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GAS TRADE AND DEMAND IN NORTHWEST EUROPE: REGULATION, BARGAINING AND COMPETITION.

By

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ABSTRACT

The paper investigates the present role of the gas transmission companies and possible effects of a deregulation of the European gas market by 1992, i.e. the introduction of the principle of common carriage or open access to the European transmission system. In a price/netback analysis, effects of a non profit pricing policy in transmission is compared with prevailing pricing policy. These calculations reveal that, at least in some countries, transmission companies have exploited monopoly power, and thus restricted gas consumption. Common carriage may be defined as "third parties" being allowed to carry gas through the existing networks paying current average transmission costs. Simulations on a gas demand model for Western Europe indicate that this kind of pricing policy will increase gas consumption of gas significantly in major consuming countries. Finally, supply responses initiated by common carriage are studied by simulating a dynamic oligopoly model for the European gas market. The simulations confirm that the potential for natural gas is far from exploited, and that consumers will benefit from the introduction of common carriage.

1. INTRODUCTION.

"Natural gas is likely to remain an underexploited fuel from the strict perspective of economic efficiency." M.A.Adelman & al.(1986)

Over a period of twenty years natural gas has become one of the major sources of energy supply for European households, business and utilities. The overall share of natural gas in the energy use in Europe has increased from somewhat above 3 percent in 1966 to just over 15 percent in 1986. Whether this expansion should be considered fast or slow is a contested issue. According to critical observers such as e.g. Odell(1988) and Adelman et al.(1986) the expansion has been far too slow as a combined result of unrealistic pricing policies of the producing companies, monopolistic practices in the transmission and distribution, misperception of the natural gas supply situation in Europe and various institutional constraints.

For the future role of natural gas in the energy supply of Western Europe the immediate years to come may be of particularly great importance for the role of gas far into the next century. The big issue is deregulation, but it is not the only matter of importance.

On the supply side there is a bargaining battle coming up between the three contenders Algeria, Norway and USSR about the replacement of Dutch export and descending indigenous gas reserves. On the demand side, there may be more countries hooked onto the main transmission grid in Europe and there will be more customers connected to the distribution network in the major gas consuming countries.

The increased awareness of environmental risks may become a factor which will work strongly in favour of natural gas which is cleaner than its closest substitutes fuel oil and coal.

Natural gas may also replace nuclear power for environmental reasons, accentuated by the Chernobyl disaster. The technological development in cogeneration etc. may also work to promote natural gas as the preferred choice on economic as well as environmental grounds.

The deregulation issue has emerged with two major references: the deregulation of natural gas markets in North America and the intention of the Commission of the European Community to remove all obstacles to free trade within the Community by 1992. The possibility of deregulation has caused some consternation in the transmission and distribution companies. At the present time, there is more bewilderness than anything else about what the consequences of the Community's intention will be for the natural gas markets. For the supplying nations outside EC deregulation of gas markets may have great economic importance and influence the producing companies ability to capture the various kinds of rents inherent in gas markets.

In the following we shall first take a brief look at the current state of the European natural gas market and the preveailing market structure (section 2). We shall then discuss the "common carrier principle" starting from elementary economic theory (section 3) and then consider the outlook for the next decade as it has been projected by different observers (section 4). In the ensuing section (section 5), we will look at the existing market structure from an angle of price/netback analyses of market segments, thereby shedding light on the current price discrimination of end users. By carrying out model simulations, we then aim at calculating the effects on European gas trade of a non-discriminating price policy. Section 6 takes this analysis further by applying a game theoretic model to the battle over future market shares between the three big suppliers: Algeria, Norway and the USSR. Section 7 concludes.

2 THE EUROPEAN GAS MARKET.

> *"..the mere five-point increase in gas' percentage contribution to the energy market over the past decade and a half represents a failure by the gas industry and government energy policy makers to accept the opportunities offered by natural gas for changing Western Europe's energy system.", P.Odell (1988)*

The discoveries of significant indigenous gas reserves, first in the Netherlands and other continental countries and later on in the North Sea, along with large supplies made available by USSR and Algeria, have enabled a gradual evolution in gas consumption in Western Europe. Due to high, but declining average costs of transportation, natural gas penetrated first to electricity generating utilities and large energy intensive industrial plants. However, as the gas distribution network was expanded, natural gas accelerated as a primary fuel chosen by households and in smaller industries and the commercial sector as well. In some countries (e.g. Italy and United Kingdom), the local distribution could make use of existing town gas networks.

In this section we will first survey briefly the evolution of natural gas in the European market. Then we turn to a discription of some important features, technological and institutional, of the present market structure.

2.1 The evolution of a European natural gas market.

The evolution of natural gas <u>demand</u> in Europe is shown in table 2.1. During the 1970s, gas demand increased rapidly in the major countries specified in the table. In the aftermath of the two oil price hikes, energy consumption in the European countries has stagnated or decreased in the 1980s. Natural gas, however, has continued to penetrate in the energy market, although at a lower pace than in the preceding decade. The share of gas in total energy demand thus rose from about 14.3 percent in 1979 to 15.2 percent in 1986. The growth in gas consumption remained strong in Italy and United Kingdom, wheras demand leveled out in Germany and France. Some smaller countries added to total gas demand.

TABLE 2.1: NATURAL GAS CONSUMPTION, WESTERN EUROPE : Million Tonnes Oil Equivalent

	1965	1970	1975	1980	1986	Average growth 1980-86,
Austria	1.6	2.5	3.6	4.2	4.4	0.8
Belgium & Luxembourg	0.1	3.5	8.3	9.1	6.7	-5.0
Denmark	0.0	0.0	0.0	0.0	1.0	
Finland	0.0	0.0	0.7	0.8	1.0	3.8
France	5.0	8.4	17.1	21.9	24.8	2.1
Greece	0.0	0.0	0.0	0.0	0.1	
Iceland	0.0	0.0	0.0	0.0	0.0	
Republic of Ireland	0.0	0.0	0.0	0.5	1.1	14.0
Italy	7.3	10.8	18.6	23.1	28.9	3.8
Netherlands	1.6	15.7	32.0	31.0	33.1	1.1
Norway	0.0	0.0	0.0	0.0	0.0	
Portugal	0.0	0.0	0.0	0.0	0.0	
Spain	0.0	0.1	1.3	1.8	2.5	5.6
Sweden	0.0	0.0	0.0	0.0	0.2	
Switzerland	0.0	0.0	0.5	0.8	0.9	2.0
Turkey	0.0	0.0	0.0	0.0	0.3	
United Kingdom	0.8	10.4	32.1	41.1	48.3	2.7
West Germany	2.5	12.8	35.0	43.3	41.8	-0.6
TOTAL WESTERN EUROPE	18.9	64.1	149.2	177.6	195.1	1.6
of which						
Electr. generation		11.5	32.5	25.1	24.1	-0.7
Industry		31.4	59.4	68.2	63.5	-1.2
Residential, commercial		28.2	55.1	79.6	99.2	3.7
AS SHARE OF PRIMARY ENERGY CONSUMPTION (%)	2.3	6.7	13.2	14.5	15.2	

Source: BP Statistical Review of World Energy, OECD Energy Balances

In recent years, natural gas has had greatest success in the residential and commercial sector (see table 2.1). In 1986, gas consumption in the sectors constituted close to 50 percent of total demand in Europe, while this share was only about 37 percent in 1975. Ease of control and high efficiency, in particular in central heating systems, have motivated households to switch to natural gas, both through conversion and retrofit investments. Even more important, however, has been the tendency of installing gas in new dwellings. In several countries, the share of gas heated dwellings among new homes has come to exceed 50 percent, and was in the range of 70-80 percent in the United Kingdom in the mid-1980s.

During the last ten years, the gas distribution network has been expanded to new areas. As indicated by table 2.2, the shares of households living in gas areas have become rather high in many countries, considerably exceeding the fractions of households actually using gas. Still, significant numbers of potential customers are not covered by local gas grids.
In the manufacturing sector, gas consumption has stagnated in the 1980s (see table 2.1). The industrial share of total gas demand has declined from 37 to 32 percent from 1980 to 1986. This has been due both to a generally low activity level in this period, energy conservation and changes in the industrial structure, as part of the energy intensive industry has moved from Europe to other regions of the world. In additon, while natural gas has been promoted in the residential sector, a common view is that this has not been the case for industrial use. On the contrary, pricing policies in several countries have in periods been directed to encourage the continued use of domestically produced coal.

TABLE 2.2: GAS NETWORK SATURATION, 1984. PERCENT.

France	68
Italy	49
Netherlands	97
Belgium	76
United Kingdom	86
West Germany	76

Source: Le Marche Domestique du Gas.
Colloque International de Marketing Gazier.

A similar observation can be made for the power industry, where consumption of gas has been reduced significantly in absolute terms. On the one hand, energy policies, both pricing policies and R&D efforts, have supported and served to conserve a structure consisting of coal fueled power plants. In additon, some countries, like France and the United Kingdom, have extensive nuclear energy programs. In the latter countries, gas sales to power stations are almost negligible, while the shares of natural gas in the total primary energy consumption in utilitites in the Federal Republic of Germany and Italy are 11 and 19 percent respectively. Most likely, there will be forces working for a continued increase of the use of coal in the sector. However, the Chernobyl incident may imply that the future implementation of nuclear power programs are postponed in countries like Italy and Germany. Combined with a growing environmental concern this may open for more extensive use of natural gas.

Turning then to the supply side, table 2.3 presents estimates of total gas reserves and production of the most important suppliers to the European market. Within the group of consuming countries, some have significant domestic gas resources of their own, but with the Netherlands as the only net exporter. Furthermore, it may be noticed that the R/P ratios of these countries are rather low. Three main producing areas are supplying the region from the outside, namely Soviet Union, Norway and Algeria. Soviet Union has close to 40 percent of the total reserves of natural gas in the world. It is the dominant supplier of gas to other centrally planned economies, and has also become the largest exporter of gas to Western Europe. With its huge reserves, there should be a considerable potential for further increase in exports to the Western countries. Algeria's exports consists partly of piped gas to Italy, and partly of LNG deliveries to several countries at the continent. Its resource base is large. Norway's offshore production of natural gas increased rapidly in the 1970s and all its production (close to 30 bcm in 1987) is exported to UK and the European continent through pipelines. The present R/P ratio is estimated to more than 100 years; Norway's weight in the total European gas supply may thus increase further in the future. An important event for Norway's supply position was the ratification of the Troll agreement in 1986. The deliveries from this large gas field and the accompanying Sleipner field will secure the deliveries to Europe in a period (from 1995 onwards) when production from other fields, both indigenous and in the North Sea, are leveling out.

TABLE 2.3: NATURAL GAS RESERVES AND PRODUCTION, 1986

	Production, bcm	Proved reserves, 1000 bcm	R/P ratio	Net exports to W. Europe
France	3.60	0.04	11.11	-19.93
Italy	12.93	0.30	23.20	-16.42
Netherlands	57.03	1.80	31.56	23.90
Norway	27.30	3.00	109.89	27.30
United Kingdom	38.27	0.60	15.68	-10.04
West Germany	11.29	0.20	17.71	-30.53
Others	4.60	0.26	56.52	-21.80
TOTAL WESTERN EUROPE	155.02	6.20	39.99	-47.52
ALGERIA	42.10	3.00	71.26	24.60
USSR	733.80	41.10	56.01	38.80

Source: Bp Review of World Gas, OECD Energy Balances

Thus, after about 25 years of evolution, the supply situation for the European natural gas market seems more abundant than ever. The consuming countries are connected to four large supply regions: Groningen in the Netherlands, the Algerian Sahara, Uringuoy and Tyumen Ublast in Western Siberia and the North Sea. The gas reserves included in these fields represent potentials for many years with total consumption at a considerably higher level than what materializes today. Moreover, most of the major countries in Europe are interconnected in a central transmission system. On this background, the convential view among analysts is that, if anything, it will be the demand side that will restrict the further penetration of gas in the European market. In turn, this is partially dependent upon the strategies pursued by the transmission and distribution companies, i.e. their efforts to expand local distribution networks and to market gas to new consumers.

2.2 A brief overview of the prevailing market structure

Natural gas is supplied by a number of producing companies having property rights to onshore or subsea resources consisting of a limited amount of natural gas. This makes natural gas an exhaustible resource which means that the cost of production includes, in addition to the factor cost of bringing it to the wellhead, an opportunity cost of reducing the amount that can be produced in the future. This opportunity cost is the rationale of a resource rent to be included in the marginal cost. Another important feature is that increased production over existing capacities will typically be made available by large scale investments in development of new fields. There is thus lumpiness on the supply side. As will be discussed in section 6, these technological features may have significant effects on market behaviour.

Gas at the wellhead is still far from the end user. The transportation of natural gas in Europe is undertaken by pipelines, first from wellheads to import terminals, then through national transmission grids and, finally, via local distribution networks to the final end users.

Table 2.4. Production, Transport and Distribution Costs 1). 1984$/mill.btu

	Norway Ekofisk low	high	Sleipner low	high	Troll low	high	Soviet Urengoi low	high	Algeria Pipe low	high	LNG low	high	Netherl. Groningen low	high
Production	1.00	1.00	1.08	3.14	0.81	1.73	0.42	0.61	0.05	0.28	0.05	0.28	0.01	0.31
Transport2)	0.50	0.64	0.55	0.85	0.66	1.36	1.03	2.65	1.46	1.84	1.96	2.73	0.12	0.18
Distribution														
-domestic	2.92	4.00	2.92	4.00	2.92	4.00	2.92	4.00	2.92	4.00	2.92	4.00	2.92	4.00
-large scale	0.58	0.87	0.58	0.87	0.58	0.87	0.58	0.87	0.58	0.87	0.58	0.87	0.58	0.87
Total unit cost														
-domestic	4.42	5.64	4.55	7.99	4.39	7.09	4.37	7.26	4.43	6.13	4.93	7.01	3.05	4.49
-large scale	2.08	2.51	2.22	4.86	2.05	3.96	2.03	4.13	2.09	3.00	2.59	3.88	0.71	1.36
CIF unit cost	1.50	1.64	1.63	3.99	1.47	3.09	1.45	3.26	1.51	2.13	2.01	3.01	0.13	0.49

Notes: 1) Sources Adelman and Lynch (1986), Dahl and Gjelsvik (1988), Messner and Strubegger (1986)
2) Transport costs to a central point of the European gas market.

The cost components of natural gas thus consist of extraction (production), transportation from wellhead to import terminals, national transmission and local distribution[1]. In table 2.4, cost estimates for a number of natural gas fields serving Europe are reported. The cost estimates vary over a large range, probably due to different assumptions on uncertain parameters such as investment costs, depletion rates/production capacities, reserve estimates etc. Distribution and transmsission costs are the dominating cost components[2]. For the inexpensive and close to market Groningen field, distribution costs exceed 90% of the total. For the "high cost" Troll field, extraction constitutes around 20%, internatinal transport around 15%, and distribution the residual 65% of total costs. Even for LNG-exports, where costs of liquifying, shipment and regasification are more than double of average international pipe transportation costs, and for gas shipped from the permafrost area Urengoi in Siberia, distribution costs exceed 50%.

The transmission lines and local distribution networks have the same lumpiness and indivisibility properties as the production capacity. A transmission and distribution network to serve a given set of end users will for this reason often have spare capacity. Increased demand may thus imply lower, rather than higher, average transportation costs per unit. Investments in new transport capacity to cater for even higher demand may also imply lower average unit costs as better use may be done of the already existing infrastructure.

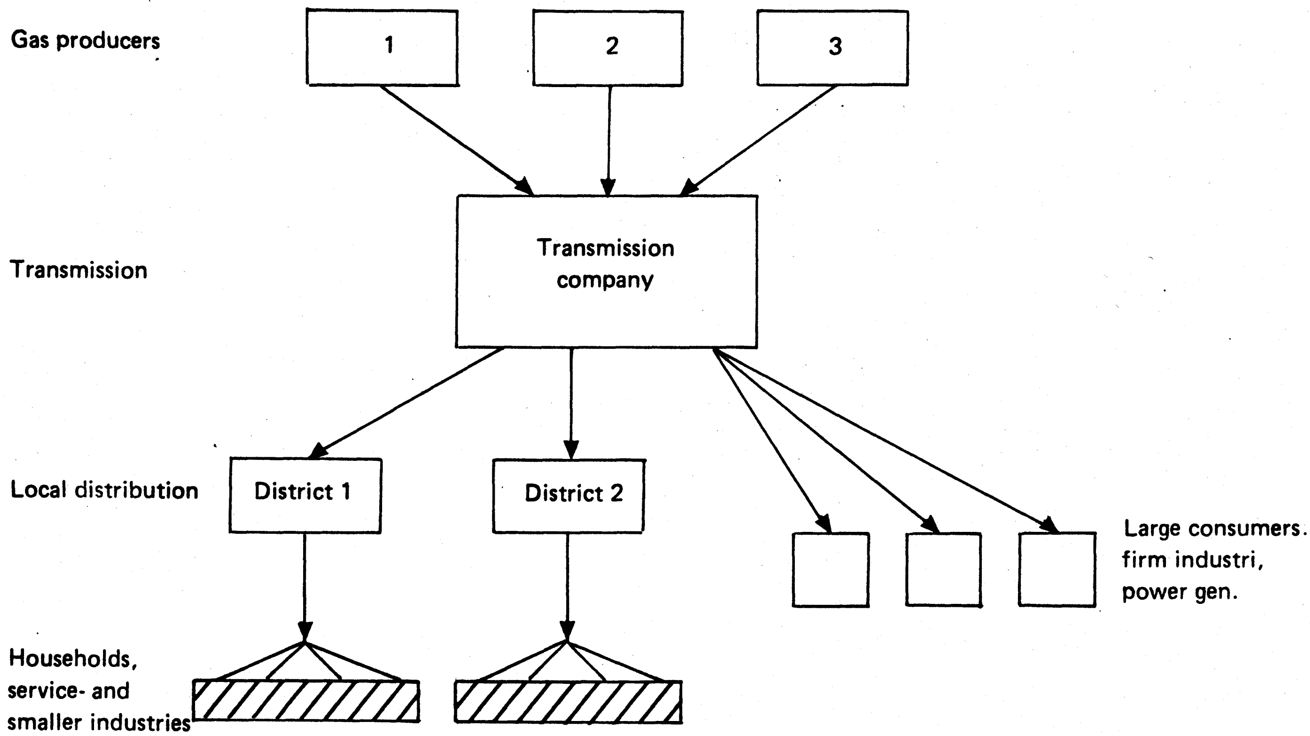
A sketch of the market structure of a region is given in figure 2.1. The suppliers are indigenous producers and exporters. The transmission company is the retail link, contracting the producers and selling it to end users and local distribution companies. Households, service- and other smaller industrial customers are linked to the local networks. Large end users, electric utilities and energy intensive industries, buy gas directly from the retail

[1] The distribution cost figures presented in table 2.4 include local distribution, storage facilities to handle peak load demand and national transmission costs.

[2] It is assumed that small scale consumers pay transmission and distribution costs while large scal consumer only pay transmission costs

transmission companies.

Figure 2.1: Market structure of a gas region



The dominant role of the major transmission companies give them a key role in the market. Economies of scale in transportation of natural gas imply that typically there will be a limited number of distribution companies serving each market. Moreover, the transmission of gas from wellheads or import terminals to local distribution companies is by and large undertaken by transmission companies of which there are only few altogether and each of which is a virtual monopoly in its region. In some countries, like the Netherlands and Belgium, there is one company controlling the national gas transmission network. In Germany there are 8 regions with 8 different transmission companies. The largest, Ruhrgas, has shares in three of the others, and more important, it controls the national transmission network. This makes Ruhrgas a dominant firm in Germany. In all other countries there is one dominant firm. With the exception of recently privatized British Gas, they are national, partly state owned monopolies. (For a more detailed overview, see Bundgaard-Sørensen and Hopper (1988))

3. AN OPEN, INTEGRATED AND SINGLE EUROPEAN GAS MARKET?

A repeated issue in recent discussions of the European gas market is the need for major structural changes in institutions and contractual arrangements. The discussion has been spurred by recent developments in the North American gas market and also by confronting the current market structure with the trade principles of the European Community (EC). The latter aspect has been emphasized, in particular, with reference to the intention of the EC Commission to remove all trade obstacles and bring the the open market into full effect by 1992. Applications of these principles to the natural gas markets have been referred to as "open access", "common carriage" or the "common carrier principle".

Critical observers of the European market have for many years argued that the prevailing market structure and market arrangements allow for exorbitant rents both to producers and to transmission companies, and that the high end user price that follows has severely limited the expansion of the market and resulted in underutilization of transmission capacity. A recent statment by a long time critic is Odell (1988) who blames the "club" of companies led by people of "limited horizons": "Thus in the Western European gas market today there is the double irony of under-exploited supply potential and an underdeveloped market. The misconceptions over gas supply and gas markets are, moreover, not simply allowed to persist by the powerful club of gas transmission and distribution companies/institutions (some state and some private). They are deliberately encouraged by them...Their management principal objective ...appears to be to find guaranteed long term supplies just adequate to meet their predetermined calculations of markets which have been chosen in such a way that they do not have to worry much at all about competition from alternative energy sources. The strategy overall reflects a 'satisficing' approach by management which is anxious to be seen doing a technically excellent job, but which has no stomach to accept the challenges and to respond to the opportunities of a competitive approach to Western Europe."

The discussions of reform centered on the common carrier principle[3] have received strong and articulate opposition from the "club" members. Ruhrgas board member B. Bergmann (Bergmann (1988)) argues that "the current healthy state of the European gas markets is due to careful long term planning and financing by national gas monopolies and large integrated companies, and that enforced common carriage would wreck havoc with gas company planning." Another statement from a similar source says that "the present system and gas supply in Europe is sufficient and that any move to modify the present strucuture by introducing throughout Europe a blanket obligation on gas companies to transmit gas for third parties would undermine security of supply, cause uncertainties in the market, and be detrimental to the interests of the end users."

The vehement reaction of the transmission companies towards a change in the rules of the game in the direction of common carriage is embedded in a set of arguments of why the North American development cannot be applied to Europe. It is argued that the common carrier principle is incompatible with the current reliance on take-or-pay import contracts

[3]There may be a distinction between "common carriage" and "open access" - the first implying the obligation to carry a shipment of gas, while the latter is the weaker obligation to carry the gas in the case of idle capacity on a first come-first serve basis. In this paper we use the two expressions synonymously for the weaker obligation.

and that a change in existing contracts cannot be enforced because in Europe there is no authority corresponding to the Federal Energy Regulatory Commission able to exert regulatory powers over all parties. Furthermore, it is argued both that common carriage would endanger the energy supply security of Western Europe and that common carriage would leave small distribution companies as easy victims of take-overs and thus result in strengthened monopoly/monopsony power rather than the opposite.

As stressed above, the transmission companies are in a strong position vis-a-vis the producing companies and control almost completely the access to end users. The producing companies can at most try to make the most out of dealing with more than one transmission company. The end users on the other hand are facing a monopoly in almost all regions. The transmission companies are thus monopolists and oligopsonists as they seem to work well together and share common views in policy matters. They are also tied together to some extent through joint ownership. On the other hand most of them have been organized on a public utility basis with government participation or working within the limits of government concessions. Thus, they may not exploit their monopoly position to the limit.

The position of the EC Commission as to what the common carriage means and how it should be implemented for the gas market is by no means clear. Various documents by the European Commission describe and discuss the problemes concerned, which may be outlined as follows

- harmonization of taxes and prices and the obligation to publish distribution tariffs and prices of individual contracts (price transparency)
- open access to the national and international pipeline systems, ie. the obligation to allow the gas suppliers to carry any volume of gas to a "third party" (end user). This principle of common carriage means the end of a system of national monopoly for gas transmission companies as retailers of gas.
- abolition of prevailing obstacles to free competition between different fuels for electricity generation. Important is the banning of gas burning and protection of nuclear and domestic coal in some markets.

The European Community has not come out with an official position in these matters yet, but several documents indicate that EC officials lean in favour of open access and other measures to promote competition in European energy markets. While efficiency considerations and the general principles of the European Community clearly favour reform of the prevailing market structure, it is still difficult to guess the final outcome of the political handling of this problem within the EC. The political authoritites of the EC has not shown a strong interest in promoting competitive energy markets until recently. The EC Council has i.a. prohibited any further use of natural gas in government owned power plants. Underlying this regulation, which clearly has to go if gas markets are to become more competitive, is the protection of domestic energy sources in the respective EC countries: coal in the United Kingdomn and the Federal Republic of Germany and nuclear power i France and Belgium. Another argument used by the transmission companies which may or may not impress the EC politicians, is - in B. Bergmann's words - that it would be foolish to "weaken the position of West European gas companies in their negotiations with suppliers outside the European Community". This is, of course, nothing but a protectionist argument.

Consumers, independent producers and regulators have common interests in looking for policy means to enforce more efficient ways of trading and transporting natural gas within

Europe.
For Statoil and other large producers it seems clear that they do not have the same interest in holding onto the take-or-pay contracts as the transmission companies. The lower prices since 1986 have created greater interest in raising additional revenue by finding outlets for supplementary gas resources, maybe to the extent of trading the apparent security of the take-or-pay contracts against the possibilities of direct contracting with end users and local distribution companies opened up by the common carrier principle. High cost producers with fields that would not have been developed under more competitive conditions, stand to lose in a more competitive market, however. Statoil's position is clearly vulnerable from a cost point of view, especially if the Glasnost thaws away any political limit set on Soviet supplies. Statoil's control over the entire Norwegian production and transportation to the Continent and the United Kingdom gives the company considerable flexibility in its marketing. In a recent statement on the development of the European gas market, the common carrier principle etc, the head of Statoil, Mr. H. Norvik, voices his concern "that the outcome of these deliberations in the Community will be based on a deep understanding of how the gas markets function in Western Europe and take account of the need for a market structure which supports the ability to undertake the long term investments particular to the gas industry".

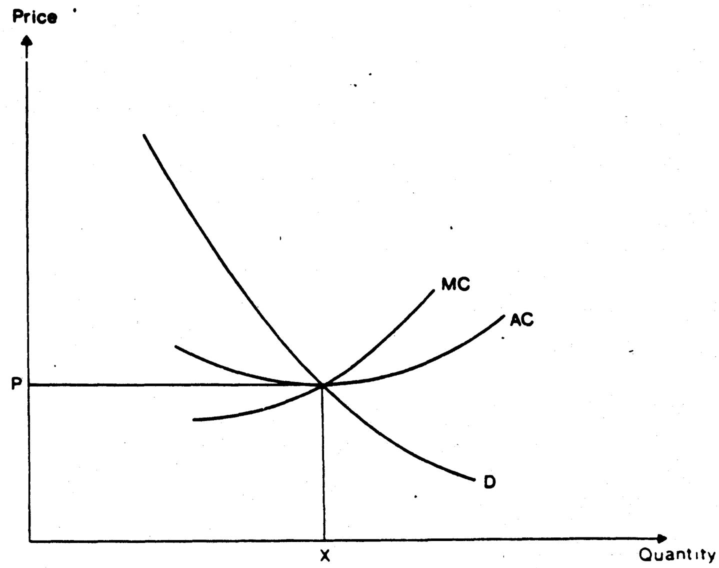
In the further discussion we shall first have a look at the common carrier principle within a simple static framework.

Static equilibrium theory applied to the European gas market

In a competitive market of an "ordinary" good the equilibrium price is defined by the intersection of a downward sloping demand curve representing the aggregate marginal utility schedule of many small consumers and an upward sloping supply curve representing the aggregate marginal cost of production schedule of many small producers. The equilibrium price is thus equal to marginal cost. The total net benefit accruing from the consumption of the good is split between "consumers' surplus" falling to the consumers and the "profit" of intramarginal producers. In a long term equilibrium intramarginal profit is eliminated by competition and the market equilibrium is depicted by the wellknown textbook figure 3.1 showing the intersection of the demand curve (D), the marginal cost curve (MC) and the average cost curve (AC). By the fundamental theorem of welfare theory the competitive equilibrium is necessary and sufficient for efficient allocation of resources in the absence of externalities (in a wide sense), but only if all other markets are in similar equilibrium. We take these textbook commonplaces as our starting point in discussing the peculiarities of gas production and trade in Western Europe.

The European gas market differs in almost every respect from the textbook paradigm except that also in the gas market there are a large number of small consumers. Let us point out the differences of greatest importance for our discussion with reference to the overview of the gas market given in section 2. As mentioned there, due to resource scarcity in the supply of natural gas different producers will have differing marginal costs, not only as a transient phenomenon to be eliminated by competition, but as a permanent feature. Intramarginal profit will thus not be eliminated by competition. Second, increased production over existing production capacities will typically be made available by large scale investments in development of new fields. And third, the number of producers is relatively small, which raises the question of imperfect competition. i.e. the producers ability to capture more than their fair share - as defined by perfect competition - of the total value of the gas produced.

Figure 3.1: The long term equilibrium of a competitive market for a reproducible good.



The transportation and retailing of natural gas are again very different from the corresponding services of "ordinary" goods, for which these aspects usually are left out of the analysis of market equilibrium, as being rather inessential. Technologically, we have the textbook case of a "natural monopoly", i.e. downward sloping average cost curves in the distribution of natural gas. Increasing returns may be caused by underutilization of capacity because of indivisibility, by lumpiness of investments as new projects are large relative to the size of the market, or by other technological reasons. The increasing returns in distribution could even outweigh decreasing returns in production. The presence of increasing returns to scale is obviously of major importance for the present state of the market. The end users are in practice constrained to purchasing from only one company, have no possibility of storing the commodity, and have thus no way of counteracting price discrimination between end users.

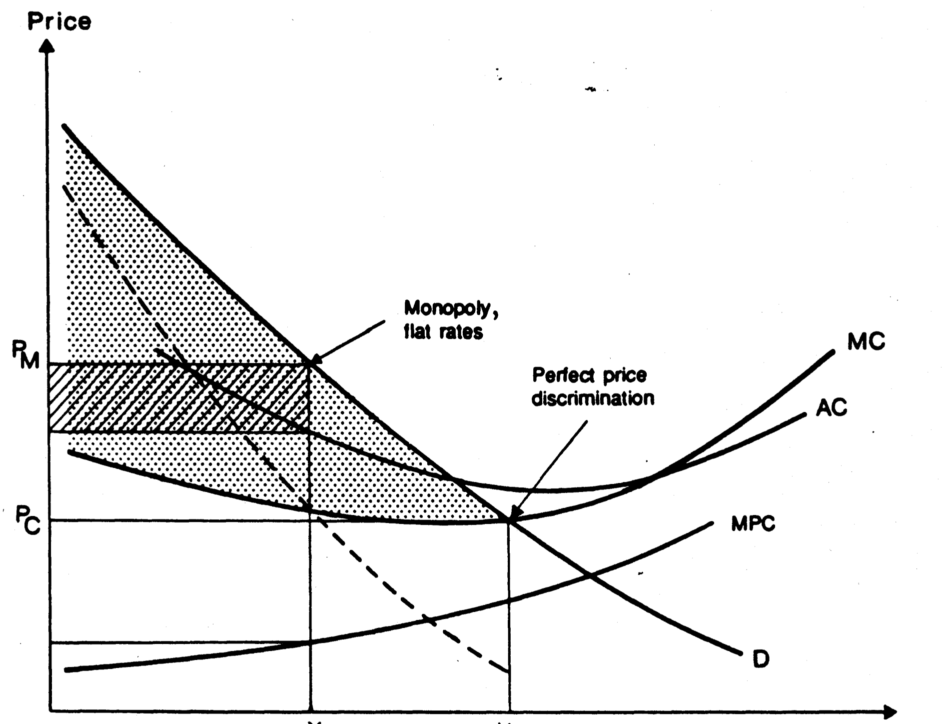
The specific features of the gas market lead to various kind of <u>rents</u>. We have already mentioned the <u>resource rent</u> accruing from the exhaustible nature of gas resources. The small number of agents producing and trading gas together with the elements of increasing returns may lead to <u>monopoly rent</u>. (If increasing returns prevail, one may have monopoly rent with zero profit.) Finally, the lack of arbitrage possibilities for end users allow <u>rent from price discrimination</u>, which in principle could amount to capturing the entire consumers' surplus.

We shall illustrate the solution in the gas market with and without regulations in a static stylized setting, with competitive conditions in production, but with a transmission monopoly. In figure 3.2, the MC-curve represents total marginal cost and the MPC-curve marginal production cost. Marginal transmission cost (MTC) is hence represented by the difference between the two curves. MPC is everywhere increasing. Where MC is less steep than MPC there are increasing returns in transmission. The curve AC is the sum of MPC and the average cost of transmission. The vertical distance between AC and MPC diminish, which means increasing returns to scale in transmission of gas. The demand curve is D, while marginal revenue is indicated by the curve MR. For simplicity it is assumed in the figure that the transmission company buy gas at competitive conditions from producers. The optimal sales volume from an overall efficiency point of view is at the intersection of the marginal cost curve and the demand curve.

A transmission monopoly free to discriminate between end users (discriminating monopoly) will in theory generate exactly this solution. The tariff structure can be designed to capture the entire consumers' surplus (gas should be offered to consumers at declining tariffs corresponding exactly to their willingness to pay). The tariff will charge each end user the same optimal marginal rate. This holds whether the monopoly owns the gas it transports or not. This hypothetical situation is depicted in figure 3.2, yielding the equilibrium quantity x_C. Since the efficiency volume is realized, there is thus a certain rationale in an unconstrained transmission monopoly. The marginal price paid by the consumers is p_C, while the average price is higher. Compared to the competitive equilibrium, the consumer surplus (the shaded area) is transferred to the transmission companies.

In practice, a transmission monopoly will not be able to apply a perfect discrimination of end users. It will rely on flat rates, at least for larger market segments, and take its profit from monopolistic rates and restricted volumes rather than perfect discrimination. The other extreme is thus no discrimination, but monopolistic tariffs. This situation, which is that of a textbook monopoly, is also depicted in figure 3.2. The monopoly solution has price p_M and sales volume x_M. In a fully exploited monopoly situation as drawn here, the average cost of transmission is smaller than the transmission companies' margin, which means a positive monopoly rent.

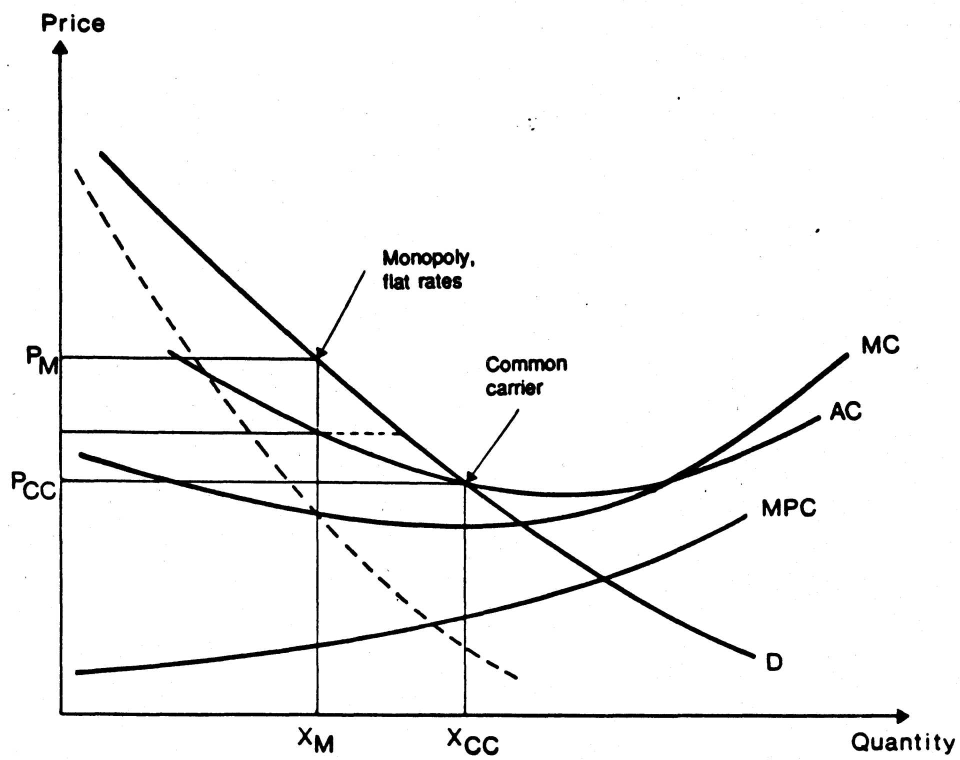
Figure 3.2: Market solutions for a transmission monopoly.



The common carrier principle can be taken to mean access to the use of the transmission pipeline at current average costs, i.e. the costs corresponding to the volume x_M in figure 3.2. Producers and end-users would then have a margin of mutually beneficial trades. Market forces could then be relied on to bring the end-user price down until it equals AC. This new situation is depicted in figure 3.3, where the "common carrier" equilibrium is given by price p_{CC} and sales volume x_{CC}. This is still a higher price and lower volume than the (unobtainable) competitive equilibrium given by price p_C and volume x_C. The main point is, however, that the move from p_M to p_{CC} reduces transmission cost. The transmission companies' surplus vanishes, and the transport tariff is reduced to average transmission costs.

Based on this stylized theoretical framework we conclude that common carriage may lead to higher volumes traded and more competitive behaviour in the gas market (See also the discussion in Hurst (1988)). There are, however, other ways of regulating the transmission monopoly. One is by forcing the transmission monopoly to set its rates on a traditional public utility cost-of-service basis. This will result in pipeline tariffs set at average costs and theoretically lead to the same result as common carriage. Another way is by direct regulation of end user prices towards the same equilibrium solution. The latter alternative combined with common carriage may be the right remedy to speed up adjustment in a transient phase of an underdeveloped market. Increasing oil prices as might result from the recent OPEC accord might help in this respect.

Figure 3.3: Market solution with common carrier



What then about the claim that common carriage will simply transfer monopoly power and benefits from the transmission companies to producers of natural gas? Clearly, one cannot disregard the possibility that producing companies will take advantage of the new situation and try to capture a part of the consumers' surplus by price discrimination. However, as pointed out in section 2 there are several potential suppliers to the European market, each having significant reserves, and in an open market there are thus reasons to expect strong competition over market shares. We will return to this in section 6.

In the arguments of the transmission companies of defending the present intstitutional settings, there seems to be a stubborn resistance towards accepting what is perhaps the most important lesson from the market reforms in United States, namely that the "natural monopoly" of gas transmission companies does not prevent competition provided that open access to the pipeline system is enforced. Typically, occurrences of considerable increasing returns to scale are indications of "immaturity". A downward sloping cost curve will by increasing demand sooner or later flatten out. The distribution of natural gas in Europe is, therefore, in our view still in an immature stage and largestimated er gas volumes traded and transported will bring the average unit costs down.

It should also be mentioned here that the United Kingdom has already enforced the common carrier principle. This was introduced in the Oil and Enterprise Act of 1982 and later extended in the Gas Act of 1986. The United Kingdom is a special case, however, both because it is a separate subsystem of gas supply as long as there are no pipelines across the Channel and because of the privatization of the British Gas Corporation. The common carriage is a part of the regulation of the privatized BGC, as are also various transparency regulations on the public access to contractual prices and tariffs.

Existing take-or-pay contracts may, of course, prove less profitable for producers as well, as a consequence of "third parties" entering the market with new deliveries. In particular, contracted gas from high-cost fields may suffer from the fact that they have been developed too early.

4 THE OUTLOOK FOR THE EUROPEAN NATURAL GAS MARKET.

> *"The horizon for natural gas in Western Europe is not, at the present time, overshadowed by clouds.", B. Bergmann(1988)*

What is the potential for future gas demand in Western Europe? We shall answer this by surveying a selection of recent projections for natural gas demand. Here, we have built upon the rather detailed overview of scenarios reported in Estrada et al (1988), and in addition we have looked more closely into the forecasts made by the International Energy Agency (IEA (1988)) and Purvin & Gertz (1987). The main emphasis will be on the evolution in existing major markets for natural gas. The main reason for this is that in section 6 the projections will be compared with simulations on an econometric model which, naturally, is calibrated on the existing market structure.

Some of the basic assumptions underlying the projections surveyed, supplemented with our own interpretations of implicit policy related issues, are briefly discussed below.

4.1 General conditions and assumptions.

(i) Limited scope for demand growth.

While the supply situation for Europe is rather abundant, there are some indications that the penetration of gas in the market is restricted by institutional barriers and the presence of a certain degree of monopoly power in the gas industry, and in particular in the national transmission companies. In the following, we assume that the projections surveyed share this consensus view; i.e. they take the present institutional settings of the gas market as given. This in turn may be important in explaining why the projections point to rather limited growth in gas demand. A critical discussion of the projections will be carried out in section 6.

(ii) The transmission and distribution system.

In coherence with the arguments under (i), the projections do not foresee any strong expansion of the distribution system for natural gas. With rather low population and energy densities in new potential markets and high costs in building new pipelines, a further expansion of the network may seem too costly to transmission companies under present institutional conditions.

(iii) Irreversible energy savings.

A common view among energy analysts is that after the oil price shocks in the 1970s, "energy projections will never again be the same" (Bergmann (1988)). In other words: even though prices have returned to a lower level, it is highly unlikely that we once again will experience growth rates in energy demand as we did in the sixties and seventies. The reason is partly that a large part of the energy savings that have occurred in the last decade is irreversible (see e.g. Schipper and Ketoff (1985)) and partly that however low energy prices fall, the expectations about future prices will be different from pre 1973. Low energy prices may thus prevent substitution away from energy to continue at the same rate, but old energy intensive technologies will not return to the arena.

(iv) Economic growth and energy structure.

Projections of energy demand in Europe are typically based on assumptions of moderate economic growth, say in the range of 1.5 - 2.5 percent per year. Moreover, in all countries total energy demand is assumed to increase more slowly (0.5 - 1.5 percent per year). Energy conservation is thus believed to lie around 1 percent on average in the projection period, in spite of the lower energy prices. An important explanatory factor for a projected decline in energy intensities is a continued trend of reduced weight for energy intensive industries in Western Europe.

(v) Prices and energy competition.

The degree and form of competition between natural gas and other fuels varies from sector to sector, and also to some extent, from country to country. In the residential sector, the traditional competitive fuel is fuel oil, with electricity playing an increasingly important role as a substitute fuel in some countries, such as France. In the industrial sector, LSFO (low sulfur oil) is the main substitute fuel, while in electricity generating, oil (HSFO or LSFO) and coal still dominate as heating fuels.

IEA's latest projections are based on the following scenario for the crude oil price: after a couple of years with prices below 20 US$/barrel, crude prices start to rise again from 1989/90 and reach a level of around 25 US$ in 2000. On average, this coincides roughly with the underlying assumptions of Purvin & Gertz. Due to differences in tax system and the overall energy policy, some differences between countries and sectors are expected. For most countries, it is foreseen that prices on heavy fuel oil to industry and power generation will increase relatively more than prices on gas oil to the residential sector.

The price path for coal is generally assumed to be favourable, i.e. show minor growth compared to prices on other energy carriers. The background for this picture is that domestic energy policies are likely to continue to promote the use of European coal reserves, both in industry and in power generation. However, regarding the future of coal, a big question mark is how environmental aspects will affect energy demand.

Electricity prices are assumed to show considerable variations between the various countries. France can safely be placed in one corner; with its strong nuclear programs and coal dominating among fossil fuels, electricity prices are expected to be kept low and outcompete other energy sources. Thus, Purvin & Gertz assumes constant real prices throughout the simulation period (until 2010). In other countries such as Italy, the Netherlands and Belgium, prices are assumed to reamin high and largely prevent electricity to penetrate into new applications and end uses.

(vi) Some sector specific features.

According to most demand projections, in the residential sector several factors are favourable for experiencing further growth in gas consumption. First, during the last decade the local distribution network has been expanded to cover new consumer groups of households. The shares of households living in "gas areas" according to table 2.2 significantly exceed the corresponding shares of dwellings actually applying gas for heating and other end uses. Accordingly, there should be scope for aditional "hookups" to the gas grid. However, the definition of availibility as measured by the figures in table 2.2 may lead to overestimation of the potential of new customers. To be located in a "gas area" simply means that there is piped gas available somewhere in the neighbourhood. To have an actual gas outlet in a dwelling may require additional investments by the local distribution company, in addition to the hookup costs paid by the individual household.

Second, in existing markets for gas forecasters generally foresee a prolonged strong position for gas as the primary fuel choice both in new dwellings and when old fuel systems are replaced. In recent years, gas has been installed in one out of two new dwellings in United Kingdom, Germany and Italy. Based on simulations on a formal model for space heating Bartlett, Olsen and Strøm (1988) estimate the isolated effect of new dwelling fuel choices on the 1985-2000 growth in gas demand to 22 percent. Also, according to Bergmann (1988), the total number of gas heated dwellings in Western Europe may increase by 15 million to

55 milion at the turn of the century.

Third, there is a general trend in the direction of increased share of central heating in the dwelling stock in many countries (see Bartlett et al, op. cit). In such systems, natural gas is convenient due to ease of control and no need for storage facilities in the individual dwelling.

In the industrial sector, the demand horizon for gas is in the direction of moderate growth, matching the projected increase in total energy use in the sector. According to Purvin & Gertz, most of the increase in industrial demand stems from increased need for gas for steam raising, while only minor changes are expected for the inputs of gas for direct heat and feedstock.

Traditionally, large energy intensive industries have typically bought firm gas directly from the transmission companies. From the industry's point of view, long term contracts of delivery may be advantageous since large investments usually are involved. For the transmission company, contracted gas deliveries were similarly necessary for them to engage in the construction of infrastructure and pipelines. After the market segment for natural gas has been broadened to include smaller industrial consumers, interruptible contracts have become more common. A high fraction of the latter type of deliveries, combined with flexible energy technologies probably stimulates demand in an environment where there is a slight price advantage for gas in the market.

In the electricity generating sector, in addition to environmental issues, the future of the nuclear industry constitutes a major uncertainty. As mentioned above, the nuclear programs in France are assumed to be almost unaffected by the Chernobyl accident. In some of the other countries, e.g Germany and Italy it is more likely that there will be at least restrictions on the further expansion of nuclear power stations. This may create new possiblities for natural gas as a fuel in this sector. On the other hand, in both these countries gas meets severe competition from coal, and especially in Italy the long term prospects for gas as feedstock in power generation are believed to be rather poor.

4.2 Demand projections for Western Europe.

Table 4.1 presents ranges of estimates for the future demand for natural gas in the major consuming countries in Western Europe, distinguishing also between different market segments. For these countries taken together, gas consumption in 1986 amounted to 178 mtoe. This constituted close to 19 percent of primary energy consumption in this group of countries, and covered more than 94 percent of total gas demand in Western Europe this year.

It is seen that a combination of the most pessimistic scenarios implies that total gas consumption will decrease and remain flat at a level of 166-167 mtoe, which may be compared to the estimated consumption of 178 mtoe in 1986. Along the upper path of the projection ranges consumption ends at 222 mtoe (2010), which represents an average yearly growth of 0.9 percent. Even this may be characterized as rather moderate compared to the historical evolution of the European gas market, as presented in section 2. The increase in total gas consumption is on average assessed to be somewhat stronger until 2000, and the following flattening in demand may be interpreted as reflecting a saturation of the market.

As mentioned above, according to the majority of the scenarios, there is still a significant potential for growth in the residential sector in Europe. The bulk of estimates for this market segment is thus rather close to the upper limit of 122 mtoe in Table 4.1, meaning an annual increase in consumption of about 1 percent. In particular, the strong expansion of the pipeline system in countries such as the FRG and Italy involves possibilities for further penetration of gas. In the more saturated residential markets in the Netherlands and the United Kingdom, the development is more likely to be characterized by slower growth. In the latter country, a decrease in the energy intensity in new homes due to better insulation standards may counteract a continued increased market share for gas in the dwelling stock. The projections for the industrial sector are in general evaluated as more uncertain. The future growth in gas demand is highly dependent on overall economic conditions, such as the development in aggregate production, its composition between different sectors and energy subsitution. Thus, if one should trace a path for expected future industrial gas demand, this would probably be more in the center of the presented interval compared to the picture for the residential sector. On the other hand, the figures in table 4.2 clearly demonstrates the possibility, as seen by some forecasters, of renewed growth in the industrial market in the range of 2 percent per year. A driving force underlying such an optimistic development is likely to be a strong substitution away from fuel oil in the manufacturing sector. The prospects for increased growth in these industries seem most promising in the FRG.

TABLE 4.1 European gas demand*), 1986-2010. Mtoe.

	1986	1990	2000	2010
GERMANY	39.2	41.5 - 45.7	40.6 - 50.4	43.1 - 56.5
Residential/comm.	19.2	20.3 - 22.0	19.7 - 24.4	23.3 - 28.5
Industry	14.3	17.2 - 19.0	16.4 - 21.0	16.4 - 23.0
Power gen.	5.7	4.0 - 4.7	4.5 - 5.0	3.4 - 5.0
FRANCE	24.8	24.8 - 26.9	25.5 - 31.5	25.9 - 34.7
Residential/comm.	13.4	14.0 - 14.5	14.7 - 17.3	15.1 - 19.2
Industry	11.0	10.8 - 11.9	10.8 - 13.7	10.8 - 15.0
Power gen.	0.4	0.0 - 0.5	0.0 - 0.5	0.0 - 0.5
UNITED KINGDOM	43.1	40.2 - 45.9	38.8 - 50.8	39.2 - 53.8
Residential/comm.	30.8	28.4 - 31.0	27.2 - 33.5	28.0 - 35.3
Industry	11.8	11.6 - 14.0	11.6 - 15.7	11.2 - 16.9
Power gen.	0.5	0.2 - 0.9	0.0 - 1.6	0.0 - 1.6
ITALY	28.4	29.3 - 35.2	31.1 - 38.1	29.4 - 36.1
Residential/comm.	12.5	13.4 - 15.2	15.1 - 17.2	15.9 - 18.2
Industry	10.4	11.6 - 12.0	12.1 - 13.9	12.5 - 15.4
Power gen.	5.5	4.3 - 8.0	3.9 - 7.0	1.0 - 2.5
NETHERLANDS	32.5	23.8 - 33.5	22.5 - 30.6	22.8 - 30.7
Residential/comm.	15.8	12.1 - 15.5	11.6 - 14.7	11.2 - 14.8
Industry	8.0	6.9 - 9.4	6.9 - 10.3	6.9 - 10.7
Power gen.	8.7	4.8 - 8.6	4.0 - 5.6	3.7 - 5.2
BELGIUM/LUX	6.7	6.8 - 8.2	7.9 - 9.6	7.3 - 10.1
Residential/comm.	3.9	3.9 - 4.7	4.7 - 5.8	4.3 - 6.1
Industry	2.5	2.6 - 3.1	3.2 - 3.5	3.0 - 3.7
Power gen.	0.3	0.3 - 0.4	0.0 - 0.3	0.0 - 0.3
TOTAL GAS DEMAND, MAJOR MARKETS	174.7	166.4 - 195.4	166.4 - 211.0	167.7 - 221.0
Residential	95.6	92.1 - 102.9	93.0 - 112.9	97.8 - 122.0
Industry	58.1	60.7 - 69.4	61.0 - 78.1	60.8 - 84.3
Power gen.	21.1	13.6 - 23.1	12.4 - 20.0	8.1 - 15.1

*) Eksclusive own losses and statistical differences.

The most striking trend in the gas market according to the reported projections, is the decline in the use of gas in electricity production. The only "disagreement" is the strength and speed of this reduction. As mentioned above, this expected downward path for gas use is a result of planned restructuring of the electricity industry in many countries. In Italy there are official programs for reducing oil import. This may give natural gas a push, also for increased use in power generating. However, in the 1990s, most forecasts expect a marked decline in the gas share in this sector, and improved positions for coal and nuclear energy. A similar scenario may be drawn for the Netherlands. However, as stated already, worries regarding security problems in nuclear plants and environmental issues, create great uncertainty regarding the future development for natural gas in the power sector.

4.3 New markets for natural gas?

Even though natural gas has penetrated the European market rapidly since the late 1960s, there are still several countries which either do not consume gas at all or where the market share of gas is relatively small. In addition to the countries included in our discussion above, the most significant gas users in Western Europe in 1986 were Austria and Spain[4], with total consumption figures of 4.4 mtoe and 2.7 mtoe respectively. In particular for the latter country, many analysts expect a significant growth in demand. This will partly come through increased LNG imports from Algeria, and partly through new pipeline systems connecting the national distribution system to the Western European grid via France. It should also be noted
that Spain already has established some of the necessary local distribution of natural gas, as many cities have been served with manufactured gas for several years. In Austria, the further expansion of natural gas is expected to be restricted by competition from other fuels, especially electricity.

Another interesting question is whether new markets for natural gas will develope in the future. Some claim that, especially with the presently low price environment, one may doubt whether anybody will find it beneficial to take the high costs of stretching pipelines to new markets (Bergmann (1988)). On the other hand, it is generally accepted that if gas got a foothold in a new market of some size, due to the econonmies of scale in transportation, there will be significant potential for future growth. In the south of Europe, Turkey may be such a case, where a new pipeline system is under construction to enable imports from Soviet Union. Recent estimates for gas demand in Turkey in 2000 is in the range of 3.9 - 6.5 mtoe per year (Estrada et al (1988)).

In the Northern part of Europe, there has been a heavy debate in recent years on the possibility of developing a Scandinavian market for natural gas. Some consumption already exist in Denmark, Sweden and Finland (3 mtoe in total). There are basically two issues that form the background for the recent discussion on an expanded gas market. One is the presence of huge Norwegian reserves of natural gas at the continental shelf, some of which has no other practical application than being used domestically or exported to Sweden or Denmark. The other important event actuating gas in the Scandinavian energy markets is

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4 If we include Yugoslavia to the Western hemispher, this should also be added to the list of significant users.

the Swedish decision that the country's twelve nuclear plants are to be phased out within 2010. This development may even be accentuated by the Chernobyl disaster in 1986.

The general view is thus that Sweden is a key country when discussing the future potential for gas in this region. Most likely, the Swedish electricity generating sector will need significant volumes of imported gas when we are approaching 2000. Natural gas is by the authorities pointed out as a favourable, and relatively "clean" alternative fuel. The distribution company Swedegas expects a level of consumption above 2 mtoe per year in the second half of 1990s, increasing further to somewhere in the range of 4 - 6 mtoe when the distribution system has been fully expanded.

Depending partly on the development in Sweden, one may also see further penetration of natural gas in Finland (with present consumption at 1.4 mtoe, and with expressed interest in having the Swedes sharing the costs of new transmission lines from Soviet Union) and in Norway, where gas utilities have been proposed as a supplement to the existing large capacity of hydro-power. Some large Norwegian manaufacturing industries have also expressed their interest in using gas as feedstock, while due to the extensive "electrification" of the economy, the prospects for gas penetrating in the residential market are rather poor. Altogether, 1 - 2 mtoe has been suggested as a reasonable estimate of gas consumption in Norway.

Denmark has easy access both to the continental gas grid and to deliveries from the North Sea. For this country as well, the best prospects for expanded gas use is in the power generating sector. Some deliveries (1.5 - 2 mtoe) to this sector are already contracted for the early 1990s. As for the other Scandinavian countries, both in the industrial sector and in households gas will meet strong competition from electricity. However, an interesting issue in the energy market in Denmark, as well in Sweden, is the penetration of district heating systems, especially in new dwelling areas (estimated to take 35 and 30 percent respectively of the new homes market in 1984). This development may represent an additional opportunity for natural gas as a primary heating source in the residential sector of these countries.

5. A PRICE/NETBACK ANALYSIS OF MARKET SEGMENTS, AND THE EFFECTS OF NON-DISCRIMINATING PRICING.

As mentioned in section 3, gas transmission companies may be regarded as natural monopolies. The majority of the companies are controlled by the governments, and even those that are privately owned, operate under government concessions. The behaviour of gas transmission companies may be that of a non-discriminating monopoly, discriminating monopoly, non-discriminating public utility or a mixture of the three. In this section we attempt to throw some light on the profitmaking behaviour of the transmission companies by presenting figures on prices paid by different consumers and costs and profit margins in the transportation of natural gas. To the extent the analysis reveal a positive netback to distribution companies and/or price discrimination, it is an indication of the use of monopoly power.

The netback analysis is carried out for the Federal Republic of Germany, France and the United Kingdom. For each of these countries, we distinguish between three market segments: households/commercial, industry on firm supply contracts and industry on interruptible contracts. Eurostat (1988) provides data on gas price for end users of different yearly offtakes in the first two sectors. For households, we have chosen a weighted price corresponding to a 125.6 GJ per year consumption level. For firm industries, the price for an offtake at 418600 GJ per year is used. For interruptible industrial deliveries, the price of heavy fuel oil is used in the calculations.

The cost figures are collected from Purvin & Gertz (1987). There, the following cost components are specified and estimated:

i) Town distribution (assumed zero for industry)
ii) National transmission, including storage costs
iii) Import price (cif)
iv) Value added tax on the components above (assumed zero for industry)

Subtracting the components i)-iv) from the end user price, gives the corresponding net profit margin or netback to the transmission company. Estimates of distribution costs and netbacks for two years, 1984 and 1987, are reported in table 5.1. These estmates are in the middle of the range reported in table 2.4. In the same table, we present calculated "unit cost prices" for each user group, defined equal to the estimated total unit costs of delivering gas.

TABLE 5.1: Netback to gas distribution by sector, 1987US$/mill. BTU

	Household/Commercial			Industry, firm contracts			Interruptible contr.	
	1984	1987	avg(80-87)	1984	1987	avg(80-87)	1984	1987
GERMANY (FRG)								
End user price (4)	12.36	7.89	11.87	9.10	5.87	8.43	7.38	3.01
VAT	1.52	0.97	1.46	0.00	0.00	0.00	0.00	0.00
Town distribution (2)	2.34	2.34	2.34	0.00	0.00	0.00	0.00	0.00
National transmission (2)	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Import price (cif)	5.12	2.44	4.47	5.12	2.44	4.47	5.12	2.44
Netback	2.54	1.31	2.76	3.14	2.60	3.12	1.42	-0.27
Total unit cost (3)	9.46	6.40	8.72	5.96	3.28	5.31	5.96	3.28
Premium factor (1)	1.05	1.41	1.13	1.23	1.95	1.45	1.00	1.00
FRANCE								
End user price (4)	12.74	9.63	11.80	6.53	3.86	6.11	7.75	2.86
VAT	2.00	1.51	1.85	0.00	0.00	0.00	0.00	0.00
Town distribution (2)	2.33	2.33	2.33	0.00	0.00	0.00	0.00	0.00
National transmission (2)	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Import price (cif)	5.33	2.18	4.23	5.33	2.18	4.23	5.33	2.18
Netback	2.21	2.74	2.52	0.33	0.81	1.01	1.55	-0.19
Total unit cost (3)	10.12	6.38	8.81	6.20	3.05	5.10	6.20	3.05
Premium factor (1)	0.90	1.09	0.92	0.84	1.35	1.07	1.00	1.00
UNITED KINGDOM								
End user price (4)	7.20	6.67	6.82	5.46	5.12	5.41	6.28	3.05
VAT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Town distribution (2)	2.43	2.43	2.43	0.00	0.00	0.00	0.00	0.00
National transmission (2)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Import price (cif)	4.04	2.92	3.59	4.04	2.92	3.59	4.04	2.92
Netback	-0.17	0.42	-0.10	0.51	1.30	0.93	1.33	-0.77
Total unit cost (3)	7.37	6.25	6.92	4.94	3.82	4.49	4.94	3.82
Premium factor (1)	0.72	1.19	0.86	0.87	1.68	1.26	1.00	1.00

Notes: (1) Ratio of gas price to alternative price, here LFO in household and HFO in industy sector. (2) Source: Purvin & Gertz (1987). (3) Total unit cost = import price + town distr. + national distr. + VAT (4) Source: Eurostat (1988)

The table shows quite significant netback margins and price differentials. In the FRG, the highest netbacks are calculated for firm industrial deliveries, while margins for interruptible contracts are rather small. The margins generally decreased from 1984 to 1987. End user gas prices declined less over these years than fuel oil (premium factors increased). Thus, in spite of the squeeze in margins, gas lost competitiveness against fuel oil, especially heavy fuel oil, but closed the gap to coal prices. - In the United Kingdom, netback margins in households and smaller industries were negative in 1984, but turned positive in 1987 after the import price plummet. The pricing policy tends to be slightly in disfavour of large industrial users, but also industry netbacks were much lower than in Germany. The calculated figures for the United Kingdom indicate that British Gas kept low prices and let a part of the gas rent be passed on to the consumers before 1987. The decrease in gas prices in 1986/87 has been relatively less. -- As opposed to the other two countries, in France the estimated netbacks are highest for the group consisting of households, commercial and other smaller industries. Based on these figures, Gas de France seems to have had a pricing policy that has favoured larger industries. The margins are at roughly the same levels both in 1984 and in 1987.

To sum up, price differentials between firm industry supplies and other users have been large in France and the United Kingdom, but insignificant in Germany. The German pricing policy seems to have been that of a non-discriminating monopoly squeezing all consumers at the same level, the French policy has discriminated against households and other smaller users, while the British policy has favoured and partly subsidized smaller consumers, probably at the expence of indigenous gas producers.

Interruptible gas cannot be easily compared with firm gas for two reasons. First, interuptible gas can be used to improve capacity utilization of the network, as supplies can be reduced in peak periods and increased in off peak periods ("peak-shaving"). Thus, the average cost of interruptible gas is somewhat lower than indicated in table 5.1. Second, demand for interruptible gas is almost perfectly elastic around HFO prices and inelastic otherwise. Accordingly, from a welfare point of view, the price should not deviate much from HFO prices, which, however, may differ from the price of firm gas deliveries. The optimal supply of interruptible gas on the horizontal part of the demand curve will be decided by the excess capacity in the transmission network.

Obviously, various uncertainties are inherent in the estimated distribution costs. Since import prices are assumed to represent the cost of gas to the transmission companies - if gas can be bought cheaper from indigenous producers, the margins will be underestimated. This may e.g. affect the estimates for the United Kingdom, where British Gas in periods has set indigenous prices below import prices on gas from Norway. Furthermore, a large fraction of the transmission and distribution costs are fixed capital costs. As a result, the unit costs presented in table 5.1 vary with several economic and geographical factors in the various countries and market segments.

How can the calculated profit margins and the actual volumes of natural gas brought to the market place be evaluated in light of the theoretical discussion in section 3? Let us again abstract from most of the problems mentioned above, and concentrate on the stylized, static setting for gas distribution discussed in section 3. Recall again figure 3.3. The average cost in transmission in the current situation generally decreases with the volume of gas transported through the pipeline. If we ignore the possibility of having a perfectly discriminating monopoly (yielding the first-best situation x_C), the observed equilibrium point, for which distribution costs are calculated, is somewhere to the left of the quantity x_{CC}, which yields a zero netback in transmission. Thus, based on the calculated costs and margins a main conclusion is that the volumes of gas in the markets are too small, i.e. smaller than what should have been attainable under more competive market conditions. To evaluate the degree of distortion in the market simply on this kind of information is, however, not possible. To do this in a satisfactory way would have required full information of the various cost and demand functions. That we do not have. In particular, we do not know how close the present market situation is to the point x_M, i.e. where the gas distribution company utilizes its full monopoly power.

What we instead intend to do in the following is to estimate the demand effects of gas prices being reduced from the actual levels to prices corresponding to the calculated total unit costs in table 5.1. If the gas companies reduced prices to this level, gas demand would increase, but still be lower than x_{CC}. So, even though ATC decreases, the distribution companies would still earn a positive margin[5].

To measure volume effects we have used a gas demand model for the European market developed in the Central Bureau of Statistics, called GEM[6]. This model covers all the major gas consuming countries in Western Europe, distinguishing in each between four sectors: households, commercial, industry and power generation. GEM has been simulated for two sets of prices: (1) average 1980-1987 end user prices, and (2) Unit cost prices, as presented in table 5.1. In simulation (1), we have used the same prices in the household and commercial sector, while firm industry prices are applied in the manufacturing sector. Other variables have been kept constant at 1984 level. Gas consumption in the power generation sector have been kept constant throughout the analysis. The model has been run over several years in order to include lag effects and compute long term equilibrium solutions.

The results of these simulations are reported in table 5.2.
According to these calculations, total gas consumption in the FRG (exclusive power generation) would increase by 8 mtoe if gas prices are decreased to unit costs. The gain is largest in the household sector, almost 4,5 mtoe, while demand in the industry sector increases with 2,5 mtoe. - In the United Kingdom, the volume effects are rather insignificant, due to the small differences in actual prices and unit costs reported above. - In

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[5]More precisely, we do not simulate what we believe would be the full effect of open access. Imagine we start out from a point on the DD-curve (fig 3.3) somewhere between X_M and X_{cc}. Assume the price is reduced to the corresponding unit cost level at the AC-curve. We simulate the movement to the corresponding point on the DD-curve at that price level.

[6] The estimation of this model generally produced rather high income elasticities and low price elasticities. This is a very common pattern in econometric demand analysis of the European gas market, and may be explained largely by the fact that gas use has increased rapidly in the observation period, while there have been moderat changes in income and prices. Moreover, elasticities for the industrial sector are obtained from data on firm gas contracts, as data for interruptible deliveries have not been available. This will also tend to underestimate price elasticities for the industry sector as a whole.

France, the total gain of more competitive pricing is 3.5 mtoe, half of which is estimated to take place in the household sector.

It should be emphasized that the losses and gains of table 5.2 are differences in long term equilibrium levels, which will only occur if the price differences are sustained over a long period of time. As stressed above, our constant average cost of transmission and distribution in these caculations tend to overestimate unit cost prices at the new volumes and thus underestimate volume effects. On the other hand, there is, of course, uncertainty related to the estimated cost figures.

Still, the model runs support the argument that current price policies of the gas companies have significantly restricted consumption in countries like Germany and France. The simulations indicate that demand in the three sectors households, commercials and industry in these countries could increase by 10 - 23 percent if more competitive pricing policies were adopted. Lifting the ban on the use of gas for power generation would add significantly to this prospect. Actually, several analysts foresee the best potential for gas in the latter market segment if gas were allowed to compete (Odell (1988), Rogner (1988)). Thus, the current 15 percent market share of gas in Europe's energy market seems far too low.

TABLE 5.2: VOLUME EFFECTS OF UNIT COST PRICING.
GEM-SIMULATIONS. Mtoe.

FRANCE		Households	Commercial	Industry	Total
1 Historical prices 80-87		7.0	9.6	8.8	25.7
2 Unit-cost prices		8.7	10.5	9.6	29.1
Deviation (2-1)		1.7	1.0	0.8	3.5
	%	24.3	10.4	9.1	13.6

WEST-GERMANY		Households	Commercial	Industry	Total
1 Historical prices 80-87		10.1	7.6	13.8	42.0
2 Unit-cost prices		14.5	9.0	16.2	50.3
Deviation (2-1)		4.5	1.4	2.4	8.3
	%	44.5	18.4	17.4	19.8

Both the comparisons between prices and costs and the model runs indicate that gas companies do not maximize consumer surplus, but rather exploit a monopoly position to capture a positive rent. However, it is also clear that the analysis is based on some rather simplifying assumptions. One complication is caused by the fact that there are a limited number of agents on the supply side as well. A realistic description of the gas market should therefore take into consideration the game situation over contracts between large producers like the Netherlands, Norway, Algeria and Soviet on one side and the national gas companies of Western Europe on the other side. The outcome of negotiations may be some kind of sharing of the total rent, arising by deducting real producer and distribution costs from end user prices.

TABLE 5.3 PRODUCER RENTS FOR SELECTED FIELDS, 1987US$/mill. BTU

	Norway Ekofisk	Statfjord	Heimdal	Sleipner	Troll	Soviet Urengoi	New,W-Sib	Algeria Pipe	LNG	Netherl. Groningen
Unit cost	1.64	2.38	3.34	3.20	3.09	3.26	3.61	2.13	3.01	0.49
Producer rent										
1980	1.81	1.07	0.11	0.25	0.35	0.19	-0.16	1.32	0.44	2.96
1981	2.93	2.19	1.23	1.37	1.47	1.31	0.96	2.44	1.56	4.08
1982	3.68	2.94	1.97	2.12	2.22	2.06	1.70	3.19	2.30	4.82
1983	3.32	2.59	1.62	1.77	1.87	1.71	1.35	2.84	1.95	4.47
1984	3.66	2.92	1.96	2.10	2.20	2.04	1.69	3.17	2.29	4.81
1985	4.59	3.85	2.88	3.03	3.13	2.97	2.61	4.10	3.21	5.74
1986	3.07	2.34	1.37	1.52	1.62	1.46	1.10	2.59	1.70	4.22
1987	0.97	0.23	-0.73	-0.59	-0.48	-0.65	-1.00	0.48	-0.40	2.12
Average	3.00	2.26	1.30	1.45	1.55	1.38	1.03	2.51	1.63	4.15

Table 5.3 presents figures that might shed some light on producer rents. The table reports costs of gas (cif.) to a central point in Western Europe for some of the fields exporting to Western Europe[7]. Producer rents are calculated by subtracting these cost figures from (cif.) import prices. The figures show that up to 1986, all producers had a positive margin. The data thus indicate that the gas contracts are designed to share rents between producers and gas companies.[8] In 1987, import prices had come down below the break even level for some of the most important exporting fields like Norwegian Heimdal, Algerian LNG and long distance Soviet gas. This stresses the point that when oil prices are very low, long term gas contracts cannot protect producers' investments in high cost fields against losses. With the lower price environment in 1987, the estimated rents should be interpreted as differential property rents, rather than resource or monopoly rents. Due to decreasing returns in gas extraction, property rents would occur even in a perfectly competitive market.

6. SIMULATION OF FUTURE GAS SUPPLIES AND PRICES IN A DEREGULATED EC MARKET

Our investigation so far does not support the "healthy" diagnosis given by Dr. Bergmann. End user prices have not (1987) come down to competitive levels and there are strong indications that the gas markets of Western Europe are under-utilized. But the argument

[7]The cost figures correspond to the upper end of the range presented in table 2.4. We believe this is clorer to the historical costs due to low capacity utilisation.

[8] Hoel, Holtsmark and Vislie (1987) model a cooperative game between sellers and buyers in the gas market. Gas companies are assumed to maximize consumer's surpluse. The solution of the game (the core) identifies a price belt bounding the contract prices. The solution allows for rents both to consumers and at least some of the producers.

that the prevailing market structure with long term "take or pay" commitments are necessary to ensure gas supplies in the long term, are still to be investigated. Will common carriage undermine the market, get rid of "take or pay" contracts and scare off investors from high cost gas projects like Troll? Or, will it be foolish of the EC to undermine the strong positions of the gas companies, leaving the battlefield open for strong and greedy producer groups ready to form a cartel?

6.1. A Brief Description of a Dynamic Oligopoly Model

To answer these questions we have made simulations on a dynamic oligopoly model (DOM) developed in the Central Bureau of Statistics, Norway. The model describes a game between three large producers: Norway, Algeria and Soviet, playing on an excess demand function (total demand of the Western European Continent minus indigenous production). This model simulates a deregulated market in which there is no intermediate barrier between suppliers and end users, and the producers compete directly for market shares.

The United Kingdom is kept out of the game, and the Dutch production is included in indigenous supply. Since the game is essentially an investment game between suppliers with a bundle of lumpy investments, and the Netherlands already have made most of their heavy investments, this seems a reasonable way to reduce number of players which makes the model easier to handle.

Each player possesses a bundle of large, lumpy investments. In the beginning of each 5-year period they can make one or more investments, or none. The moves are done simultaneously, only previous investments are known. The investments are operative in the next period.

The players maximize discounted cash flows over the horizon of 17 5-year periods starting in 1985. They have perfect information of demand, costs and projects and can predict the other players' best moves. The players choose their best actions on the basis of this prediction (Nash equilibrium).

A model solution consists of a complete plan of how to act in all future periods. The plans (strategies) consist of a set of actions, conditioned on previous outcomes. Thus, the solution also shows the alternative optimal actions whenever another player deviates from the optimal action by, say, postponing an investment. This property will be utilized in the model runs.

The model is solved by dynamic programming, and the solutions are perfect Nash equilibria[9]. The solutions of this investment game are dependent on the solution of the short run game for given investments[10]. Also, price and quantity supplied for given capacities are dependent on the specification of the short run behaviour. For the sake of simplicity we have chosen the Bertrand price game (Bertrand (1883)). This implies full capacity utilization and lower prices compared to a short run Cournot game.

[9] In some cases the Nash solution is not unique, i.e there are two or more Nash equilibria. Rationality in such situations is not easy to define. We assume the minimax solution will be chosen in this case.

[10] The solution of the short run game have no impact on the state variables of the investment game

The supply behaviour assumed by DOM is strikingly different from that of a static Cournot (investment) game. In Mathiesen et al (1986) a Cournot model of the European gas market is specified, based on long term marginal cost curves and demand curves in year 2000. In such a model, the deviations from competitive equilibrium are dependent on the curvature of LTMC curves and demand curves, and the number of players. The model allows the producers to hold back on supplies because end user prices exceed marginal cost of supply according to the familiar Cournot equilibrium.

The Cournot investment game is played once and for all, i.e. the players cannot respond to each other's actions or moves. The Cournot equilibrium is Pareto-dominated by the collusive solution (monopoly) which, however, is not achievable when producers cannot cooperate. This is known as The Prisoners Dilemma.
But if the game is repeated, and the players have so-called trigger strategies, the collusive solution may be an equilibrium (Friedman (1983)). In this repeated game solution, if a player breaks out, this will be observed by the other players, and one or more of the others will play high supply for a number of periods, teaching the villain a lesson. As opposed to a one period static game, in a dynamic setting this strategy is perfectly rational, even if the players punish themselves in the short run.

However, we will argue that as a description of behaviour in the market for natural gas, the collusive repeated game solution is not appropriate. The main reason is that the existence of irreversible investments give little power to trigger strategies. If Norway has developed Troll, Soviet can punish Norway by making big investments, but this will not be rational from the Soviet point of view because Norway's investment is permanent and irreversible[11].

To grasp the basic implications of the existence of large and irreversible investment projects in the gas market, a model building explicitly on dynamic game theory is required. In such a game the players are perfectly aware of that their current actions has important implications in future periods. If Norway decides on a large investment in period 0, this will not only increase total supply and decrease market prices, but also decrease profits on the competitors' future investments. In such a dynamic game, the states and the strategies at various points in time will depend on previous actions and outcomes in the market. In equilibrium, the players will balance the profits from discouraging other supplies by making an investment, against the profits from restricting supply by postponing the investment. This point may be illustrated by the following paragraph.

6.2 A Dynamic test identifying strategic investments

In a perfectly competitive market, where suppliers are price takers, investments are not justified before price exceeds average costs (break even price). In DOM, it may be optimal to implement investments before this point in time, if this restricts other agents' investments sufficiently to increase profits later on. We will refer to this type of investments as <u>strategic investments</u>. This means that the price path can deviate both from a perfectly competitive path and the price trajectory implied by a simple Cournot game, being lower in periods of

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11 Since variable costs are a minor share of total cost, it will normally not be rational to close down fields or pipes temporarily.

strategic investments and higher later.

A comparison of the dynamic game solutions calculated by DOM and the simple Cournot solutions for the investment game can be undertaken in the following way: At the beginning of each period a player can invest or not, and using the Cournot assumption that the other players will not change their actions, she will invest if the net profit from the investment exceeds zero, i.e. if[12]

$$NPI = [p_1q_1 - p_0q_0 - (c_1q_1 - c_0q_0)](1+r)^{-1} - rI > 0$$

Prices p and quantities q and variable unit costs c with subscript 1 refers to the investment being carried out, while the subscript 0 denotes that the investment is postponed. The term in the square bracket is the net income from investing. Discounting this one period and subtracting interest payments on the investment rI yields the net profit of initiating the investment in the present period. If NPI is negative, the investment must be strategic, i.e the player would not have invested if she were a Cournot player, it is the effect on others players' investments later on that motivates the investment. This is indicated in the tables in the appendix with a minus sign.

6.3. The base case

i) Demand assumptions

The price- and income elasticities are averaged over those used in the GEM model referred to in previous sections. The aggregate demand function gives a lower demand in 1990 and 1995 than the IEA and Purvin & Gertz projections for the same income and price assumptions, but a slightly higher demand in 2000 and 2010[13]. Indigenous production was 123.2 bcm in the base year 1985, and is assumed to decrease by 1.2% throughout the horizon.

ii) Initial production and excess capacities

In 1985, exports to the demand region was 13, 17.8 and 28.6 bcm for Norway, Algeria and Soviet respectively. Norway had initially no excess production capacity. Exports are assumed to increase to 15 bcm in 1990, but decrease later on as fields expire. Algeria had idle capacity of 4.7 bcm in the Transmed pipeline to Italy in 1985. We assume this capacity to be fully utilized by 1990. Similarly, the 27.4 bcm idle capacity in the Soviet export pipeline to Europe is assumed to be absorbed by 1990.

iii) Investments

Each player has three possible projects. For Norway these are Sleipner (5 bcm) and Troll I and II with 24 bcm each. Algeria can install a compressor platform in Transmed, adding 5.5 bcm to total capacity. The second project is building another pipeline across the Mediterranean Sea, adding another 18 bcm to total export capacity. The third possibility is

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12 More precisely, we assume that the other players will not change their investment paths. This is the open loop solution of the game as opposed to the closed loop solutions in the DOM model.

13 The model has been run for a more accurate calibration to Purvin & Gertz (1987)'s implicit demand function. This did not change the DOM-solution

utilizing and restoring "idle" LNG capacity, amounting to 20 bcm. Soviet can install extra compressors increasing existing pipeline capacity by 12 bcm. The other options are two new pipelines to Western Europe with 30 bcm capacity each.

The estimated cumulated investment costs are (in mill US$)

Projects	1	2	3
Norway	1900	8400	14400
Algeria	400	6700	7700
Soviet	200	9200	18200

iv) Variable costs and discount rate.

In the DOM model, variable costs are the sum of variable production costs like labour, material, insurance and energy costs, and transport costs to a central point in the European market. For producers not investing in pipelines, transport costs are total average unit costs including capital costs. This applies to all three Norwegian projects, which are all field investments.

The first two of the Algerian projects increase the share of pipeline gas. This will imply lower variable unit costs for two reasons. First, the new investments include a share of total capital costs of transporting the gas to central point in Europe. Second, the share of LNG with high variable unit costs of liquefying, sea transport and regasification, is decreasing. The third Algerian project increases the LNG share and thus increase variable unit cost.

All Soviet projects are pipeline projects and thus transport tariffs paid exclude incremental capital costs. If we assume Soviet gas transported through existing pipelines pay total cost tariffs, increased investments imply decreasing variable unit costs. The size of the tariff should in any case depend on whether there is idle capacity or not in the pipeline. In a long run equilibrium, the tariff should balance against total marginal costs. In the DOM model, we have chosen a simplified way of assessing variable costs. These are actually set constant, equal to what will be the estimated variable costs after all potential investment projects have been carried through. This cost level is about the average Norwegian transport costs.

The base case discount rate is set at 10%.

6.4 Results from the DOM simlations.

The base case results are shown in the Appendix. In 1985, the players optimal decision is project 0, 1, and 1 for Norway (N), Algeria (A), and Soviet (S) respectively. This means that Norway does not invest in this period, while Algeria and Soviet starts both compressor projects. These capacities are added to 1985 supplies and excess capacities, increasing total import from the three suppliers to 111 bcm in 1990. The price will plummet to 60% of 1985 level at 2.34 1985$/mill BTU (93.6 $/1000 cm^3) as a result of this massive flow of gas pouring into the market. Still, the cif-price level is above the observed 1987-level. All suppliers have positive operating profit, but the Algerian is down to 18 $/1000 cm. At this price, some of the costs for existing fields are below break even level. Algerian LNG sales does not cover variable costs, and would be shut down if the model allowed the existing sales to be shut down.

Norway decides to start the Sleipner investment in 1990, the Troll I investment in 1995, and Troll II in 2010. Algeria initiates the pipeline investment in 1990, and the LNG investment as the last investment simply at the point of time (2045) when this action maximizes discounted cash flow. Soviet puts in the first new pipeline project in 2015 and the second in

2035. As a result of these investments, the price does not exceed 1985 level until 2025. In 2050 all investments are productive, the game is over and the price increase at the speed set by the excess demand function.

Due to our assumption regarding the short run (Bertrand) game, all existing capacities in the production and transmission system is absorbed immidiately. However, the most striking result from the base run is that the market absorbs an additional 50 bcm volume growth from 1985 to 1990 even though the price is above current level. Although there is presently some growth in gas demand, this is far from the 10 bcm yearly predicted by the model. As a mirror picture of the continued heavy investments in supply regions, gas continues to penetrate the European market in the 1990s and reaches 273 bcm in 2000 (see the appendix). Thereafter, there is no furhter expansion in consumption until gas from Troll II enters the market after 2010. The results from this model simulations may be compared with the scenarios for the gas market drawn in section 4. According to these, gas consumption will show a growth somewhere between -5 and 21 percent until year 2000 (see table 4.1). DOM, however, projects an increase in consumption of close to 50 percent in the same period!

The explanation for the very strong consumption growth in the DOM model in the early years of the simulation period is partly that we assume that end user prices will decrease proportionally with cif-prices. In fact, as pointed out in section 5, the end user prices have recently decreased less than proportionally, particularly in France and Germany. Another factor restricting the observed demand may be presence and influence of short run price elasticities, which are actually less (in absolute value) than those (long run elasticities) actually applied in the model. This will, however, only represent a severe problem if there are significant lag effects in gas demand (longer than 5 years).

Looking at the "test" indicators in the appendix, we observe positive NPI values all over, showing that there are no signs of strategic investments in this model solution. Thus, all the investments undertaken in the base run would also have been made at the same point in time in a Cournot game. However, as we shall see below, by introducing other assumptions for the exogenous variables, we get qualitatively different results.

<u>High indigenous production. 5% discount rate.</u>

In this case, we assume that indigenous production will not decrease as assumed in the base case, but rather increase to 150 bcm in 2000, and then stay constant at this level. This may be more in line with the general growth in the market that will result from common carriage, and also more in line with the scenario of Odell (1988). In addition, we have lowered the discount rate from 10% to 5%. This will lower the opportunity cost of investing and thus encourage strategic behaviour. The results from the new simulations are shown in the appendix.

In this alternative, Soviet and Algeria each undertakes 2 investment projects in period 0. This postpones Troll I one period (5 years), and Algerian LNG 10 years compared to the base run. The price is below the base case price in all periods, and is only 44% of 1985 level in 1990 implying very low operating unit results that period. The test value of NPI is negative, showing that the second Soviet investment is strategically motivated.

The strategic implications of this investment can be illustrated by simply not allowing the second Soviet investment in 1985. This will be observed by the other players, and they compute their optimal investment plans given this information (according to their optimal strategies). Below, the results from imposing this restriction is compared to the previous unrestricted game.

Years of postponement of investments if Soviet postpones project 2			
Projects	1	2	3
Norway	-5	-15	-25
Algeria	0	0	0
Soviet	0	25	0

In this case Norway turns out to be the agressive player, putting in all her projects in 1990. The second Soviet project will be postponed for 25 years. This proves that the second Soviet investment decision of 1985 in the previous solution was a strategic investment.

The Soviet postponement leads to a higher price in 1990, while the price is somewhat lower in next two periods. Norway and in particular Algeria gain from the postponement, while Soviet suffers a minor loss.

One period postponement.

Another run was made to check the consequences of a one period postponement of the complete game. This means that none of the investments are undertaken in the 1985-1990 period, and the game starts in 1990. This may be interpreted to simulate more accurately the 1992 deregulation of the EC market. The simualtion yields the same results as in the case of Soviet postponement above. The only difference is that the price is higher in 1990 as a result of the fact that none of the 1985 investments are initiated.

Two periods postponement.

In the final run, we postpone the game two periods and assume that Norway has developed Sleipner and Troll I in 1995, i.e. according to the present contracts. This brings us back to the same solution as in the no postponement case and price and flows are identical from 2005 on. Discounted cash flows are higher for all players because prices are higher in the period 1990-2000.

Sensitivity tests have been done to check the significance of some base case assumptions, like price - and income elasticities, oil price and costs. In general, the investment paths are dependent on the development of the excess demand function of these parameters, but the price path is affected less. The explanation is that an investment vil be initiated if the market can absorb it at the relevant cost level. If the market is favourable (high demand) more investments will be initiated, and vice versa. In addition to cost levels, the discount rate is an important parameter determining the price path. If this parameter is unchanged, the model will provide a relatively stable price projection, which in particular is not very dependent on the oil price.

6.5.Summary of results.

This section has investigated possible consequences of common carriage by simulating a dynamic oligopoly model for the European gas market. We assume that the intermediate barrier between suppliers and end users is done away with, and the players compete directly for market shares. Clearly, a necessary condition for this assumption to hold is that a well functioning regulatory body can be set up to ensure common carriage.

The opening of the market leads to a sharp fall in gas prices from 1985 levels, partly due to lower oil prices, but mainly due to utilization of excess capacity and heavy investments. The end user prices continue their downward trend from 1986 even though oil prices are assumed to recover. This holds unless our cost estimates are on the lower side. In some of the model runs the dynamic game leads to **strategic investments** aimed to prevent other players' investments.

The model describes an investment game assuming lumpiness on the supply side. Lumpiness, however, is not a necessary condition for the existence of strategic investments (Brekke et al (1987)).

The model is not designed for projecting the development of the European gas market in any detail. But it demonstrates an important theoretical point, that oligopolistic competition can lead to a fierce fight for market shares, even though there are a few players. If the basic assumptions holds, that is: Common carriage prevails, the players cannot cooperate, have information of prices and costs and heavy investments can be financed, there seems to be little reason for worries about future supplies of natural gas to the European market if the market is deregulated. The consumers would surely benefit from it, producers will increase capacity utilization and gain market outlets for new investments, but compared to the present state of the market, they may lose rents from selling high price gas to premium markets when oil prices are high.

7. CONCLUSIONS.

The main purpose of this study have been to investigate possible effects of a deregulation of the European gas market, that is: Introduction of the principle of common carriage or open access to the European transmission and distribution system.

After a brief description of the European gas market, we have discussed the role of the transmission companies in the light of static welfare economics. In the price/netback analysis effects of a non profit pricing policy in transmission is compared with prevailing pricing policy. These calculations have revealed that, at least in some countries, transmission companies have exploited monopoly power, and thus restricted gas consumption. Based on these analysis, we conclude that the potential for natural gas is far from utilized, and that due to increasing returns to scale, costs can be reduced by increasing volumes.

The game between suppliers in a deregulated environment is described by a dynamic oligopoly model (DOM). The model runs indicate that there is no reason to worry about future supplies of gas in the absence of long term "binding" supply contracts, provided that the rules of the game are non-cooperative. The supply game leads to a battle for market shares, and to a significant increase in total gas consumption in Europe. This occurs even though there are only three supply regions, Norway, Algeria and Soviet Union. An important element underlying the obtained results is the existence of **strategic investments**, aimed to discourage other players' investments.

The study also surveys projections for the gas market given by leading institutions, based on status quo assumptions, i.e. that prevailing barriers and institutional restrictions will continue. These prospects vary between a 4 percent reduction and a 26.5 percent increase of gas consumption up to 2010. The DOM-runs, assuming common carriage, predict a consumption growth between 47.5% and 80%. This demonstrates that consumer will benefit from the introduction of common carriage. Suppliers will gain new market outlets but may loose shares of monopoly rents in existing contracts.

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APPENDIX: RESULTS FROM THE DOM SIMULATIONS.

Closed loop

Base run

Year	State Nor	State Alg	State Sov	Cap. Bcm Nor	Cap. Bcm Alg	Cap. Bcm Sov	Cons Bcm	Price Norm	Market Shares Nor	Market Shares Alg	Market Shares Sov	Test Nor	Test Alg	Test Sov
Int	0	0	0	13,0	17,8	28,6	183	1,00	0,07	0,10	0,16			
1985	0	1	1	13,0	17,8	28,6	183	1,00	0,07	0,10	0,16		+	+
1990	1	2	1	15,0	28,0	68,0	233	0,60	0,06	0,12	0,29	+	+	
1995	2	2	1	16,0	46,0	68,0	250	0,70	0,06	0,18	0,27	+		
2000	2	2	1	40,0	46,0	68,0	273	0,77	0,15	0,17	0,25			
2005	2	2	1	40,0	46,0	68,0	271	0,85	0,15	0,17	0,25			
2010	3	2	1	40,0	46,0	68,0	270	0,93	0,15	0,17	0,25	+		
2015	3	2	2	64,0	46,0	68,0	293	0,91	0,22	0,16	0,23			+
2020	3	2	2	56,6	46,0	98,0	314	0,90	0,18	0,15	0,31			
2025	3	2	2	55,8	46,0	98,0	312	0,99	0,18	0,15	0,31			
2030	3	2	2	53,0	46,0	98,0	308	1,11	0,17	0,15	0,32			
2035	3	2	3	53,0	46,0	98,0	306	1,22	0,17	0,15	0,32			+
2040	3	2	3	53,0	46,0	128,0	335	1,17	0,16	0,14	0,38			
2045	3	3	3	53,0	46,0	128,0	334	1,29	0,16	0,14	0,38		+	
2050	3	3	3	53,0	66,0	128,0	352	1,30	0,15	0,19	0,36			

Closed loop

High indogenous production. 5% discount rate

Year	State Nor	State Alg	State Sov	Cap. Bcm Nor	Cap. Bcm Alg	Cap. Bcm Sov	Cons Bcm	Price Norm	Market Shares Nor	Market Shares Alg	Market Shares Sov	Test Nor	Test Alg	Test Sov
Int	0	0	0	13,0	17,8	28,6	183	1,00	0,07	0,10	0,16			
1985	0	2	2	13,0	17,8	28,6	183	1,00	0,07	0,10	0,16		+	-
1990	1	2	2	15,0	46,0	98,0	289	0,44	0,05	0,16	0,34			
1995	1	2	2	16,0	46,0	98,0	300	0,54	0,05	0,15	0,33			
2000	2	2	2	16,0	46,0	98,0	310	0,64	0,05	0,15	0,32	+		
2005	2	2	2	40,0	46,0	98,0	334	0,63	0,12	0,14	0,29			
2010	3	2	2	40,0	46,0	98,0	334	0,69	0,12	0,14	0,29	+		
2015	3	2	2	64,0	46,0	98,0	358	0,68	0,18	0,13	0,27			
2020	3	2	2	56,6	46,0	98,0	351	0,77	0,16	0,13	0,28			
2025	3	2	3	55,8	46,0	98,0	350	0,84	0,16	0,13	0,28			+
2030	3	2	3	53,0	46,0	128,0	338	0,97	0,16	0,14	0,38			
2035	3	2	3	53,0	46,0	128,0	377	0,90	0,14	0,12	0,34			
2040	3	2	3	53,0	46,0	128,0	377	0,99	0,14	0,12	0,34			
2045	3	2	3	53,0	46,0	128,0	377	1,08	0,14	0,12	0,34			
2050	3	2	3	53,0	46,0	128,0	377	1,18	0,14	0,12	0,34			

Soviet postponement

High indogenous production. 5% discount rate

	State			Cap. Bcm			Cons	Price	Market Shares			Test		
Year	Nor	Alg	Sov	Nor	Alg	Sov	Bcm	Norm	Nor	Alg	Sov	Nor	Alg	Sov
Int	0	2	1	15,0	46,0	68,0	259	0,52	0,06	0,18	0,26			
1990	3	2	1	15,0	46,0	68,0	259	0,52	0,06	0,18	0,26	+		
1995	3	2	1	64,0	46,0	68,0	318	0,50	0,20	0,14	0,21			
2000	3	2	1	64,0	46,0	68,0	328	0,59	0,20	0,14	0,21			
2005	3	2	1	64,0	46,0	68,0	328	0,65	0,20	0,14	0,21			
2010	3	2	2	64,0	46,0	68,0	328	0,71	0,20	0,14	0,21			+
2015	3	2	2	64,0	46,0	98,0	358	0,68	0,18	0,13	0,27			
2020	3	2	2	56,6	46,0	98,0	351	0,77	0,16	0,13	0,28			
2025	3	2	3	55,8	46,0	98,0	350	0,84	0,16	0,13	0,28			+
2030	3	2	3	53,0	46,0	128,0	377	0,83	0,14	0,12	0,34			
2035	3	2	3	53,0	46,0	128,0	377	0,90	0,14	0,12	0,34			
2040	3	2	3	53,0	46,0	128,0	377	0,99	0,14	0,12	0,34			
2045	3	2	3	53,0	46,0	128,0	377	1,08	0,14	0,12	0,34			
2050	3	2	3	53,0	46,0	224,0	377	1,18	0,14	0,12	0,34			

The game initialized in1990

High indogenous production. 5% discount rate

	State			Cap. Bcm			Cons	Price	Market Shares			Test		
Year	Nor	Alg	Sov	Nor	Alg	Sov	Bcm	Norm	Nor	Alg	Sov	Nor	Alg	Sov
Int	0	0	0	15,0	22,5	56,0	224	0,64	0,06	0,18	0,26			
1990	3	2	1	15,0	22,5	56,0	224	0,64	0,06	0,18	0,26	+	+	+
1995	3	2	1	64,0	46,0	68,0	318	0,50	0,20	0,14	0,21			
2000	3	2	1	64,0	46,0	68,0	328	0,59	0,20	0,14	0,21			
2005	3	2	1	64,0	46,0	68,0	328	0,65	0,20	0,14	0,21			
2010	3	2	2	64,0	46,0	68,0	328	0,71	0,20	0,14	0,21			+
2015	3	2	2	64,0	46,0	98,0	358	0,68	0,18	0,13	0,27			
2020	3	2	2	56,6	46,0	98,0	351	0,77	0,16	0,13	0,28			
2025	3	2	3	55,8	46,0	98,0	350	0,84	0,16	0,13	0,28			+
2030	3	2	3	53,0	46,0	128,0	377	0,97	0,14	0,12	0,34			
2035	3	2	3	53,0	46,0	128,0	377	0,90	0,14	0,12	0,34			
2040	3	2	3	53,0	46,0	128,0	377	0,99	0,14	0,12	0,34			
2045	3	2	3	53,0	46,0	128,0	377	1,08	0,14	0,12	0,34			
2050	3	2	3	53,0	46,0	128,0	377	1,18	0,14	0,12	0,34			

The game initialized in1995, Norway has developed Troll and Sleipner.

High indogenous production. 5% discount rate

	State			Cap. Bcm			Cons	Price	Market Shares			Test		
Year	Nor	Alg	Sov	Nor	Alg	Sov	Bcm	Norm	Nor	Alg	Sov	Nor	Alg	Sov
Int	2	0	0	40,0	22,5	56,0	259	0,67	0,15	0,09	0,22			
1995	2	2	2	40,0	22,5	56,0	259	0,67	0,15	0,09	0,22		+	+
2000	2	2	2	40,0	46,0	98,0	334	0,58	0,12	0,14	0,29			
2005	2	2	2	40,0	46,0	98,0	334	0,63	0,12	0,14	0,29			
2010	3	2	2	40,0	46,0	98,0	334	0,69	0,12	0,14	0,29			+
2015	3	2	2	64,0	46,0	98,0	358	0,68	0,18	0,13	0,27			
2020	3	2	2	56,6	46,0	98,0	351	0,77	0,16	0,13	0,28			
2025	3	2	3	55,8	46,0	98,0	350	0,84	0,16	0,13	0,28			+
2030	3	2	3	53,0	46,0	128,0	377	0,83	0,14	0,12	0,34			
2035	3	2	3	53,0	46,0	128,0	377	0,90	0,14	0,12	0,34			
2040	3	2	3	53,0	46,0	128,0	377	0,99	0,14	0,12	0,34			
2045	3	2	3	53,0	46,0	128,0	377	1,08	0,14	0,12	0,34			
2050	3	2	3	53,0	46,0	128,0	377	1,18	0,14	0,12	0,34			

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