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The Nuclear Review

Elroy Dimson, Robin Jeffrey, Martin O'Neill M.P.,
Colin Robinson and Mike Staunton

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The Nuclear Review*

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ABSTRACT

David Hawdon

This paper brings together contributions originally made to a Surrey Energy Economics Centre seminar on the Nuclear Review. The seminar was held after the conclusion of formal hearings for the Review but before the government announced its proposals for the nuclear industry on 9 May 1995. It includes analysis and policy recommendations from the nuclear industry, the political arena and from academics. It should therefore serve as a timely contribution to the important debate on the future role of nuclear generated electricity in the UK.

Dr Robin Jeffrey of Scottish Nuclear points to the success of his company in transforming a loss making public sector company into a profitable one. Nuclear generated electricity appears attractive if proper account is taken of the risks of higher gas prices, appropriate environmental costs, and the potential vulnerability of the UK energy system to dependence on one fuel - gas. Decommissioning costs, he argues, should be met from a secure long term insurance fund.

Martin O'Neill MP, the Labour Party spokesman on energy, restates Labour's position on nuclear energy - that 'a future Labour government would not build any new nuclear stations nor extend the lives of existing plant.' He challenges the need for further nuclear investment in view of the relative abundance of cheaper gas fired generating plant. He believes that past investment have been motivated more by scientific advance and experimentation that by economic considerations. The attractiveness of 'stations which will be smaller, nearer their markets, environmentally friendly and cheap to run' is likely to persist. Although privatisation is 'not on Labour's agenda', a policy of 'pragmatic tolerance' of the nuclear industry is advocated.

Professor Elroy Dimson and Dr Mike Staunton of the London Business School provide a detailed investigation of the appropriate rate of return to apply to nuclear investments. They estimate that Nuclear Electric should earn more than 11% after tax (13% pre tax) on new investment following

privatisation. This compares unfavourably with Nuclear Electric's present required rate of return of 8%, and is likely to lead to an over-valuation of Sizewell C and Hinckley Point C proposals. Investing in gas fired generating plant rather than nuclear is advocated.

Finally, **Professor Colin Robinson** summarises his arguments in favour of privatisation. The basic problem of state ownership is that politicians' time horizons are too short 'for an industry which needs to take a long view'. He argues that in any privatisation, the companies should not be tied to a specific technology of nuclear generation. Firms should be of equal size so that their entry into the supply industry would have maximum impact. Colin Robinson indicates the conditions under which privatisation of the nuclear industry could be beneficial.

I THE NUCLEAR REVIEW

Dr Robin Jeffrey

1 INTRODUCTION

I am very pleased to be here today and to have this opportunity to speak to you about how Scottish Nuclear have responded to the Nuclear Review. I note that Colin Robinson seems to have followed the government's approach to the review with the order for today's speakers - first of all the industry puts forwards its views, then the politicians consider it, next the economists point out all the flaws and finally the academics dissect it. So here is a view of the prospects for nuclear power from someone in the industry's hot seat.

2 A LITTLE BIT OF HISTORY

First, can I go back a little in time and remind you of why we are where we are today. During 1988 and 1989 preparations were made to privatise the electricity supply industry, including the Nuclear component. What is now Nuclear Electric would have been the nuclear division of National Power and Scottish Nuclear would have been the nuclear operating company for Scottish Power.

However in late 1989, the Government decided to withdraw the nuclear stations from privatisation, to impose a 5 year moratorium on new build and to review the Prospects for Nuclear Power in 1994. One specific aspect of this review was to be the lifting of the moratorium subject to making good progress on Sizewell B, on which construction had just began.

3 NUCLEAR REVIEW

Those five years have now passed . . . resulting in the Government issuing the Terms of Reference for the Nuclear Review in May 1994.

4 ADVISERS

To assist with their thinking, the Government appointed three groups of advisers - BZW to look at the feasibility of privatisation; KPMG to consider how best to manage long term nuclear liabilities and NERA to consider the benefits of diversity in the electricity market.

All three advisers have reported and, quite frankly, I do not know what they have put into their reports. I do know that there are discussions on nuclear matters being held amongst members of the Cabinet and we are hopeful of seeing a White Paper by mid-Summer.

5 OUTCOME OF THE REVIEW

There is much speculation on the outcome of the Review and I can only guess what this will be. However, I will now look into my crystal ball and suggest what the Government might say in its White Paper.

The Review is largely about the two nuclear generators - Nuclear Electric and Scottish Nuclear. It is unlikely to say much about the AEA, for which proposals have already been made to privatise one part and leave the remainder in public ownership.

BNFL has of course an important relationship with the two nuclear generators, so I would expect some statement to be made on their involvement with magnox; the management of the long term liabilities and the long term contractual relationship between BNFL and the generators. However, the White Paper is likely to focus attention on the two generators, that is Nuclear Electric and Scottish Nuclear.

6 ROLE OF GENERATORS

So what might the White Paper say about us. Well, from my crystal ball I can hear a quiet round of applause for the way the business has been turned from loss maker into profit earner. I also see the Government noting that the AGR is now the best performing reactor type in the world - well done the UK.

7 NEW BUILD

On the new build moratorium, the applause could be somewhat muted. Nuclear Electric will be commended on the construction of Sizewell B, to programme and within budget. But additional stations - well, Nuclear Electric and Scottish Nuclear are running businesses now. If they can deliver a fully commercial case for new nuclear stations, then the

Government would welcome this proposal, as it would undoubtedly help increase competition in the electricity market.

But ... and a big but ... does the package come with private finance and commercial off-take contracts? And can it be established without Government subsidy? If it can, then the Government may then raise the level of its applause, but if not, we may have to wait a little longer until the market conditions change. And, if I may add, that is the way it ought to be.

8 INDUSTRY STRUCTURE

Unfortunately, when I look further into my crystal ball, and ask questions about industry structure, the picture is very cloudy. There have been strong rumours that Nuclear Electric will be divested of its magnox stations but with no crystal ball to guide me, I am not able to comment.

Other rumours have suggested that Nuclear Electric and Scottish Nuclear be amalgamated into a single nuclear utility. If this happens our Scottish Headquarters would inevitably move south of the border and one of Scotland's centres of engineering excellence would be lost. This would be a tragedy for Scotland and will be firmly opposed.

Another possibility is the reallocation of assets between Scottish Nuclear and Nuclear Electric to create two roughly equal companies. This idea was floated by the Treasury some time ago - to gauge public opinion I suspect - and certainly the Regulator has made similar proposals. I prefer not to comment on any of these points without the support of a clear picture from my crystal ball.

9 DIVERSITY AND SECURITY OF SUPPLY

However, on diversity and security of supply the picture is clearer. We know where the Government stands - it believes in market forces and in applying private sector disciplines to reduce bureaucracy and inefficiency. And this may well be the appropriate route in the short term. But in the longer term, we will need to see market based instruments to allow the right level of diversity and security of supply to be established.

10 SCOTTISH NUCLEAR'S SUBMISSION

Now I would like to move from this larger picture to some detail and look at the business of Scottish Nuclear and its submission to the review.

This is Scottish Nuclear's submission to the Review, you should all have a copy in your pack[1]. I'm confident that you will find it both refreshingly open and sufficiently detailed to enable you to understand not only the true costs of nuclear power in the UK, but also how Scottish Nuclear has tackled the enormous changes of the past few years.

11 SOME BACKGROUND ON SCOTTISH NUCLEAR

Let me begin by giving you some background on Scottish Nuclear. We operate two Advanced Gas Cooled Reactors, or AGR's and we are also in the process of decommissioning one of the older magnox stations, Hunterston A.

We produce about 50 per cent of Scotland's electricity requirements and much of this is exported down the UK transmission system. Yes, Scotland doesn't just sell its gas and whisky to England but also its good, clean, environmentally friendly electricity.

Unlike England and Wales there is no nuclear levy in Scotland. Instead between 1990 and 1994 Scottish Nuclear received a premium price for its electricity and since then we have started to move down to a price related to the baseload price in the E&W market. We estimate that this will decrease our selling price from around 3.2ppu to about 2.7ppu by 1998.

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[1] The pack consists of:

1. Annual Results 1993-94
2. Paper: The Nuclear Review Utility Perspective
3. Leaflet: If a Scottish company was generating around half of all Scotland's electricity, would you ...
4. Paper: Securing our Energy Future
5. Paper: The need for an energy framework
6. A portfolio analysis: Diversity in UK Electricity Generation

Individual copies of the above, and other material relating to Scottish Nuclear and the Nuclear Industry can be obtained from: Corporate Communications Department, Scottish Nuclear Ltd, 3 Redwood Crescent, Peel Park, East Kilbride, G74 5PR. Tel: (013552) 62000 Fax: (013552) 62626.

Or in other words it will mean losing about £100m of turnover. Given that our annual income is £500m, this represents a substantial reduction. It is difficult to envisage a tougher commercial challenge even in the so called "real world" of the private sector.

Scottish Nuclear has made enormous progress since 1990. A loss of £33 million has been turned into a profit of £72 million and by September, 1994 we had increased output by 40%, raised productivity by 50%, cut our generating costs from 3.2 pence per kilowatt hour to 2.8 pence per kilowatt hour - all this with approximately 20% less staff.

I can confidently predict even more improvements this year and we are on target to achieve a unit generating cost of 2.5p/kWh. Remaining competitive with other electricity generators is the key to long term survival for Scottish Nuclear and that is why the Company recently set a new target for generating costs to be below 2.0p/kWh by 1998. That is the cost of manufacturing one unit of electricity from one of our factories, and is fully inclusive of waste and decommissioning costs.

Scottish Nuclear is confident that with these improvements its AGR business will continue to trade commercially and profitably.

12 GAINSHARE

How have we achieved these improvements? By involving all of our staff in the change process, through a total quality management programme called TOP: Target Outstanding Performance. This has three core messages: examine every business process; cut out the unnecessary; do what is essential better.

And so who reaps the reward from these improvements. Well, MP's may be investigating "utility chiefs" pay but those "utility chiefs" are in the private sector. What we in Scottish Nuclear have done is to introduce a reward scheme that <u>all</u> staff will share in - everyone in Scottish Nuclear is clear about his/her personal contribution towards making improvements and meeting targets. This approach is known as "Gainshare", and this scheme will enable staff to earn up to £2000 in a year, provided demanding company targets are met.

13 COMMERCIALISATION

We call this process of change in Scottish Nuclear "Commercialisation". Our first priority is to reduce costs in order to remain competitive but we hope that we can persuade Government ministers that commercialisation goes beyond cost cutting - it entails commercial freedom. I will come back to the subject a little later on, but now onto the specifics of today's seminar; the nuclear review and Scottish Nuclear's submissions.

14 THE TERMS OF REFERENCE FOR THE REVIEW

The review posed four key questions:

- first, the requirement for future nuclear power stations;
- next, whether nuclear offers particular environmental benefits or benefits in diversity and security of supply;
- thirdly, the role of private finance and privatisation;
- and finally, the issue of nuclear liabilities.

15 REPLACEMENT PLANT

What is Scottish Nuclear's requirement for replacement plant and how will it plan this? Based on current plant life estimates, we will require replacement capacity by 2011 for our Hunterston B AGR power station.

Scottish Nuclear's base case is to replace nuclear with nuclear, and I firmly believe nuclear has many advantages for the UK. But quite simply, it is a fact of life that in today's climate any new plant can only be funded by the private sector and therefore must be able to achieve commercial rates of return on the investment. And in today's market that is not the case. Again a fact of life.

However, over the next ten to fifteen years a number of things could increase the attractiveness of nuclear as an investment. These include an upward movement in gas prices; and the environment, for so long considered to be the achilles heel of the industry, may just turn out to be the catalyst for future investment. As emission controls tighten and as concern about the effects of burning fossil fuel on a global scale becomes more and more pronounced people will begin to see that nuclear and renewables must be maintained to at least offset the growing levels of greenhouse effect and acid rain emissions. All of the above will serve to shift the economics in favour of nuclear power. Nuclear may well be competitive in its own right. This is my vision; a bright future for nuclear power.

Would this shift provide sufficient incentive to attract private sector finance? Well only time will tell, but here are the three hurdles:

- first economic viability; does the project provide electricity at a competitive cost against other forms of electricity generation?

- secondly the project's commercial viability; is the project a commercially attractive proposition for either an existing private sector company or for a new private sector investor.

- and lastly its financial viability; could funds be raised successfully?

If a commercial case for nuclear stations cannot be made then clearly in the long term it will be in the interests of Scottish Nuclear to consider other forms of generation. While this in no way reflects on the Company's confidence that nuclear is safe, economic and environmentally benign, the ongoing prosperity of the Company must be central to our strategic planning. We run a business, not an ideology.

It seems crazy to me that there is no method whereby the environmental benefits of nuclear power can be reflected in its price relative to other fuels for example, through the introduction of a carbon tax. This would have a positive impact on the Nuclear Industry's competitive position and would be fundamental in determining the economics of power stations in the future. Our submission to the review makes this point strongly.

16 DIVERSITY

If nuclear offers advantages from an environmental point of view, does it also offer advantages for diversity? Britain currently has an abundance of energy supplies and a diverse range of fuels but I don't happen to believe this position will continue indefinitely. As part of the review we commissioned a study on diversity in electricity generation. Portfolio analysis was used to examine the relationship between the risks and costs associated with different future mixes of generating plant. Choosing a diversified energy portfolio is much like buying insurance i.e. paying a small cost now to reduce the risk of large potential losses in the future.

Again, copies of this study are in your pack. You will need to read it carefully, the arguments are complex, but I hope you find the conclusions compelling. The UK runs the severe risk that although the so called dash for gas has produced favourable results thus far however, carried to the extreme, this could leave the UK dangerously vulnerable in ten years time.

17 ENERGY FRAMEWORK

I believe there is a continuing role for Government in establishing a balanced energy framework and again, there is a copy of our pamphlet on this in your pack. This outlines a range of market based instruments to enable Government involvement to be established in a cost effective manner through competitive means.

18 PRIVATISATION

And now to privatisation, which is perhaps the most difficult question of all and certainly one which is a minefield at present with everything that is happening at British Gas, Northern Electric, the Post Office, British Rail etc. etc.

Well, the Scottish Nuclear viewpoint is very clear, privatisation is a means to an end - it is not an end in itself. So why are we even thinking about it, why am I taking up valuable time at this seminar debating it?

The answer is straightforward, we wish to stay in business and this means replacing our assets when they eventually close. Quite simply, as things stand at present, with Scottish Nuclear part of the PSBR there is just no way we could raise the £2 billion which a new nuclear power station will cost. So to stand any chance of continuing the commercial success of Scottish Nuclear to secure the jobs for our staff, we simply have to be in the private sector.

And furthermore, within the arcane rules of the PSBR we cannot diversify - our company articles confine us to nuclear generation.

But I stress that is things as they are. Maybe the Nuclear Review will change all of that. Perhaps the world instead of being perceived to be flat will now be seen to be round - or at least sort of round!

19 WHAT HAS CHANGED SINCE 1989?

You might rightly ask why privatisation is possible now when only six years ago nuclear was unceremoniously pulled from the privatisation process. Well there are a number of factors.

- First, nuclear liabilities are better understood and practical decommissioning experience has allowed us to revise our cost estimates downward.

- Secondly, the perception of the high price of nuclear power in 1989 has now changed. Nuclear costs can match those of other base-load generators.

- Thirdly, Britain's AGRs are now the best performing reactors in the world.

- And finally, construction risk associated with new build is much better understood. The construction of Sizewell B has given increased confidence that nuclear power stations can be built to programme and within budget.

20 SEGREGATED FUND FOR LONG TERM LIABILITIES

There is one further aspect of our submission that I would like to talk about. As far as decommissioning is concerned, it may not be appropriate for Scottish Nuclear whether privatised or not to retain the responsibility for long term decommissioning, since this is currently planned to be undertaken up to 150 years after station closure. To put this in perspective, if decommissioning was in its final stage now, this would relate to operations which ceased in 1844.

Our solution to this is the creation of a segregated fund, we call it FundCo. This would be akin to an insurance fund. The way this would work is that during the operational life of each power station, Scottish Nuclear would pay into the fund a sum which when prudently invested would provide for the future decommissioning activities.

The advantages of this are threefold:

- First, it works. Such funds are already in place in the Nordic countries.
- Secondly, it is simple, everyone will be able to examine and audit for themselves how the scheme works.
- And finally it is "horses for courses". A privatised plc to run the power stations and an insurance fund with its long terms perspective to handle the equally long term liabilities.

21 WHAT SCOTTISH NUCLEAR WANTS FROM THE REVIEW

And so I should now like to conclude by summarising what Scottish Nuclear hopes to get out of the Review.

- First, that Government separates the successful ongoing AGR business from the historical magnox liabilities, remember our magnox station was closed down the day before we were created five years ago and at the same time we were lumbered with £1.6 billion of magnox liabilities;
- Next, we propose a segregated fund to deal with the long term AGR decommissioning and waste liabilities;
- Thirdly, measures are introduced to enable non-fossil generators to capture the appropriate environmental, diversity and security of supply benefits.
- Fourthly, we would like Government to review the relationship between the Company and Treasury rules related to the PSBR, so as to allow greater commercial freedom;
- and finally Government sets in motion the privatisation of Scottish Nuclear or alternatively finds some other means of achieving the above.

I understand the White Paper is being drafted as we speak. I don't know the results but what I do hope is that one way or another the Review clearly sets out the path for the nuclear industry. ***It must not dodge hard issues.***

I am optimistic about the future of nuclear in the UK and of Scottish Nuclear's long term role in the electricity marketplace.

Thank you for listening to me.

II THE NUCLEAR REVIEW

Martin O'Neill, M.P.

It is a pleasure to be able to participate in today's seminar on a subject which as we all know is a sensitive one for Labour. Although our gathering today is operating under Chatham House rules, I feel it is necessary to reassert Labour's position on the nuclear industry in the light of a considerable amount of press speculation on the subject in recent weeks.

Labour's position remains as it was at the last general election, namely that a future Labour Government will not build any new nuclear power stations beyond those that are already up and running, and will not undertake any measures to prolong the workings of those already contributing to electricity generation beyond their natural lives.

The reasoning behind this policy is based mainly on the proven lack of support for nuclear generators amongst the general public beyond those directly connected with the nuclear industry, and linked inextricably to Labour's commitments to the environment. There are no plans to alter this policy statement.

It is also no secret however that Labour is currently considering a review of its energy policy. Now is not the time or the place to get drawn into what the consultation document that is eventually produced will contain - there will be plenty of time for consultation with all parties concerned at the appropriate time.

I can say however that we expect the results of the Government's Nuclear Review to contain much-needed research into the long term viability of nuclear power, and that Labour along with the rest of us, will be reading the results carefully. Much of the attitude towards nuclear power amongst the public and interest groups is based on fear and not information. I hope the Nuclear Review will play a part in correcting that.

I would like to split my remarks into 3 sections:

- Future generating needs and in particular whether nuclear should feature in any additional capacity required.

- The structure and ownership of nuclear generation.

- The arrangements for waste management, processing and storage.

The whole of the nuclear debate hinges around perceptions of our need for nuclear capacity.

We have several different generations of nuclear power stations in Britain, each with different unit costs. The first commercial nuclear power station built in Britain was a Magnox reactor at Calder Hall in 1956. This was the first of many, the last Magnox station being built at Wylfa in 1971.

The second generation of nuclear power stations in Britain were Advanced Gas Cooled Reactors, much more energy efficient than the Magnox stations. The first AGRs came on stream in 1976 at Hinckley Point B and Hunterston B, with the seventh and final one being built at Torness in 1988.

The third and final generation in nuclear power is the pressurised water reactor (PWR). Britain has only one PWR - the newly-opened Sizewell B - despite the PWR design being the most popular world-wide accounting for two thirds of total operational nuclear power stations in the world.

In order to examine our future generating needs, we need to look at the shelf life of each of these types of reactors.

The Magnox stations are already coming to the end of their useful lives. Three of them have already closed down at the rest will enter the initial stages of decommissioning after the turn of the decade. The effect of this would be the considerable reduction in the UK's reliance on nuclear power. The AGRs will probably enter the decommissioning stages around 2020.

The fact that part of our nuclear capacity is currently being run down is seen as an argument in favour of the building of a Sizewell C power station at the earliest possible opportunity. This is of course an argument of dubious logic, since Britain at the moment has no need for that extra capacity. The result of the dash for gas has meant that generation from gas-fired power stations increased from 76 MW in 1991 to 6136 MW in 1994 with a further 6500 MW of CCGT capacity currently under construction. In addition the efficiency benefits of the increased reliance on Combined Heat and Power stations and the greater efficiency of CCGTs over gas fired power stations further diminish the need for any additional nuclear capacity, in the short to medium term.

In the past, the debate about future generating capacity has been conducted by the CEGB and its Scottish counterpart, supported by the equipment suppliers and the Government.

The consequence has been large capital intensive stations usually located near coal fields, or in the case of nuclear, in relatively unpopulated areas.

Their size has meant that one or perhaps two stations would be built at a time with rarely the same design being used more than once.

The guiding factors in the construction of stations have been the latest scientific advance, the need for manufacturers to get orders and only lastly the demand for electricity.

In truth the last criterion hardly ever applied since an energy-rich country like Britain was not going to be seriously challenged for fuel.

One of the first changes brought about by electricity privatisation has been the willingness of players to look to new energy sources and technologies.

The dash for gas can be explained by the availability of a relatively cheap fuel source which can be burned in power stations capable of construction in 18 months and employing about as many staff.

Moreover the attraction to the RECs of not being wholly dependent on the two big generators has resulted in them being attracted by new technologies and new generating sources.

National Power and PowerGen themselves have turned their backs on new coal stations and with ever tightening emission controls I would think they would take some persuading to go down that road.

I would imagine that these trends will continue and that when decision makers look at generating options at the turn of the century they will take some convincing that large scale nuclear or coal options are the most attractive.

They will be under pressure to commit their funds to stations which will be smaller, nearer their markets, environmentally friendly and cheap to run.

It is possible that the European Union debate afford third party access into continental partners' grids could be won by the UK and lead to some large scale facilities in the South East which would feed Europe by way of an interconnector.

These could be nuclear, gas or coal but the last would have to be fuelled at prices which may not be within the range of British production costs even if emission concerns were met.

There has been renewed speculation this week about whether the Government intends to privatise the nuclear industry. I doubt whether it is possible before the General Election, and thereafter it would not be on Labour's agenda.

It is perfectly clear that the general public do not want to see Nuclear Electric and Scottish Nuclear in private hands. There is a real fear of nuclear power in Britain and the British people do not trust the private sector to act in their interests where safety and long-term decommissioning are concerned.

We can safely say that in the face of so much opposition, the only reason the Government would want nuclear generation to be in private hands would be for revenue raising purposes.

It is not at all clear even whether even a sell-off would attract the confidence of the City. When the Government attempted to include its nuclear portfolio within the 1989 privatisation of the electricity supply industry it had to be abandoned because private sector investors did not have confidence in the future profitability of the industry.

At the time the costs of nuclear-generated electricity were estimated by Nuclear Electric as being as high as 9p per kilowatt hour, or about three times more expensive than coal-fired stations.

Although many here today will assert that costs have fallen considerably since then, especially if the costs of decommissioning the Magnox stations are conveniently ignored, it was this figure that led the then Secretary of State for Energy, John Wakeham, to announce on 9 November 1989 that Government-owned companies would retain control of all nuclear power stations and would not support any more Pressurised Water Reactors after Sizewell B until a full review of the viability of nuclear had taken place.

Hence the Nuclear Review, the conclusions of which we have been awaiting for a long time now.

Of course the Non Fossil Fuel Obligation resulted in the Nuclear Levy which has provided a financial cushion for the nuclear industry. I choose my words carefully here as you are all aware that under a Conservative Government there is no such thing as a subsidy.

There is now a consensus supporting the proposition that the NFFO funds should be ring-fenced and made available exclusively for decommissioning and back end costs.

If the case for the privatisation of nuclear power stations is unfounded, then the case for the privatisation of the so-called back end operations such as decommissioning, spent fuel reprocessing and storage is even more tenuous.

It is absolutely clear to me that these operations need to remain in the public sector, although not necessarily in the form that they are now in. I doubt if the rump of the AEA which is not being privatised will remain on its own. Indeed I would support it being linked to BNFL.

I hope that the Review will look at BNFL's contractual arrangements with the Nuclear Generators as I believe that more work should be done in achieving transparency in these areas.

Attention also needs to be given to Nirex. I am of the opinion that Government needs to be cautious in giving its approval to future projects for the disposal of intermediate level waste. The NIREX proposal for an underground laboratory is currently awaiting consideration by a planning enquiry. Should it be given to go ahead and the geological concerns are met, then it should be the subject of regular scientific and financial review.

We have seen from the situation that THORP currently finds itself in, that it is possible that large scale investment cannot always be financially justified in the long term. We do not want to find ourselves in a situation where so much has been laid on the line that a necessary retreat is no longer an option.

I have already spoken of Labour's commitment to a publicly owned nuclear industry. Public ownership however does not necessarily imply continual intervention by the Government.

I am currently considering a scenario not unlike that which we experienced when The British Petroleum Company was held mainly in the public sector yet operated independently. The BP example is an interesting one. From 1914 until its privatisation in 1987 the Government held a variable majority stake in BP and had the right to appoint two Directors to the Board. There was an agreement however that these directors would not exercise their right of veto in commercial decisions. In practise the Government representatives on the Board had practically no need to intervene because their very presence meant that the considerations of the Government were taken seriously.

Another possible model could be the BNOC. I would envisage a situation when this example could work well in practice when applied to nuclear generation.

We could have two nuclear generation companies, a Northern and a Southern Nuclear operating independently whilst being subject to the Government's environmental responsibilities and answerable only where necessary to the Secretary of State. I would be interested in any comments those assembled today may have on this subject.

Overall, Labour's attitude to the nuclear industry is one of pragmatic tolerance. We are not convinced that there is a long term necessity for nuclear power, but at the same time we are interested in any technical developments the industry may come up with.

We would like to sustain a dialogue with the nuclear industry if not least because it has been the case for far too long that attitudes towards nuclear have been based on fear not fact. For this reason we will also examine the results of the Government's Nuclear Review with interest to see what new information it throws into the public arena.

Come the General Election, nuclear power will still be contributing in excess of 20% of electricity. It will still be a major employer of some of the most able and best qualified people in the country.

I can understand that many of them are champing at the bit when they see what they regard as the heavy hand of the state on their shoulders.

I can assure them that Labour will not be returning to the practice of Ministers continually interfering in the running of their business or by holding it up by vacillating when tough decisions have to be taken.

I see the handling of a publicly owned nuclear industry as one of the greatest challenges to new Labour.

The development of an overall energy policy has to be a major responsibility of a Government.

Nuclear will continue to have a role for many years to come. It should be given the means whereby it can challenge its critics and the sceptics and there is no reason why that cannot be done in the public sector.

III THE REQUIRED RATE OF RETURN FOR NEW NUCLEAR INVESTMENT, AND THE CHOICE BETWEEN NUCLEAR AND GAS PLANT

Professor Elroy Dimson and Dr Mike Staunton

Summary: *The British Government is in the process of reviewing its strategy for nuclear power, which is largely in the hands of Nuclear Electric, a candidate for early privatisation. We estimate that the after-tax real return which must be earned on new investment by Nuclear Electric is at least 11 percent. The corresponding pre-tax required rate of return is at least 13 percent in real terms. The fact that some of the investment risks of nuclear power can be shifted onto competitors or consumers should not, in a regulated industry, be allowed to lower the discount rate. Nuclear Electric's current required rate of return of 8 percent before tax is too low, and leads to an overstatement of the value of the Sizewell C and Hinkley Point C proposals. Based on Nuclear Electric's own plant parameter assumptions, going ahead with both stations will be some £4 billion more expensive than the gas alternative. Incorporating best estimates of capital cost and plant performance, we estimate the two proposals would result in a combined loss in value of approximately £6-7 billion.*

1 INTRODUCTION

The cost of power from a nuclear station is largely determined by three factors. These are the initial investment in the power station, the discount rate which is used to transform the initial capital cost into a per kWh cost, and the operating performance of the facility in question. As MacKerron (1992) notes, discount rates are the most important of these three parameters. Thomas (1988) estimates that a change in the discount rate of only one percentage point alters total generating costs by 12 percent. Yarrow (1988) and Virdis and Rieber (1991), amongst others, make the same point.

In the UK, where power generation is largely a private sector activity, investment in generating capacity should be evaluated along private sector lines. It would be wholly inappropriate for a major investment such as this simultaneously to be regarded as unprofitable by the private sector and as profitable by a public sector investor. Nuclear Electric (1994) puts forward a proposal for privatisation and seeks to apply private sector criteria for appraising its investments. It is therefore important to clarify the required rate of return for investment in the nuclear industry, and to use the resulting discount rate to appraise the major projects under consideration within Nuclear Electric.

1.1 Overview

The structure of this paper is therefore as follows. In the next section, we consider the rate of return which needs to be earned by Nuclear Electric in order to satisfy private sector shareholders. We consider the impact of the tax system on capital investment decisions such as Sizewell C and Hinkley Point C, and this enables us to specify a pre-tax, as well as an after-tax, required rate of return. We make comparisons with alternative investments in the UK and other countries, and identify the appropriate discount rate for the UK's nuclear sector, which is at least 11 percent after tax. We then consider in section 3 the extent to which discount rates could be lowered by shifting risk onto debtholders, competitors or customers, and conclude that required rates of return are not altered significantly by restructuring proposals such as those put forward by Nuclear Electric (1994).

In section 4 we quantify the losses attributable to incorrect estimation of the discount rate. Erroneous use of an 8 percent discount rate applied to Nuclear Electric's central estimates of pre-tax cash flows, as compared to 11 percent applied to Nuclear Electric's after-tax cash flows, leads to a misestimation of the value of the Sizewell C and Hinkley Point C proposals amounting to several £ billions. Based on best estimates of the critical parameters, the overall loss in value from proceeding with these two projects is £6-7 billion.

2 REQUIRED RATE OF RETURN FOR NUCLEAR INVESTMENT

In this section we examine the role of the required rate of return for appraising capital investment projects such as new electric utility plant. We then discuss the impact of the corporate tax system on required rates of return, and identify the impact of risk on required rates of return. After separate discussions of the risk-free interest rate, the risk premium and the riskiness of nuclear instrument, we conclude section 2 with an estimate of the overall cost of capital for Nuclear Electric.

2.1 Alternative Appraisal Criteria

Investment projects involve spending money up front in the expectation of achieving a financial return in later years. Well-managed companies appraise long-lived projects by estimating the initial investment expenditures and projecting future cash flows; the net cash flows are then discounted at an appropriate required rate of return. The total of these discounted cash flows is referred to as the net present value (NPV) of a project. The net present value is an estimate of the extent to which the investment adds value to (or subtracts value from) the firm.

The advantage of this approach is that it identifies whether shareholders will gain or lose from going ahead with the investment, and measures the aggregate gain or loss from project acceptance. When a major investment is to be considered, the widely used NPV approach helps decision makers to concentrate on the big picture - the contribution of the project to shareholder value.

If a company is to be floated or privatised, an estimate of the present value of the business is essential: without an estimate of present value it is not possible to determine the flotation price. In the case of Nuclear Electric, where there is a possibility of flotation with a commitment to build uneconomic power stations, a subsidy will be necessary in order to achieve the flotation price which would otherwise be attained in the absence of such a commitment. The minimum subsidy required to make the power stations financially worthwhile for Nuclear Electric is given by the NPV of these unprofitable investments.

Given the cash flows of a project, the NPV is determined by the choice of discount rate, or required rate of return, for new investment. The discount rate should be appropriate for the maturity, risk and tax status of the project, and this is the subject of later sections of this report.

An alternative approach for evaluating projects is to calculate the internal rate of return (IRR) of the stream of cash flows. The IRR is the discount rate which would give rise to a net present value of zero. It is inappropriate to compare investments on the basis of their IRRs, because the internal rate of return fails to take account of the scale of the project. Nevertheless, the IRR can be helpful as an indication of whether a project provides, or fails to provide, the prospect of a positive net present value: this occurs when the IRR is less than the required rate of return.

The IRR has no meaning unless the required rate of return is specified as a basis for comparison. Again, we cannot use the IRR criterion for evaluating investments such as Sizewell C or Hinkley Point C, unless we have determined an appropriate hurdle, namely the required rate of return for investments of this type.

If a company has to choose one project out of a range of alternatives, it is common to look at their profitability on a standardised basis, per unit of output. In the electricity supply industry the unit of output is the kWh, and alternative investments are often evaluated by considering their lifetime levelised cost. While we, too, follow this procedure, it is important not to lose sight of the net present value of an investment such as Sizewell C. Under alternative assumptions, the levelised cost may vary by pennies; the net present value can vary by billions of pounds. It is the latter which provides a guide to the level of subsidy required for Nuclear Electric's new investments. Levelised costs, as well as NPVs, can only be determined if the required rate of return has been estimated.

Clearly the required rate of return is a crucial element of the project appraisal process. Yet there is a great deal of confusion over what this figure is and how it ought to be calculated. In the latest CBI Special Survey, Junankar (1994) reports that 42 percent of all surveyed companies demand a real required rate of return of 20 percent or more before they are prepared to undertake new capital projects. This is excessive, and - as argued elsewhere[1]- discriminates against potentially worthwhile investments. On the other hand, some utility regulators have argued in favour of unrealistically low required rates of return, which can lead firms to engage in projects which are not financially worthwhile.

How then should the required rate of return be estimated - in both general terms and in the case of Nuclear Electric in particular? This is the primary focus of our paper. In the next section, we deal with an initial issue which has clouded much of the debate on the required rate of return: is the required rate of return to be used for discounting cash flows before or after

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1 On February 9 1994, for example, Elroy Dimson and Paul Marsh published an article in the *Financial Times* arguing that the typical investment project has a required rate of return of 6-7 percent above the risk-free interest rate. Real risk-free rates at that time were 2-3 percent, and are now close to 4 percent. A real required rate of return of under ten percent would be reasonable for a typical project. An after-tax rate of over 20 percent is very difficult to justify.

the corporate tax has been paid? Later we turn to estimating the magnitude of the required rate of return.

2.2 Pre-Tax Discount Rates and After-Tax Required Rates of Return

Price Waterhouse estimate that Nuclear Electric has a required rate of return of 11 percent in real terms (see Nuclear Electric, 1994). The interpretation of this rate is crucial. Unfortunately, in much of the debate on the recent increases in required rates of return for nuclear investment - see, for example, OECD (1992 page 24) - there is lack of clarity as to whether the real required rate of return is to be applied to pre-tax or post-tax cash flows.

This may well be because, until recently, almost all OECD members had non-taxpaying, public sector entities as the owners of their utilities. However, the nature of the required rate of return is a matter which should not be contentious for a private sector company. Investment expenditure can only be justified if subsequent cash flows generate a positive net present value. Amongst these cash flows are corporate tax payments made by the company.

What is the relationship between the pre-tax discount rate and the after-tax required rate of return? There is no simple answer to this question. To estimate even an approximate relationship, it is necessary to know something about the shape of the cash flows from the investment project. The simplest pattern of cash flows would be one in which projects require an initial outflow of cash to be set aside at the commissioning date, followed by a level stream of net cash inflows. Under some further simplifying assumptions, it can be shown that the relationship between pre- and post-tax rates is as follows:

$$\text{Pre-tax "return"} = \text{Post-tax "return"} \,/\, [1 - \text{Tax rate} \times (1-\text{WDA}/p)] \qquad \{1\}$$

where the "return" denotes the reciprocal of the annuity factor[2] corresponding to the pre-tax or post-tax returns and based on the life of the

2 An annuity, in financial terminology, is a level stream of cash flows which will continue for a specified number of time periods. If the annuity is for £1 per year for n years, the annuity factor is the present value (at the required rate of return) of this cash flow stream. The reason we refer to the reciprocal of the annuity factor as a "return" is that for very long lived projects (such as a nuclear station), the reciprocal of the annuity factor is very close to the required rate of return.

asset, the corporate tax rate is currently 33 percent, WDA is the annual writing down allowance, and p is the incremental annual operating cash flow expressed as the proportion of the incremental initial investment.[3]

To illustrate our formula, consider investment in a power station where the decision is an *incremental* one: to invest in a nuclear station in preference to combined cycle gas turbine (CCGT) plant with similar capacity. The assets are assumed to have a 25-year life (WDA = 4 percent per annum) and incremental operating cash flows of £100 million per £1 billion of capital investment (p = 10 percent). With a 33 percent tax rate, the term in square brackets in equation {1} is equal to 0.8. This implies a pre-tax "return" equal to the post-tax "return" divided by 0.8. This investment would therefore have a pre-tax "return" one-quarter higher than the post-tax "return". The gap between pre-tax and post-tax rates is narrower than this for a Sizewell-type investment, however, since WDA is smaller and p is larger for the project in question.

Figure 1 shows the relationship between pre-tax discount rates and after-tax required rates of return for an investment with the cash flow profile of Sizewell C. We assume a station life of 40 years, and illustrate our formula for the case where the after-tax required rate of return is 11 percent. As may be seen from the upward-sloping curve, an after-tax required rate of return of 11 percent could equate to a required discount rate of 12, 13 or 14 percent (or even more as p increases, up to a maximum of 16.6 percent), to be applied to pre-tax cash flows.

We estimate that Sizewell C will have incremental operating cash flows (when compared to a CCGT alternative) of approximately 4.3 percent of capital costs. As one can see on the graph, this implies that an 11 percent after-tax rate would be equivalent to 13 percent on a pre-tax basis. A similar analysis using the nuclear industry's current required rate of return of only 8 percent, applied to pre-tax cash flows, would imply a value for

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3 Note that we assume that p $\geq$ WDA, which implies incremental operating cash flows that are at least equal to the undiscounted usage of the asset. Our primary simplifying assumptions are that inflation may be ignored and that the asset is written off for tax purposes on a straight-line basis over the life of the asset; for example, with a 25-year asset, WDA = 4 percent. The algebraic derivation of formula {1} is given in Dimson and Staunton (1994).

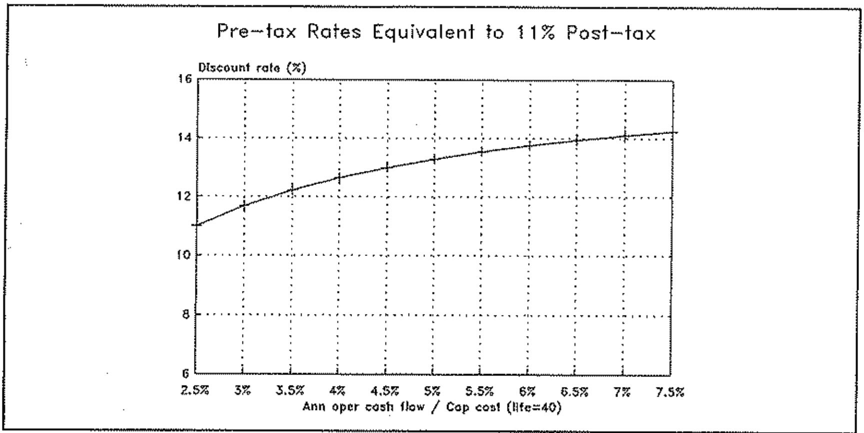

Figure 1: Pre-Tax Discount Rates Equivalent to an 11 percent After-Tax Required Rate of Return

p of approximately 5.3 percent[4], and hence a real discount rate of approximately 6 percent applied to after-tax cash flows.

It may be seen that for the discount rates which have recently been discussed in the context of Sizewell C and Hinkley Point C, there is a gap of some two percentage points between the pre-tax and after-tax rates. If the two projects were more profitable (ie, if they were to have a higher value for p) the gap between the two rates would be larger than this. The widening of this gap is not a penalty for success: it reflects the fact that tax payments are a drain on the business which do not reach the investing shareholder.

If a level playing field is to be maintained between private sector and public sector generators, or between fossil fuel and nuclear based generators, then it is essential that investments are evaluated on a basis which takes full account of the corporate tax system. After-tax required rates of return should be applied to cash flows after deduction of corporate tax, while larger pre-tax discount rates should be applied to pre-tax cash flows. If this is not done, projects which are unprofitable for tax-paying corporates will spuriously appear worthwhile to their non-taxpaying counterparts.

4 This value for p has been calculated from Nuclear Electric's cost estimates for Sizewell C, and takes account of the phasing of capital expenditures over the construction period.

Because our formula involves extreme simplification of the cash flows which are expected from a nuclear investment, it should be noted that our pre-tax discount rate is no more than an approximation. The exact rate will depend on the tax position of the nuclear power industry - for example, on the provisions for tax depreciation by Nuclear Electric, and on the extent to which tax losses can be sold to other, taxpaying corporations. In ongoing work, we are developing a general model of the linkage between pre-tax discount rates and after-tax required rates of return, an area which is of particular relevance to utilities and energy companies.

In the analysis that follows we focus on an after-tax required rate of return. In order to provide comparability with current public sector procedures, we subsequently use our simplified formula {1} to estimate the pre-tax discount rate which is broadly equivalent to the after-tax rate which we have computed.

2.3 Risk and Required Rates of Return

The standard approach to estimating the cost of capital is based on the capital asset pricing model or CAPM. According to this approach, the expected rate of return on an asset should be equal to the risk-free rate of return plus a premium to compensate for risk. To be specific, the required rate of return is given by the following formula:

Required return = Interest rate + Beta x Equity market risk premium {2}

where returns include both capital gains and dividends, the interest rate is a riskless rate, and the equity market risk premium measures the amount by which the return on the equity market is expected to exceed the riskless rate of interest. Beta quantifies the extent to which the value of the asset is sensitive to fluctuations in the overall stock market. [5]

It is important to note that the capital asset pricing model refers to expected returns, namely returns expected over a period in the future. The

5 There are alternatives to the CAPM which are less widely used in practice. These alternatives include the dividend growth model (DGM), arbitrage pricing theory (APT) and the Fama-French (1992) variant of the latter. For a discussion of the DGM see Myers (1972) and Myers and Borucki (1994), while Goldenberg and Robin (1991) and Elton, Gruber and Mei (1994) provide illustrative applications of the APT. Also see Schink and Bower (1994) for an application of the Fama-French method to utilities.

three major inputs to our formula should, therefore, all be forecasts. The risk-free interest rate should be the rate that could be obtained *now*, the beta estimate should be an unbiased prediction of the riskiness of the asset over future periods, and the equity risk premium should also reflect the market's consensus about the excess return from equities in preference to riskless investment. Each of these elements of the CAPM is important, and we discuss them in turn below.

2.4 Risk-Free Rate of Interest

The riskless rate of interest should be specified in the form of a rate which is available *today*, namely at the time of undertaking an investment or of valuing a company. The riskless rate of interest measures the time value of money, and it is inappropriate to substitute interest rates which are unavailable today. For example, it would be incorrect to employ the average of returns over the past on a risk-free asset. Equally, it would be incorrect to adopt a riskless rate of interest as of an agreed base date such as New Year 1994, without updating the rate as market conditions evolve. Finally, one should not be taking a "view" about the course of risk-free returns in the future. The correct measure is the current yield on a riskless investment, as determined within the capital markets.

The risk-free interest rate may be short-term or long-term; and it may be stated in nominal (money) terms or in real (inflation-adjusted) terms. Since we are concerned with long-term investments, there is a case for using a long-term riskless rate of interest. And since we are appraising investment in real assets, there is also a cogent reason for using rates of interest denominated in real terms. We elaborate on the difference in Figure 2 below.

Figure 2 displays the gross redemption yield for both types of bond. The upper line-plot shows the level of *nominal* yields on a long-maturity UK government bond, the 7¾ percent Treasury 2012-15, while the lower line-plot shows the equivalent *real* yield on a long maturity index-linked gilt, the 2½ percent Index-Linked 2016. These graphs provide a monthly record of the level of nominal and real yields over the course of the last decade.

Both nominal and real yields have fluctuated over time. Comparing the upper with the lower series in Figure 2, it is evident that the volatility of nominal yields is greater than that of real yields. This reflects the fact that

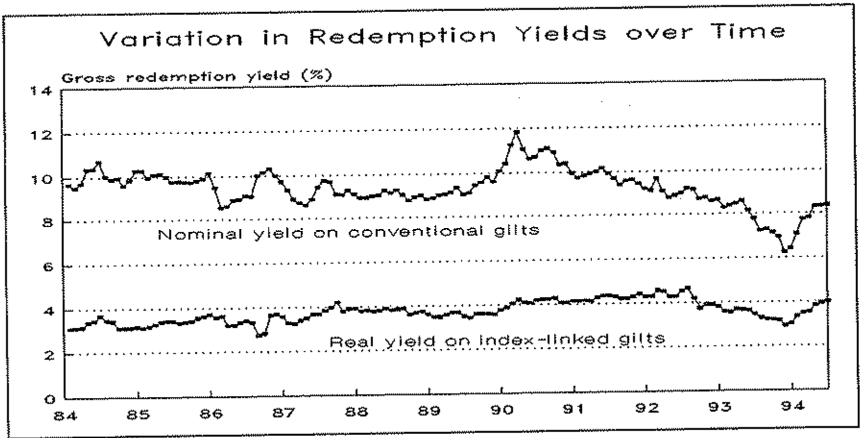

Figure 2: Variation in Redemption Yields over Time

nominal yields vary not only with real rates of interest, but also with changing inflation rates. More importantly, from the point of view of selecting an appropriate riskless rate of interest, the index-linked series represents a particularly appropriate benchmark to use for appraising utility investments, since utilities' prices are broadly linked to the level of the retail price index.

A distinguishing feature of nuclear investment projects is that they have lengthy cash flow profiles. At times, the annualised interest rate on government bonds with, say, a twenty-year maturity can be very different from the rate on short-term government bonds. It is therefore helpful to look at the yield to redemption not only for shorter maturity UK government bond, but also for the full range of maturities. Fortunately, at the present time the gross redemption yield is flat, and the interest rates on bonds maturing in the next century is similar regardless of maturity. This may be seen in Figure 3.

Nominal interest rates are at present a little under 9 percent, while index-linked gilts currently provide a prospective real interest rate of just under 4 percent. These figures are consistent with a consensus forecast for long-term inflation of around 5 percent.

Though the real yield on index-linked gilts has varied over time, it is instructive to refer back to Figure 2 to see whether real interest rates are, at present, unusually high or low. In fact, although they rose by more than

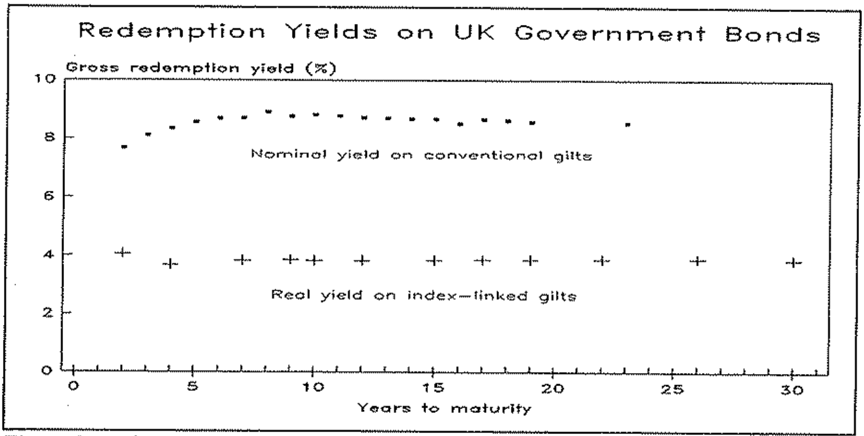

Figure 3: Redemption Yields on UK Government Bonds

one percentage point over the course of 1994, they are currently in the middle of the range of yields which have been available during this decade. Coincidentally, the redemption yield on index-linked gilts is similar to the level recorded at the time of the Hinkley Point inquiry (see Dimson, 1989).

In interpreting the redemption yield on index-linked bonds, it is relevant to note their tax treatment. The gross redemption yield is available in full to tax-exempt institutions such as pension funds. Individual investors who pay the standard rate of tax receive capital gains and the inflation uplift free of taxation, and only pay tax on the very tiny proportion of the total return which represents the real coupon on these securities. Deducting the weighted-average, marginal tax rate of index-linked investors, their yield after payment of personal tax is around 3½ percent. This is the riskless rate of interest which should currently be used in estimating the cost of capital for investment by Nuclear Electric.

As noted previously, an alternative risk-free return might be the return on long-term gilts. The standard American textbook in this area, Kolbe and Read (1984), lends some support to this view, but only in the context of a country where there are no index-linked government bonds in issue, and writing at a time when even the UK had barely begun issuing sterling denominated index-linked bonds[6]. Since Nuclear Electric's cash flows are more readily forecast in real terms than in nominal terms, we would consider the risk-free rate to be better indicated by the yield on index-linked gilts.

2.5 Equity Market Risk Premium

The equity market risk premium represents the excess return which is expected from equities, as compared to risk-free investments. However, while the current yield on a government bond is known today, the forward-looking equity market risk premium cannot be observed directly. We therefore resort to estimating investors' expectations from the long-run historical record. In proxying the equity market risk premium from its historical average we are asserting that at the start of each year the market has provided a consensus view as to what equities are worth. If this consensus is unbiased, the average risk premium experienced over a large number of independent periods from the past will approximate to the mean of investors' return expectations.

To appraise a capital investment project, each return observation from the past should be computed over the same interval as that used in the project appraisal process. If Nuclear Electric's projects are evaluated by discounting a stream of semi-annual cash flow projections, then the risk premium should be estimated from semi-annual returns; if capital budgeting focuses on quinquennial cash flow forecasts (ie, a single flow in each of years 5, 10, 15, ...), then the risk premium should be based on quinquennial returns. Nuclear Electric employs an annual interval for its cash flow projections. It follows that we are interested in estimating the average *annual* risk premium from investing in equities rather than in riskless bonds.

In Table 1 we show what the average annual real returns have been, over the last 40 years, from the main asset categories in the UK. The first line of the table shows the returns on a comprehensive, capitalisation-weighted

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6 Kolbe and Read (1984) state that the *"nearest analogue (to the risk-free rate of interest) is the yield on short-term US government securities, such as 90-day treasury bills. However, in rate-of-return testimony a longer maturity government bond is often substituted. The rationale for this substitution is not always clearly stated. It may be an attempt to forecast the average treasury bill rate over the period for which rates are to be set. It may also be an attempt to smooth out fluctuations in the cost of capital"*.

index of all UK equities.[7] The arithmetic average real return on equities has been 10.4 percent per annum. In the following three lines of the table we show the returns on conventional gilts, index-linked gilts (for which the history commences in 1981), and rolled-over treasury bills. The means of the 39 yearly returns for long gilts and treasury bills are 1.9 percent and 1.7 percent respectively.

Table 1: Average Annual Real returns, January 1955-January 1995

Asset Category	Arithmetic mean %	Standard deviation %	Geometric mean %
1. Value-weighted index of all UK equities	10.4	24.8	7.4
2. Long-maturity conventional gilts	1.9	13.6	1.0
3. Index-linked gilts (from 1981 only)	2.1	8.8	1.7
4. Treasury bills	1.7	3.9	1.6
5. Equity risk premium (= "1" minus "4")	8.7	24.6	5.6

Source: Dimson and Marsh (1995)

The final row in the table shows the equity risk premium, namely the difference between the average equity market return and the treasury bill return. This is 8.7 percent. If the risk premium were to be calculated relative to conventional gilts it would be 8.5 percent. Though a full 40-year history of index-linked returns is not available, the risk premium relative to index-linked gilts is also of the order of 8-9 percentage points. This procedure for estimating the risk premium has for some years been fairly standard, and both Kolbe and Read (1984) and Ibbotson Associates (1994) advocate a similar procedure.[8]

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7 Other studies have employed the BZW Index which comprises only 30 constituents, or the FTSE-Actuaries "All Share" Index which contains only a minority of, rather than all, shares.

8 Kolbe and Read advise that *"the historical risk premium on the Standard and Poor's 500 Common Stocks calculated by Ibbotson & Sinquefield is frequently used as an estimate for the expected US market risk premium. The mean excess return (common stocks minus treasury bills) from 1926 to 1981 was 8.3 percent per annum."* The US average updated to 1994, would be 8.6 percent, very similar to the UK. Though one might be tempted to base required rates of return on a geometric calculation, they point out that this would be incorrect: *"The quantity desired is the rate of return that investors expect over the next year for the random annual rate of return on the market. The arithmetic mean is the unbiased measure of the expected value of repeated observations of a random variable, not the geometric mean".* Ibbotson Associates (1994) confirm that *"the expected equity risk premia should always be calculated using the arithmetic mean".*

The table above also shows the standard deviation of the annual returns for each asset category, as well as the geometric mean return. The standard deviation measures the year-to-year variation in the magnitude of each asset's return, while the geometric mean measures the compound rate of return achieved over the entire 40-year holding period.

Since we are using an historical average as a proxy for investors' expectations, it is inappropriate to examine intervals as brief as five or ten years. After a decade of underperformance, for example, one would not deem investors to have a consensus view that equities will continue to underperform in subsequent periods. Nevertheless, to give a feel for how the average risk premium has varied in the past, Figure 4 provides a record of the historical average.

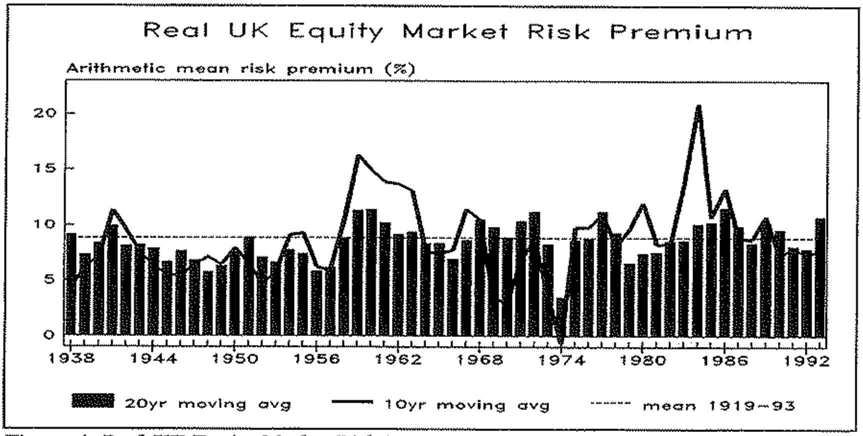

Figure 4: Real UK Equity Market Risk Premium

In Figure 4, the bars represent the arithmetic mean equity risk premium measured over a rolling period of 20 years; the solid line plot displays the averages over rolling periods of 10 years; and the horizontal dashed line shows the arithmetic average of the risk premium over the last 75 years. BZW (1994) report a real equity return averaging 10.5 percent and a real treasury bill return averaging 1.6 percent, implying an arithmetic mean risk premium of 8.9 percent, an estimate which is close to our own figure based on more recent and comprehensive data. Indeed, there is virtually no difference between the risk premium estimated here for the post-1955 period and that which is available from Dimson and Brealey (1978) for a similar length interval ending in 1955. We conclude that the estimate of an 8-9 percent equity market risk premium is reasonably robust.[9]

Our estimates of the risk premium are computed on a gross basis, assuming that investors are tax exempt. This may not be a reasonable assumption, and it is therefore important to check whether and how our results might vary if the risk premium is computed after deduction of personal tax. In Table 2, we have recalculated the risk premium for the period from 1919 to 1994 under a variety of alternative tax scenarios.[10]

It is clear from this table that our estimate of the risk premium is insensitive to assumptions made about the tax rates of investors. The reason for this lack of sensitivity to tax assumptions is that, over the long haul, the taxable dividend element of equity returns has been of similar magnitude to the taxable element of income from risk-free interest payments. Deducting income tax from *both* of these components of return has an almost negligible impact on the estimated risk premium.

Table 2: Arithmetic Average Risk Premia Assuming Alternative Investor Tax Rates

Tax Regime	Risk Premium (percent)
1. Investors pay no tax on equities or bills	8.9
2. Investors pay each year's standard rate on income	8.9
3. Investors pay today's 25 percent rate in every past year	9.0
4. Investors pay each year's corporate tax rate	9.2
5. Investors are indifferent to dividend policy *	8.8

* In each year, investors' tax rates leave them indifferent between dividends or earnings retained by the firm

Historical estimates of the risk premium are available for an increasing number of markets around the world, including Australia, Canada, Germany, Japan, the Netherlands, New Zealand, Spain, Sweden, Switzerland and the US (see Dimson and Marsh, 1995). Those studies

9 Over an even longer historical timescale, Ibbotson and Brinson (1994) construct a stock market return series going back to 1790, and report that the average real returns recorded for each of four successive half-centuries did not differ significantly from each other or from the two-century average.

10 We are grateful to Professor R A Brealey for providing the data employed in this exhibit.

which cover longer time periods have estimates of the risk premium which cluster in the interval 8 to 9 percent. We conclude that the UK's historical risk premium of around 8-9 percentage points is similar to the arithmetic average premia observed in comparable countries.

2.6 Equity Beta Estimates For Nuclear Electric

The third element of the capital asset pricing model measures the financial risk of an investment. Risk, in the context of the capital asset pricing model, is measured by beta - the sensitivity of changes in the value of the investment to fluctuations in the stock market. Nuclear utilities have a number of attributes which make them potentially more risky than other utilities. As Yarrow (1988) points out, their assets are highly specific and they are capital intensive businesses; they therefore have considerable operational gearing.[11] Brealey and Myers (1991, page 200) cite high operational gearing as being strongly associated with having a high beta, and provide a list of empirical research studies confirming their view.

Perhaps the most important attribute in this regard is the irreversibility of the initial investment. If a plant is closed early, there is no way of extracting any of the value which had originally been anticipated when the facility was initiated. There is therefore the prospect that the levelised cost of power, when computed *ex-post* at the abandonment or closure date, far exceeds the *ex-ante* levelised cost, since capital costs will fall more heavily on each kWh of output. De Bondt and Makhija (1988) report on no fewer than 110 nuclear projects which were abandoned, so this is a very real risk. The net effect is to increase the *ex-ante* operational gearing of the nuclear business, and hence to raise its beta. [12]

11 Operational gearing, or operating leverage as it is referred to in US textbooks such as Brealey and Myers (1991), measures the extent to which fixed costs add to the beta of a project. This works in the same way as the impact of fixed debt charges on the riskiness of a business. The fixed costs for a nuclear facility are primarily capital costs, but the fact that reactors cannot easily be switched on and off contributes further to their operational gearing since their fixed costs must also incorporate the present value of unavoidable future operating costs. This is why nuclear plant is given a high position in the "merit order" for electricity production: most costs are fixed, and little is saved by foregoing the utility's output.

12 These risks of cost escalation or early closure also contribute to the specific risk of the project, but the latter should be taken into account in the cash flow projections for a project, not in the discount rate.

To a considerable extent, the beta for an investment has to be determined not by theory, but by drawing on empirical evidence. While bearing in mind the likely margin between the risk of a nuclear investment and that of its fossil fuel counterpart, we begin by looking at the beta for comparable utilities in the United Kingdom.

Table 3 documents the beta predictions[13] published in the *Risk Measurement Service* for each quarter since New Year 1992. Our current estimate of the beta for National Power and Powergen is close to 1.0, and is slightly above the corresponding figures for British Gas and British Telecom. The Scottish generators and some of the regional distributors have slightly lower betas than National Power and Powergen, though they are virtually all above 0.7.[14]

Table 3: Predicted Equity Betas for UK Utilities

Utility	92:1	92:2	92:3	92:4	93:1	93:2	93:3	93:4	94:1	94:2	94:3	94:4	95:1
National Power		1.31	1.13	1.08	1.00	1.00	1.01	0.93	1.02	0.98	0.94	1.01	**1.01**
Powergen		1.05	1.05	1.01	0.91	0.92	0.93	0.84	0.94	0.93	0.91	0.99	**1.00**
Scottish Hydro			0.70	0.95	0.55	0.57	0.58	0.61	0.69	0.80	0.77	0.98	**0.97**
Scottish Power			0.58	0.42	0.52	0.55	0.57	0.59	0.69	0.75	0.74	0.90	**0.90**
British Gas	0.82	0.84	0.81	0.90	1.09	0.95	0.95	0.96	0.96	0.95	0.94	0.92	**0.84**
British Telecom	0.74	0.75	0.76	0.72	0.94	0.94	0.94	0.92	0.92	0.96	0.94	0.95	**0.92**
Highest beta REC	1.04	1.12	1.05	0.96	09.4	0.95	0.96	0.92	0.97	1.02	0.96	1.06	**1.06**
Lowest beta REC	0.79	0.84	0.86	0.71	0.67	0.69	0.70	0.68	0.76	0.77	0.74	0.86	**0.85**

Source: Dimson and Marsh, Eds, 1995 Note: REC = Regional Electricity Company

Given the greater risk of nuclear utilities - both in terms of the theory outlined at the start of this section and in terms of evidence to be presented

13 When estimating the equity beta from historical information, it is necessary to convert the historical record into a forecast. There are well validated statistical procedures for doing this (see Dimson and Marsh, 1983), and these procedures are embodied in London Business School's *Risk Measurement Service*.

14 In Dimson (1989) information such as this was used to produce a prediction of the post-flotation beta for National Power. Our view then was that "*it seems likely that the figure for shares in National Power will be within the range 0.7 to 1.0*". As it turned out, this was closer to the outcome than the Central Electricity Generating Board estimate of only 0.3 (see HPPI, 1990).

in the next section - we would expect the underlying risk of the business to be at least as great as that of the non-nuclear generators listed in Table 3. Assuming that Nuclear Electric is floated with a similar capital structure to National Power, we would therefore expect at least a similar equity beta[15]. A broad range within which the company's beta might be expected to lie is 0.8 - 1.2.

Giving greater weight to the more recent figures for the English generating companies - for which more precise beta estimates are available than in the case of their Scottish counterparts - our estimates might be narrowed down to being between 1.0 and 1.1. This estimate is, of course, provisional, and we consider it further in section 2.7 in the light of our research on US utility betas.

The UK's regulatory regime for nuclear power and the business risk of nuclear generators may together imply differing risk attributes for nuclear, as compared to fossil fuel, investment. We therefore take an empirical approach to identifying whether nuclear generating capacity appears to be associated with a higher risk exposure than is displayed by non-nuclear generators.

2.7 Impact of Nuclear Capability on Estimated Beta

To research this question we investigate a comprehensive sample of investor-owned utilities, located in both the United States and Japan. The companies concerned comprise all those with complete stock price histories on Datastream over the period from the end of 1972 to date, and for which information on nuclear capability is available at both the start and end of this research period. At the end of every month, starting at 31 December 1977, we compute each company's beta, measured over the preceding sixty months. In this section, we analyse the time-series and cross-sectional attributes of these series of estimated betas.

We start by reminding the reader of the marked influence of the regulatory environment on the betas of utilities (this is discussed further in section 3 below). In the Hinkley Point inquiry, counsel for the Central Electricity Generating Board argued that despite the UK's price-cap regime, betas might be similar to those observed under rate-of-return

15 We discuss the impact on beta of different capital structures in section 3.1 below.

regulation in the United States (see HPPI, 1990). This is, and was, implausible[16]. It is equally unlikely that we can simply apply the betas of Japanese utilities to the UK environment. The betas of utilities in different locations reflect a variety of local factors (see Pettway, 1978, and the subsequent literature cited in our list of references) and do not provide reliable evidence of likely betas in another country.

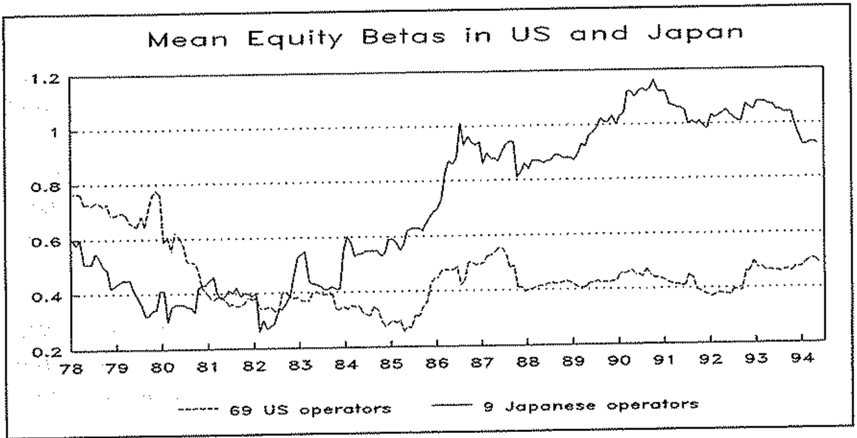

Figure 5: Mean Equity Betas in US and Japan

To substantiate this assertion, Figure 5 presents a graph for the average betas of our full sample of 69 US and 9 Japanese utilities[17]. The Japanese experience demonstrates that the shares of power utilities can have a beta of more than 1.0 in other countries. The comparison shows that when betas are low in one country they are not necessarily low in another, and *vice versa*. Nevertheless, there are upward and downward shocks to beta, whereby both US and Japanese betas move in the same direction. These utilities experience both domestic market and worldwide industry risks.

16 Even within the United States, the intensity of regulation varies from state to state. Norton (1985) finds that intensively regulated electric utilities have low betas, while more loosely regulated electric utilities have much higher betas.

17 The US sample is defined below. The Japanese utilities comprise the following firms: Chubu Elec Power, Chugoku Elec Power, Hokkaido Elec Power, Hokuriku Elec Power, Kansai Elec Power, Kyushu Elec Power, Shikoku Elec Power, Tohoku Elec Power and Tokyo Elec Power.

Although they function in different regulatory environments, we can still use data from other markets to see whether, from the point of view of investors, nuclear utilities have a lower or higher risk. Given the limited number of comparable companies in Japan, this effectively requires us to research the betas of US utilities in some detail.[18] This can provide valuable insight into investor expectations regarding the required rate of return on nuclear, *vis á vis* non-nuclear, investments

The major issue is thus whether nuclear utilities in the US have a higher or lower beta than non-nuclear utilities. This question has not always been addressed with the rigour it demands. For example, Phillips & Drew (1990) assert that nuclear utilities in the US (which were then on average 77 percent non-nuclear) have an average beta of 0.46 as compared to non-nuclear utilities with average beta of 0.35. They extrapolate that a nuclear-only utility would have a beta 2.4 times as large as a non-nuclear generator, and estimate the implausibly high value for Nuclear Electric's beta of 2.2, a bigger estimate than the London Business School's *Risk Measurement Service* has ever recorded in 16 years' quarterly publication for *any* industrial or commercial company. Averages at one point in time cannot be more than indicative. In our research, we estimate betas as of each of 197 month-ends, for all continuously listed electric utilities.[19]

Nuclear utilities are defined in our research as those which are recorded in Moodies (1993) or McGraw Hill (various issues) as having had nuclear generating capacity throughout the period from end-1972 to date, plus

18 Countries other than the US and Japan have even fewer exchange-listed generators. Nuclear Electric (1994, Volume 3) cite only six non-US, non-Japanese nuclear utilities which are "substantial" and where the facility is investor-owned. With a sample limited to the two nuclear utilities in each of Spain and Germany and one each in Switzerland and Belgium, there is little scope for rigorous empirical analysis of the non-US experience with privately owned generators.

19 Of 86 listed utility stocks, 77 have a continuous stock market history. Eliminating three firms for which their nuclear capability was not known and four firms for which debt/equity ratios were unavailable, the sample size was reduced to 70. We also excluded General Public Utilities, the proprietor of the Three Mile Island plant. Of our final sample of 69 utilities, there were 23 which were non-nuclear throughout, 15 which were nuclear throughout and a further 31 which adopted nuclear power from 1973 onwards. The last date of commissioning a nuclear facility was June 1987.

those which adopted nuclear power during this interval[20]. Non-nuclear utilities comprise those with no nuclear capability at any stage[21]. Figure 6 plots for each month since the start of 1978 the average beta of each group of utilities, with the beta at each date estimated using the immediately preceding 60 months of returns data.

As might be expected from previous studies (eg Pettway, 1978), the beta of utilities wanders substantially over time, and the difference between the betas of nuclear and non-nuclear generators is small compared to fluctuations in the riskiness of utilities as a whole. It must be recognised that a substantial number of nuclear utilities have a nuclear capability which is modest compared to their fossil generating capacity, and the gap between a (hypothetical) nuclear-only sample and the non-nuclear sample would be larger. Nevertheless, Figure 6 makes it clear that the nature of its technology is a secondary influence on the beta of a utility.

There is, nevertheless, a tendency in recent years for nuclear utilities to have a slightly larger beta than their non-nuclear counterparts. In the United States a number of researchers have investigated the beta of nuclear utilities, finding higher betas for nuclear generators, e.g. in the aftermath of the Three Mile Island accident (see Bowen, Castanias and Daley, 1983, and Hill and Schneeweis, 1983), and after the Washington Public Power Supply System (WPPSS) bond default (see Fuller, Hinman and Lowinger, 1990). More recently, Fields and Janjigian's (1989) study of pre- and

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20 The 15 utilities which were nuclear throughout the period comprise Boston Edison, Carolina Power & Light, Central Maine Power, CMS Energy, Commonwealth Edison, Commonwealth Energy System, Consolidated Edison NY, FPL Group, New England Elec System, Niagara Mohawk Power, Northern States Power, Rochester Gas & Elec, San Diego Gas & Elec, SCECorp, and Wisconsin Energy. The 31 nuclear adopters consist of American Electric Power, Atlantic Energy, Baltimore Gas & Elec, Central Hudson Gas & elec, Central & Southwest, Delmarva Power & Light, Detroit Edison, DQE, Duke Power, Energy Corp, Florida Progress, Houston Industries, Illinois Power, Iowa-Illinois Gas & Elec, Kansas City Power & Light, Long Island Lighting, NY State Elec & Gas, Ohio Edison, Pacific Gas & Elec, PECO Energy Co, Penn Power & Light, Pinnacle West, Portland General, Public Service Ent Group, Public Service New Mexico, SCANA, Southern Co, Texas Utilities, Union Electric, WI Public Service, Wisconsin Power & Light.

21 The 23 non-nuclear utilities are Allegheny Power, Central Illinois Light, Cincinnati Gas & Elec, CIPSCO, Citizens Utilities, DPL, Hawaiian Elec Ind, Idaho Power, Interstate Power, KU Energy, Minnesota Power & Light, Montana Power, Nevada Power, NIPSCO Industries, Oklahoma Gas & Elec, Orange & Rockland Utils, Potomac Elec Power, Sierra Pacific Resources, Southern Indiana Gas & Elec, Southwestern Public Service, TECO Energy, Tucson Elec Power Utilicorp United.

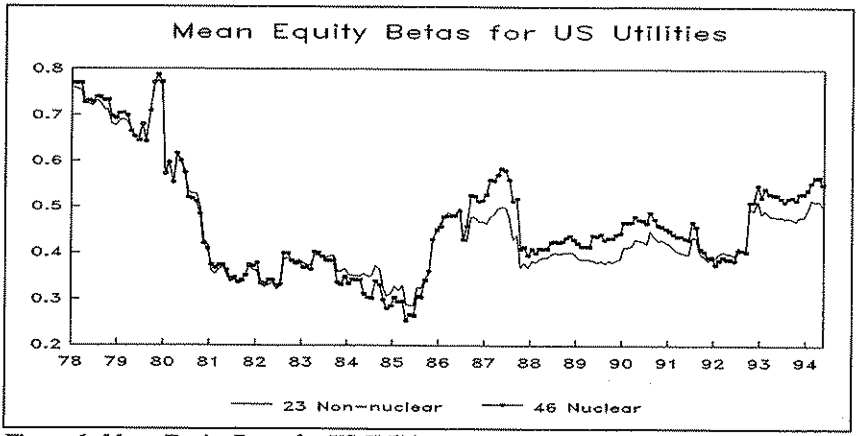

Figure 6: Mean Equity Betas for US Utilities

post-Chernobyl betas disclosed markedly higher betas for nuclear utilities, both before and after the Chernobyl accident. Farber (1991) also documents higher betas for nuclear utilities[22].

To purge our analysis of the immediate effects of the Three Mile Island, WPPSS and Chernobyl events, and in order to focus on contemporary attributes of nuclear generators, we use the most recent data to investigate further the relationship between the beta and nuclear capability. Figure 7 shows a scatter diagram of the most recent equity beta plotted against nuclear capability for all utilities.

Using the data in Figure 7, a regression of the equity beta for these companies against their nuclear capability generates a relationship of the following form:

$$\underset{\text{(Standard error)}}{\text{Equity beta}} = \underset{(0.03)}{0.50} + \underset{(0.16)}{0.23} \times \text{Nuclear capability} \qquad \{3\}$$

22 It is interesting to note from this study that these larger betas for nuclear utilities are not compensated by US regulators, who set the same allowable rate of return for nuclear and non-nuclear utilities. There is no equivalent of the UK's "nuclear levy".

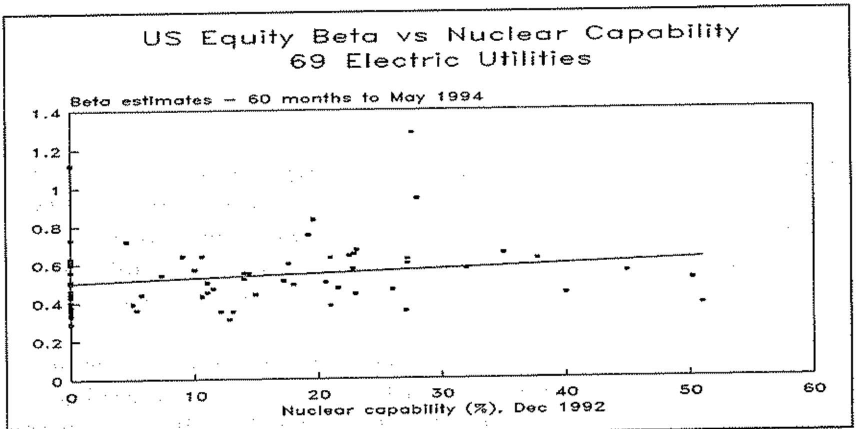

Figure 7: US Equity Beta vs Nuclear Capability

The upward slope of relationship {3} is important.[23] Based on the full sample of utilities we infer that a non-nuclear utility would have a beta of 0.50 as compared to a (hypothetical) all-nuclear utility which would have a beta of 0.73 (ie, 0.50 + 0.23 x 1). The additional return warranted by the incremental beta of 0.23 is given by the CAPM (see equation {2} in section 2.3), and is equal to the Equity Market Risk Premium multiplied by 0.23. This equates to a required rate of return which is two percentage points higher for an all-nuclear generator, as compared to its non-nuclear competitor.

Though the relationship is weak, it is apparent that beta tends to be higher for utilities with a greater nuclear capability. Why might this be? Conceivably our results might reflect higher financial gearing for nuclear than for conventional plant, in which case there would be no such relationship if the impact of gearing were removed. We therefore undertake a similar regression using the asset beta for each company, with similar results. The asset beta for firms with a higher nuclear capability

23 Regression {3} is based on the full sample of utilities. We also estimate the same relationship based on the 46 utilities with a non-zero nuclear capability. This regression yields an intercept of 0.51 (se=0.05) and a slope coefficient of 0.22 (se=0.22).

also tends to be larger[24]. Our findings are consistent with the literature cited earlier, and with the view that nuclear investment continues to be more risky than non-nuclear investment.

While we cannot explain away the higher average equity betas of nuclear utilities by their capital structures[25], there are a host of factors which contribute to the differing betas estimated for our sample of utilities.[26] It would therefore be helpful to know whether the positive relationship between beta and nuclear capability is typical of earlier periods as well.

We therefore replicate regression {3}, using the same sample of utilities, for each month to June 1994. At each date we use the preceding 60 months' equity returns to estimate a beta for each utility. We then regress these beta estimates on the nuclear capabilities. The cross-sectional regression equation, which is estimated for each month is therefore:

Equity beta = Constant + Coefficient x Nuclear capability {4}

Figure 8 presents the results from this regression for the period from 1986 to date. In the chart, the solid line measures the Coefficient that is associated in regression {4} with Nuclear Capability. For June 1994, for example, we see on the right-hand edge of Figure 8 that the Coefficient is 0.23. This confirms the estimate presented previously in regression {3}.

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24 The asset beta measures the riskiness of the underlying assets of the firm, after removing from the equity beta the impact of financial gearing. The adjustment required to derive the asset beta is specified in section 2.8 below. The regression equation corresponding to {3} is:

Asset beta =	0.32 +	0.09	x Nuclear capability
(se)	(0.03)	(0.13)	

25 Nuclear and non-nuclear utilities in fact have extremely similar capital structures. The ratio of the market value of debt to the market value of the firm averages 66 percent for nuclear utilities and 63 percent for non-nuclear utilities.

26 Note, in particular, that we have not made any adjustment for measurement error in our estimates of beta. The dispersion of utilities' true betas must be narrower than that of their estimated betas, each of which is estimated with some measurement error (see Dimson and Marsh, 1984). Some of the scatter in Figure 7 and in regression {3} is therefore attributable to our having used raw, historical estimates of beta.

The remainder of Figure 8 shows the parameters estimated for earlier time periods.[27] The interval starting in mid-1991 is based on betas estimated over the post-Chernobyl period. However, we have only a two-year history (mid-1992 to mid-1994) for which all nuclear utilities have betas that are estimated from post-adoption stock prices. Over this limited period, the increment in beta associated with having a nuclear capability is around 0.2. During earlier years, the coefficient is sometimes lower than this, though it is mainly positive.

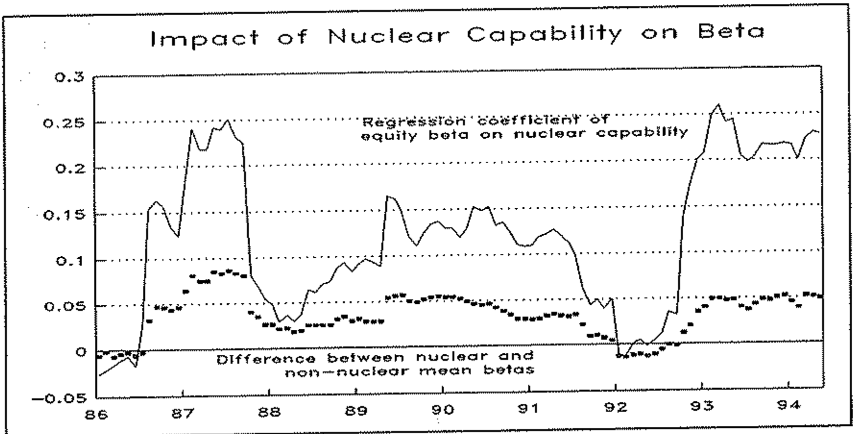

Figure 8: Impact of Nuclear Capability on Equity Betas for US Utilities

The dotted line in Figure 8 plots the difference between the mean betas of the 46 nuclear and 23 non-nuclear utilities over the sample period. Given that the nuclear utilities on average have a capability which is only 21 percent nuclear and 79 percent non-nuclear, the difference between the respective betas is quite marked. Considering, for example, the June 1994 figures, the difference in beta between the two samples is 0.05, which would imply a difference of 0.2 between a (hypothetical) all-nuclear and a non-nuclear utility. This is consistent with the results based on regressions {3} and {4} which also indicate an increment in beta of 0.2 for an all-nuclear utility.

27 For the period prior to 1986 (not shown in Figure 8, which is limited to the period after virtually all new nuclear plant had come fully into service), the slope coefficient is on average close to zero.

Given that the beta increment for nuclear companies was lower than 0.2 in some years, a conservative estimate might be that nuclear utilities have a beta which is approximately 0.1 higher than their non-nuclear counterparts. We employ this conservative estimate, in the next section, to calculate the cost of capital for nuclear investment.

2.8 Overall Cost of Capital for Nuclear Investment

For UK electric utilities which have little debt in their capital structure, the beta of their shares (their "equity beta") is similar to the betas of their business (their "asset beta"). However, it can be important to draw the distinction between a company's equity beta and its asset beta, since highly geared firms have larger equity betas as a result of their borrowing.

The cost of capital for a *project* should reflect the underlying risk of the project, rather than the level of debt in the firm's capital structure. Since we are considering projects that are similar to the underlying business of the entire company, we can use the firm's asset beta to estimate the required rate of return for new investment by Nuclear Electric.

The asset beta of a company is an estimate of the beta the company would have it were financed solely through equity and without any debt in its capital structure. The estimated asset beta can then be used in the capital asset pricing model, in order to provide a required rate of return for investment in nuclear capacity.

Computationally, the asset beta is roughly equal to the equity beta multiplied by the proportion of equity in the firm's capital structure (see Brealey and Myers, 1991). Taking the most recent estimate for National Power's equity beta of 1.0, as an illustration, we may estimate the asset beta of this company by multiplying its equity beta by the equity proportion in its capital structure. In market value terms, approximately 85 percent of National Power's capital employed is currently represented by its share capital. The asset beta for the UK's largest generator is therefore approximately 0.85. This estimate is at the lower end of the spectrum of betas estimated historically for National Power.

Since the US evidence indicates that nuclear utilities are riskier than non-nuclear utilities, with a beta which is at least 0.1 larger than the latter, we consider that Nuclear Electric would have an asset beta of approximately 0.95. On the assumption that Nuclear Electric has the same capital structure as National Power, this would be consistent with an equity beta for Nuclear Electric of around 1.1.

The required rate of return for nuclear investment is given by the capital asset pricing model, as described in equation {2} in section 2.3. The required rate of return is as follows:

Required return = Interest rate + Beta x Equity market risk premium {5}

We have already estimated the after-tax riskless rate of interest as being around 3½ percent in real terms. The beta for Nuclear Electric is estimated at 0.95, and the historical risk premium on the market has been in the range 8-9 percent. Multiplying the equity market risk premium by the beta gives a risk premium of close to 8 percent (ie, 0.95 x 8½). Adding the risk premium of 8 percent to a riskless rate of interest of 3½ percent gives a real required rate of return of 11½ percent. We prefer to work in round numbers, and therefore conclude that the required rate of return is at least 11 percent in real terms.

While our estimate is well above the NUCG (1994) estimate of an 8 percent *pre-tax* required rate of return, it is similar to the 11 percent real required rate of return which Nuclear Electric (1994) attribute to their advisors, Price Waterhouse[28]. It is also similar to Yarrow's (1988) estimate of 11½ percent, and close to the 10 percent rate which was adopted by the Hinkley Point inspector (see HPPI, 1990) and which is increasingly becoming the industry norm (see OECD, 1992), albeit as pre-tax rates in all cases. However, if there is to be a level playing field between Nuclear Electric and other private sector firms, the required rate of return must be employed as a post-tax figure. The important point to note is that our discount rate should be applied to corporate cash flows *after payment of corporate taxation*.

The final stage in estimating the cost of capital for nuclear investment is to identify the pre-tax required rate of return which corresponds to an after-tax rate of 11 percent. Formula {1} given in section 2.2 expresses

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28 It is lower than Scottish Nuclear's (1994) estimate of the equity cost of capital for new CCGT power projects, which Lazards assess at 18-23 percent per annum post-tax, corresponding to about 13-17 percent per annum post-tax in real terms. However, Scottish Nuclear's submission is confused regarding the impact of gearing, and contends that "*the likely cost of capital for a new nuclear station can only be assessed nearer the time on the basis of a specific proposition*".

the pre-tax required return as a function of the post-tax required return. New nuclear plant is assumed to have a 40-year asset life, and hence a writing-down allowance of 2½ percent per annum. The annual incremental operating cash flow for Sizewell C compared to gas is 4.3 percent of its capital cost, and the corporate tax rate is 33 percent. Inserting the values WDA = .025, p = .043 and tax rate = .33 into the formula, we obtain the pre-tax required rate of return, which is 13 percent.

This is a conservative estimate of the required rate of return for investment in new plant, however, for at least three reasons. First, we have rounded down our estimate of the after-tax required rate of return from 11½ to 11 percent. Second, we have given no additional weight to the higher operational gearing and risk factors associated with being in the business of nuclear construction, rather than just plant operation. And third, we have implicitly assumed that new nuclear investment need provide no higher a return than existing assets, whereas most scholars in this area would agree that major capital investment projects are more risky than existing assets. For these reasons, we regard 13 percent as the minimum rate of return that should be demanded from investment in new nuclear plant.

3 IMPACT OF RESTRUCTURING ON REQUIRED RATES OF RETURN

Nuclear Electric (1994, Volume 3) proposes transfer of *"the largest possible proportion of Nuclear Electric's activities to the private sector including financial responsibility for new investment"*. An important element of the restructuring necessary to privatise Nuclear Electric is a review of the company's commercial relationships both with other companies in the nuclear supply industry and with customers. As outlined in Volume 1 of Nuclear Electric's report, the intention is that *"by sharing and limiting the risks borne by investors the Government would reduce the cost of capital by extending the capacity to raise debt. Subject to a satisfactory overall transfer of risks, this would reduce the direct cash cost of Government support and facilitate the arrangement of a private sector financing package"*.

It appears that Nuclear Electric have in mind various types of restructuring that will effectively transfer risks to other participants in the capital and energy markets. This would be undertaken so as to make investment in nuclear plant less risky, which would in turn lower required rates of return and hence (i) reduce lifetime levelised generating costs and (ii) enhance the firm's flotation value.

We do not deny the importance of good contract design for project finance and power purchase agreements, and endorse Nuclear Electric's desire to *"allocate the various risks to the parties best able to control them"* (Volume 1). However, Nuclear Electric's plans to disaggregate the total project risk and allocate elements to various parties does not reduce the level of project risk; instead, it only transfers risk between project participants. It is the overall level of risk of an investment that is likely to be invariant, and any claims of financial alchemy should be strongly challenged. We elaborate on this principle in the following two sections, dealing first with the financial structure of Nuclear Electric and later with the contract between the company and its customers.

3.1 Capital Structure

We consider first the claim that *"extending the capacity to raise debt...would reduce the direct cash cost of Government support"*. This hints at the idea that since debt is less costly than equity, a high debt/equity ratio will lower Nuclear Electric's overall cost of capital.

Ignoring for the moment any tax considerations, let us consider a project with an expected return of 11 percent. We can also think of financing this with 80 percent of debt with an expected return of 8 percent, and with 20 percent of equity, with an expected return of 23 percent. This also has an average return of 11 percent - but now due to the presence of the high proportion of debt, the equity is much riskier. This is exactly what goes on in project finance/power purchase agreements.

We can use the concept of weighted average cost of capital to show how this should give the same cost of capital as that we derive using an asset beta. The cost of equity for a company with an equity beta of 1.1 and with equity representing 85 percent of the capital structure (as we assume for Nuclear Electric) would, using the capital asset pricing model, be a risk-free rate of 3.5 percent plus a risk premium of 9.5 percent, totalling 13 percent. The weighted average cost of capital would then be 13 percent x 0.85 + 3.5 percent x 0.15 = 11.5 percent.

If we instead envisage a company with more debt, say 30 percent of the capital structure, then while we might accept that the cost of debt would remain at 3.5 percent, there would be more risk to the equity shareholders. We would need a required return on equity closer to 15 percent (thus implying an equity beta of 1.28) for the new weighted average cost of capital also to be 11.5 percent. At this required rate of return, the weighted average cost of capital would be 15 percent x 0.70 + 3.5 percent x 0.30 = 11.5 percent, which is the same as in the less geared example.

A similar type of fallacy occurs when proponents use the weighted average cost of capital to supposedly show how changes in capital structure can reduce the required return on a project. Using fixed returns for debt and equity, for a variety of capital structures, is inappropriate. Instead, having a high level of gearing simply increases the required return on equity, such that the weighted average cost of capital will be similar regardless of whether there is a lot of equity and a little debt in the company's financial structure, or a more even split between these two sources of finance.

In fact, as pointed out in standard textbooks such as Brealey and Myers (1991) or in articles analysing the impact of capital structure on UK discount rates (see, for example, Ashton, 1989), the only advantage to debt is a tax advantage. This arises from the tax deductibility of interest payments, and under the UK tax system this would, at most, reduce required rates of return by a small fraction of one percentage point.[29]

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29 To see this, note that if there is a *full* tax advantage to the tax deductibility in the UK, the reduction in the company's weighted average cost of capital is equal to the Tax Advantage to Debt multiplied to the Ratio of Debt to Debt-plus-Equity. The Tax Advantage to Debt is the difference between the corporate and personal tax rates, divided by 100 minus the personal tax rate; and thus the Tax Advantage to Debt is at most 10.67 percent With a debt/equity ratio as high as one half, and hence Debt being one third of Debt-plus-Equity, the reduction in weighted average cost of capital is therefore 10.67 percent multiplied by one-third, or 3.6 percent of the weighted average cost of capital estimate. With a cost of capital of 11 percentage points, the tax deductibility of debt would *at most* reduce the weighted average cost of capital by 3.6 percent of this or by less than one half of one percentage point. To sum up, in the UK tax system, the tax benefits of debt financing are trivial and, for reasonable levels of gearing, may be ignored.

3.2 Other Forms of Risk Transfer

In the previous section we have explained that, under the UK tax system, the weighted average cost of capital is largely unaffected by the proportion of debt in a company's financial structure. Required rates of return simply cannot be reduced to a significant extent by raising debt. It follows that the major opportunity for reducing the discount rate must involve the transfer of risk from prospective investors to others. The intention of this section is to examine the view that by shifting risk onto other members of the industry and/or onto consumers, the required rate of return for new investment can thereby be lowered.

Consider the circular treatment of investment risk when output prices are determined by regulatory reviews. For a regulated company, the cash flows from a project depend to an important extent on the rate of return which is regarded as acceptable in the periodic review. However, in the UK regulators set price caps by giving consideration to the rate of return which shareholders might reasonably expect. In other words, the regulator allows a rate of return which reflects the riskiness of the company's cash flows, while the riskiness of the firm's cash flows depends on the rate of return which the regulator considers to be reasonable.

This problem is well known; see, for example, Brennan and Schwartz (1982 a,b). The extent to which the regulatory framework reduces investment risk will obviously depend on whether there is a US-style allowable rate of return regime, a UK-style price-cap system or some other alternative. If regulators allow companies to set prices so as to recover in full their shareholders' required rates of return, and if regulators react immediately to changing circumstances (ie, there is no regulatory lag), then investment risk will effectively have been eliminated (see Norton, 1985, for empirical evidence in support of this contention).

However, even if virtually all risk were eliminated from the utility, this does not mean that the underlying investment projects are themselves riskless, for what will have happened is that the regulator has enabled the utility to push risks elsewhere in the supply chain. Most obviously, consumers will bear additional risk, since prices will be varied to allow the utility to achieve its target rate of return. At the same time, other members of the industry may also have additional risk imposed upon them. For example, if a nuclear generator creates capacity which is surplus to total system requirements, it will force some non-nuclear capacity into a position which is lower in the merit order. These competitor facilities will then experience an unexpectedly low rate of return.

Suppose that the consumer pays a price per kWh which covers incremental capital investment by the utility. There is no means of conveying to the regulator what the consumer's discount rate is, and the utility and regulator may both be tempted to look solely at the cash flows to the shareholders of the utility. If this occurs, the agreed discount rate will be too low, and there will be a bias towards investing in capital-intensive projects. In the electricity supply industry, the most important bias will be towards nuclear investment. This unwanted by-product of regulation should be controlled by insisting on the use of private-sector required rates of return, as employed in profitable (and tax-paying) investor-owned companies.

4 IMPACT OF THE DISCOUNT RATE ON APPRAISAL OF NEW PLANT

The choice of required rate of return used by Nuclear Electric has a major impact on the relative attractiveness of building additional nuclear power stations. To demonstrate this, we compare the benefit from choosing a nuclear station with the capacity of Sizewell C and/or Hinkley Point C in preference to a number of CCGT gas stations. The capital and operating costs for CCGT are taken from Nuclear Electric's evidence (Volume 1, paragraph 47). Section 4.1 uses Nuclear Electric's central estimate of nuclear costs, whereas section 4.2 uses the estimates of nuclear costs derived by independent experts.

4.1 Nuclear Electric Central Case Assumptions

To analyse Nuclear Electric's central case, we use capital and operating costs as estimated by Nuclear Electric (1994) for Sizewell and Hinkley Point (Volume 1, Table 2.1) and for CCGT. The capital costs excluding interest during construction are nuclear £3520 million and gas £1176 million; fuel costs per kWh are nuclear 0.37p and gas 1.55p; and operating costs, including nuclear decommissioning, are nuclear 0.66p and gas 0.34p. These estimates provide an insight into Nuclear Electric's own judgements of the competitiveness of nuclear power relative to gas.[30] By performing the calculations for ourselves, we can make adjustments for the discount rate which could be used in conjunction with Nuclear Electric's other key parameters.

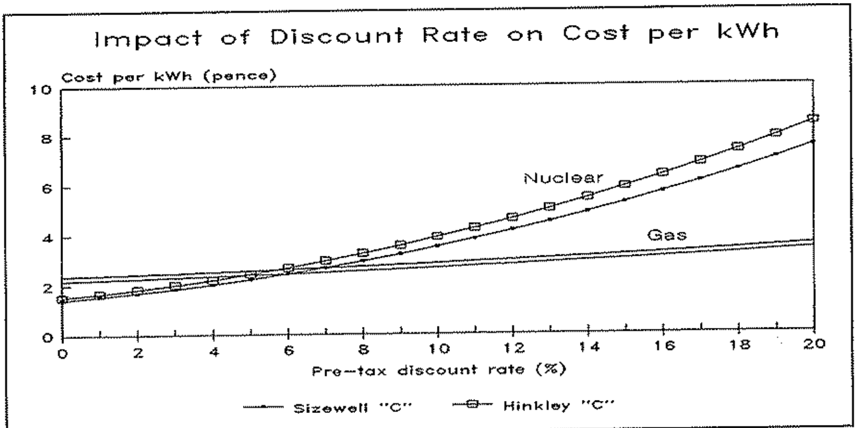

Figure 9: Impact of Discount Rate on Cost per kWh

Figure 9 shows the cost of electricity in pence per kWh for both nuclear and gas, using pre-tax real discount rates ranging from zero to 20 percent. There are two curves for nuclear power : the upper one represents the smaller scale investment in Hinkley Point, while the lower curve represents the larger investment in Sizewell. Sizewell C is a lower cost generator than Hinkley Point C at all discount rates. There are also two curves for gas, the upper one representing Nuclear Electric's projections and the lower one being based on the NUCG (1994) estimates. At a discount rate below 6 percent, nuclear is unequivocally the cheaper alternative. However, the cost per kWh of nuclear power rises sharply as the discount rate is increased and at 7 per cent even the more efficient Sizewell reactor is inferior to the CCGT alternative.

A comparison of the economic value of the nuclear and gas alternatives may also be undertaken in terms of the net present value (NPV) of the resulting cash flows. As outlined in section 2.1, the NPV is simply the

30 For good measure, we also use the CCGT cost estimates published by the Nuclear Utilities Chairman's Group (NUCG, 1994). These estimates are slightly lower, and are represented by the lower curve for gas in Figure 9.

sum of the discounted values of the annual cash flows, using the required rate of return as the discount rate. The most straightforward case to analyse is the choice between building Sizewell C plus Hinkley Point C, on the one hand, or equivalent CCGT capacity on the other.

We therefore evaluate the NPV of 29 gW of nuclear capacity *minus* 29 gW of gas capacity[31]. Since there is no difference between these two capacities, the NPV computation is based solely on the cost differences between the two technologies and does not depend on any assumptions about the price at which the output will be sold.

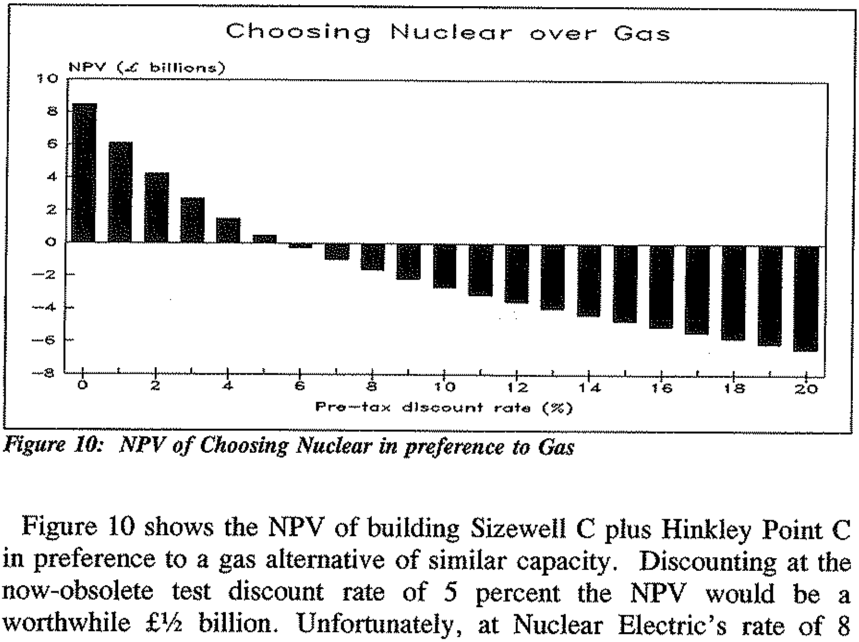

Figure 10: NPV of Choosing Nuclear in preference to Gas

Figure 10 shows the NPV of building Sizewell C plus Hinkley Point C in preference to a gas alternative of similar capacity. Discounting at the now-obsolete test discount rate of 5 percent the NPV would be a worthwhile £½ billion. Unfortunately, at Nuclear Electric's rate of 8 percent the NPV is below -£1½ billion, while at the 11 percent pre-tax rate mentioned in Nuclear Electric's (1994) submission, and using Nuclear Electric's own cost estimates, the NPV from accepting the two proposals in preference to gas is below -£3 billion.

31 To equate the productive lives of the nuclear and gas alternatives, we assume that each CCGT station will be replaced by another one after 20 years, at the same real cost as the initial station. This analysis therefore discriminates somewhat against gas, since reinvestment at the middle of our period provides an opportunity to benefit from advances in CCGT technology and/or from the opportunity then to switch to more economical alternatives.

We have shown, however, that the 11 percent discount rate should be applied to after-tax cash flows. The equivalent pre-tax rate is at least 13 percent. Applying the latter rate to the Sizewell and Hinkley Point proposals, we see that the NPV if Nuclear Electric go ahead with both these projects would be -£3.9 billion. Under Nuclear Electric's privatisation proposals, this loss in value would be reflected in a need for Government subsidies, retention of residual public sector liabilities and lower flotation proceeds. Even using Nuclear Electric's own plant parameters, the flotation is thereby projected to raise several billions of pounds less than could otherwise be the case[32].

4.2 Independent Experts' Central Case Assumptions

A major implication of the capital asset pricing model is that risks which are specific to a particular investment should *not* be reflected in the discount rate. The discount rate should reflect only market-related risk, as measured by beta.

Risks which are specific to a particular investment, however, are not to be ignored. They should be reflected in the cash flow projections for the investment. In this section, we therefore replace Nuclear Electric's published projections by expectations which take account of the full range of project risks to which the Sizewell C and Hinkley Point C proposals are exposed.

Sizewell C and Hinkley Point C are characterised by a number of financial risks which may not adequately be taken into account in Nuclear Electric's projections. These risks include the prospect of construction cost increases; the risk of failing to achieve targets for operating performance; the fact that a major accident might lead to safety changes, cancellation or closure; the possibility of increases in spent fuel management and commissioning costs; and the possibility that Nuclear Electric, who wish to pre-sell the output of Sizewell C, might be unable

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32 With the possibility of privatisation in the near future, it might be asked whether the stock market responds to information of this type - whether it values a utility more highly if the utility abandons a project with a negative NPV. Chen, Farrow and Gorman (1987) find that, even long after the Three Mile Island accident, US utilities' stock prices rise significantly when they announce abandonment of their nuclear generation construction projects. Fuller, Hinman and Lowinger (1990) estimate that a nuclear utility is valued at 20 percent less than a comparable non-nuclear power utility.

to do so. Such risks are not, and should not be, taken into account in the discount rate.

Instead, when projects are being discounted by a required rate of return, the cash flows should be expectations which fully take into account the probability of adverse outcomes. Barker (1994) reviews the impact of construction cost and performance risks on the financial parameters for Sizewell C, as estimated by two independent experts (MacKerron, 1994 and Sadnicki, 1994); and it is these revised figures which we use as a basis for reappraising Nuclear Electric's investment plans.

We use capital and operating costs for Sizewell C as summarised in Barker (1994). The capital costs excluding interest during construction are nuclear £4000 million ("Case 1") or £4600 million ("Case 2"), and gas £1176 million; fuel costs per kWh are nuclear 0.46p and gas 1.55p; and operating costs, including nuclear decommissioning, are nuclear 0.74p and gas 0.34p. The analysis is thus based on independently derived central case assumptions for nuclear, in conjunction with the same CCGT projections as were employed in section 4.1. We discuss first the lifetime levelised cost of nuclear electricity, under these cost scenarios.

With a pre-tax rate of return of 13 percent, the levelised costs for Sizewell C are 5.6 pence per kWh (Case 1) and 6.3 pence per kWh (Case 2). The respective figures for Hinkley Point C are 6.3 pence per kWh (Case 1) and 7.0 pence per kWh (Case 2). In contrast, the lifetime levelised costs for gas-based electricity is only 2.9 pence per kWh.

Whereas the analysis presented in section 4.1 estimates the *incremental* NPV of investing in nuclear stations in preference to gas stations, it may also be helpful to estimate the NPV of investing in each project on a stand-alone basis. If electricity can be sold for an extremely high price, then it is conceivable that nuclear power stations would be profitable (i.e. have a positive NPV) even though they would be much less profitable than gas stations. Similarly, if electricity can at best be sold for a very low price, then not only nuclear but also gas stations might be unprofitable (i.e. have a negative NPV). In order to estimate the NPV of the Sizewell C and Hinkley Point C proposals - on a stand-alone basis - we need to make an appropriate forecast of the market price for electricity. If we are able to do this in an internally consistent way, we can then make a more informed estimate of the subsidy required to compensate Nuclear Electric for engaging in otherwise unprofitable capital expenditures.

To make a consistent forecast of electricity prices, we assume that the private sector investors in CCGTs are competing to provide electricity generating capacity. In a competitive electricity supply industry such as this, the marginal investor will expect to achieve NPV of zero. Intra-marginal investors will expect to achieve slightly positive NPVs, while the sub-marginal investor (if he chooses to go ahead with the project) will anticipate a negative NPV. We therefore infer an internally consistent forecast of the electricity price by identifying the price which would generate a marginally positive NPV at the required rate of return. Using Nuclear Electric's parameters for CCGT and the required rate of return of 13 percent (on a pre-tax basis) we estimate that the electricity price would have to be 2.9 pence per kWh to ensure that investment in CCGT capacity has a positive value.[33] We therefore estimate the NPV of various alternative scenarios, all based on a market value for electricity of 2.9 pence per kWh.[34]

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33 To be precise, the estimated market price for electricity is 2.85 pence per kWh, which we round up to the nearest 0.1 pence. If the price is exactly 2.9 pence per kWh, this would generate a very small positive NPV at a discount rate of 13.0 percent, which falls to zero at a discount rate of 13.7 percent (as may be seen in Figure 11).

34 The estimate of 2.9 pence per kWh is consistent with Nuclear Electric's CCGT parameters. If, on the other hand, we were to employ British Gas' asset beta of 0.67, we would estimate a risk premium of 6 percent, which would imply an after-tax required rate of return of 9½ percent and a pre-tax rate close to 11 percent. Under this assumption, the internally consistent market price for electricity would be 2.7 pence per kWh. We have replicated all of our analysis using a price of 2.7 pence per kWh, and our results remain qualitatively unchanged.

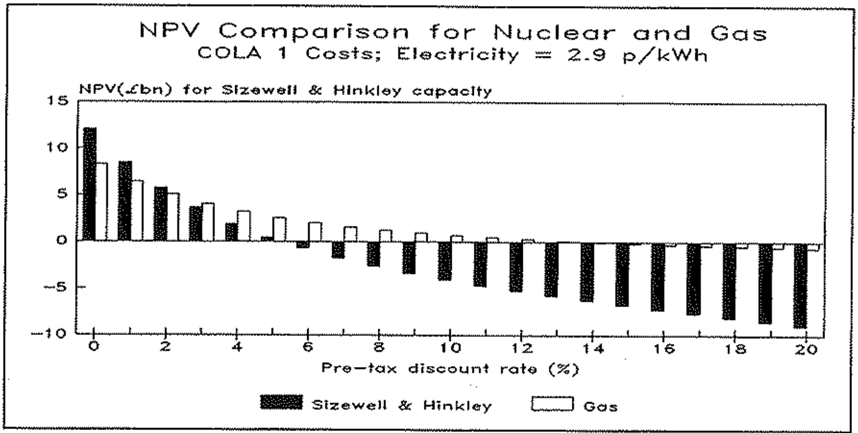

Figure 11: Impact of Discount Rate on NPV for Nuclear and Gas

Figure 11 presents the results of our comparison of nuclear investment with the gas alternative. The comparison is based on the conservative Case 1 estimates of capital costs, combined with a nuclear availability of 75 percent. The gas costs are taken from Nuclear Electric (1994), as mentioned earlier. Each solid bar in Figure 11 provides an estimate of the NPV for the two proposed nuclear facilities taken together, while the unshaded bars provide the corresponding NPV for gas, at a series of discount rates ranging from zero to 20 percent.

With a discount rate of zero, the NPV from investing in gas is some £8 billion, but this is clearly unattractive when set against the £12 billion NPV from investing in the two nuclear facilities. Once the discount rate is larger than a couple of percentage points, however, the relative attractiveness of the nuclear option declines, and its NPV is lower than that of the gas option. Focusing on the unshaded bars for gas, it can be seen that this technology remains profitable for discount rates up to 13 percent, but even at higher rates the loss in value is comparatively moderate. In contrast, the NPV of the nuclear investments becomes negative at required rates of return in excess of 5 percent, and at realistic rates, the NPV is substantially negative.

The comparison given in Figure 11 is expressed in terms of net present values, taking account of the prospective sales price of electricity. However, as explained earlier, the two alternatives have been constructed so as to generate the same level of output (approximately 29 gW). While the NPVs clearly depend on the price at which electricity will be sold, the *incremental* NPV (as used in section 4.1) does not depend on the price of electricity. The incremental NPV is simply the difference between the shaded bars (representing nuclear) and the unshaded bars (representing gas) in Figure 11. The difference in height between each pair of bars measures the loss in NPV from choosing nuclear in preference to CCGT capacity. At a required rate of return of 13 percent, the incremental NPV for selecting nuclear rather than gas is -£5.9 billion.

5 SUMMARY AND CONCLUSION

Using the capital asset pricing model (CAPM) as our framework, we have estimated the after-tax required rate of return for investment in new capacity by Nuclear Electric. Our estimate is at least 11 percent in real terms. If the 11 percent rate is to be applied to pre-tax cash flows, the required rate of return must be scaled up to a pre-tax level of at least 13 percent.

Our calculations begin with the after-tax riskless rate of interest, which is currently around 3½ percent in real terms. The equity market risk premium has averaged between 8 and 9 percent over the long term, while the asset beta of Nuclear Electric is estimated at around 0.95. The latter is marginally higher than the corresponding figure for National Power, in view of the evidence that nuclear utilities tend to have a higher beta than non-nuclear utilities. Combining these figures together, the CAPM indicates a post-tax required rate of return of over 11 percent (ie, 3½ percent + 0.95 x 8½ percent ≈ 11½ percent). The pre-tax equivalent of 13 percent is the appropriate rate to use for valuing the cash flows from Sizewell C and Hinkley Point C on a before-tax basis.

These required rates of return are already adjusted for the effects of Nuclear Electric's capital structure decisions, since they are based on asset betas rather than equity betas. They cannot be reduced significantly by selecting a relatively high debt/equity ratio for the firm, since the tax advantage to debt is small in the UK tax system. The only way to lower Nuclear Electric's required rates of return would be for the firm to unload some of its investment risk onto competitors or consumers. The fact that regulated businesses can, with the support of Government or the regulator, force excess costs onto consumers should not influence the required rate of return which is employed in appraising investments, for there is no reason to suppose that consumers are less risk-averse than corporations.

The net effect of selecting an inappropriately low discount rate is to overstate the value of new investments. In Nuclear Electric's case, we have estimated the impact of valuing the Sizewell C and Hinkley Point C projects at a pre-tax 11 percent, in preference to our estimate of 13 percent. On an 11 percent pre-tax basis, Nuclear Electric's figures imply that investing in nuclear rather than gas would generate a loss of value amounting to well over £1 billion per location.[35] Using our estimated discount rate of 13 percent with Nuclear Electric's cost estimates, the figure is closer to double this, and hence the total value loss attributable to both projects would amount to some £4 billion. This is illustrated in the first two bars of the following bar chart.

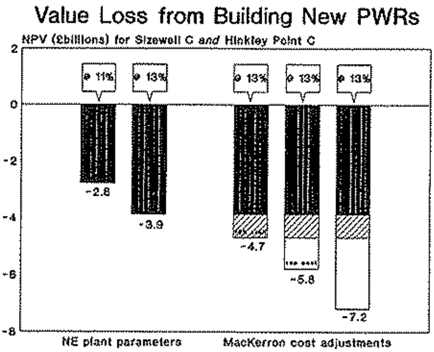

Figure 12: Loss of Value from Investing in Sizewell C and Hinkley Point C

While Nuclear Electric's own figures indicate a value loss of some £4 billion from investing in Sizewell C and Hinkley Point C, this understates the total loss in value if independent experts' estimates of capital cost and availability are accepted. Figure 12 also shows the impact of plant availability and capital cost assumptions on the overall valuation. If MacKerron's estimate of 75 percent availability is substituted for Nuclear Electric's estimate of 85 percent, the value loss is £4.7 billion.

In addition, using MacKerron's conservative Case 1 estimates of capital costs, the required loss rises to nearly £6 billion, while the Case 2

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35 The precise figures are £1.6 billion and £1.2 billion for Sizewell C and Hinkley Point C respectively.

estimates imply a loss of over £7 billion.[36] Even if the Government subsidised the proposed nuclear facilities to the extent of £1 billion each, it would be necessary to find other indirect subsidies (such as government guarantees for decommissioning, low cost loans from the Government, extension of the nuclear levy, etc.) in order to bring these two projects into the black.[37]

It remains possible that the Government may seek to privatise Nuclear Electric, complete with a commitment to engage in projects which have a negative net present value, even after receipt of a subsidy from the Government. This simply replaces the Government subsidy by a reduction in the flotation proceeds from sale of the industry.

If the Government subsidises each nuclear investment to the tune of £1 billion, we show that on Nuclear Electric's own cost estimates the flotation value of the company will be reduced by a further £2 billion. On independent estimates of the capital cost, even after taking account of subsidies totalling £2 billion, the flotation proceeds would be lower by £4-5 billion as a result of Nuclear Electric's commitment to these two projects. Strictly on a commercial basis, Nuclear Electric should publicly abandon Sizewell C and Hinkley Point C now.

36 This analysis considers Sizewell C and Hinkley Point C jointly. Hinkley Point C is somewhat smaller than the Sizewell C proposal, but in relation to its size is slightly less worthwhile. For the four cases displayed towards the right of Figure 12, where we discount cash flows at 13 percent pre-tax, the Nuclear Electric case comprises a value loss of £2.4 billion for Sizewell C and £1.5 billion for Hinkley Point C. The corresponding losses for Case 1 are £3.6 billion and £2.2 billion respectively, while for COLA Case 2 the losses are £4.5 billion and £2.7 billion respectively.

37 It is interesting to note the contribution from each of the experts' revisions to the key parameters. For the two stations combined, the shift from 85 percent to 75 percent availability reveals a value loss of £0.8 billion, the shift from Nuclear Electric to revised capital costs implies a loss of value of £1.1 billion (Case 1) or £2.5 billion (Case 2), while alterations to the required rate of return lead to all of the remaining value loss.

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IV THE NUCLEAR REVIEW

Professor Colin Robinson

This brief paper summarises the evidence I submitted in September 1994 to the government's review of the nuclear industry[1]. It concentrates on three questions:

- why privatise?
- what should be the privatised structure?
- what benefits can be expected?

1 WHY PRIVATISE?

- The "economic and commercial viability of new nuclear stations", to which the terms of reference of the nuclear refer, can be determined only if capital markets judge proposals for new stations and their product is sold in competitive markets.
- Halfway houses (such as private finance for state industries) are inherently unsatisfactory. Inevitably they lead to continued political interference. Moreover, it will remain extremely difficult to estimate future costs, in the absence of competitive markets.
- Continued state ownership will lead to death by nationalisation because politicians' time horizons are too short for an industry which needs to take a long view and because costs are likely to be excessive if standards are not being set by competitors.
- Privatisation would free the nuclear companies from Treasury rules, de-politicise decisions and allow the companies to diversify, taking advantage of market opportunities.
- The aim of privatisation should be to establish two diversified

1 Published as *Privatising Nuclear Power: evidence for the review of future prospects for nuclear power,* Colin Robinson, SEEDS 79, November 1994.

generators, based on Nuclear Electric and Scottish Nuclear, not to privatise nuclear power *per se*.

2 WHAT STRUCTURE?

- Magnox stations should be retained in state ownership but their operation should be contracted out to enhance efficiency. The Magnox company should bid into the Pool and contract its output independently.

- The rest of Nuclear Electric and Scottish Nuclear should be privatised as companies with generation as their main businesses (not as nuclear generators).

- Plant should be re-allocated so the successor companies are approximately equal in size.

- All protective arrangements (the fossil fuel levy, the NEA in Scotland and geographical market-sharing) should be removed as soon as possible.

3 WHAT BENEFITS?

- There would be efficiency gains from what would amount to market entry by two formidable new generators/suppliers (plus, for a time, a Magnox company), able to invest in new plant and purchase existing stations and to sell their product where they chose.

- Some of the major weaknesses of the electricity privatisation scheme would be corrected.

- - consumers would gain in the short/medium term from lower pool and contract prices and from more choice in contract terms as the influence of National Power and PowerGen waned;

  - in the longer term, there would be additional gains from a competitive market process which stimulated entrepreneurship and innovation;

- regulation of the industry (now so difficult because of the weakness of competition) would be more straightforward as rivalry in generation and supply safeguarded consumers' interests and regulation concentrated on the natural monopoly network of wires.

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