Inter-Energy Competition and Natural Gas Prices in the United States

RONAN HUITRIC AND
JOHN CROWLEY

This paper provides an analysis of the process within which spot prices in the US natural gas market are determined. While some have argued that the gas "bubble" is the primary explanation of recent movements in gas prices, it is argued here that inter-energy competition is still the driving force behind the formation of US gas prices. In order to see that, it is necessary to calculate prices for each fuel that are comparable in relation to their final uses and to take account carefully of seasonal variation in demand and the relation between regional gas markets. The analysis has implications for, among other matters, the likely effects of growing gas demand in the northeastern US. It is also relevant for the European gas industry in relation to the current debate over the introduction of more competition into a largely monopolistic market.

Cet article nous livre une analyse du processus qui détermine les prix "spot" du gaz naturel sur le marché américain. Il est souvent suggéré que la "bulle" sur le marché du gaz naturel fournit l'explication centrale de l'évolution des prix sur ce marché. Ici, par contre, les auteurs suggèrent que la concurrence entre les différents combustibles joue encore le rôle principal dans la détermination des prix. Pour se convaincre de ce point, il est nécessaire de calculer des prix pour chaque combustible qui sont comparables du point de vue de leur utilisation ultime. Il faut aussi prendre en considération la saisonalité de l'offre et de la demande, ainsi que les liens qui existent entre les différents marchés régionaux. Cette analyse révèle des conjectures concernant, tout particulièrement, la demande de gaz dans les états du nord est américain. Elle est aussi d'importance pour le marché européen du gaz naturel en vue du débat concernant la transition possible d'un marché présentement largement monopolistique vers une structure beaucoup plus concurrentielle.

The authors are at TOTAL - Compagnie Française des Pétroles in Paris. Ronan Huitric is in charge of market analysis in the Trading and Middle East Division. John Crowley is an oil analyst in the Economic Analysis Department. An earlier report on this study was published, as Occasional Paper No. 8, by the International Research Center for Energy and Economic Development, Boulder, Colorado.

The idea that inter-energy competition is the driving force behind the formation of natural gas prices in the United States is not in itself controversial. However, the breakdown of traditional relationships between gas and crude has led many observers to assume that, because of "bubbles," surpluses and the other features of current demonology, the mechanics of inter-energy competition have temporarily ceased to operate.

We consider that this view is excessively narrow. As a result of deregulation, inter-energy competition cannot be understood without reference to the whole range of competing fuels. We show specifically that seasonal opportunities for variable-cost competition between gas and coal are currently the fundamental driving force behind the fluctuations of gas prices.

Despite the clear differences between gas markets in the United States and in Europe, we suggest that this aspect of US experience is highly relevant to Europe, particularly in the light of the ongoing debate on the introduction of competition into what was previously a largely monopolistic market.

1. History and Regulatory Structure

The most distinctive feature of the US gas market is that it is impossible to discuss any part of its recent history without reference to the legislative and regulatory background, and in particular to the various court cases that have influenced the development of supply and demand.[1]

Until the 1970s, the two most significant events were the Natural Gas Act (NGA) of 1938 and the judgment in Phillips Petroleum Company vs. State of Wisconsin in 1958, which is the source for a large body of case law protecting consumers in one state from price increases on the part of producers in other states.

The avowed objective of the law has always been to combine efficiency and equity. The consequence, however, was the creation of a two-tier system, regulating the price of gas crossing state borders, but not that of gas produced and consumed locally. This led to a dual market: an interstate segment with necessarily moderate price-ceilings and an intra-state segment, limited to producing states, where price freedom allowed a genuine equilibrium price to be reached.[2] The main result was a migration of energy-intensive industry from the northeast US to the south, where gas, while more expensive, was at least available. Despite successive increases in price ceilings, the discrepancy widened to the point where, in 1976, the average intra-state price was double the average interstate price.

The shortages of the 1976-77 and 1977-78 winters, which were a consequence of this situation, led to the introduction of new legislation by the Carter administration. The Natural Gas Policy Act (NGPA) of 1978, which was the eventual result, has been much derided.[3] Nonetheless its objective was to reach, after an appropriate transitory period, a competitive, unregulated natural gas market. The definition of the transitory period for the various categories of gas was the subject of tortuous debates in Congress, which were complicated by the widespread involvement of pressure groups.

Progress towards deregulation proved more difficult than it had seemed in 1978. The events of the early 1980s (the oil shock and the subsequent recession) rocked the laboriously designed plan. The Federal Energy Regulatory Commission (FERC) therefore decided in 1985 to provide a further impulse. A number of regulatory orders were enacted (Order nos. 380, 436, 456 and 500, to mention only the most important). Their objective was to restrict the traditional vertical integration of the gas industry, with close links between producers, transporters and distributors, in order to promote competition in a previously rather uncompetitive market. These orders created a new institutional framework, especially for interstate transport, with the introduction of the principle of third-party carriage.[4]

These new relationships allowed the development of the spot natural gas market, which rapidly became the dominant channel of exchange.

This study focuses on the period from early 1985 to the summer of 1990. The choice of 1985 as a starting point is based on the fact that the new regulatory framework was active and almost complete at that time (i.e., enough gas was already, or was about to be, deregulated for a genuinely competitive market to appear). The development of the spot market as a result of the institutional changes of 1986 was the second major factor of the new price-formation mechanism. Such a market is the only one in which, as in the economic theory of competition, the marginal consumer is in a position to set the price.

1/ A detailed description of the market is provided by Stobaugh & Yergin (1983). An analysis of the pre-1985 regulatory structure is given by O'Neill (1985). For more recent information, see Lookadoo (1988) and Teece (1990).

2/ The difference in prices prevented inter-state transporters from acquiring new reserves, required to meet demand, because the price they were authorized to pay was too low.

3/ See for example the description in Carpenter *et al* (1987).

4/ Common carriage is the standard term. However, at least to the extent that there are close contractual relations between parties, the term "contract carriage" would often be more appropriate.

2. The Current Situation: from the Gas Bubble and Gas-to-Gas Competition to . . .

Since 1985, the formation of natural gas prices has often been explained as the result of competition between gas of different origins, combined with a surplus of production capacity improperly referred to as a gas "bubble".[5] Several factors combine to make this interpretation unconvincing.

The first, and most obvious, is the shape of the gas-price curve in the past five years. As Figure 1 shows, the price has been broadly stable, on a monthly basis, except during the peak heating season. If gas-to-gas competition were the driving factor, one would expect a more unstable price. The oil market is an example of a spot market in which competition among suppliers of the same product is the determining factor. If one looks, for instance, at the first half of 1986, oil prices are much more variable in this case, and the overall situation is very different from that of gas.

It is useful to remember that there are at least four different ways of measuring gas prices, of which only one is shown in Figure 1. In the order of physical flows (which is distinct from the logical order of price-formation) these are:

- the wellhead price actually received by the producer;
- the delivered-to-pipeline price paid by the transporter, i.e., the wellhead price plus gathering costs;
- the city-gate price paid to the transporter by local distribution companies (or by-pass consumers), which includes transmission costs; and
- the burner-tip price, which includes distribution costs and varies widely depending on the category of consumer.

These prices respond to different rationales and do not necessarily vary in parallel. Thus, for example, wellhead prices vary less between producers in a given region than delivered prices between pipelines. Thus Figure 1 arguably overstates the variability of prices.

A second important factor that goes against the idea of gas-to-gas competition as a price-setting mechanism is that the gas price swings from a summer floor to a winter ceiling. It is generally accepted (albeit rarely proved with any rigour) that the ceiling is fuel-oil related, but the floor price is often ignored.

According to the gas-to-gas analysis, the summer price should, given the existence of surplus production capacity, be set by the marginal cost of production of the most costly gas at any one time. From this point of view the relevant gas to consider is that which is sold in summer. The quantities of gas, if any, that are withdrawn from the market cannot, despite frequent suggestions to the contrary, set the price. This reasoning, based on marginal-cost analysis, which would be correct for a non-substitutable good in a competitive market, fails to take account of inter-energy competition.

In particular, this interpretation requires one to regard as a coincidence the fact that the floor has in five consecutive years been reached at the **same level** (about 1.20 $/MMBtu at the wellhead). There is no reason why the marginal cost

5/ The "bubble" analysis relies, whether consciously or not, on a confusion between two quite distinct notions. First, natural gas follows a "load curve" as does any non-storable good (or good with insufficient storage capacity) subject to seasonal demand. This means that production and transportation capacity required to meet peak system load is necessarily underutilized for much of the year. In this sense of the word there is, and always has been, a "bubble". In addition, gas capacity has, in recent years, been consistently greater than maximum system demand. This unrelated phenomenon is also often called a "bubble". As the cold snap of December 1989 indicated, it is largely circumstantial and could, if investment in the various parts of the industry remains inadequate, disappear completely in the future. But these two senses of the word should not be mixed, and their simultaneous use can lead only to confusion. Our analysis is intended to show that the first is the more significant for the mechanics of price-formation (except in the extreme case where winter shortages are so acute that only residential and commercial demand can be met). For examples of bubble analysis, see Sawhill (1987, 1989), First Boston Equity Research (1987), Energy Modeling Forum (1989), Woods (1988), and *Bulletin de l'industrie pétrolière* (1990). Interpretations of the bubble closer to that given here may be found in US Energy Information Administration (1989) and *Energy Economist* (1989, pp. 21-22).

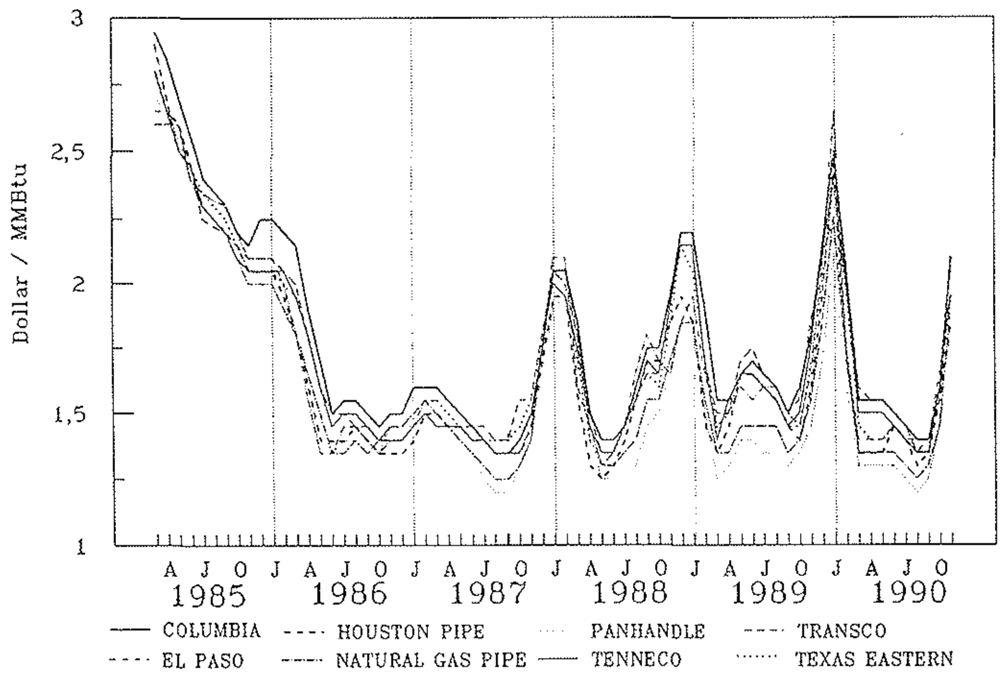


Figure 1: US Spot Delivered-to-Pipeline Gas Prices Paid by Transporter

of the highest-cost producer should remain constant over such a long period, especially given significant changes in quantities actually produced.

Given these reservations, it is natural to look for a different analytical framework, one that explicitly introduces the mechanics of inter-energy competition and explains convincingly both the level and the stability of the price floor.

3. . . . Inter-Energy Competition

General Principles

The US gas market is now sufficiently "deregulated"[6] to be, as far as a real-world gas market can be, competitive in the sense of economic theory. It is therefore possible to apply economic principles to the analysis of price formation mechanisms.

Because of the opportunities for inter-energy substitution, the analysis of competitive price formation in the case of energy requires one to take account of the various competing products. Competition can be understood only as between energy forms, as several products are in competition to meet the energy requirements of any given sector. The main exception to this principle is the transportation sector where, at least at present, substitution opportunities are negligible for any given form of transport.

The principle of inter-energy competition leads to an equalization of the prices of competing energies at the margin (per unit of useful energy at the burner tip). This reasoning must naturally take into account differences between fuels in both heat content and ease of use, which

6/ In many ways, of course, the US market is actually still very highly regulated (see for instance Teece, 1990). But its characteristic feature is that prices are very largely freed from the influence both of government intervention and of long-term indexed contracts. In addition, much of the regulation is designed to promote (in an arguably artificial manner) competition, rather than to stifle it.

may induce consumers to pay premiums (on a heat basis) for certain fuels. The peculiarity of gas is that it has no genuinely captive market (with the minor exception of some chemical feedstock uses). As a result it is in competition with different fuels in its different end-use markets and several cases must therefore be considered in order to determine its marginal price.

If the marginal consumer needs gas for space-heating or to raise steam, competition should be evaluated on a heat basis; e.g., in Btu in US usage. The only correction required to convert from specific units (of mass or volume) to comparable units is for heat content. If, on the other hand, the marginal consumer requires energy to generate electricity, it is in addition necessary to take into account differences in thermal efficiencies between fuels, since in this case the number of kWh produced for any given number of Btus consumed varies.[7]

Thus the marginal price of natural gas is equal to the price of the fuel with which it competes at the margin (expressed in dollars per comparable unit calculated by accounting for the marginal consumer's specific use). Since, in a competitive market, there can only be one price for a good at a given place and time, the marginal price is **the** gas price.

The consequences of this marginal price equality may be more or less complex according to the stability over time of the inter-fuel competition pattern. In the US, because of the wide geographical and seasonal variations in gas use and the separation of producing and consuming regions, there is no *a priori* reason to expect a stable annual parity between the price of gas and any one competing fuel.[8] Whether such a parity prevails can be shown only by empirical analysis. Despite this complexity, we shall attempt to show that applying the theoretical principle of inter-fuel competition to the US case provides a satisfactory interpretation of the mechanisms of gas price formation.

Application of the Principles to Gas Prices

The marginal consumers of gas in the US will be found among electricity generators (either independent power producers or, more probably, utilities) or large industrial consumers with interruptible contracts. Indeed, in regard to an application of price theory, it is not possible to distinguish between these two groups of consumers.[9] They are the only ones that can actually switch fuels, either at plant level (when their equipment has multi-fuel capability), or by transfer between plants (in the case of a utility with a diversified plant mix and a merit order determined by marginal generating cost).[10]

To simplify the argument, we shall assume in the first instance that the marginal consumer is always an electricity generator, whatever its particular legal or institutional set-up.[11]

The central role of the electricity generator may, given the importance of electricity issues in the US, have a considerable impact on the future trend of gas prices. If the numerous cogeneration and combined-cycle projects currently mooted, in the northeast in particular, can be taken at face value, the future supply-demand balance could

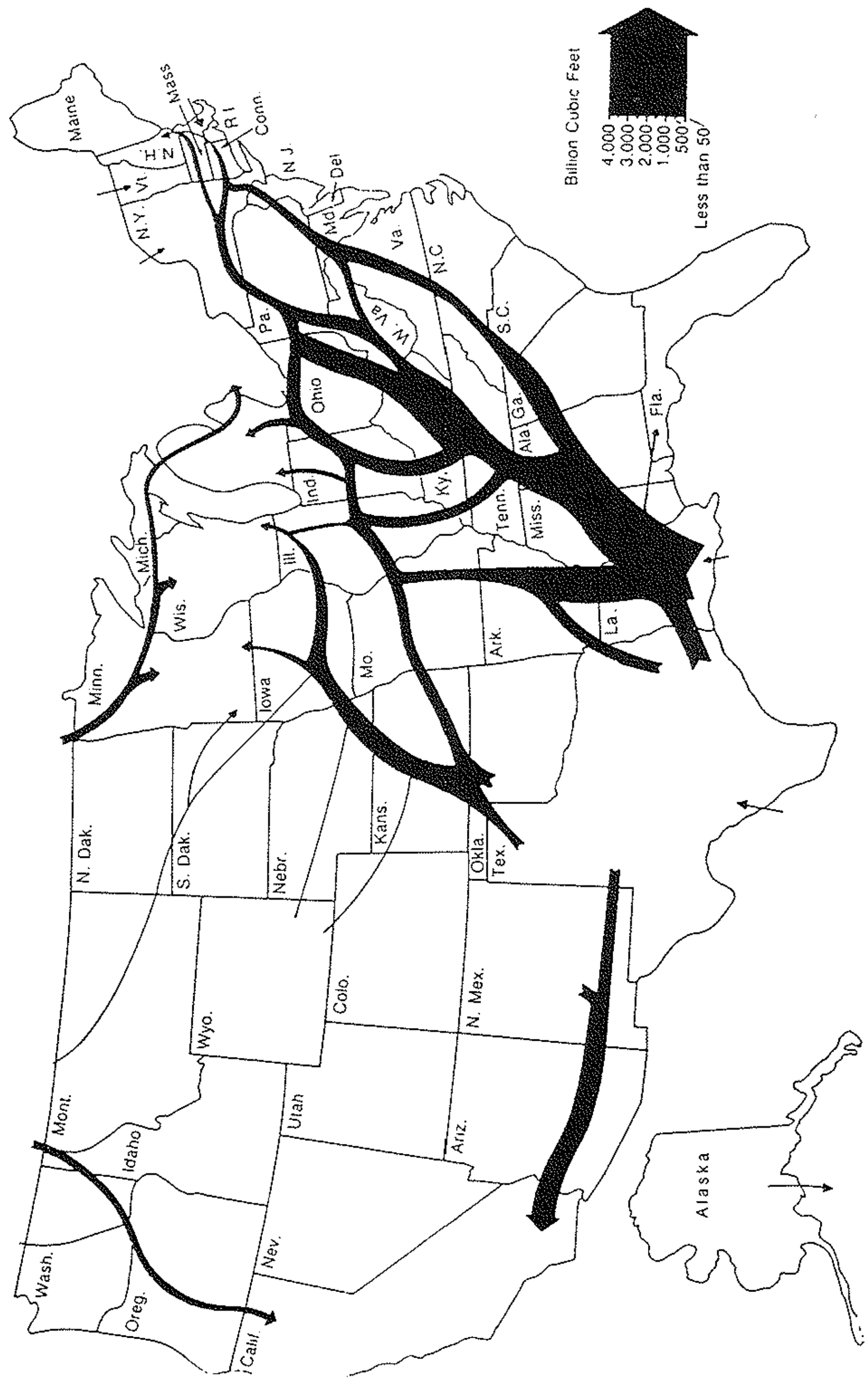
7/ Our calculations assume net thermal efficiencies of 35%, 36% and 40% for coal, oil and gas respectively. This is of course a simplification — there are considerable variations in efficiency across plants depending on age, size and technology, and even for any one plant depending on load factor.

8/ Failure to appreciate this point leads to the rather absurd attempts commonly made in the US to define gas-price formation on an annual average basis. For reasons that will be detailed later, it is, for instance, literally meaningless to write, on the basis of average prices, that gas "tracks" 70% of the price of residual fuel-oil (*Natural Gas Intelligence*, 1989, p.5).

9/ Cogenerators will never be marginal consumers because of their very high efficiencies (which guarantee a technological rent, whereas the marginal consumer, by definition, enjoys no rent whatsoever), and also because of their limited opportunities for substitution (distillates being in practice their only alternative fuel).

10/ In the case of a generator, the marginal consumer can even be a larger entity, when several utilities are grouped in a power pool with centralized dispatch.

11/ This simplification is obviously debatable in principle. In addition, as we shall subsequently show (see Figures 4 and 5), it is not fully vindicated by the evidence. Its purpose should therefore be seen as purely presentational.



Principal Interstate Natural Gas Flows

differ significantly from that described here. Historically, including during the period since deregulation, gas consumption for electricity generation has been of limited scope compared to other uses. It is presumably for this reason that most specialists have given little attention to the possibility that the power sector might be at the heart of the price formation mechanism. However, in the theoretical framework that has just been described, the importance of the marginal consumer is a consequence of his "marginality": regardless of the quantities purchased,[12] his consumption sets the current price.

These principles having been laid down, it is possible to describe the mechanism of price formation.

During summer, gas is amply available to meet current demand, including storage injection. Gas therefore displaces as much fuel-oil as possible, especially in power generation where the existence of multi-fuel capability is not a necessary condition for switching. This is particularly the case in the northeast, where there are large quantities of fuel-oil that can be backed out (Figure 2).[13] Once there is no more demand in the northeast (i.e. once all potentially gas-consuming plant is saturated), the marginal consumer "migrates" southward and "reappears" as a power generator in the gas-producing regions.

In this market, there is only one fuel in competition with gas, namely coal (Figure 3). It is therefore no surprise to find that the floor price is 1.3 $/MMBtu, since this corresponds, after allowing for differences in thermal efficiency, to the price of spot coal for Texas utilities. This analysis naturally assumes that there is spare generating capacity for both coal and gas, so that there is at least one consumer able in practice to choose between the two fuels. This point will be discussed in more detail later.

In winter, on the contrary, there is not enough gas in the northeast to meet both summer levels of electricity demand and seasonal demand for residential, commercial and industrial heating, not least because of constraints on production and transportation. There are, however, still small quantities of gas in competition at the margin with fuel oil for power plant or industrial use. In this case it is logical for gas to sell at fuel oil parity in the northeast.

By combining these two situations it is possible to explain gas-price formation as a result of parity with the competing fuel determined by the marginal consumer. Gas-to-gas competition is an integral part of this mechanism. However it explains only the **seasonal swing** in price alignment (from oil parity to coal parity and vice versa), and not the actual price levels reached. Regional price disparities are a consequence of differing transportation costs.

It should be stressed that this analysis gives an extremely important role to the marginal consumer. Even if this hypothetical buyer consumes only small quantities of gas, he has a disproportionate effect on prices. There can however be only one marginal consumer at any given time, all others being price takers, for whom the delivered price is equivalent to that of the marginal consumer, corrected for transportation differentials.[14] For example, if the marginal consumer is a New York utility, the price paid by an industrial consumer in Michigan will be equal to the

12/ While this theoretical construction is not a perfect description of the real world, it has the crucial advantage of underlining the irrelevance of average annual quantities: if there is an effect of the overall "mass," it can only be instantaneous, at the moment when its price influence is supposed to operate.

13/ The idea that gas displaces as much fuel-oil as possible in the northeast during summer may seem surprising, since, despite a sharp decline, oil consumption remains significant. It is, however, compatible with reasonable assumptions on electricity load curves and the availability and use of nuclear, hydro and coal-fired power in the region at this time. This reflects the fact that, for any given generating capacity, the amount of gas that can be consumed per unit of time depends on the slope of the load curve and the position of the relevant capacity on the vertical axis. In fact, according to our best information (which should always be treated with caution in the case of generating capacity), load factors for gas and oil in the northeastern US are (in round figures) 10% and 50% respectively in winter, and 50% and 30% respectively in summer.

14/ This implies that any non-marginal consumer having the effective ability to switch between fuels enjoys an economic rent.

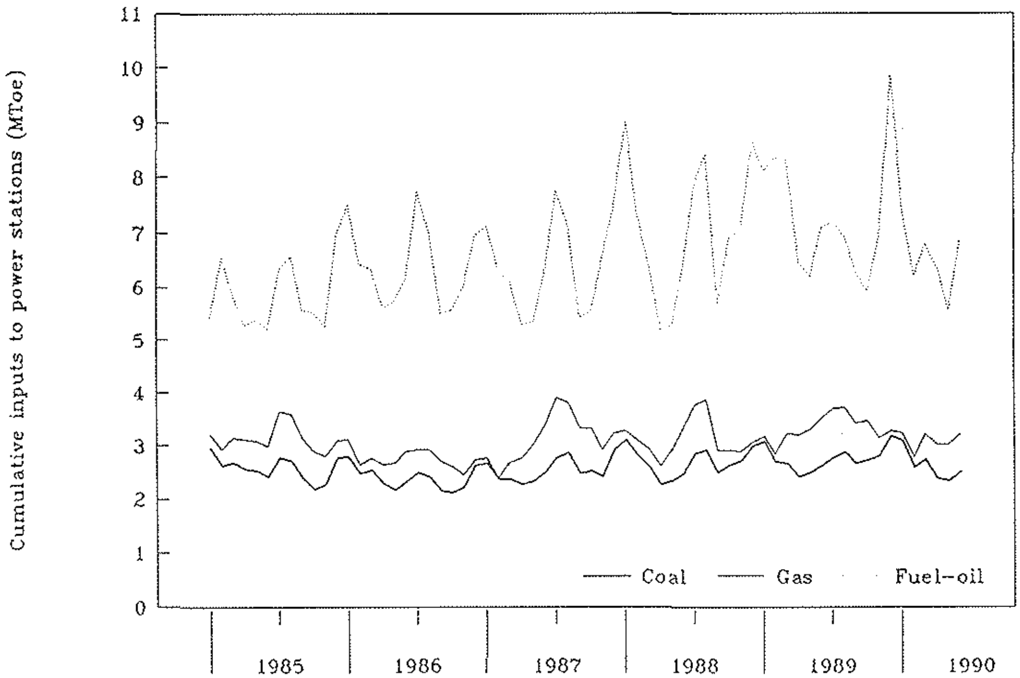


Figure 2: Fuel Consumption for Power Generation — Mid-Atlantic/New England

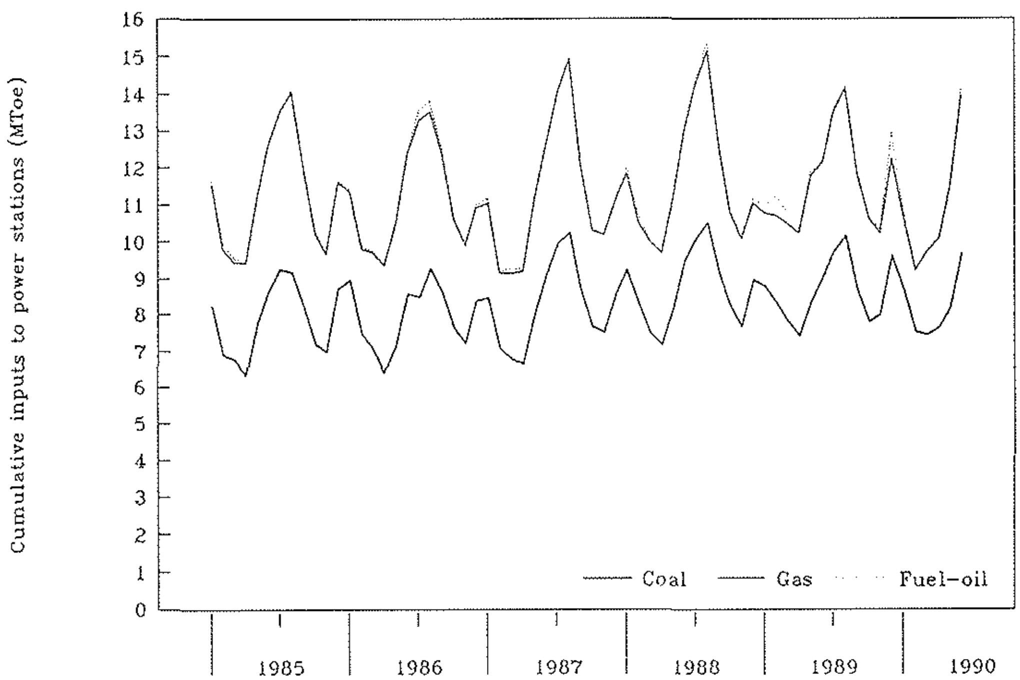


Figure 3: Fuel Consumption for Power Generation — South

New York price corrected for the transportation differential. There is no reason for this price to be equal to that of fuel-oil in Michigan — one can at the very most say that it will be lower if there are industrial consumers with switching capability and if the market is genuinely competitive in the sense of there being no price discrimination. It can therefore be anywhere between the coal floor and the fuel-oil ceiling. If, on the other hand, the price reached one of these limits, it would be a sign that the marginal consumer was actually in Michigan. This would, of course, imply that no gas was being consumed in switchable uses in New York.

The principle is similar for those states which, for whatever reason, can never be in the marginal position. This is the case, for example, of Florida (a captive consumer because of pipeline constraints) and of California (because of transportation, but also more crucially because of environmental regulations).[15] It is quite possible that increased integration of the US gas market and pipeline investment may change this situation, particularly in the case of California, but it is at present an acceptable simplification to neglect the influence of these two important consuming regions on price formation.

4. Illustration and Calculation: 1985-90

Finding empirical evidence for the phenomena described here is no easy matter, since precise identification of the marginal consumer is impossible. While detailed information on spot purchases of coal, gas and oil by utilities is available on a monthly state-by-state basis, its use leads to results that are difficult to interpret. Such data hide too many distortions due to particular local or institutional distortions that are difficult to correct. Our methodology is based on a comparison of spot fuel prices on a regional basis.

While it is easy to find representative prices for fuel-oil[16] or coal,[17] gas is problematic, since the only genuine spot prices available are determined at the wellhead or at delivery to the pipeline. We therefore derived consumer prices for each region by adding to delivered-to-pipeline prices an estimated transportation cost.[18] We did not, on the other hand, add in a local distribution cost assuming (uncontroversially) that the marginal consumer is an industrial or utility user able to buy gas on a city-gate basis.

These Btu prices are converted into an effective kWh basis, taking account of the theoretical thermal efficiencies defined above.

Such a regional approach has the merit of avoiding an illusory precise location of the marginal consumer. Conversely it does not fully reflect the complexity of particular situations. It can, however, be regarded as a first step towards a complete understanding of gas price formation in the US. The comparison between the real world and the generic framework presented here illustrates the differences between a theoretical pure competitive market and the institutional and other barriers of existing markets.

Figures 4 and 5 show the prices, in both Btu and kWh terms, of the various fuels in the south-

15/ Californian standards, particularly in regard to the sulphur content of petroleum products, have reached the stage where effective switching capability no longer exists, even when it is technically available. Consumers are therefore prepared to buy gas whatever its price, and can thus never be marginal.

16/ Prices for 1% sulphur fuel-oil (Houston for the South and New York harbour for the northeast) are taken from Platt's *Oilgram Price Report*.

17/ The prices (low-sulphur coal from Texas for the South and Pennsylvania for the northeast) are taken from *Coal Outlook*.

18/ As differences in effective transportation costs between companies are significant, it is impossible to define a single representative figure for transport from the Gulf Coast to the northeast. To obtain a theoretical figure that fits the facts as closely as possible, we used a recent study (Schlesinger, 1988) that gives actual costs for transport between various producing and consuming regions. This indicates a representative average of 66 ¢/MMBtu from the Gulf Coast to the northeast, rounded to 70 ¢ in our calculations. This is of course a simplification (which is particularly unsatisfactory, as we shall show, for December 1989). It would be preferable, in order to improve the analysis, to introduce variations in cost on an annual, or even a seasonal, basis. For the south we assumed that the transportation cost is on average equal to the cost of delivery to the inter-state pipeline, and thus that there is no extra cost to be added to the spot price used.

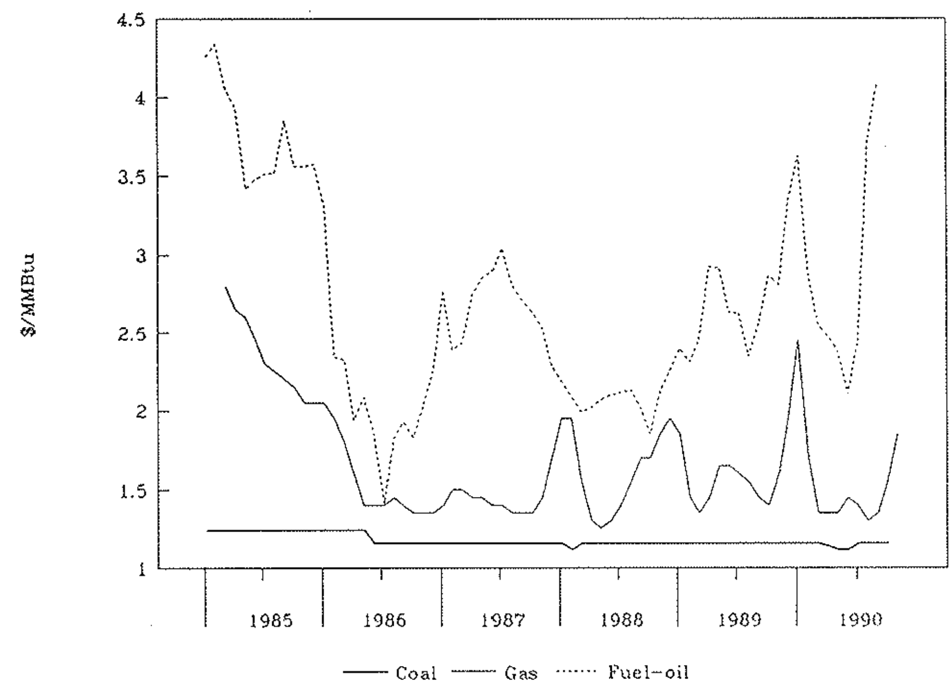


Figure 4: Spot Prices of Competing Fuels — South

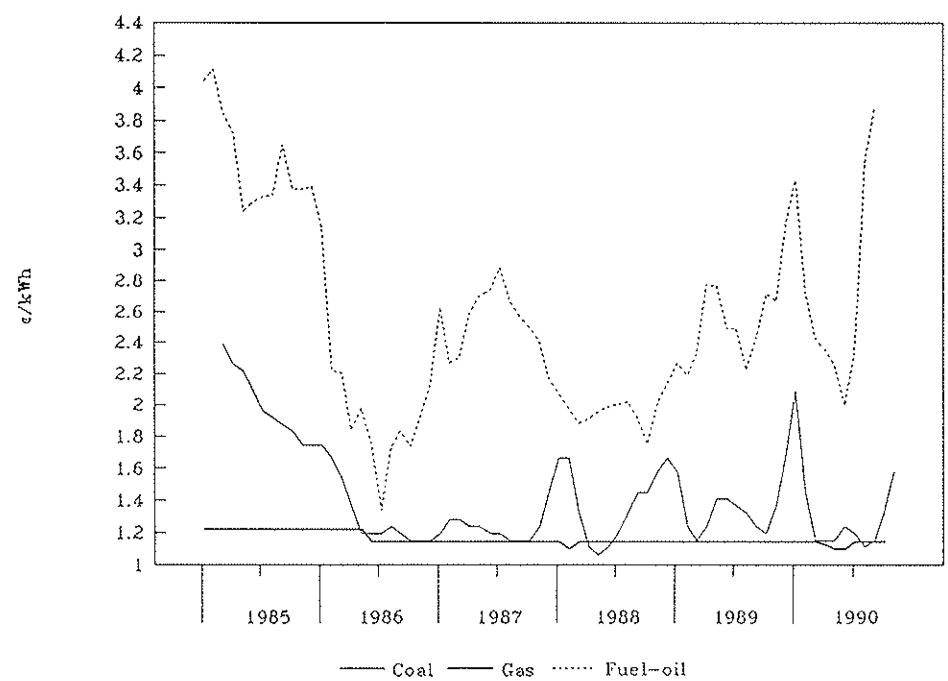


Figure 5: Fuel Prices for Power Generation — South

ern producing states.[19] They show a regular return to parity between coal and gas for power generation after the winter peak, whatever the price may then have been. The timing may however vary considerably. Except in 1987, the floor has usually been reached in the spring (March to May), but the summer situation has varied. While 1986, 1987 and 1990 showed a broadly flat summer curve, leading into the autumn rise (usually in October), 1988 saw an exceptionally early increase to fuel-oil parity in the northeast (from August through to January). More striking was 1989, with the appearance of a genuine double peak in gas prices. These variations are not in themselves troublesome. Energy competition is driven by demand and the availability of alternative fuels, not by the calendar. Whether coal parity exists in any particular month is therefore not relevant, so long as it can be shown to appear in the known off-peak periods for gas demand. Conversely, any precise prediction of seasonality on the basis of inter-fuel competition would be illusory. From this point of view the real problem is to reconcile 1989 with the overall analysis. This is discussed in more detail below.

Figures 6 and 7 give the same data for the northeast:[20] they indicate gas/residual fuel oil parity during winter. For the rest of the year, on the other hand, the gas price is equal to the southern coal parity plus transportation. It is thus, as the theoretical approach suggested, somewhere between the coal price and the oil price. The four graphs show the significance of thermal efficiencies for the empirical study of inter-energy competition.[21]

5. An Exception that is Only Apparent - 1989

The analytical framework applied here, first sketched in the spring of 1989, was very rapidly tested. The events of 1989 were sufficiently unusual to require the rejection of any simplistic interpretation of the hyposthesis, and therefore also to cast some doubt on its validity. As the data show, both summer and winter seem troublesome. After hitting its coal floor in March 1989, the gas price started to rise, reaching exceptionally high levels throughout the summer, before dropping back in the autumn. To understand why, and to show that the framework presented here can account for it, one must come back to the fundamental principles of inter-energy competition.

Utilities in Texas can be marginal consumers of gas, and thus cause coal parity, only if they can in practice choose between coal and gas. If this is not the case, for instance if electricity demand and the state of the available generating stock are such that all coal-fired capacity must be used at maximum load,[22] the only choice is between gas and fuel-oil. They will then be prepared, like consumers in the northeast, to buy gas at any price not greater than that of the competing product. They will therefore be able to divert gas from the northeast. Unless gas supply is highly price-elastic, this will lead to a shortage in the northeast, at least in the sense that some consumers will have effective gas-burning capability (given the shape of load-curves etc.) and no gas at the right price, which is not usually the case in summer.

One would expect this to lead to fuel oil parity in the northeast, as in winter and for exactly the same reasons. Indeed this seems to have been the case in the late summer and autumn of 1988. However, the 1989 summer price was too far

19/ Defined here as Texas, Oklahoma, Louisiana and Arkansas.

20/ Pennsylvania, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont and Maine.

21/ The Btu parity in the northeast in winter seems in fact to be closer than the kWh parity. This could mean that the marginal consumer at that time is an industrial user, rather than a utility, which is of course quite compatible with our reasoning. However, it is equally possible that the spot price used is not representative and, in particular, that our estimated transportation cost is misleading. For the reasons given in note 14 above, this could well be the case. In the absence of any conclusive evidence one way or the other, we prefer, in order to simplify the presentation, to retain our original hypothesis.

22/ The peak season for electricity demand in Texas is in July-August, because of air-conditioning requirements.

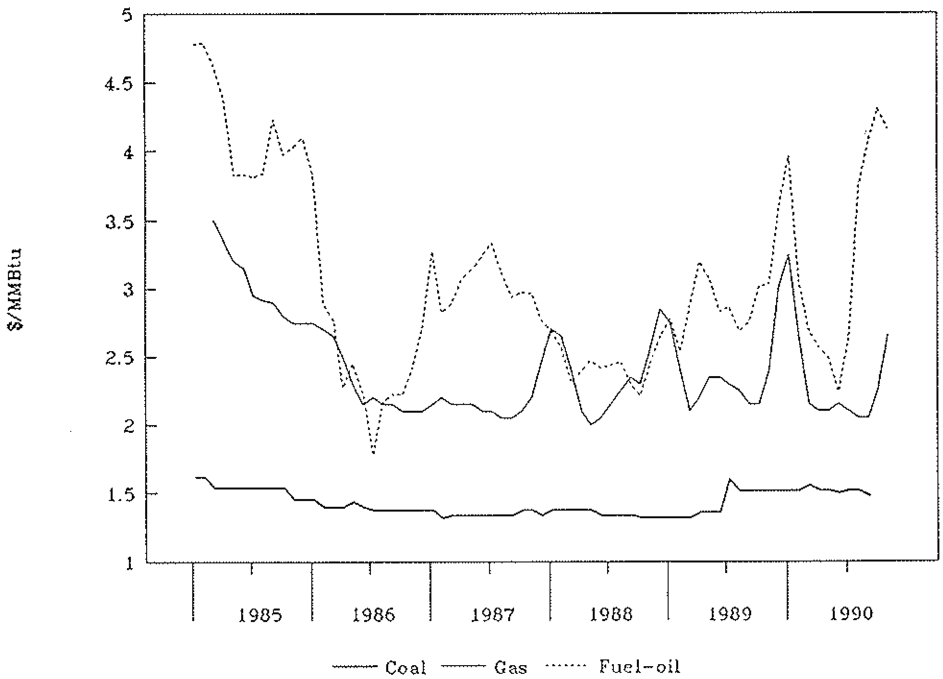


Figure 6: Spot Prices of Competing Fuels — Mid-Atlantic/New England

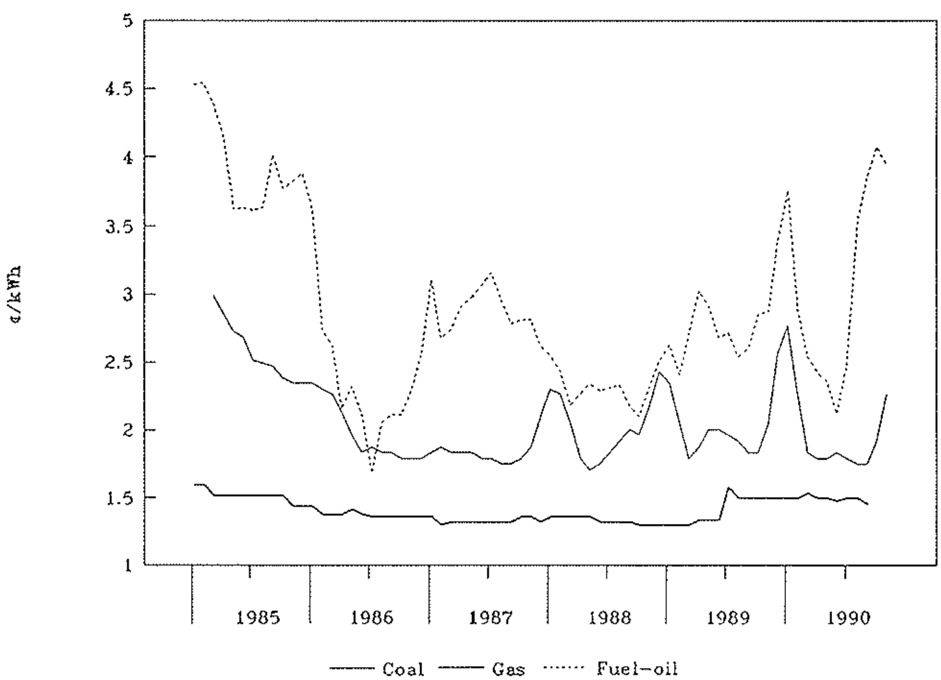


Figure 7: Fuel Prices for Power Generation — Mid-Atlantic/New England

below fuel-oil parity for the discrepancy to be explained away by, say, data problems or our very broad-brush approach to price estimation. Clearly, the northeast was not at this time the price-setting region and there was no "shortage" of gas (in the restricted sense just defined). This could be reconciled with our overall approach in two ways:

a) As a result of the specific supply and demand conditions, the marginal consumer may have moved out of the southern producing states without going as far as the northeast (which must in that case have had enough gas to saturate all effective demand).

b) The marginal role may have been played, not by a region at all, but by storage demand, the economic logic of which is not ultimately based on inter-fuel competition. There is considerable circumstantial evidence that, for primarily weather-related reasons, the usual spring build-up took place significantly later in 1989. The idea that storage may have been the major influence thus has some plausibility.

Until detailed empirical work is done on these points, the summer of 1989 remains a weak point in the analysis. However, both of these hypothetical explanations have the advantage of showing why the normal coal-related parity occurred in the spring and autumn. Electricity demand in Texas is at its lowest annual levels at that time, so that the south returns to the position of marginal consumer as soon as consumption in the northeast is saturated, which will be the case except when either the weather or generating-plant availability is unusual.

The problem posed by the 1989-90 winter (strictly speaking of December 1989, since the rest of the winter was exceptionally mild) is to understand why, despite the usual sharp increase over the autumn, the price stayed, in our calculation, significantly below the (extraordinarily high) fuel-oil price. As explained above, we assumed a constant transportation cost of 70 ¢/MMBtu. In view of the known capacity constraints on the US transmission system during the "cold snap" (with even some "non-interruptible" consumers being curtailed), it seems reasonable to assume a temporarily much higher transport cost. However, even an extra 30-40¢ would not bring the price up to fuel oil parity. This leads to an apparent contradiction. If gas was still available to northeastern consumers, they would have switched from more expensive fuel oil, leading back to parity. Or, if all transmission capacity was saturated, then, for the same reasons, consumers with switching capability would have bid transport prices up to the fuel oil level, creating an economic rent for the transporter. Thus the only satisfactory explanation is that regulation of transmission tariffs prevented the appearance of such a rent, despite effective saturation of capacity. If this is the case, it would be reproducible in any further comparable cold spell.

6. Perspectives for the Future

To reiterate, we have explained the seasonal variations of the gas price in the US (Figure 1) as the result of inter-energy competition. This analysis fits with observed facts since 1986 on condition that different possible uses of gas, and in particular the influence of thermal efficiencies on the economics of gas burning for power generation, are taken into account. We can thus interpret the floor price as reflecting coal parity in the south (Figure 5) and the ceiling as reflecting fuel oil parity in the northeast (Figure 7).

What perspectives does this hypothesis suggest for the future?

First, if the characteristics of demand (seasonal variations and geographical location, the quantities being in this case of minor importance) remain unchanged and if the institutional structure is not fundamentally altered, there is no reason to expect the mechanism described here to be modified. However, the results can vary, as the case of 1989 indicates.

Widespread optimism in the US gas industry leads to a general belief that demand for gas will increase steadily (particularly in the northeast, where energy supply is chronically, though not severely, inadequate), causing (in view of a largely inflexible supply) a rise in prices. While this would be obvious for a non-substitutable good, gas clearly has substitutes. How then would increased demand in the northeast affect prices in our analysis?

For as long as potential consumption in the northeast is not saturated in winter and there are consumers who can genuinely switch between gas and fuel oil,[23] the geography of the region will make it the usual marginal consumer. The gas price will therefore be set in winter by the fuel oil price in the northeast. At other times of the year these conditions do not apply and changes in the pattern of winter demand therefore have no effect on the summer price.

One can imagine a scenario in which, as a result of rising demand and insufficient infrastructure and/or production capacity, only non-switchable demand can be met.[24] In this case the effective competitor for gas is gas-oil or LPG,[25] and one would therefore expect its price to rise above the fuel oil ceiling.

For the reasons that have just been detailed, this would be incorrect. If the northeast is in a situation such that no consumer is in a position to switch between gas and fuel oil, it ceases to be the marginal, and therefore price-setting, region. This role would then be played by that part of the US, among those where the potential for competition exists, for which transportation costs are the highest. If this turns out to be, say, the Great Lakes, the price would be set by reference to fuel oil parity in Chicago.[26]

Our analysis in the first part of this paper made the assumption that the balance between generating capacity and electricity demand in Texas is such that at least one consumer can genuinely switch between coal and gas. What happens when this condition is no longer met?

Our interpretation of the unexpected situation of summer 1989 provides the answer. When coal-fired capacity must be saturated to meet electricity demand, competition with gas shifts to fuel oil and the south ceases to be in the marginal position so long as there is unsaturated demand in other parts of the country. Utilities in Texas therefore enjoy a rent, enabling them to buy as much gas as necessary to meet demand, while still staying below the local price of fuel oil (the geographical differential in fuel oil prices being far smaller than the transportation cost of gas).

This, however, requires a further implicit condition. Why does increased consumption in the south lead to unsatisfied demand in the northeast? Why presume that the overall amount of gas available is given? It is commonly assumed in the US that the seasonal variability of price leads a significant number of producers to shut in their gas for part of the year, either because the prevailing price does not enable them to cover their marginal costs of production, or because they deliberately play on the difference between peak and off-peak prices. In this case the appearance of fuel oil parity in summer should lead to a sharp increase in the amount of gas available (see, for example, Hager, 1989).

This idea, which is at the heart of the "bubble" approach, is at first sight plausible. It does not however stand up to detailed analysis. First, the variations of production are smaller than is commonly suggested (Figures 8 and 9). Summer production in Louisiana is 20% lower, and in Texas 15% lower, than the winter peak. Allowing for the fact that some of this decline (say at least 10%) is a result of the deliberate scheduling of maintenance during the off-peak season, voluntary production restrictions are clearly at best of limited significance. More crucially, the figures show that the unusual price increase in the summer of 1989 did not cause any major change in production in the main producing areas. This points to

23/ This involves the assumption that residential and commercial use does not take all available gas and that there is no insuperable technical or regulatory constraint on the use of fuel oil.

24/ This is not identical with residential and commercial demand, since cogenerators, which are considered likely to account for much of the increase in consumption, are not in practice interruptible consumers.

25/ Circumstantial evidence of this was widespread in December 1989.

26/ If the fuel oil price in Chicago is approximately the same as in New York and if gas-transportation costs from Texas to Chicago are lower than from Texas to the northeast, fuel oil parity in Chicago will lead to a higher wellhead price. This would be the effect predicted by the fashionable "bubble" analysis, though for entirely different reasons.

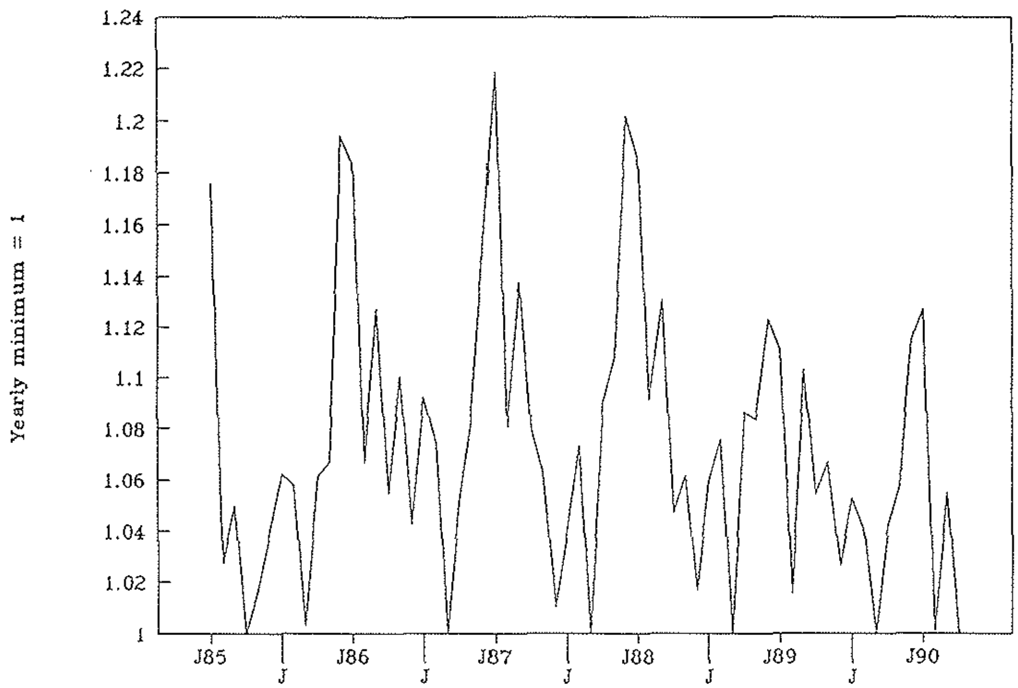


Figure 8: Monthly Indices of Marketed Production — Texas

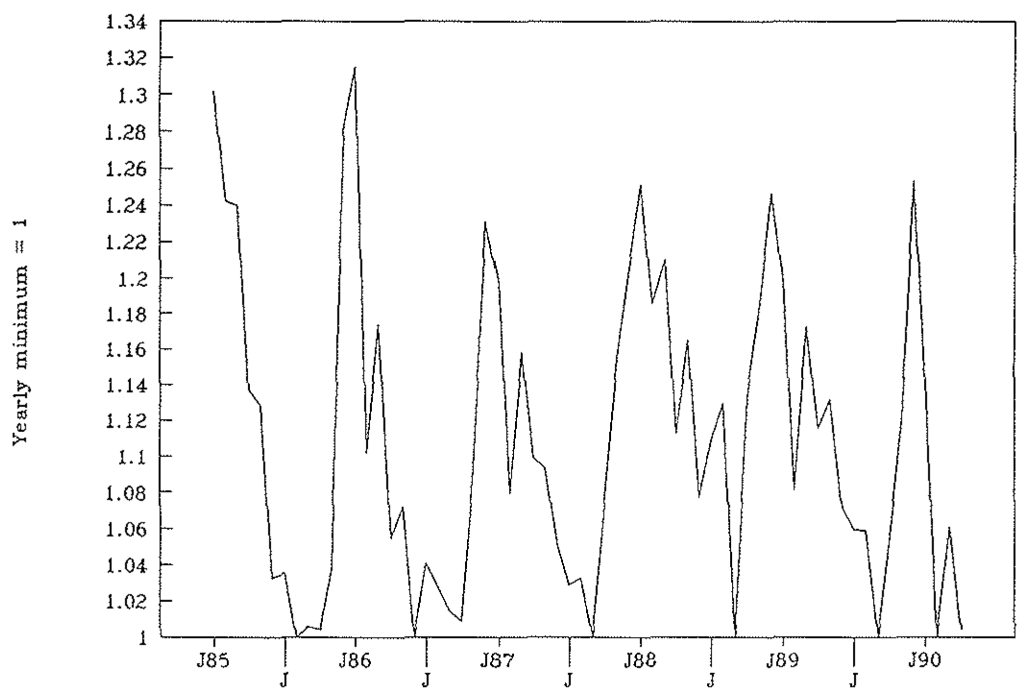


Figure 9: Monthly Indices of Marketed Production — Louisiana

a largely inflexible seasonal pattern of gas supply.

Such behaviour is hardly surprising in view of the economic and institutional pressures to which US producers are subject. Conscious arbitraging between winter and summer prices implies that the producer is financially strong enough to live for several months with a limited cash-flow in the expectation of a higher price.[27] In the final analysis this will mainly reflect his level of indebtedness. There comes a point when the need to meet monthly and quarterly repayments is so acute that no conceivable seasonal price differential would justify that kind of arbitrage. Most American gas producers, and particularly the smaller independents, have been in exactly that position since the 1986 slump in oil and gas prices. In addition, the decision to shut in a field will not usually be made only by the operator. The agreement of all partners will be required, and among these there will very often be at least one financially stretched producer.

It is therefore not unreasonable, though it goes against conventional wisdom, to describe the summer availability of gas as fairly insensitive to price. This means, to sum up the whole argument, that the disappearance of effective opportunities for coal-gas competition in Texas power generation could lead to a price curve with fuel oil parity in the northeast in both summer and winter (or more accurately during periods of peak power demand in both the south and the northeast) and coal parity in the south during the rest of the year. This of course means a higher mean annual price (as in the current US consensus), though without any change in the fundamental mechanisms of price formation.

Whether this dual-peak price curve will occur in any given year is for the moment highly uncertain. The balance of coal capacity and electricity demand in Texas is tight enough for fairly minor variations to have a significant impact on prices. Thus, in 1990, the same phenomenon did not occur, or occurred only so microscopically as to be insignificant. A definitive move towards a dual-peak is, however, possible if electricity demand continues (as it has done in recent years) to increase more rapidly than coal-fired (or for that matter primary) capacity. In that case, the balance would eventually be such that, in all but the most exceptional circumstances, coal-fired plant would be saturated. As Texas utilities have, at least on paper, some 14 GW of coal-fired capacity on order for delivery in the next ten years, this cannot be taken for granted. It must however be stressed that the completion of these projects is highly uncertain, not least because of the uncertainties caused by new US environmental legislation.[28]

Conclusion: Is the US Experience Relevant to Europe?

The answer is yes; since the analysis is based on the principles of economic theory, it is at least generalizable. It shows that, in a competitive gas market with strongly seasonal residential and commercial demand and significant gas consumption in base-load power generation, the gas price will tend to vary between fuel oil parity (at times of peak demand) and coal parity (at times of "slack").

Europe does not currently fit this description. The gas market is dominated by national monopolies and base-load gas-fired generation is almost non-existent. This could change in the next decade as a result of the desire of the European Commission to introduce more competition and a likely increase in gas burning in power stations. In line with the mechanism described here with reference to the US, this could lead to a major change in the formation of gas prices in Europe.

Such a move is in fact starting even without direct regulatory impetus. Economic pressure on the part of large gas consumers (utilities or industrial plants) is leading to contracts basing the

27/ This requirement also explains why the development of the futures market has had no effect on the basic seasonal pattern of prices.

28/ While the rival Clean Air Acts of the Senate and House of Representatives have now been reconciled, the consequences are still unclear. It is difficult for US utilities to know with any degree of certainty which regulatory environment they will be working in over the next decade.

price of gas, in various ways, on that of coal, particularly in Germany, the UK, Italy and the Netherlands (*Energy Economist*, 1989, pp.22-24). For these consumers, the results of common carriage may be obtained without any explicit institutional change. The difference between such a system and a genuine competitive market is, however, considerable. These contracts increase market fragmentation (since the opportunity to buy at coal-related prices is not open to all consumers), whereas common carriage in the strict sense of the word would, as in the US, imply the unification of gas prices and the appearance of a representative spot market.

The spontaneous appearance of a US-style market would thus require not just consumer pressure, but also the breakdown of the traditional relationship between the gas producers and the European transmission oligopoly. As in the US, such a breakdown would probably occur only if a latent surplus of gas at current prices and transport capacity at current levels of consumption created an incentive for companies to move outside the traditional long-term contractual framework and make sales on a short-term basis. While such an upheaval may seem remote, it is important to remember that there is in Europe a potential seasonal surplus of gas, hidden only by the swings imposed on producers and by the widespread availability of storage in some consuming countries.

This means that Europe cannot assume that the three currently fashionable norms for the gas market — "green-ness", competition and security of supply — are necessarily compatible. If competition leads, as the analysis presented here suggests, to a change in price formation and to a fall in prices, it may not be possible to develop the costly gas reserves needed to increase the share of gas in power generation while meeting the traditional requirement of security of supply.[29] In this sense, the US experience is an indispensable point of reference for the evaluation of future European gas policy.

References

Bulletin de l'industrie pétrolière (1990) "Le marché gazier américain: il est temps de voir au-delà de la «bulle»", No. 6521, January 25.

Carpenter, P.R., H.D. Jacoby & A.W. Wright (1987) "Adaptations to change in natural gas markets", in R.L. Gordon, H.D. Jacoby & M.D. Zimmerman, *Energy, Markets and Regulations*, MIT Press.

Coal Outlook (various issues).

Crowley, J. (1990) "The price implications of increased gas-fired electricity generation in Europe", a paper presented to the EAEE/ITEP Conference, *Energy Trends: Integrated Europe -Decentralized USSR*, Tallinn, October 21-24, Conference Proceedings, Volume II, pp.302-314.

Energy Economist (1989) "World status: gas prices", April, pp.21-22.

Energy Modelling Forum (1989) *North American Natural Gas Markets*, Stanford University, EMF Report 9.

First Boston Equity Research (1987) *The Spot Gas Price Rise: a Winter Phenomenon or Longer-lived Adjustment?*, November 10.

Hager, R. (1989) "US gas producers cut production to wait for gas hike", *Oil and Gas Journal*, March 20, p.34.

Lookadoo, P.G. (1988) *Natural Gas Regulations Handbook*, Government Institutes, Inc.

Natural Gas Intelligence (1989) August 28.

O'Neill, R. (1985) "The evolution of natural gas markets", in W.F. Thompson & D.J. DeAngelo, *World Energy Markets, Stability or Cyclical Changes*, (Boulder, Col.:Westview Press).

Platt's *Oilgram Price Report* (various issues).

Sawhill, J.C. (1987) "The outlook for domestic supply and demand", in J.P. Kalt, F.C. Schuller, dir., *Drawing the Line on Natural Gas Regulation* (Cambridge, Mass.: Energy and Environmental Policy Center, Harvard University).

Sawhill, J.C. (1989) "Putting the US gas industry back together after the bubble," *Oil and Gas Journal*, August 28, pp.25-27.

Schlesinger, Benjamin and Associates (1988) *Development of Natural Gas Transmission and Distribution: Information for North American Regional Gas Model*, Bethseda, Md.

Stobaugh, R. & D. Yergin (1983) *Energy Future*, Vintage Books, 3rd edition.

29/ For a more detailed presentation of these arguments see Crowley (1990).

Teece, D.J. (1990) "Structure and organization of the natural gas industry: differences between the United States and the Federal Republic of Germany and implications for the carrier status of pipelines", *The Energy Journal*, 11(3), July, pp.1-35.
US Energy Information Administration (1989) *Annual Energy Outlook 1989*, Department of Energy, Washington (DC).
Woods, T.J. (1988) *The Long-term Trends in US Gas Supply and Prices: the GRI Baseline Projection of US Energy Supply and Demand to 2010* (Chicago: Gas Research Institute).