent economic downturn and restructuring of the Eastern Bundesländer. In the UK, downsizing of the domestic coal industry in the 80s and the subsequent «dash for gas» in the power sector in the 90s reduced CO_2-emissions very significantly.

Commitments, but little action

Germany and England big achievers - for 'wrong reasons'

The message here is that no countries have yet initiated abatement policies that in their own right have significantly altered base line emissions, i.e. emissions that would occur if no GHG abatement measures were put in place. This is not to say that no new policies have been adopted. In many countries, renewable energy receives more generous support than before, industry and government have negotiated agreements for «voluntary» actions, performance standards for energy consuming equipment have been tightened, codes for insulation of buildings have been reassessed and carbon taxes have been introduced in Scandinavia and the Netherlands.

No country has significantly reduced emissions

Targets and time tables a precondition

However, despite these initiatives, *stabilisation by 2000 will not be accomplished. The present half-hearted policy response is not likely to change before an agreement with binding commitments on targets and timetables has been negotiated.* Taking emissions down to 1990 level by 2010 will necessitate drastically different policy measures than those adopted so far. What these measures may be if industrialised countries get serious on global warming and how they may alter the energy business and energy markets is hard to predict. To the extend that it is possible to draw on past experience, the follow seem likely:

National autonomy in choice of policy instruments

- *Government will maintain full autonomy on the choice of the policy instruments they choose to employ*, and the mix of instruments that in sum could be labelled each country's GHG abatement strategy. This does not rule out co-ordinating efforts on a sectoral or regional basis. However, such initiatives are likely to have only limited success due to the strong and often different political as well as economic interests involved.

Industries competing internationally - a special case

- Industry exposed to international competition and energy sector interests will tend to be sheltered or less severely affected. *To the degree possible, the competitive position of energy intensive industries will be affected as little as possible.* The same goes for energy sectors competing internationally, like generation of power in a more liberalised market. In primary energy production, domestic producers (i.e. the coal sector) are likely to be favourably treated compared to imports.

Expect oil to be hard hit

- One should also *expect policies to be structured directly and indirectly in such a way as to hit oil use particularly hard, but also affect seriously other imported energy carriers such as gas and internationally traded coal.*

However, with the present set of technological options in energy production, conversion and use, significant reductions in OECD carbon emissions will prove both economically and politically expensive. This will represent an obstacle to short and medium term emission reductions, and further enhance the trend observed over the last few years to increase the focus on R&D. Arguments to support such a reorientation, in particular as opposed to a heavy reliance on taxation as the remedy to the problem, are twofold:

'Technology forcing'

On one hand, *technology forcing* (i.e. demanding that polluters develop technology that enable them to meet ambitious targets for emission reductions in the future) was very important to control local air and water pollution from manufacturing industries. *Targets to significantly reduce CO_2 emissions from fossil fuel use 10 to 20 years ahead are likely to spur very significant actions from industries affected, and would start the search for technologies that are able to do what we cannot do today.*

Secondly, when *considering global warming and given the present state of cost and technology, a de-coupling of economic growth and GHG emissions does not seem very likely, and would entail some very fundamental tensions between countries* (think of coal based economies like India and China or the oil producers in OPEC), *between energy carriers* (actively favouring some at the expense of others) *and between service industries and more carbon intensive industries*. If abatement policies are structured so as to confront the very existence or fundamental interests of fossil fuels, one should expect that countries and vested interests systematically discriminated by such policies will be able to mobilise very significant opposition. Neither countries, nor industries should be expected to give in easily in such a political fight. *The accumulated power that potentially could be mobilised to oppose an efficient and well implemented abatement policy are significant, and perhaps overwhelming.*

Serious tensions between countries, fuels and industries to be expected

Among of the options that could be put in use to limit emissions, R&D could prove to be very productive and less likely to be opposed by industry, indeed perhaps supported.

Mobilise industry to develop new options

4.3.4 A strategic R&D vision for energy sector

A strategic R&D vision for the energy sector should attack energy production and use on a broad scale. The "solution" is not likely to be found in one technology or one area. R&D directed to significantly reduce emissions of GHG from the energy sector should:

Not to aim at one single «solution»

-increase the efficiency of all energy use,

-commercialise renewable technologies,

-reduce specific emissions of GHGs from the energy sector itself, and

-decarbonise fossil fuel in the long term.

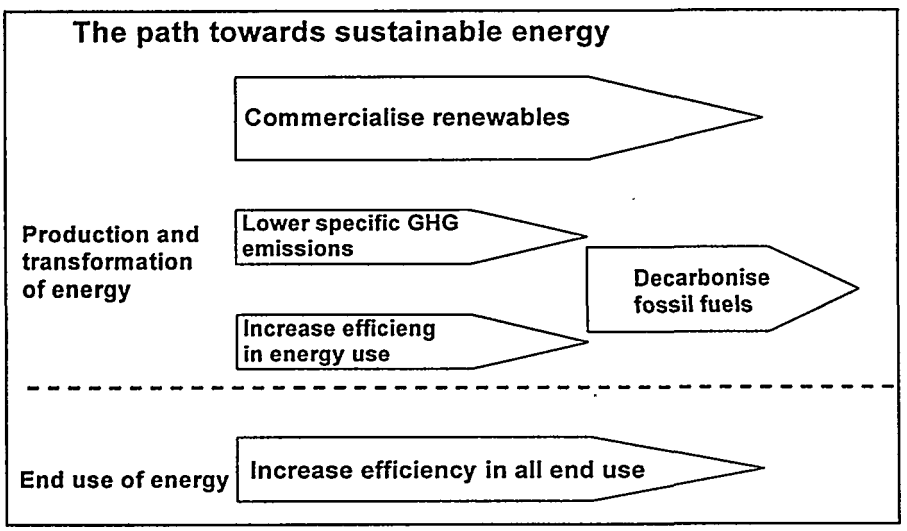


Figure 4.15: The R&D policy agenda

Vision 21: A hope for fossil fuels?

Both energy industries and governments are developing strategies along these lines. A novel and very interesting proposal is put forward in the report «Federal Energy R&D for the Challenges of the Twenty-First Century», which has recently been submitted to the US President by President's Committee on Science and Technology (PCAST, 1997). This report portrays a wide range of technology options in the short as well as in the long term. For the oil and gas industry, of particular interest is the idea called *Vision 21, with «the objective (to develop) economical coal and gas power and fuels technology with zero-to-small CO_2 emissions».* The centrepiece of the logic outlined, is a future whereby CO_2-emissions by mid next century are very significantly reduced, in fact *a future where fossil fuel use is de-coupled from CO_2 emissions.*

The vision of a zero emission platform

Strategic approaches along similar lines are also put forward by the petroleum industry. In Norway, Saga Petroleum has adopted *the vision of a zero emission platform* as the target for the next generation of offshore developments. Statoil is developing an ambitious R&D program to develop technologies that could separate carbon from exhaust gases and reinject the carbon in the ground, develop the fuel cell technology, or even move towards hydrogen fuelled systems.

Fight policies or fight the problem

Fight industries or mobilise their skills and resources

To summarise, it may prove to be the case that global warming become the final stumbling block for fossil fuel industries. To significantly reduce, not only stabilise emissions, which is what science tells us is required to control global warming, is the most fundamental challenge that the oil and gas industry has ever been up to. *To company executives, the choice is to fight the problem, and policies put in place to do something with it; or to mobilise resources and skills to search the horizon of new technical options. To policy makers, the choice is to fight fossil industries (and countries heavily dependent on these industries) head on, or to work with the industry with the aim of finding solutions that could radically alter the way we use energy.*

Commitment and visionary executives called for

To executives, the choice should be simple. If radical breakthroughs are made, *the hope is that in a decade or two, oil and gas may earn the label «sustainable».* If not, the possibility remain that their own company may develop technology and insights that could form the platform for new business opportunities. Global warming is a true long term issue. So are solutions. *The oil and gas industries are fortunate that the world in any case will need their products for decades. No alternatives are able to substitute for oil and gas in large scale over the next two decades. Thus, there is time, but commitment and visionary executives are called for.*

4.4 Why the oil industry will survive against all odds

Oil - the bad guy

Oil industry attracts attention for 'wrong' reasons

In the pecking order of the energy industries, oil tends to be the energy industry that always attracts the most attention for the (right and) wrong reasons. When energy is high on the policy agenda and pressure builds up

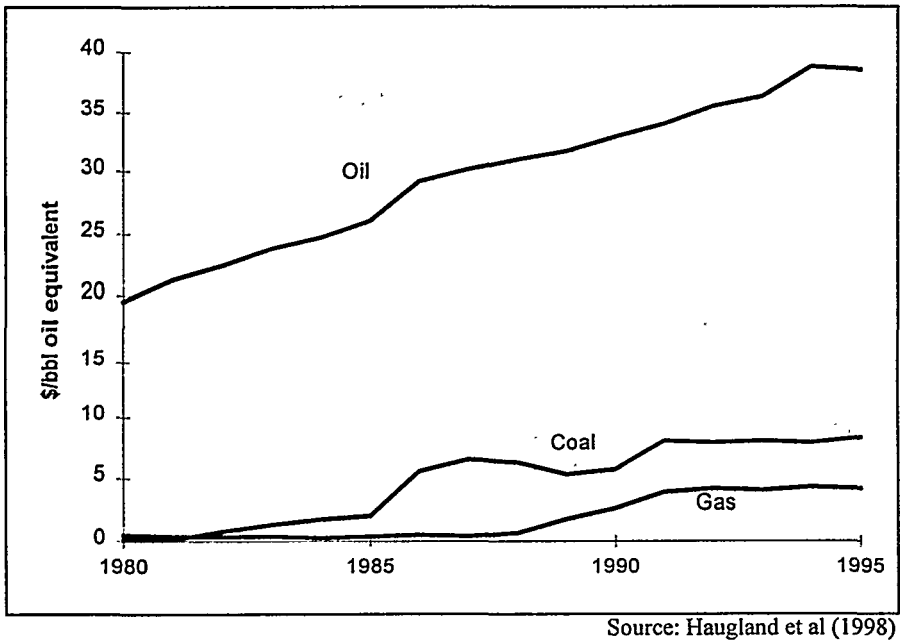
behind claims that political action is needed, this pressure is often ventured by adopting new policies solely or primarily directed towards the oil sector (and the nuclear industry). There are good and bad for this being the case. This industry developed a poor public image problem already in the 60s, when multinational oil companies became a symbol of oppression and exploitation of the poor countries and foreign control of their natural resources. OPECs fight to increase host country take in the rent generated in oil production and the subsequent nationalisation of production fall well into the picture of North-South divide and antagonistic view of the liberation movements in the former colonies.

Due to the oil crisis in the 70s, oil became the focal point for concerns over security of energy supplies. Again, trouble was associated with oil traded internationally in chains controlled by multinational companies which often was assumed to pursue goals not in the interests of either the producing countries, nor the consuming nations. Oil, supplied by international oil companies from places far away used to be cheap, not so much any more, but for sure was less reliable and controllable than domestic sources. Thus, *security of supplies turned out to be synonymous with unreliable oil.*

Security of supplies = unreliable oil

A cornerstone in many modern peoples feeling of uneasiness with modern lifestyles and our environmental and ecological challenges is mass mobility made possible by private cars. *In Europe, this widespread popular discontent with the side effects of private car use* (air pollution, lead, accidents, noise, huge areas committed to roads and infrastructure, impact on design of cities etc.) despite our appreciation for the freedom that mobility in itself represents, *have facilitated an environment where high taxes on fuels have become acceptable. Gradually, over time, oil products have turned out to be the treasury's favourite.* Over the last decade, subsequent to the oil price fall in 1986, increasing taxation on petroleum products have shifted a substantial share of the rent in this sector from producing to consuming countries.

Oil products - the treasury's favourite



Source: Haugland et al (1998)

Figure 4.16: Average tax on fossil fuels in OECD Europe

Energy taxes discriminate against oil

Also, over time, *the tax burden on energy has increasingly turned out to discriminate against oil.* Nuclear was introduced to the market by heavy government subsidies and a favourable regulatory framework. Coal could not be taxed, it was a domestic industry with strong vested interests. In fact, coal in many countries needed protection not only from internationally traded coal, but also from domestic competition with other sources of energy. Subsidies to the coal industry increased dramatically. To illustrate the point, by the mid 90s, average costs of German coal were close to three times the price on the world market.

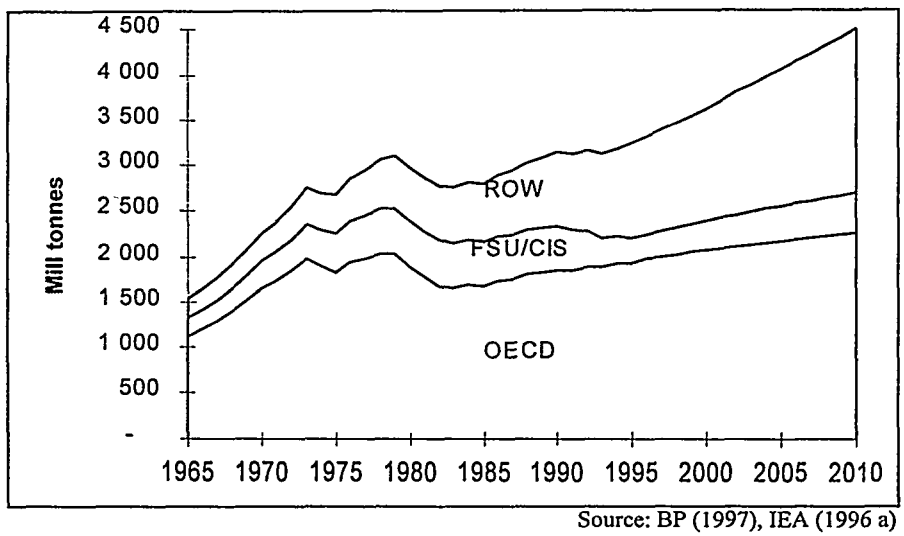
Abating global warming may again pay particular attention to oil

To summarise, *energy policy in industrialised countries has for a long time focused attention on oil.* Policies to conserve energy, taxes or levies on energy introduced for environmental or other reasons and other policy measure are with few exceptions focused on oil, sometimes even beyond what is justified by the issue at hand. *The oil industry should not be surprised if global warming abatement policies starts out with a particular attention paid to oil products.*

The comparative advantages of oil

Policies to curb oil demand did affect consumption in industrialised countries, in particular in stationary uses. Growth in consumption of 7,3 per cent in the 50s and 60s was reduced to 1,1 per cent from 1972 to 1996. However, taking into account the attention paid to energy policy (for different reasons) over the last 25 years and the strong «anti» oil bias embedded, the surprising question is why the oil industry is still up and going. Oil consumption is growing rapidly in LDCs. Evidence from the last few years suggest that consumption in the OECD area is back on a continuos increase.

Figure 4.17: Oil consumption by region



Source: BP (1997), IEA (1996 a)

A number of reasons explains why oil competes favourably with other sources of energy in many end uses. *Petroleum products:*

Why petroleum products are extremely hard to do without

- *are cheap to move,*
- *are easy to store,*
- *have no real substitutes in transportation,*

- *have responded to environmental concerns through modifications of products and technology in which it is consumed, and*
- *are consumed in technologies which are globally available and manageable even in the most remote places in the third world.*

All together, even in the decades ahead, *there is good reason to believe that petroleum products will remain:*

- *the dominant fuel in transportation,*
- *will be needed to supply an increasing feedstock demand in petro-chemical industries,*
- *will prove competitive in a vast number of stationary uses, and*
- *may even prove to be attractive in the power sector in a number of locations.*

Why petroleum will remain competitive

In particular, oil is very attractive and even necessary to fuel economic growth in developing countries also in applications where other sources of energy is preferred in the OECD area. Important to note in this regards is the fact that oil as opposed to gas, electricity and also to some extend to coal, are less demanding in terms of infrastructure and regulatory framework. This very much favours oil in poorer developing countries.

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Appendix: List of abbreviations

ASEAN	Association of South - East Asian Nations
bcm	billion cubic metres
CCGT	Combined Cycle Gas Turbines
CEE	Central and Eastern Europe
CIS	Confederation of Independent States
CO	Carbon Monoxide
CO_2	Carbon Dioxide
EU	European Union
FERC	Federal Energy Regulatory Commission
FSU	Former Soviet Union
GDP	Gross Domestic Product
GHG	Green House Gases
HQ	Head Quarters
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPPs	Independent Power Producers
IT	Information Technology
ITT	International Telephone and Telegraph corporation
LNG	Liquefied Natural Gas
MNC	Multi National Corporations
mtoe	million tonnes oil equivalents
NAFTA	North American Free Trade Association
NGO	Non Governmental Organisations
NGPA	Natural Gas Policy Act
NO_X	Nitrogen Oxides

NPF	Norwegian Petroleum Society
OECD	Organisation for Economic Co-operation and Development
OPEC	Organisation for Petroleum Exporting Countries
PC	Personal Computer
PCAST	President's Committee on Science and Technology
PDO	Plan for Development and Operation
R&D	Research and Development
R/P	Reserve/Production
ROW	Rest of the World
TOP	Take-or-Pay
TPA	Third Party Access
TPE	Total Primary Energy
USD/b	US Dollars per Barrel
UK	United Kingdom
UNCTAD	United Nations Commission for Trade and Development
US	United States
VOC	Volatile Organic Components
WTO	World Trade Organisation