The Future of Research and Development in the UK Gas Industry

by

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1. Executive Summary

R&D expenditure has fallen sharply in the privatised UK energy industries. Concentrating on the case of the UK gas industry, this report asks whether or not this decline matters from a public policy perspective, and, if so, what might be done about it in the new and more competitive world in which the energy industries exist.

Section 3 presents a framework for analysis. Just because the private energy industries now do much *less* R&D does not prove that they do too *little*. State-owned monopoly industries often carry much wider duties than private companies and may often have spent excessively or unwisely. However, it is widely accepted that private, competitive markets will tend to under-provide R&D for a variety of reasons: its results are uncertain; the benefits cannot often be appropriated by the firm spending the money; it produces more than just the commodity 'knowledge', especially skilled people; and in environment and safety, the appropriability issue becomes even more acute.

While quantified evaluation of R&D is difficult (especially in advance of research programmes), follow-up evaluations often show very high private rates of return to R&D - the range averages 20 per cent to 50 per cent annually - and even higher social rates of return. These arguments do not mean that there should be across-the-board public support for R&D but that in 'public-interest' areas, the case for public support for R&D may be strong, with a variety of mechanisms available to governments, regulators and industry for the encouragement of more and better R&D Mechanisms include direct public expenditure through consumer-funded R&D via regulation, compulsory levies on industry, tax incentives and governmental brokering devices. Finally, it is difficult to treat much R&D as a standard commodity purchase that can be efficiently contracted out. This is because much of R&D is essentially a search process rather than a routine form of production.

Section 4 is a mainly factual review of the role of R&D in the former British Gas from privatisation in 1986 up to the present. Levels of R&D spend were around £75m to £85m from 1986 to 1994 and only after 1995 did levels of expenditure fall sharply, to a current level in the National Grid Transco Group of £40m. Centrica (the UK retailing gas company) now spends negligible sums on R&D, and the chief reductions have been in long-term R&D and user-related expenditure.

Section 5 briefly analyses the gas industry in Europe, concentrating on the implications of the Gas Directive adopted in the EU in 1998 and strengthened in 2003. While the new Directive does accelerate liberalisation, the UK is still far ahead of its mainland European counterparts in opening up its industry. Germany and France, possibly the two most important other European markets, have been much less ready to break-up existing companies and introduce real competition. The implication of this lag is that there could be a disadvantage to UK companies like Advantica trying to compete is a wider European gas R&D market, where overseas companies will have full competitive access to the UK, while, in practice (if not in theory) access to other European markets may be limited or possibly non-existent.

Section 6 analyses the position of the US gas industry in relation to R&D. The US case is interesting, partly because of the very large and well-documented volume of R&D spend in the gas industry but mainly because of the long-established tradition, now breaking up, of funding public-interest gas R&D by means of a compulsory levy on the pipeline industry. The debates in the US about the future of R&D funding quite closely parallel those in the UK and are particularly concerned with the question of whether or not it is feasible or desirable to organise a collaborative R&D programme in an increasingly competitive market.

Section 7 gives a history and analysis of the treatment of R&D expenditure by the gas and electricity economic regulators (now combined as Ofgem, the Office of Gas and Electricity Markets). Before 1997 the regulators allowed R&D costs to be passed through to consumers as 'recoverable expenditure' more or less automatically. However since that time R&D expenditure has been subject to greater scrutiny, and the Utilities Act of 2000 does not require regulators to give any specific attention to R&D issues. In 1997 the gas regulator (then Ofgas) proposed to disallow all R&D expenditures proposed by Transco, an attempt subsequently overturned by the Monopolies and Mergers Commission. Also in 1997, there was a similar but more detailed argument involving Offer (then the electricity regulatory office) over National Grid Company's proposed R&D expenditure. Again the initial proposal was to disallow all proposed R&D from being passed on to consumers, a position later modified to allow almost all R&D (except for 10 per cent defined as long-term). This issue did not arise in the 2002 review of Transco charges.

Section 8 looks at future prospects for gas industry R&D, and looks at the advantages and drawbacks of two main kinds of future model for energy R&D organisation. In the first model, Advantica (and equivalent organisations in other industries) would remain a wholly owned part of a major group like National Grid Transco (the new home of Transco). The advantage would be that Advantica might be a strategic asset for Transco, but there could be regulatory pressure to strip all 'non-core' activities out of Transco. Further there could be disadvantages for co-operative research strategies if Advantica was still owned by Transco. The second model would see Advantica separated from National Grid Transco (much as AEA Technology was separated from UKAEA as a stand-alone technology company). This might cause Transco the problem of how to remain an informed customer but would provide a clearer focal point for industry-wide R&D collaborations. As far as funding is concerned, many models exist. Straight government expenditure is no longer very plausible, but joint industry/government funding, or industry finding via compulsory pipeline levies both deserve further attention. In either case the need to consider more collaborative R&D programmes is urgent, as is the need, partly for safety and environment reasons, but also for long-term competitiveness of the gas industry, to reverse the long-term trend of declining R&D expenditures.

2. Introduction

Levels of research and development (R&D)[i] spending have fallen sharply in the privatised energy industries of coal, gas and electricity, including nuclear power. From a level of over £300m in 1993, annual spending on research and development in these industries fell to only £95m in 1997.[ii] There has been substantial concern that these falls represent a short-term response to new market pressures, and may mean, as the DTI put it in 2000:[iii]

> 'that this downward trend in public and business funding would be inconsistent with the technological challenges likely to be faced by the energy industry in the future and would ultimately impact on the competitiveness of UK industry and therefore impact on jobs.'

In addition to such worries about competitiveness, especially in the long-term, there are also concerns about issues of safety and the environment, where incentives for private R&D funding may be even weaker than in areas directly connected to competitiveness.

There are some signs that the long decline in publicly funded energy R&D may be coming to an end. The DTI has increased expenditure on new and renewable energy[iv] and has instituted a review of both public and private R&D in the energy sector. However, there are still pressures towards reduced R&D. The economic regulatory agency for the gas and electricity industries, Ofgem is subjecting expenditures on R&D to new and more detailed levels of scrutiny, and the Utilities Act (2000) no longer requires regulators to promote R&D.

This report looks at the question of levels of R&D expenditure in the UK gas industry and asks questions about future organisation of R&D in that industry. The particular focus is on the situation of Advantica (formerly BG Technology), which is now a part of the National Grid Transco group created in 2002 from the merger of the electricity transmission network company, National Grid Company and its equivalent in the gas industry, Lattice.

The structure of the report is as follows:

- Section 3 raises general questions about the nature and funding of R&D and asks why the level of funding and organisation of gas industry R&D should be a public policy issue. Under privatised and liberalised markets, why cannot the industry be left to determine its own levels and organisational practice in R&D?
- Section 4 explains the relevant history of BG, Transco and BG Technology (now Advantica).
- Section 5 looks at the gas industry in Europe.
- Section 6 examines the relevant experience of gas R&D in the USA.
- Section 7 analyses the experience of regulatory treatment of R&D in both the BG/Transco case and for the National Grid Company in electricity.
- Section 8 outlines, in the light of the earlier sections, what are the options for financing and organising R&D in the UK gas industry in the future, with particular emphasis on the position of Advantica, and looking in turn at the position of government, Ofgem and the industry itself.

3. The nature and funding of R&D: Analytical framework

3.1. History

State-owned and generally monopolistic energy companies have historically carried out substantial volumes of R&D activity across a wide range of countries. The R&D conducted has partly been in the immediate interests of the firms and their customers but it has also contained an element of national or public service objectives. In other words governments have been content, or even enthusiastic, that large energy firms carry out wide-ranging R&D programmes that might address very long-term problems (such as funding advanced nuclear power), generic safety issues (as in gas and nuclear power) or which address wider issues than concern the company alone (for instance research on environmental impacts).

However these patterns of substantial R&D funding have not always depended on state ownership. For example in the USA the privately owned gas and electric utilities carried out large programmes of R&D, much of it collaboratively funded and conducted via the Gas Research Institute (GRI) and the Electric Power Research Institute (EPRI) respectively. The key here was the monopoly status of the firms concerned, which gave them two incentives not available to firms in competitive markets. First, and with the consent of their economic regulators (generally the State level Public Utility Commissions) the costs of these programmes could be passed through to consumers. Second, the non-competitive status of the industry meant that commercially valuable new technology could be equally applied by all firms within their own monopolistic domains - there were no worries about the ‘appropriability’ of the technology.

The processes of privatisation and especially liberalisation, where liberalisation is taken to mean the introduction of competition into the relevant industry, have changed this situation radically. Private investors rightly perceive R&D as inherently uncertain, and often long-term in its payoff, and it is not amenable to conventional rate-of-return calculations in advance of programme spending. In addition, a major problem for investors is that much of the knowledge produced by R&D cannot be fully appropriated by the firm that finances it. The risk that other forms will capture some of the commercially valuable gains from the results of R&D is a classic ‘free rider’ problem; benefits may be gained by those who do not pay, and this is a serious disincentive to paying in the first place.

3.2. How much R&D? Why markets under-provide

Just to observe that the newly privatised energy and gas industries have seriously cut back their R&D budgets is not the same thing as saying that they now do *too little* R&D. It is often observed that much past R&D conducted by state energy monopolies was poor value for money (e.g. the money spent over several decades on the fast breeder nuclear reactor by the electricity industry, or on synthetic natural gas in the gas industry) and so it is not necessarily the case that the new levels of R&D spending are too low. There are however both theoretical and practical reasons to be sceptical of the view that competitive market places provide enough R&D spending.

At the level of theory, it is very widely accepted in economics that private markets, including competitive markets, will tend to under-provide R&D, and that this provides a strong potential case for public policy to intervene and induce increased levels of spending. The main arguments[v] are four-fold:

- R&D is inherently an uncertain activity, the results of which, including their timing, cannot be predicted accurately in advance. The reason for this is that R&D is about search processes rather than simply the production of routine knowledge. Such processes may often produce very high economic returns and sometimes they will produce little or nothing. Private capital markets tend to be very wary of such uncertain investments.
- R&D has many of the characteristics of a ‘public good’, a commodity available to all. Once new knowledge and technology is available to one firm, it is hard to avoid to all firms in a market acquiring the same knowledge. Indeed one of the main arguments in favour of R&D for the economy as a whole is precisely that it has such large ‘spillover’ effects. However this provides a disincentive to an individual firm to spend on R&D for fear that the benefits will also be available to competitors without their having had to pay. Ironically, the more competitive a market the worse this ‘market imperfection’ may become,

as uptake of new ideas by competitors may be more rapid. The problem here is generally known as one of limited appropriability of R&D results.

- R&D activity produces usable knowledge or information seen as a commodity. It also produces trained people whose skills may be used elsewhere in the economy, and stimulates the development of networks, which may also have real productive value.[vi]
- In recent years, a fourth argument has been added. The increasingly important category of R&D into environmental improvement may be under-provided to an even greater extent than other R&D. In this case companies generally cannot appropriate any of the benefits (cleaner air etc) because there are generally no financial rewards available for environmental improvement.

In practice, it is possible to exaggerate the second of the above arguments, on appropriability. As we move from pure or basic research through applied research and towards commercial development, so the extent of capture of private benefits (appropriability) becomes greater. In addition, it is simplistic to think of all the outputs of R&D as simply 'knowledge' that is somehow available 'on the shelf' to all-comers. R&D also produces outputs in the domains of learning, skill acquisition, network development and problem-solving capabilities. This view is associated with the idea that much 'new knowledge' is not codified in manuals, blueprints or computer programmes, but depends on the tacit and cumulative skills and practices built up in both individuals and teams. In this view 'knowledge' is not a simple commodity, easily available and immediately applicable to improved economic activity, but needs to be seen in *process* terms, in which both development and application of knowledge are context-specific. And where there is complexity in technological development, it may be enough that a company performing R&D can achieve a 'first-mover advantage' and keep ahead of the competition. In addition, there are legal mechanisms, in particular the patent system, which attempt with varying degrees of success to protect the innovations made by individual firms. Indeed if there were not these mitigations to the 'non-appropriability' argument, it would be difficult to see how private firms would finance *any* R&D.

Nevertheless the overall force of the four arguments is strong and more or less uncontroversial: private markets, including competitive markets, are expected systematically to under-provide R&D in relation to what is socially desirable.

3.3. Evaluation and empirical evidence

A good deal of empirical evidence supports the argument that markets under-provide R&D. While it is impossible to do serious cost-benefit (rate of return) appraisal *before* an R&D programme is launched, it is possible to conduct such appraisals, with difficulty, *after* programmes are complete. There are two main kinds of result of most such evaluations:

- the average annual rate of return to publicly and privately funded R&D often falls in the range 20-50 per cent, well above the levels normally expected of ordinary capital investment;[vii]
- the society-wide returns to such R&D investment exceed the private returns to individual companies, often by a large multiple.

There are methodological difficulties in measuring such rates of return even after the event,[viii] but the consistency of such results is striking, and provides some intellectual justification for the willingness of governments to spend substantial sums in subsidy to R&D efforts.

The evaluation question, applied in advance of R&D expenditure is particularly acute. Clearly R&D is only undertaken in the expectation that *some* level of return will be made. In this sense R&D expenditures are conceptually very similar to other, physical or tangible investments. But *when* the return will be made, at what level of *uncertainty*, in combination with what other level and type of *inputs*, and whether or not it will even appear in *quantified monetised* form (as in the case of safety or environmental R&D) are all difficult or impossible questions to answer. They mean that application of standard DCF/rate of return calculations to R&D projects in advance of the project are essentially doomed. Putting it the other way round, if a proposed R&D project appears to have a predictable rate of return, then it is probably not a genuine R&D project, but probably rather an applied engineering project that is building on the results of earlier R&D work.

The point about complementary inputs is particularly important. Success in R&D, measured in the market place, will normally depend not only on good research and technology performance, it will also need other important and firm-specific inputs, such as high quality production engineering, good strategic management and good marketing skills. Attempts to separate out and isolate the specific contribution of R&D to the overall success of a process that may nevertheless depend on the R&D is therefore often a misguided process. This is an important point to bear in mind in relation to attempts by economic regulators (Competition Commission or Ofgem) to evaluate the returns to R&D when they consider whether or not to allow R&D cost pass-through to consumers.

In the recent past, there have been attempts to try and shift the focus of *ex ante* evaluation of R&D away from conventional rate of return methods and towards the growing field of option valuation. This is a development from finance theory and has been applied to investment processes more widely. Where an investment project involves irreversibilities (sunk costs which cannot be fully recovered), there are uncertainties about outcomes of investment and there is the possibility to delay investment, then the traditional net present value (DCF) approach to investment appraisal becomes inappropriate.[ix] In such circumstances firms with an opportunity to invest are holding 'real options' (analogous to financial market options) and may rationally choose to delay making an investment while accumulating more information relevant to their decision. The relevance of this to R&D is that R&D is itself a specialised kind of investment expressly designed to acquire more information relevant to wider investment decisions. Firms may use R&D as a device, in postponing a wider investment decision, to acquire the information they need. More generally, R&D may be seen as the process of creating new future 'real options' which themselves have value for firms considering investment strategies. This implies that the value of R&D may be significantly higher than the (admittedly already quite high) values that retrospective rate of return evaluations tend to give. This also could have implications for the way in which regulators treat R&D expenditure.

3.4. R&D classifications: which types deserve public support?

The question of exactly where subsidy to R&D can be justified, and in what circumstances, is difficult. A traditional distinction among R&D types is between basic research at one end of the spectrum (broad-based and curiosity-driven), through applied research (directed at a more specific purpose with a possible commercial application in view) to technology development (the process of developing products or processes from the results of earlier research).

At the basic research end of the spectrum, governments are willing to engage in large-scale disbursements, for example in the funding of universities, while at the opposite end (commercial development) it is clear that government support is inappropriate and would distort markets. This leaves large grey areas between basic research and commercial development where governments take different views on the legitimacy and desirability of funding R&D.

The issue of what public support should be given to R&D is in reality more complex than making the simple and somewhat linear distinction between basic research, applied research and technology development, and then arguing that public support should dry up as we move along the spectrum towards development. We need to make further distinctions, many of them highly relevant to the gas industry. The first distinction runs in terms of the beneficiaries of R&D activity. In the USA the distinction is sometimes made between public-interest and private-interest R&D.[x] This is not exactly the same as the sequence from basic research through to technology development, even though basic research is normally public interest. The essence of the idea of public interest is that it is R&D that contributes to wider social goals than those of the firms and consumers of the industry involved. Thus research that impacts on health, safety, the environment, energy efficiency and 'pre-competitive' (e.g. basic) research would in principle be seen as 'public interest'. Such R&D may, however, be close to, or even devoted to, commercial development. An example could be the development of new safety-related technology fulfilling a regulatory requirement applicable to all workers in an industry. Such R&D could easily qualify for support as 'public interest' R&D.

Another distinction often made is between long-term and short-term research, where the former is presumed to be a matter for public subsidy and the former for private funding. Some long-term R&D (for instance into new drugs in the pharmaceutical industry) is quite easily funded by the private sector: equally some short-term R&D (for instance into environmental improvements in waste-handling) may be public in character and deserve subsidy.

These various different dimensions along which R&D may be characterised: from basic research to commercial development; from public interest to private interest; and between long-term and short-term, are by no means identical, and in considering the case for public support of R&D it is important to be aware of all these dimensions and not simply assume (as is often done) that only basic research should qualify for subsidy.

3.5. Who should pay and how?

The public interest/private interest continuum is in some ways the most useful dimension along which to consider practical decisions about who should pay for R&D. Essentially there are three main sources of funds for R&D in relation to the gas industry:

- companies, in other words shareholders that risk their own money. This will be appropriate where benefits are expected to accrue mainly to the company involved, as in the case of reduced production costs
- consumers, to whom R&D costs may in some cases (such as monopoly network services provided by companies such as Transco) be passed on as part of price control reviews. An appropriate case here might be the R&D costs of developing new and improved metering technology
- the public, or strictly taxpayers, who will pay if government decides that public subsidy is justified. The appropriate cases here will be relatively ‘pure’ public interest situations such as environmental or safety benefits, or long-term pre-commercial projects.

This discussion leads on to the question of the roles that public governance systems may play in the organisation and financing of R&D. The broad options are as follows, running from most public to most private:

- direct subsidy from central government
- direct subsidy from government but on condition that industry contributes a share of R&D costs (often, in the USA, amounting to 50 per cent of all costs)
- enforcing consumer expenditure on R&D by allowing cost pass-through in regulated monopoly activities
- enforcing industry R&D expenditure via a system of compulsory levies on the industry, together with a grant system for the expenditure of the levies on R&D projects
- allowing tax incentives for R&D, in much the same way as ordinary capital expenditure may be given incentives
- brokering R&D initiatives in collaboration with companies, especially where collaborations between companies are possible. Such action may help reduce the transaction costs otherwise incurred by private firms, and encourage trust
- leaving all R&D to private decision-making.

Not all these methods have been commonly used in the UK. For example, tax breaks and levy systems have a relatively limited history here compared to the USA, while the other methods have more commonly been used.

3.6. Can R&D be contracted out?

One of the dominant characteristics of recent history across much of industry, and especially the privatised utilities, is a concentration on core skills or competencies, and a strong push to out-source or ‘contractorise’ all other goods and services needed by the firm. This obviously works in a number of important areas. Where firms need to acquire standard goods or services produced efficiently by other firms they will clearly save resources by buying those goods and services in. The importance of the idea that such goods and services must be reasonably standard is that the downside of out-sourcing is the extra transaction costs that must be incurred in setting up the process of out-sourcing. Such costs will include search costs and the process of setting up a contractual framework for the supply of specialised services. If such transaction costs become too high, then internal provision may again become desirable.

The newly privatised utilities have also experimented with the idea of contracting out the provision of research and technology services. In some case this will be an efficient solution, especially in the areas of R&D that are closest to development and where R&D tasks are clearly defined and monitored. However the problem is that much of R&D is not a standardised ‘product’: it is rather a search process with unpredictable results. If a firm wants to contract out R&D services it will need to be an ‘informed buyer’ of such services, and this often means that the firm will need to have substantial research resources of its own. This can sometimes mean that these 'transaction costs' will be high - it will be difficult and costly to evaluate the relative merits of competing suppliers of R&D services. This will often mean that even when R&D services are contracted out they will often be to a 'preferred supplier' rather than subject to the arduous and potentially costly rigours of a fully competitive process.

There are further problems in contracting out R&D services. First and most generally the recognition that technology is not just the production of 'information' readily available to all, but is part of a social process in which success depends on tacit as well as 'objective' knowledge and where processes of development are cumulative and long-lasting, implies that frequent changes of technology supplier may well be a highly inefficient. Most significant technology development is not discrete and self-contained into 'work package' chunks for whiten large numbers of firms may easily compete. much technology development is a cumulative process where new developments need to be built by specialised teams on earlier knowledge. This is especially true in an industry like gas, which consists of complex and interdependent systems rather than an aggregation of individual products. Where safety R&D is involved such considerations are reinforced further.

These arguments do not mean that R&D must always be performed on a monopoly basis 'in house' but they do suggest that frequent changes of supplier and open and competitive processes for the acquisition of R&D are likely to be inefficient, and where safety is concerned, potentially dangerous. An analogy, not completely direct but nevertheless instructive, occurred in 1998 in relation to the UKAEA at its nuclear site in Dounreay. A series of potentially serious incidents at Dounreay led to a comprehensive review of management practice at the site. One of the main problems was that UKAEA had excessively contractorised its decommissioning work at Dounreay, and did not manage safety as closely as it should. Many of the contractors did not have the technical experience or understanding to appreciate the nature of the risks involved at the site. The response by the UKAEA has not been to abolish contractorisation but to seek to become a better informed customer and to take back at least some technology-related functions for itself. It has for instance employed a further 200 people of its own on the Dounreay site and will undoubtedly pay more attention to the technical experience of its contractors in its future pre-qualifying processes. The UKAEA experience suggest some of the limits to competitive contractorisation in an industry with high technical complexity and serious safety issues (and in those respects is analogous to gas).

The answer to the question posed at the start of this section is therefore that R&D certainly can be contracted out in various circumstances but that these circumstances will be specific, and application of the 'open competition contractorisation' model to R&D services is usually inappropriate. In industries like gas, operating complex and highly technical systems and with significant safety issues at stake, large companies need substantial in-house capability in R&D and will need to operate on a preferred supplier basis in many important R&D fields.

4. British Gas and the role of R&D

This section reviews the main corporate changes to British Gas and its successor companies from the time of privatisation in 1986 to the present. It pays particular attention to the role of Research and Development and the technology development part of the business.

4.1. 1986-1996

British Gas was privatised intact in November 1986 as a fully integrated gas company. It had interests in gas production in the North Sea and it was the monopsony buyer of all gas produced in the British sector of the waters around Britain. It owned and operated the British gas transmission and distribution network and had monopoly rights to supply gas to all but the largest final consumers in Britain.

Table 1 Main Characteristics of British Gas – 1985-96

	Turnover (£m)	Operating Profit (£m)	R&D Budget (£m)	Employees (th)
1985/86	7687	706	76	91.9
1986/87	7610	1001	74	88.5
1987/88	7364	1053	77	84.6
1988/89	7526	1120	80	81.8
1989/90	7983	1095	75	80.5
1990/91	9491	1249	86	81.8
1991	10485	1268	90	84.5
1992	10254	1103	89	84.0
1993	10386	(310)	80	79.4
1994	9698	987	75	70.0
1995	8601	583	66	55.4
1996	9453	(182)	54	43.1

Sources: Annual Reports and Accounts (various)

Notes

1. Profits are calculated on a current cost accounting basis.
2. Employment is the average number of employees employed during the year in the UK and outside.
3. From 1991 onwards, the accounting year was changed to calendar year. There is therefore some overlap between the figures for 1990/91 and 1991.

In the last full financial year, 1985/86, before its privatisation, the British Gas Corporation had a turnover of £7687m of which £75.8m (1 per cent) was spent on research (see Table 1). About 43 per cent of this expenditure was on natural gas production technology and substitute natural gas studies, about 28 per cent was spent on transmission and distribution technology and the rest was on consumer technologies and general support work. Research was carried out at several locations primarily in London, Solihull and Killingworth (Newcastle).

There was little change in the figures in the first year after privatisation, although an objective was expressed that research be centralised to a new location. However, by 1989, there was public dissatisfaction with British Gas, which was perceived as a privately owned monopoly that was making unjustifiably high profits. As a result, British Gas was under investigation by the Gas Regulator, James McKinnon (then of Ofgas) and other regulatory bodies and there was pressure to split up the company to ensure that competition in the wholesale and retail gas markets would emerge. In 1989, the company was split internally into three divisions, much the largest of which was the Gas Business in Great Britain. Exploration and Production (E&P) and Global Gas were both international businesses. The R&D division, part of the Gas Business in Great Britain, was also more fully identified in the accounts and, despite the changes, overall spend on research was maintained with surprisingly little change in the focus of the research programme. By 1991, 1600 people were employed in the R&T division.

The structural changes within British Gas were insufficient to satisfy regulatory authorities or government. Following further investigations by regulatory bodies, British Gas was forced to re-structure the company again in 1993, splitting the Gas Business into a monopoly division, Transco, and a competitive division, British Gas Trading. Whilst Transco was highly profitable, British Gas Trading was making increasingly heavy losses. There were two main factors behind the steep decline in British Gas Trading's position. First, Ofgas required the company to give up market share in the sectors of the market that were then competitive (consumers using more than 2500 therms per year) to encourage the emergence of a competitive gas supply market. Second, a steep reduction in the price of gas from the North Sea (about 40 per cent in the period 1990-95) had left British Gas with a portfolio of long-term gas contracts that were well above current market prices. British Gas took heavy accounting losses to renegotiate these contracts in order to continue to be competitive with new entrants.

The total number of employees in British Gas began to fall steeply and, by 1996, it employed little more than half the number of people that worked for it only four years earlier. Inevitably, R&D expenditure could not be insulated from the general financial problems affecting the company and R&D expenditure fell by 40 per cent in the same period. However, in 1993 almost all R&D activity had been consolidated on to a new single site at Loughborough, though Killingworth (the last of the other R&D sites) did not finally close until 1995. However, no details of the breakdown of R&D expenditure were published after 1991.

4.2. 1997 onwards

In December 1996, the decision was taken to split the company in two parts and in February 1997, the two companies were formally de-merged. The first company, known as BG plc, was much larger and was based around the Transco division, which operated the pipeline network (see Table 2). Included in BG plc were the E&P business (except for the Morecambe Bay gas field, which was transferred to the second company), and the Global, Generation, and Pipeline Integrity Businesses (Pipeline Integrity was sold off in February 1998) and other activities including Property, Leasing and Technology. In overseas markets, BG was allowed to continue to trade using the brand name British Gas. The Transco business was highly profitable, masking the relatively poor performance of the other parts of BG. About two thirds of BG's turnover but 84 per cent of profits came from the Transco business. The E&P division (17 per cent of turnover and 10 per cent of profits) and the International Downstream Division (6 per cent of turnover and 2 per cent of profits) provided most of the rest of the business. 'Other' activities including Property and Leasing, as well as BG Technology, made up only about 3 per cent of turnover and 1 per cent of profits. In 1998, BG Technology employed about 600 people, mainly at the Gas Research and Technology Centre in Loughborough.

Table 2 **BG plc – 1997-1999**

	1997	1998	1999
Turnover (£m)	4300	4474	4787
Transco	3084	3062	3058
BG Storage	126	106	79
E&P	710	823	836
International downstream	261	393	764
Other activities	212	205	158
Less intra group sales	(126)	(136)	(108)
Operating Profit (£m)	1201	1570	1591
Transco	1030	1224	1160
BG Storage	9	7	(8)
E&P	118	161	220
International downstream	27	64	102
Other activities	17	114	117
Employment	18928	17513	16735
Transco	16222	15043	14264
BG Storage	49	156	255
E&P	541	456	377
International downstream	877	506	627
Other activities	1239	1352	1212
R&D expenditure (£m)	39	40	40

Sources: Annual report and accounts (various)

The second company, known as Centrica, was based around the British Gas Trading (BGT) division including the Service and Retail businesses. British Gas Trading was a heavy loss-maker and so, to give the company some chance of survival, E&P’s highly profitable Morecambe Bay field was included in the group. For the first year or two after its creation, there was continuing speculation about possible take-overs of the Centrica company, but its financial performance has improved significantly and it is no longer seen as so vulnerable. Centrica has an interest in developing new user technologies that it can use to enhance its gas supply business, for example, the development of very small-scale electricity generation technologies. However, it no longer has any reason to favour BG Technology over other suppliers of gas technology. It has continued to place a small amount of research with BG Technology, but it is taking advantage of the large amount of technology that has been developed in the USA under the auspices of the gas utility research body, the Gas Research Institute, for new technologies. However its overall spend on R&D is now very low and has continued to decline. In 1999, Centrica spent only £0.4m on R&D, compared to an expenditure by the then BG of between £15m and £19m annually on user technologies in the late 1980s and realty 1990s (see Table 3).

Table 3 Research & Development Spend – 1985-91 (£m)

	E&P and SNG	Inspection and Transmission	Distribution	User techs	Other	All
1985/86	33	12	10	15	6	76
1986/87	35	7	9	15	8	74
1990/91	30	5	14	19	17	86

Source: Annual report and accounts (various)

Notes: No breakdown of R&D costs was provided after 1991.

The Transco business has continued to be highly profitable despite the imposition by the Regulator of significant reductions in the prices it charges. In April 1997, it was forced to reduce its charges by 21 per cent in real terms, followed by annual reductions of 2 per cent a year until 2002, a cumulative reduction of 27 per cent. The process has just been opened to set charges from April 2002 onwards. The national gas transmission and distribution system is now largely mature and not growing very rapidly, and the regulator (now Ofgem) is likely to continue to require real reductions in price for transmission and distribution services. The Transco business is therefore unlikely to grow significantly in terms of turnover or profitability.

In March 2000, BG plc announced a further splitting up of the company. This took effect in October 2000 and resulted in the creation of a largely UK-based company centred on regulated businesses, plus a largely international company. The UK company was known as Lattice and its centrepiece was the Transco pipelines business. The Lattice Property Portfolio primarily cleaned up the sites of old gas works and the Leasing group undertook a variety of leasing activities. The Technology activity, renamed Advantica Technologies, was also included in Lattice. The trend from the regulatory side is increasingly to require that regulated businesses are run separately from competitive businesses to reduce the risk that monopolies will cross-subsidise competitive companies.

The rest of the business remained in BG plc. Its divisions now include Exploration and Production, a largely new Liquefied Natural Gas business, the international Transmission and Distribution business, Power Generation and Gas Storage in Britain. Much of this activity will place it in direct combination with some powerful international companies and it remains to be seen whether it will remain an independent company or whether it will be taken over, perhaps by an oil major looking to move downstream. Advantica will also have to compete with a strong field of international companies for business with BG plc, which will now have no incentive to favour Advantica over these companies.

The split transferred most of the previous BG plc business to Lattice. Of BG’s 1999 turnover of £4.8bn, about 70 per cent was attributed to businesses that passed to Lattice. About 87 per cent of BG’s 1999 profits of about £1.5bn and about 73 per cent of the BG plc’s assets (£18.6bn) were attributed to businesses that are now part of Lattice.

In 2002, in what was described by the companies as a merger of equals, Lattice merged with National Grid Group and was renamed National Grid Transco plc (NGT). In its annual report of 2002/03 NGT wrote:

> ‘Advantica provides technology-based solutions to Transco, other utilities and pipeline operators worldwide. Following last year’s acquisition of software and technology company Stoner, the company now operates in the US

> as well as Europe. After a review, Advantica has been defined as non-core and its management has taken action to reduce costs, prepare the company for disposal and to seek a purchaser for the business.'[xi]

However, in March 2004, NGT announced that it had not received any satisfactory bids for Advantica and that it would remain part of NGT.

Advantica has expertise in four main areas, oil and gas production, pipelines, hazard and risk management, and energy and the environment. For each of these areas, it offers up to six different types of service. These include technology consultancy, training, testing and certification, engineering, software and product development.

In 2002/03, NGT spent £18m on R&D compared to £16m in the previous year, but gave no breakdown of where the research took place.

5. The gas industry in Europe

The UK gas industry has been fully liberalised since 1998. It is de-integrated into three sectors, the wholesale market and the retail market, which are now competitive, and the infrastructure sector, which is a regulated monopoly. Liberalisation has progressed much further than in the rest of the European Union, where consumers are still largely served by regulated monopolies, often publicly owned integrated companies. The UK downstream gas technology industry could potentially be at an unfair disadvantage if European companies with monopoly privileges compete against it in the UK at sub-economic prices or if British companies do not have open access to European markets. This section briefly reviews the state of gas liberalisation in Europe and examines the industry structure in the main countries.

5.1. The EU Gas Directives

The EU Gas Directive (1998/30/EC), which sets the rules for the internal market for gas was adopted in June 1998 and member states had to translate it into national law by 10 August 2000. The Directive required member states to comply with a number of requirements on the organisation and operation of their gas industries. The Gas Directive was replaced by a stronger new Directive (2003/55/EC) passed in June 2003. Four of these requirements are of particular relevance:

- Market opening. The original Directive required that 20 per cent of the gas market be opened to competition from August 2000. The new Directive requires that all non-household consumers can choose their supplier by 2004 and the market should be fully open by 2008.
- Access to the system. The Directive requires that member states put in place arrangements that ensure non-discriminatory access to the network by buyers or sellers of gas by regulated third-party access (TPA).
- Unbundling. This requires that the activities in the gas supply chain, e.g., retail supply and transmission, are operated by separate companies so that it is clear that companies that operate in both competitive and monopoly sectors are not abusing their market position.
- Regulation. The Directive requires a regulatory authority be designated.

5.2. Implementation

Of the 15 member states, for these purposes, Greece, Finland and Portugal can be ignored because their gas industry is regarded as ‘emergent’. The key countries, because of the size of their industries are probably Germany, France, Italy and the Netherlands (see Table 4). The UK consumes more gas than any other country in Europe and about a third of primary energy consumption is now gas. Gas consumption has increased by more than 80 per cent since 1980. In 2000 (the last year for which statistics for Europe are available), about 17 per cent of gas consumption was burnt in power stations, compared to about 2 per cent in 1990.

Gas is a smaller element of the energy economy in Germany than in Britain and less than 20 per cent of gas is used in power stations. Demand for gas has increased more slowly than in most other European countries, growing by 40 per cent since 1980. Residential consumers use a significant proportion (a third) of the gas consumed. As in its electricity industry, there are a large number of private companies active in the industry, and ownership of the network is split amongst many companies. Some, such as Ruhrgas (taken over in 2003 by one of the two large electric utilities, E.ON) are relatively large companies, while many are very small. In some respects, Germany appears to be adopting a relatively liberal approach with a promise that the market will be made 100 per cent open. However, the fragmentation of ownership of the infrastructure, the lack of a strong regulatory body and the proviso that opening of the market would be conditional on progress in other countries mean that there must be serious doubts about whether final consumers will really be able to choose.

In France gas is a relatively small part of the energy economy, and demand has grown only by about a third since 1980. Gas consumption is mainly for industrial and residential use and little is used in the power generation sector. A long-established state-owned company, Gaz de France (GDF), which owns most of the network and supplies most consumers, dominates the industry. As with electricity, France will be late translating the Directive to national law and France is doing no more than the minimum to meet EU requirements. In the short- to medium-term, there seems little likelihood that the dominance of GDF will be challenged.

The Italian gas industry is relatively young. Demand has more than doubled since 1980 and accounts for nearly a third of Italy's primary energy consumption. This rapid growth has been partly for power generation, which uses four times as much gas as it did in 1980 and in the residential and commercial sector where gas use has more than doubled. The network and supply to final consumers is dominated by SNAM, but the Italian government is taking rapid steps to break up the industry and introduce competition for all consumers.

The Dutch energy economy has long been heavily dependent on gas produced in its own fields. As far back as 1973, more than 45 per cent of its energy came from gas. Much of this is used in power generation, but, on a per capita basis, consumption in the residential sector is high. Gasunie owns the transmission system, but supply to final consumers is carried out by a relatively large number of suppliers, many of which are publicly owned and many of which also supply electricity. Like Italy, the Netherlands is moving relatively quickly to a fully liberalised structure. What are the implications of these changes in Europe for the market in R&D for the European gas industry? The risk before the first Gas Directive was that R&D suppliers from other parts of the EU were free to compete against Advantica in UK R&D markets, while Advantica might be prevented from similarly competing elsewhere in Europe because of a less liberalised structure.

The new Directive may help Advantica in European competition. Experience with the longer-established and more liberal Electricity Directive of 1996 is that in practice markets open up more quickly than the minimum conditions stipulated in the Directives. Further the Dutch and Italian industries are clearly opening up rather quickly. To this extent, the competitive position of Advantica may well be reasonably fair. However there may be problems in relation to both France and Germany, especially France where the degree of conformity to the Gas Directive is still minimal and GDF remains an integrated company with a large R&D capability. There is a real risk that GDF may try to compete in Advantica's home R&D markets while not affording reciprocal opportunities to Advantica in France. This will be defensible under the Directive and wider European competition law as GDF will be free to source its R&D needs internally, though it might constitute a discriminatory practice against Advantica. However, the French R&D market in gas is not very large and the wider movements towards more rapid liberalisation elsewhere in Europe may well reduce the extent of this potential discrimination over a relatively short time horizon.

Table 4 Liberalisation of key gas markets in Europe

	Consumption MTOE (2001)	**% of energy/ % used for elec**	**Market Opening**	**Unbundling of transmission /distribution**	**Regulation**
Germany	75.6	22 / 20	100%	Management/ Accounts	Regulator planned for July 2004
France	1655	13 / 11	37%	Accounts	Separate body with advisory powers
Italy	2682	33 / 33	100%	Legal	Independent gas and electricity regulator
Netherlands	1593	46 / 32	60%	Management/ Legal	Independent gas and electricity regulator
UK	3789	37 / 29	100%	Ownership	Independent gas and electricity regulator

Sources: DG TREN Working Paper (2004) 'Third benchmarking report on the implementation of the internal electricity and gas market' Commission of the European Communities and European Commission 'European Union energy and transport in figures: 2003'

6. The Gas Technology Institute and other US gas R&D

The US Gas Research Institute (GRI) was set up in 1976 to carry out a co-operative research programme on gas technology for the benefit of the gas industry and its consumers. In April 2000, it merged with the Institute of Gas Technology (IGT) to form the Gas Technology Institute (GTI). It has been funded largely by a consumer surcharge, approved by the Federal Energy Regulatory Commission (FERC). Its annual budget peaked, in real terms, at $187m in 1987. However, since then, as competition was progressively introduced into the gas industry, support in the industry for a co-operative programme of research has waned. From 1993 onwards, there have been efforts to restructure the funding of the research programme and in 1999, the GRI and FERC agreed that, by the year 2005, the research programme would be entirely voluntarily funded. The detailed debates that have taken place over the period since 1993 represent a useful source of information on the arguments surrounding the need for research on gas technologies in a liberalised market.

6.1. The Gas Research Institute

The Gas Research Institute was one of a number of powerful US consortia formed to manage co-operative research programmes. These include organisations managing research for the electricity industry (EPRI), the semi-conductor industry (Sematech), and the telecoms industry (Bellcore) as well as the GRI. These organisations do not carry out research themselves but act as managers for research programmes that are sub-contracted to commercial companies. In the past, this model of research funding seems to have been most successful for utility industries that have franchised service territories, and where the utilities do not compete with each other. In these circumstances there are few barriers to utilities pooling their research funds to develop new technologies. Unlike the UK where in the past, utility services have typically been provided by a single nationally owned company, in the USA there are hundreds of gas and electric utilities, many privately owned and some very small. In this situation, it made sense for them to pool their resources to get the maximum benefit from their R&D expenditure. The consortium approach to R&D also has the advantages of common approaches on safety and environment, and also may facilitate alliances with other research partners such as the government.

A requirement for success in the circumstances where many different firms provide R&D services for the industry has been that the central staff of GRI have had to have a wide-ranging technical grasp of the technology issues, so that it act as an ‘intelligent customer’ in procuring R&D services. It is fair to say that the majority of GRI projects have been relatively low-risk and near the commercial development end of the R&D spectrum, which simplifies somewhat the procurement task.

The GRI was set up with the encouragement of FERC because of a perceived inadequacy in the level of R&D spending on gas technology. FERC believed that, because benefits from R&D programmes are difficult to capture for individual firms, utilities would tend to under-invest in R&D. It therefore allowed utilities to recover GRI contributions from consumers. R&D was therefore essentially cost-free to utility owners. From 1976 to 1993, the GRI was funded by a uniform surcharge (per unit of volume of gas). As consumers were paying for the research, its focus had to be primarily to provide benefits to them. There were also mutual benefits for the companies through making gas use more attractive and expanding their market. When the GRI was formed, and until the mid-to late 80s, the whole of the industry was fully regulated, and the GRI programme was able to expand, reaching a peak in 1987.

However, by the late 1980s the industry was beginning to be liberalised, first in the interstate pipeline area, where competition was introduced. This raised practical issues about how the surcharge could be collected and by 1993, a more complicated formula had to be introduced to raise funds for GRI. Similar pressures were beginning to affect the Electric Power Research Institute (EPRI), which is funded on a voluntary basis but with costs recoverable from consumers. These pressures led to a steep decline in EPRI research in areas that were being opened to the market, primarily electricity generation.

Over the period until 1998 the formula for funding GRI was continually revised and the budget continued to decline in real terms until January 1998. An agreement was then reached between GRI and FERC for a transition over a seven-year period from full funding of the research programme from consumers to one in which the programme was funded by all-voluntary contributions. This settlement allowed a three-year transition during which GRI research would be progressively divided into a core programme funded mainly by consumer contributions and research funded from other sources. FERC-approved funding for the overall programme would be $164m in 1998, $132m in 1999 and $98m in 2000. There would then be a four-year post-transition period during which FERC-approved funding would only be used for the core programme. FERC-approved funding would fall to $70m in 2001, then $60m per year for the following three years until 2005 when funding for the Gas Technology Institute (or GTI, as it has now become) would be all voluntary.

The core programme would focus on six elements intended to provide widely dispersed benefits to consumers. The elements and the percentage of funds devoted to them were:

- Enhancing environmental quality, 19 per cent;
- Lowering operating and maintenance costs, 17 per cent;
- Enhancing health and safety, 8 per cent
- Improving gas system reliability and integrity, 27 per cent;
- Increasing efficiency of use, 9 per cent; and
- Increasing gas supply from emerging resources, 20 per cent.

Within these 6 core areas there were 43 projects in 2000, of which 6 were concluded. In addition, GTI was conducting 22 non-core projects in 2000. In 1999, the actual total budget was $161m, of which $145m came from FERC approved sources, and GRI employed 172 staff. Co-funding for this core programme is projected by GTI to increase from $26.5m in 2001 to $43.2m in 2004. Given that the 2001 co-funding figure is only half that for 2000, it is not clear how realistic these figures are. GTI blames the decline primarily on diversion of funds from the core programme, with its widely dispersed benefits, to more targeted short-term projects. Overall, GTI projects a 10:1 benefit to cost ratio, which, if supportable (despite the measurement difficulties), does suggest the research programme will be very good value for consumers' money.

A targeted benefits programme in which GTI would work in partnership with individual or groups of companies to develop new competitive technologies will supplement the core programme. The focus of GTI would therefore switch away from being a co-operative organisation.

6.2. The Institute of Gas Technology

The IGT was founded in 1941 as a not-for-profit R&D organisation funded by membership contributions from energy industries in the USA and Canada. The IGT carries out research in-house, unlike the GRI, which is an organisation that manages research programmes that are contracted on the market. It represents in this respect a polar opposite model to the GRI. In 1999, it had about 200 members and international associate members. The membership fee for North American members varies according to the size of the company from about $1000 to $100,000 per year. The members elect a Board of Trustees that provides the overall direction for the Institute. The international associate members pay $2500 and have no voting rights.

Apart from direct contributions from members, IGT receives funding from the GRI, the US Department of Energy, the Environmental Protection Agency and industry. It is difficult to establish the total annual budget and the staffing level of the IGT, but the budget appeared to be less than $10m. The budget and the staffing level are reported to have declined steeply in the past 20 years.

6.3. US Department of Energy Funding and other industry R&D

In the early 1990s, US government funding of natural gas R&D was about $100m. Under pressure from the gas industry, this sum was increased to about $200m by the mid 1990s. For 2001, the Department of Energy has requested a budget of $201m. This is divided between nine areas:

- Natural gas infrastructure and operations;
- Microturbines;
- Reciprocating engines;
- Advanced gas turbines;
- Industrial combustion systems;
- Microgeneration/fuel cells;
- Building cooling, heat and power;
- Natural gas vehicles; and
- Natural gas exploration and production.

In 1994, the GRI and Department of Energy signed a memorandum of understanding to increase joint strategic planning of R&D. A 1992 study identified $260m of R&D on gas funded by individual companies. Most (85 per cent) of this was accounted for by R&D carried out by gas producers and nearly all the rest was accounted for by distribution companies, which were able to recover this expenditure from consumers.

6.4. The debate about the future of GTI funding

There have been a number of key elements to the debate on the future of GTI funding that it is useful to rehearse here. Many of them echo the issues raised in Section 2 of this report. The issues include:

- In a competitive utility environment, will companies tend to under-invest in R&D? The argument remains that because the benefits of innovation are increasingly difficult for an individual utility to capture, there is little incentive for an individual company to fund research.
- In a competitive utility environment, is a co-operative R&D programme funded by consumers feasible or desirable? The FERC settlement implies a view that such a programme is either not feasible or that it is not desirable. However, the Californian regulatory authorities seem to take a different view. They place research into three categories: research on competitive parts of the industry; research on the monopoly functions; and public interest research, for example on the environment. They argue that the first category should be funded by the market while the second two categories should be funded by consumers.
- How should research priorities be set? It seems logical that the aim of consumer funded research should be primarily to benefit consumers. However, representatives of industry primarily set research programmes and consumer groups are conspicuously not represented.

7. Regulatory treatment of R&D expenditure

A key determinant of the way in which regulated companies view R&D expenditure is how the regulatory authorities treat it. At one extreme, if regulators allow regulated companies to pass on all R&D expenditure to final consumers, there will be a strong incentive to carry out R&D because there will be no risk to its shareholders in incurring such expenditure. Such an arrangement would however invite over-investment in R&D as, if the research fails, the company can still recover the cost from consumers. At the other extreme, regulators might argue that R&D expenditure should not be passed through to final consumers. R&D programmes should be made to pay for themselves from the savings they make for consumers and the profits from technology sales. For monopoly companies whose markets are not threatened, such a condition may give too little incentive for companies to innovate. In more competitive markets, there may equally be little incentive to innovate because of non-appropriability concerns.

In practice, things are more complicated. While it is difficult as argued in Section 2 to use cost-benefit analysis as an *ex ante* method to evaluate R&D in all circumstances, it is clear that it is effectively impossible in relation to research on safety and the environment. However, there clearly is a difficult regulatory balance to be struck that provides an environment in which companies are willing to innovate without providing a blank cheque for them to carry out R&D regardless of its value to consumers.

One issue that deserves further study is the classification of R&D expenditure in accounting and regulatory terms. In accounting terms, R&D is conventionally treated as an operating expenditure, largely because it involves payment for salaries and consumables. However because R&D is only ever carried out for the sake of expected future benefit, it is in economic rather than accounting terms an investment item rather than consumption. Assessment by regulators already implicitly treats R&D as investment (hence the desire, explained below, to see R&D evaluated in rate of return terms) but there is an interesting issue of the extent to which companies carrying out R&D might find that capitalising R&D expenses may be to their advantage. Railtrack already capitalises its R&D.

This section examines how R&D expenditure has been treated by the regulatory authorities in the gas industry and also in the electricity transmission sector (National Grid Company (NGC) now parent of Transco), where the underlying principles are similar. In the electricity distribution sector, R&D expenditures are small, and treatment of R&D expenditure has not emerged as an issue.

7.1. The British Regulatory System

Under the British system of regulation, the income a utility company can obtain for providing a monopoly service is determined by the formula ‘RPI-X’. Under this formula a company can raise its income by the rate of inflation (RPI = Retail Price Index) minus X per cent. In short, the company must improve its efficiency by X per cent a year if it is to maintain its level of profits. The X factor applies for a period of 5 years and is set by the industry’s regulator. In the case of gas, this was the Director General of Gas Supply (DGGS) with the assistance of the Office of Gas Supplies (Ofgas). For electricity, this was the Director General of Electricity Supply (DGES) with the assistance of the Office of Electricity Regulation (Offer). In 1999, the two posts and the support staffs were combined and the new Regulator became the Director General of Electricity and Gas Supply (DGEGS) with the support of Ofgem. During 2001, the single person regulator was replaced by the Energy Markets Authority, a board, with five executive and five non-executive directors.

In the electricity industry, the Regulator had a legal duty to encourage innovation. The 1989 Electricity Act required the Regulator and the Secretary of State, as one of five secondary duties, “to promote research into, and development of, new techniques by or on behalf of persons authorised by a license to generate, transmit or supply electricity”. There were no comparable provisions in either the 1989 or the 1995 Gas Act. However, the 2000 Utilities Act replaced the Regulator’s duties listed under the previous Acts with a duty to protect consumers. Specifically, it stated “The principal objective of the Secretary of State and the Gas and Electricity Markets Authority (in this Act referred to as “the Authority”) in carrying out their respective functions under this Part is to protect the interests of consumers in relation to gas conveyed through pipes, wherever appropriate by promoting effective competition between persons engaged in, or in commercial activities connected with, the shipping, transportation or supply of gas so conveyed.” No requirement to promote research was included.

In the first reviews of privatised utilities, e.g., BT in 1988 and NGC in 1993, X was not set by any systematic process. However from 1993 onwards, the methods became more formal and X was set so that the profits of the company supplying a monopoly service were related to the capital invested in the business. This involved determining four main factors: the value of the assets in place at the beginning of the period, the asset base; the volume of investment required over the five year period covered; a fair rate of return on the investment made; and the direct cost of operating and maintaining (O&M) the system. If R&D were to be regarded as expenditure that could in part be recovered from consumers, it should logically be categorised as an O&M cost. If it was classified as a capital item, the company would be able to make a rate of return on R&D expenditure and this clearly would not be appropriate.

The process of setting X factors has evolved and the pattern that seems to have become established is as follows. About 2 years before the time when the new price formula is set to apply, the Regulator publishes a document setting out the issues that he intends to focus on in the review of charges. This is followed by a questionnaire to the regulated company intended to elicit information on its business plan for the period for which the price review will apply. On the basis of the replies received, the Regulator then publishes an initial assessment of the plan and commissions consultants to examine aspects of it. He uses this information to make draft proposals on the X factors that will apply. The regulated company comments on these draft proposals and, 4-6 months before the review is to come into force, the Regulator publishes final proposals. If these are unacceptable to the regulated company, it can ask for an investigation by the Competition Commission. The Competition Commission will make recommendations that the Regulator implements.

7.2. British Gas/Transco

In 1992, the Regulator (James McKinnon) set the 'X' factor for the 5 years from April 1992 forward. An X factor of 5 was proposed by Ofgas and accepted by British Gas. However, at that time, British Gas was still a fully integrated company, producing gas and buying gas on the wholesale market, operating the distribution network, and retailing gas to final consumers. Consumers using less than 2500 therms per year were still then captive. As a result of a number of investigations by other regulatory bodies such as the Office of Fair Trading and the Monopolies and Mergers Commission, there were proposals to reduce its market power in the retail and wholesale gas markets. There was also a requirement for British Gas to make a much fuller separation of its monopoly businesses from its competitive businesses. These provisions ultimately led to the complete split of British Gas in 1997 into BG plc, with its subsidiary Transco which operates the gas network in Britain, and Centrica, whose subsidiary British Gas retails gas to final consumers in Britain.

As a result of the proposals by Ofgas to implement these recommendations, British Gas argued that the basis for the 1992 X factor had changed. Because of this and other broader concerns, there was a major investigation of British Gas by the MMC, which, amongst other things, ruled on the level of X that should apply.

British Gas, in their case to the MMC, suggested an X factor of 1, argued that R&D expenditure should be an allowable expenditure and requested that £101m be allowed to pass on to monopoly consumers for the five-year period from 1992-97. There is a short discussion in the MMC report about the productivity of gas company research in other countries and how research is organised. However, the figures appear to have been accepted by the Regulator and the R&D costs allowed. As a result of the MMC inquiry, the MMC recommended and Ofgas accepted that the X factor be reduced to 4.

By the time the price control came up for re-negotiation for the formula to apply from April 1997, the corporate structure of British Gas had changed markedly. The 1995 Gas Act (passed in November 1995) required a much fuller split of monopoly and competitive activities and also opened the way for all gas consumers to have choice of gas supplier. On March 1 1996, the parent company, BG plc, set up a subsidiary, British Gas Trading, leaving the transportation and storage business, as well as the research division with BG in the Transco subsidiary. In February 1997, the split became complete and British Gas trading was floated off as Centrica.

The Regulator (then Claire Spottiswoode) began consultations on the new price control to apply to the transportation and storage from April 1997 in June 1995. The Regulator's initial proposals in May 1996 required a cut in prices in April 1997 of 20-28 per cent followed by an 'X' of 5 to apply in the following four years. This would have resulted in a total reduction of 35-41 per cent. After consultations, these requirements were made less severe and Regulator's final proposals of August 1996 required the initial cut be reduced to 20 per cent, followed by an 'X' of 2.5 (28 per cent total). BG would not agree to these terms and the Regulator referred the matter to the MMC in October 1996.

R&D played only a small part in this investigation, but it was a matter of dispute. Transco claimed it should be allowed to recover operating expenditure over the five-year period of £7.3bn in its 1997 plan, but the Regulator proposed only to allow it £6.1bn. A small part of the difference was accounted for by the fact that Transco included in its operating expenditure a total of £111m for R&D, while the Regulator was not prepared to allow any R&D cost pass-through. She argued that R&D should be a self-financing activity from savings made and from royalties from the sale of the technologies developed in foreign markets. The MMC did not accept the Regulator's views and allowed R&D expenditure in O&M costs. The amount allowed is not specified in the MMC report, but it is reasonable to assume the whole sum requested was allowed. The net result of the MMC's investigation was that the initial cut should be 21 per cent followed by four annual reductions of 2 per cent. The net reduction over the period (27 per cent) was little different to that proposed by the Regulator, but BG had little option but to accept it.

The Regulator (by then Callum McCarthy) published a consultation document in May 2000, setting out the considerations that would apply for the formula to be used from April 2002, but no explicit mention of R&D was made in this. Much of the discussion in the setting of the X factor concerned the proposal to split up the gas network into a high pressure national network and eight local distribution zones (LDZs). The LDZs will have individual X factors from April 1 2004 and by early 2004, National Grid Transco was beginning to sell some of the LDZs. The X factor was set at 2, with an initial price cut of 4 per cent in 2002. Transco expenditure on R&D did not appear to play any significant role in the discussions on the level of 'X'.

7.3. National Grid Company

The 1997 review of transmission charges was the first to systematically review NGC's expenditure. However, the only mention of R&D expenditure was in response to a comment from a respondent to the consultation document about NGC's R&D policy. The Regulator (Stephen Littlechild) stated that R&D expenditure was a matter for the company, but he also stated that he had not proposed any reduction in NGC's proposed expenditure in this category. This may well have reflected the then statutory position that one of his secondary duties was to promote R&D activities.

However, by the next review, the results of which applied from April 2001, R&D expenditure was a subject of much greater debate, bearing in mind that the Regulator no longer has statutory duties in the area of research. In response to the replies provided by NGC in its Business Plan Questionnaire (BPQ), the Regulator (now Callum McCarthy) commissioned a study, carried out by Arthur Andersen Consulting, of the operating cost efficiency of NGC. In its BPQ, NGC had projected R&D expenditure of about £8.3m per year. The study did not question the need for NGC to carry out research but, for various reasons, disallowed almost all NGC's programme, leaving only about £0.6m. The main grounds were that NGC had not demonstrated that the research would be cost-effective. It suggested that the costs could be recovered only when the benefits had been established. Some environmental R&D was disallowed on grounds that the cost should be shared (partner not specified) and long-term research was disallowed entirely on grounds that no consumer benefit had been demonstrated. This report (like that of Ofgas in the 1997 review) took the implicit view that R&D should be appraised on orthodox rate of return grounds, and did not acknowledge the unique characteristics of uncertainty in R&D spending.

NGC responded strongly to this proposal, and provided more details on the justification of its programme. It categorised its R&D programme in three groups. The largest part (about 60 per cent) included projects intended to deliver benefits in the short to medium term.[xii] The second group (about 33 per cent) was categorised as emerging issues, mainly in the environmental area (for example, electro-magnetic field health effects), where benefits could not readily be established. The third, small group was long-term research, for example on super conductivity for which benefits were at least 5-10 years into the future. NGC argued that in addition to direct benefits to consumers, their R&D programme had strategic benefits to the UK economy, for example, supporting universities, and informing debates on environmental legislation. In other words the NGC used 'spillover' arguments to help justify its R&D programme.

Andersen then argued that a proportion of R&D costs should only be allowed when benefits to consumers have been demonstrated. They proposed a 50 per cent split in costs for the first category of R&D expenditure (those with short to medium term benefits), with half the total being recovered in advance and half once the benefits had been demonstrated. Despite the difficulty of measuring these benefits, an annual reporting scheme was proposed to track costs and benefits. For the second category of expenditure (environment, safety etc), Andersen maintained its position that half the cost should be provided by partners, reflecting the broad range of beneficiaries for such work. The long-term research programmes would be treated in the same way as short to medium term research, i.e. costs would be part recovered *ex ante* and part *ex post*. This analysis was strongly contested by NGC, who, nevertheless, did offer to report to Ofgem on an annual basis on the benefits of the R&D programme.

In the final proposals submitted by the Regulator, all NGC's short to medium term research was allowed, as was the programme of research on environment, health and safety. However, the small amount of research on long term issues (less than 10 per cent of the total) was not allowed.

7.4. Analysis

Before discussing in detail how regulation should treat R&D costs, it is worth examining how far regulation of monopolies has come since the RPI-X formula, or price cap regulation, was proposed in 1982 and implemented with British Telecom in 1984. The main proponent of this form of regulation was Littlechild, who wrote in 1982 that:

"The level of X would, in practice, be the outcome of bargaining between [the utility] and the government; an exhaustive costing exercise is not called for. The purpose of the constraint is to reassure customers of monopoly services that their situation will not get worse under privatisation. It 'holds the fort' until competition arrives, and is inappropriate if competition is not expected to emerge. It is a temporary safeguard, not a permanent method of control."

The 'X' factor would be set for about five years to allow firms to make long-term investment plans. This period between revisions was expected to significantly reduce workload compared to rate-of-return regulation, where tariffs are regulated every 12 months. Companies would be able to find their own way to achieve the performance standards that the Regulator required of them. If they could meet them more cheaply than was implied by the 'X' factor, they could keep the savings, and if not, the extra costs would come out of profits.

Without delving too deeply into methodology, it is clear that the practice of RPI-X regulation is far-removed from the ideal it was meant to represent when it was introduced. Given that the Regulator of the electricity industry for the first 10 years after privatisation was Littlechild himself, it seems likely that there must have been strong reasons why the original vision of non-prescriptive regulation could not be imposed. The regulatory analysis of R&D expenditure, for example involves detailed argumentation on annual costs for long-term R&D of about £600,000 per year, less than 0.1 per cent of NGC's annual turnover. The vision of a regulatory system that would impose tough targets on regulated companies, but leave them entirely free as to how they would achieve them, has disappeared. Regulation is now highly prescriptive and the regulated companies are 'micro-managed' by the Regulator.

The rising cost of regulation is reportedly a subject of concern to the government and the highly detailed treatment of comparatively small expenditures is a symptom of the much bigger issue of how detailed should the scrutiny be of regulated companies. Nevertheless, it seems inevitable that, in the Transco price review process, just started, R&D expenditures will be under detailed scrutiny and there will be pressures to remove or drastically restrict the amount of money for R&D that can be charged to consumers.

The philosophy that lay behind the challenges to R&D expenditure in both the 1997 Transco and 2001 NGC regulatory reviews is clear, and, leaving aside the issue of whether the Regulator should be scrutinising expenditure in this level of detail, to some extent intuitively reasonable. Consumers should not be asked to pay for research unless there is a prospect of a clear net benefit to them. The problem remains as to how to anticipate benefits in areas of such uncertainty though potentially high returns as R&D. The dilemma remains: how to safeguard consumers against inefficient or excessive R&D expenditure while giving companies an incentive to do useful R&D that the market does not provide.

It seems reasonable to assume that Transco research can be put in similar categories to that established for NGC, that is, research with short to medium pay-offs for consumers, research on environment, safety and health and long-term research. For research with short to medium term pay-offs, some method of *ex post* evaluation the success of the research programme is feasible if difficult. However, to cover the inevitable uncertainty about research programme outcomes, it might be more sensible to judge the R&D portfolio as a whole, rather than individual projects. For research projects with an environmental, health or safety focus and for long term research, clearly no cost-benefit approach would be appropriate and the community of interest is much wider than just for consumers, implying partnerships with other funders including government. Shareholders would have a strong interest in ensuring the company is informed about factors that could impact on the industry, while government clearly has a responsibility to be informed on such issues. In addition, regulated companies such as Transco and NGC are in a uniquely good position to direct such research. Nevertheless, they are private companies whose first duty is to their shareholders, not consumers. The idea of sharing the cost of research programmes with other stakeholders is intuitively attractive, and is explored briefly in Section 8.

8. Future prospects

What, in the light of the foregoing discussions and recent changes in corporate structure and regulatory practice, is the future for gas research in the UK, and what might be the implications for the new NGT subsidiary Advantica? It is not our purpose to *propose* specific models here, but we do set down some possibilities and look at their advantages and weaknesses.

There are important contextual factors to take into account:

- Exactly what are the boundaries of the industry we are talking about? We are clearly excluding the major research and technology effort that is conducted by the offshore oil and gas sector. We are principally concerned with the gas industry downstream of offshore production (even though Advantica has some expertise in oil and gas production, it is not really in the same technology business as the oil majors and their main partners). However as a report to DTI concludes,[xiii] the gas industry is not just what that report designated 'the licensed gas supply chain' meaning the companies which are responsible for getting gas from landing points at the coast to final consumers (traders, shippers, transporters, and suppliers). The gas industry is also the complex network of suppliers of goods and services, including technology, to that licensed supply chain, and its R&D needs are intimately connected to those of the 'utility' industry.
- There are important regulatory constraints. First there is a strong trend towards encouraging the 'natural monopoly' elements of network industries to become wholly separate from competitive activities. This may militate against continued ownership of Advantica by the NGT. Second, the climate in which R&D expenditures were almost automatically passed through to consumers in regulatory price review has now gone. While many R&D expenses will probably still be allowed (for targeted short-term projects, plus safety and possibly environment projects) long-term R&D is at risk. Given the strategic importance of long-term R&D to future competitiveness and ability to deal with environmental issues, this is potentially serious.
- There are signs of change in government approaches to research funding. Together with the Wellcome Foundation and others partners government has been spending large sums in recent years on research infrastructure at universities, and has announced large targeted programmes of basic research in areas of high technological need (such as bio-technology). In addition, the government is now taking a longer-term interest in a number of policy areas, especially carbon emissions, than used to be true. The R&D implications of this are not fully clear, but for instance falls in the size of renewable energy budgets at DTI have been reversed. It is therefore at least possible to imagine that increasing reluctance of regulators to allow R&D expenditure to be consumer-financed may be partly replaced by a government willingness to consider funding more long-term research itself
- It is desirable to consider new types of research partnerships and sharing of R&D funding. In the past BG was responsible for the lion's share of all downstream R&D expenditure (increasingly through Loughborough), and few other players had significant roles. Now that the industry is splitting into ever-larger numbers of companies in the 'utility' segment of the industry, it is necessary, as a report to DTI argues,[xiv] to think creatively about new ways to ensure that more collaborative R&D work is done (i.e. work involving several partners), and to seek collaborative funding. Funding need not be solely from government, consumers, or the companies themselves; various combinations of these funders could in future be combined in new ways. Regulators for instance may not need to take all-or-nothing decisions about compelling consumers to pay for particular types of R&D: some long-term funding could for instance be part-financed by consumers, part by government or EU, and part by the industry itself. Ways also need to be found to bring the equipment and service industry into the R&D picture more systematically
- Finally it is also important to remember that the issue of gas industry R&D concerns a wide range of stakeholders. These include - besides the industry itself, consisting of upstream producers in the North Sea, the licensed gas supply chain, and the suppliers of equipment and services to the industry - government in the shape of DTI and DETR, plus safety and environmental regulators, energy consumers across the board and the interests of the UK's overall competitiveness.

With these broad considerations in mind, there seem to be two main types of way forward for Advantica and for the wider R&D provision for downstream gas.

The **first** would be a continuation of Advantica as an arm of the NGT group, essentially a subsidiary (as the rest of the industry would see it) of Transco. It would be able to sell some of its services to other buyers of technology both in the UK and abroad, but its primary function would continue to be the main source of R&D for Transco.

The analogy or model here is with the former research functions of the NGC in the electricity industry, which fulfils very similar purposes in electricity as Transco does for gas (monopoly transportation). In NGC, R&D was integral to the company rather than in a separate entity as is Advantica in the gas case. NGC spent less than Transco (£8 m annually) on R&D but still maintained some 160 employees in R&D. Around a third of NGC's research staff were employed mainly to sell technology services to other companies, but the research function is still integrated within the company. NGC did not appear to have considered separating off its research function in a separate unit, and was not yet under pressure from the regulator to do so.

The advantage of this approach would depend on Transco supporting Advantica as a 'preferred supplier' of R&D services in which Advantica has built up strong competencies over many years. This advantage would be even greater if Transco were to regard R&D as a strategic issue rather than a service issue. This could provide a continuing base on which Advantica could still sell its services to other customers at home and abroad.

The drawbacks to this approach, apart from the obvious lack of interest in NGT in retaining a gas R&D capability are several. First, regulatory pressure would certainly be to ensure that Transco was seen not to be preferring Advantica as a supplier for reasons of tradition or ownership. Regulatory pressure might in any case insist that Advantica was no longer owned by NGT in the longer term, as the regulation of the natural monopolist Transco would be more transparent if the monopoly was completely isolated from ownership of other activities. Second, Advantica is seen by other parts of the industry as partly captive to Transco, the dominant industry player. This has not been helpful in creating the trust needed to expand Advantica's contribution to other companies' R&D needs. In other words, it may be more difficult for Advantica to grow its non-Transco business if it shares ownership with Transco. Third, the new collaborative research and funding arrangements that might be desirable for the gas industry as a whole might also be harder to implement in an unchanged ownership structure. Fourth, the corporate separation of the eight Local Distribution Zones means that Transco would no longer be the main customer for research.

For these reasons, it may well be the **second** option will prove more feasible: Advantica may need to become demerged from NGT and either stand alone or be owned by a party less dominant in the gas industry. The immediate problem would be that Transco would no longer possess expertise in being an 'informed buyer' of R&D. In any demerger of Advantica, Transco would therefore need to consider incorporating some Advantica expertise into its own structure. Achieving such a transfer without damaging the competencies remaining within Advantica might prove a significant problem.

In this self-standing model there are several possible variants, but the main advantage would be that as an independent player, Advantica would be freer to develop itself as a focal R&D point for industry-wide R&D efforts, funded in principle by varying combinations of government, consumers and firms. The self-standing option would also be a more likely way of bringing in the 'non-utility' part of the gas industry (providers of goods and services to the licensed supply chain) to a more collaborative overall R&D effort. There is evidence that the ownership of Advantica by Lattice was seen by some firms in the gas industry (especially those in equipment and service supply rather than the licensed supply chain) as preventing their access to Advantica's facilities.[xv] This perception that Advantica is 'captive' to Transco would be largely removed by floating Advantica as a separate company and would enable it to market its services more effectively across the whole industry.

The closest analogies for this kind of model would be AEA Technology and the Electricity Association (Technology). AEA Technology was a collection of the more commercial activities of the UKAEA, and these were formed into a separate company and privatised in 1996. AEA Technology initially contained a range of diversified (non-nuclear) R&D activities. These have so far developed in relation to its nuclear capabilities that in November 2000 AEA Technology proposed to sell off its nuclear 'core' business on grounds of relative unprofitability, in order to concentrate on newer and faster growing technology areas, especially environmental. This is a good example of the way in which independence call allow the growth of new capabilities. On the other hand the smaller EA (Technology), the technical wing of the former

Electricity Council (a federal state-owned body formerly responsible for overseeing the electricity industry in England and Wales) has had a greater struggle to grow and stay profitable. There is therefore no guarantee that independence will bring success.

There are however many possibilities for future mixes of funding and control of gas industry R&D under the 'separation' model. Clearly a mixed model of funding would be desirable, with government potentially contributing as a partner in areas of R&D which are genuinely long-term, or involve wide social benefits, as in environment and public safety research. Consumers would no doubt contribute via regulatory review, but as mentioned earlier, the presumption must be that the extent of consumer funding of R&D may be expected to fall under regulatory pressure in the next few years. The question of how the industry might more systematically contribute to R&D funding is difficult. In the more fragmented climate of recent years, new players have tended to value innovation but have been reluctant to pay for R&D.

If Advantica were to become an industry-wide focal point for R&D the question arises as to how industry might be induced to contribute more widely to R&D programmes. Clearly this could be attempted on a voluntary basis, with collaborative arrangements for funding and managing programmes, but to work at all well, government would need to act as a broker, in order to reduce firms' transaction costs and to encourage trust among potential partners. One promising area here might be work on safety and the environment. Safety has always been a very significant issue in the gas industry and the emergence of carbon monoxide as an issue has emphasised this again. DTI has recently set up a Gas Industry Safety Group, in a largely brokering role. This Group is designed to include all major sub-sectors of the gas industry. However, inducing competing forms to participate financially in safety-related R&D may still prove difficult. The case for government financial support in the safety area is therefore strong in an increasingly fragmented industry.

The possibility of trying to organise a levy system, possibly along the lines of the old US GRI, could also be considered. This is being phased out in the US and company resistance to the scheme has been high. This resistance was at least partly to do with the increasing difficulties of collecting the levy fairly given the existence of literally hundreds of pipeline companies in the USA. In the UK the mechanics of such a levy system would be easier: all users of the Transco network, which transports the vast bulk of all gas to UK consumers, could be charged a very small fee for doing so.

The governance of such a fund, which could be quite limited in size and be confined to plainly public-interest research, would be a major issue, and a controlling board would need to contain wide representation from government and consumers as well as industry. Ensuring that the fund also addressed important issues and did not pursue only those projects that no company was interested enough to fund individually would also be an issue (past levy systems in the UK, as in the case of training, sometimes led to 'training for its own sake' rather than valuable or well-targeted expenditure). And the political obstacles to a levy system might also be substantial, as levy systems have been generally falling out of favour, partly for the reasons just given, in recent years. On the other hand, the Health and Safety Commission is well-disposed to levy systems, at least in the area of safety. Further, US experience also suggests that voluntary industry contributions may be very small and potentially leave serious gaps in long-term R&D provision. This means that levy systems may need to be seriously considered if long-term R&D is not to be neglected.

Finally it is important to stress that the total amount of resource devoted to R&D activities in the UK gas industry has declined substantially in recent years, and that it is long-term work (including safety and environment) that has been reduced most. Much of the ongoing R&D work is living off the accumulated expertise developed during past periods of larger scale activity, and as this expertise dissipates further, even the present R&D efforts in shorter term work may become more difficult to sustain. The case for government, regulator and industry to find new ways to fund R&D and to reverse the long decline in resource commitments, is urgent.

Notes

[i] In this report the terms we use the term 'R&D' throughout, although in some industrial use (including BG Technology/Advantica) the term 'research and technology' (R&T) is used instead. While these two categories are not

always identical, they overlap to a very large extent, and we use the generally more common term 'R&D' to cover 'R&T' as well.

[ii] Department of Trade and Industry (1999) 'The Energy Report', Chart A1.5, p 186, and Table A1.5, p 187.

[iii] Department of Trade and Industry (2000) 'The Energy Report', para 5.2, p 54.

[iv] Department of Trade and Industry (2000) 'The Energy Report', pp 54-56.

[v] See N. Rosenberg (1990) 'Why do firms do basic R&D (with their own money)?' Research Policy vol 19, no 2, pp 165-174, for a good summary of the arguments.

[vi] See B. Martin et al (1996) 'The relationship between publicly funded basic research and economic performance: A SPRU review for HM Treasury'.

[vii] B Martin et al, op cit pp 7-9.

[viii] These difficulties include the problem that the economic productivity of most R&D depends on collaborating inputs not captured in the analyses. Thus, successful exploitation of R&D will often depend on good strategic management, effective production engineering and good marketing as well as the original R&D expenditure.

[ix] See A Dixit & R Pindyck (1994) 'Investment under Uncertainty', Princeton University Press, for a good exposition of the 'option value' theory of investment.

[x] See C Blumstein & S Wiel (1998) 'Public-interest research and development in the electric and gas utility industries' Utilities Policy vol 7 no 4 pp 191-199.

[xi] National Grid Transco (2003) 'Annual report and accounts', NGT, p 22.

[xii] One of the several problems in measuring the benefits of R&D spending is that they may sometimes take the form of cost reductions or the prevention of cost increases (the latter otherwise potentially arising from more stringent environmental or safety regulation). The problems of constructing counter-factuals - what would have happened to costs in the absence of the R&D - is a major problem in evaluating the benefits of R&D, especially if the issue is preventing cost increases (i.e., observed cost levels are largely unchanged).

[xiii] SQW (1998) 'Offshore Technology Management Ltd and ILEX Competitiveness Analysis of the Downstream UK Gas Industry' Final Report to DTI, July 1998.

[xiv] See ref 12.

[xv] See ref 12, paras 6.40 to 6.42, p 55.