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# How should investors value nuclear liabilities?

Simon Taylor

## Biographical details

Simon Taylor is University Lecturer in Finance at Judge Business School, University of Cambridge. He teaches corporate finance on the MBA degree and teaches final year undergraduate microeconomics for a number of colleges. His research interests include the economics and financing of nuclear power and the role of equity research in the efficiency of stock markets. His book on the financial crisis at British Energy was published by Routledge in 2007. Simon joined the Judge faculty in April 2007. Previously he had some 14 years of experience in investment banking mostly as an equity research analyst covering the electricity sector. He was also deputy head of equity research at JPMorgan Securities in London, where he helped to set up JPMorgan's Global Research Centre in Mumbai, India. Simon is the director of the new Cambridge Master of Finance degree, which is based at Judge Business School and begins in September 2008.

## Abstract

Nuclear liabilities are an extreme form of long term deferred cashflows. The valuation of these liabilities matters for assessing the viability of new nuclear power stations and was a factor in the financial crisis at the privatised nuclear company British Energy in 2002. There is only a modest accounting literature on nuclear liabilities but their similarity to pension liabilities means that the extensive literature on pension accounting, valuation and investment is directly relevant. Drawing on that literature it is argued that funded nuclear liabilities (where there are segregated assets to cover the future costs) should be discounted at the risk free rate. The credit risk in liabilities arising from the probability that the company will default requires a discount rate higher than the risk free rate. So unfunded liabilities should be discounted at the AA corporate bond rate used in pension liabilities. Examples are given of the mistaken approaches to valuation by analysts of the liabilities of British Energy, which contributed to the company's financial crisis. The paper argues that these mistakes arose in part because of the lack of a clear valuation and accounting framework for nuclear and pension liabilities in the late 1990s.

## 1. Introduction

This paper addresses the question of how investors should value the liabilities of nuclear generation companies. The context is partly historical – Taylor (2007) argues that mis-valuation of nuclear liabilities was an important contributor to the financial crisis of the company British Energy plc in 2002. But it is also relevant to the possibility of more privately funded nuclear power stations being built in the UK and US. The question is more important in the UK because government policy means the liabilities are proportionately far greater than in the US. More generally, nuclear liabilities represent an extreme case of long term cashflows in investment analysis.

Nuclear liabilities are the cash outflows arising from: i) decommissioning nuclear power stations; and ii) the treatment, storage and disposal of spent fuel and associated nuclear waste (known as "back end fuel costs"). These costs arise long after the generation of the power, though they are accounted for at the time the revenue arises. The gap between the accounting accrual and the actual cash outflow gives rise to a conceptual and practical problem of what discount rate to use.

We argue below that the problem is similar to the question of how to value pension fund liabilities. Changes in accounting rules for pension liabilities are still underway (as of 2008) and still generating controversy among practitioners (Financial Times 2008). The controversy lies in part in the complexity of the problem but also in disagreements among four groups of interested parities: the actuaries profession, the accounting profession (split between the US, UK and international bodies), financial economists and investors. But the debates over international and British accounting standards for pension liabilities have at least illuminated the problem usefully and there is now scope to apply some of that debate to the related question of nuclear liabilities.

The practical importance of valuing liabilities correctly is that they form a significant part of the economic cost of nuclear power generation. Incorrectly valued they could lead to mistaken investment decisions. Taylor (2007 chapter 11) argues that investors underestimated the liabilities of British Energy because they used too high a discount rate. This in turn led the company's shares to be overvalued and encouraged excessive leverage that left the company vulnerable to the collapse of power prices which eventually forced it close to bankruptcy in September 2002.

This paper proceeds as follows. Section 2 explains the nature of nuclear liabilities and the reason why they are more important in the UK (and to an extent in other European countries) than in the US. Section 3 defines the idea of a liability more precisely and considers the economic framework for thinking about them. Section 4 reviews the accounting principles used for nuclear liabilities. Section 5 then argues for the analogy with pension liabilities and discusses the recent history of pension accounting standards. Section 6 compares pension and nuclear liabilities and draws some conceptual conclusions about the correct discount rate to use. Section 7 then analyses how equity analysts valued the company British Energy at and after its privatisation in 1996, showing that a variety of approaches were used, none of them sound. Section 8 draws some conclusions about how investors should value nuclear liabilities.

## 2. Nuclear costs

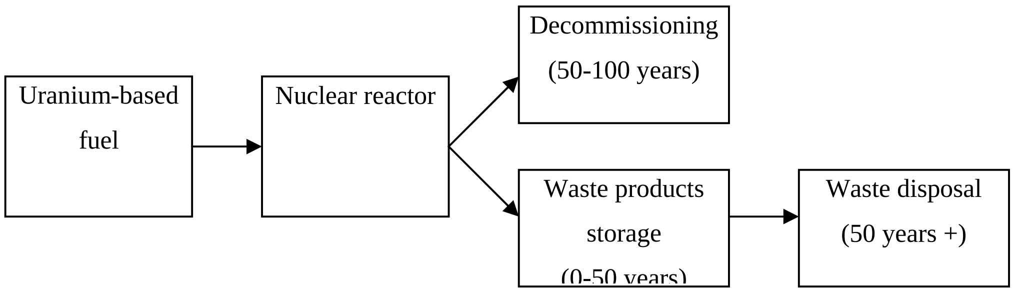
Nuclear power generation is the generation of electricity using uranium fuel in a reactor that creates heat for raising steam to turn a turbine. Uranium fission leads to irradiation of parts of the power station, which must be decontaminated and removed safely. This process of decommissioning cannot safely or economically be done for many years after the station has ceased operating, so one of the main costs of production is deferred, typically by decades.

Uranium fuel that is "burned" in the reactor is not fully used up. What is left in the reactor is a mixture of unused uranium and various fission products. This combination of materials is known as spent fuel and remains highly radioactive for many years. It must be removed from the power station then stored for several years until the most radioactive materials have cooled down sufficiently for them to be made suitable for long term disposal, probably in an underground repository. No country has yet completed full arrangements for waste disposal and the time scale for such costs is very long indeed.

Spent fuel costs are often summarised as the “back end” of the fuel cycle, distinct from the “front end”, which consists of uranium mining, enrichment, fuel fabrication and assembly (Nuttall, 2005 chapter 3). Back end costs, like decommissioning costs, arise in large part long after the power station’s operating life.

Figure 1 shows the main elements of nuclear power production and the deferred costs.

*Figure 1 Nuclear Fuel Cycle, Duration of Activities*




The time scales for these costs depends in part on the specific reactor type. Older nuclear reactors were designed for up to forty years of operations, though some have been extended. New reactors are being designed with lives of sixty years (Nuttall, 2005 p.129). Decommissioning of the stations cannot start until they have been shut down and the reactors emptied of all spent fuel. But the reactor remains highly radioactive for a time and normal practice is to wait for several decades to allow the radioactivity to decline to a relatively low level that permits the demolition of the station and the removal of the materials to a storage facility. This would be around forty years for a standard pressurised water reactor (PWR) and up to one hundred years for the British advanced gas cooled reactors (AGRs) (British Energy, 2007). So for a brand new power station the decommissioning costs could quite plausibly lie a century or more in the future.

Note that nuclear power is not unique in this, because other industries also face long term decommissioning and land restoration costs, for example oil production platforms and various extractive industries. The obligation to return landscapes to their original state, after say oil tar sands have been extracted, might easily lie many decades into the future.

Back end fuel costs are potentially in a class of their own in respect of time. Some of the fission products remain radioactive for very long periods: the half life of plutonium-239 is 24,000 years. These materials must therefore be kept safe from the general public (and from terrorists), so long term disposal entails substantial capital investment and some form of continuing security costs into the indefinite future. The actual procedures chosen for long term storage and disposal unavoidably require significant state involvement, but the economic cost is in most countries expected to be borne by the nuclear generator. There is therefore a very long gap between accruing this cost and the actual cash outflow.

US government policy has, perhaps more realistically than in some other countries, confronted the second type of deferred costs head on by placing all responsibility for back end fuel treatment on the federal government. Nuclear generators pay a fixed levy of 0.1c/kWh of power produced but have no further liability (World Nuclear Association, 2008). In contrast the UK and most European countries require the companies to take economic responsibility for the back end fuel liability, even though the companies are largely dependent on state policy and decisions for a practical solution. Some of the costs are therefore very difficult to estimate.

There is one other difference in the economics of the two sorts of deferred costs. Decommissioning costs arise as soon as a nuclear station is operated because irradiation is essentially a one off event. The notoriously expensive Shoreham nuclear power station in New York state was only operated briefly but that was sufficient to irradiate it and incur decommissioning costs (Nuttall 2005, p.8).

Back end fuel costs arise only as fuel is used and therefore increase in relation to the power station's output and length of operation. A nuclear station that was suddenly shut down would incur no further incremental back end fuel costs but the decommissioning cost would remain.

Practical experience in decommissioning nuclear power stations is limited as of 2008 because relatively few have been shut down, though there is growing experience from the decommissioning of naval reactors. The costs of fuel disposal are almost entirely conjectural since no long term facility yet exists – though intermediate storage sites have been built in Finland (World Nuclear Association, 2007). How credible are the cost estimates that companies use in measuring their deferred costs? There is a substantial margin of error because of the very long time scales. Table 1 shows the effect of discounting over very long time periods and illustrates the powerful effect of compound interest rates.

Table 1 Illustration of Discounting Over Very Long Periods

| Decommissioning cost | $350m | $350m | $350m |
|---|---|---|---|
| Years till costs occur | 40 | 100 | 100 |
| Real discount rate | 2% | 2% | 3% |
| Present value | $159m | $48m | $18m |

Source: Decommissioning cost estimate from MIT (2003, Table A.5-A.4); author's estimates

Table 1 shows that over a forty year period, the period between the closure of a PWR and its decommissioning, a future cost of $350m has a present value of only $159m when discounted at a real rate of 2%, which is approximately the long term real risk free rate. But for a new or young station, or one of the British reactors with longer decommissioning timescales, a period of 100 years is more realistic. In this case the present value shrinks to just $48m. Using a discount rate of 3% real, which is British Energy's policy under UK GAAP (British Energy, 2007, p.52) and EDF's policy under IFRS (EDF 2007, note 29.2.1), the figure is only $18m. Over such time scales even dramatic changes in the actual future costs have a very small impact on the present value.

## 3. Costs and liabilities

In section 2 we referred to deferred costs. But there is an accounting and economic distinction between costs that simply arise after the revenue with which they were associated and future costs which acquire some degree of obligation. A standard discounted cashflow valuation of a project or a whole company brings expected revenues and costs (cash inflows and outflows) together and discounts them at an appropriate risk-adjusted rate. But if some of these costs are legally or commercially committed, even if the revenues aren't generated, then they are different in kind from other costs.

The International Accounting Standards Board (IASB) definition is:

> A liability is a present obligation of the entity arising from past events, the settlement of which is expected to result in an outflow from the entity of resources embodying economic benefits. (IASB, 2001 p.2)

The US Federal Accounting Standard Board (FASB) definition is:

> Liabilities are probable future sacrifices of economic benefits arising from present obligations of a particular entity to transfer assets or provide services to other entities in the future as a result of past transactions or events. (FASB, 1985b para. 35, footnotes omitted)

The accounting treatment linked to such liabilities is to create a charge against profit called a provision, which ensures that the current profitability is stated net of the future cost, even though the cash settlement of the obligation may lie far in the future. The critical question arising in the calculation of the provision is the relation between the current and future values of the cost ie the rate of discount. As section 5 below shows, the principle that such liabilities be valued at an appropriate discount rate has only recently been confirmed in US and IFRS accounting. Which discount rate to use remains controversial though.

From an economic point of view the case for valuing liabilities differently from other future costs that do not (yet) entail an obligation is that the obligation represents an asset for some third party. If the nuclear company incurs either a contractual obligation or automatically has a legal requirement to decommission its power station then that promise is an asset for the state or its agencies. The asset is of course a liability for the power company and should be deducted from the value of the company's other assets in order to get a correct fair value of the shareholder's interests.

This principle was recognised in the case of pension liabilities at least as early as Sharpe (1976). The discount rate to use should therefore reflect the same process as choosing any other discount rate, namely the amount of risk involved. The value of the asset is reduced to the extent that there is some doubt as to whether the obligation will be met. Since the obligation arises from a limited liability company (in the case of investor owned power generation companies) there must be some doubt as to whether the obligation really will be paid, particularly when it lies so far in the future, long after the company's operating assets have disappeared.

There are two categories of risk of the obligation not being paid. One is moral hazard, or deliberate fraud, in which a company pays out its operating cashflows to shareholders and then declares itself bankrupt when the liabilities fall due. The second risk is that even if the company's directors make provision for the costs, the funds set aside fail to meet the costs when they fall due, owing to poor investment performance.

This raises the question of funding the liabilities. Given the obvious moral hazard risk, government policy in most countries requires nuclear operators not only to make accounting provisions for decommissioning liabilities but to set aside cash in segregated funds that are ring fenced from the company's other finances. These funds are a way of reducing the risk that the liabilities will fail to be met. But these funds still leave the second type of risk, namely that even well intentioned investment policies may fail to achieve a rate of return sufficient to ensure the segregated funds grow enough to meet the liabilities.

In terms of the appropriate discount rate, a fully funded liability is far less risky than an unfunded one. Since the asset is less risky it should be discounted at a less risky rate, possibly the risk free rate itself. An increase in the value of the asset makes the corresponding liability to the company also higher, but if it is matched by segregated funds then the net value is zero.

To summarise (see table 2), nuclear deferred costs fall into three categories: i) funded decommissioning costs, where the liability is partly or fully offset by segregated financial assets; ii) unfunded decommissioning costs, which are an obligation of the firm and carry the risk that the firm will default on them; and iii) other back end fuel costs which typically do not have separate funding and so also carry some default risk.

*Table 2: Main categories of nuclear liabilities*

| | Decommissioning | | Back end fuel |
|---|---|---|---|
| | Funded | Unfunded | |
| Risk to counterparty | Minimal | Default risk | Default risk |
| Accrued | At start of operations | At start of operations | As fuel is burned |
| Counterparty | Local/national state | Local/national state | National state/reprocessing company (*) |
| Applicable countries | All nuclear | All nuclear | UK, Germany, France, Japan |

(*) UK, France and Japan only

## 4. Accounting for nuclear liabilities.

Private nuclear power generation goes back to the early 1960s and there are now investor owned power companies with nuclear operations in several OECD countries, including the US, Germany, Spain, Japan, Sweden and South Korea. The UK's more modern nuclear power stations were privatised in 1996 and the French electricity giant (and largest nuclear operator in the world) EDF was privatised in 2005 (though the equity is majority owned by the French state).

This section reviews the different accounting principles applied to nuclear liabilities for evidence of how investors should approach the problem.

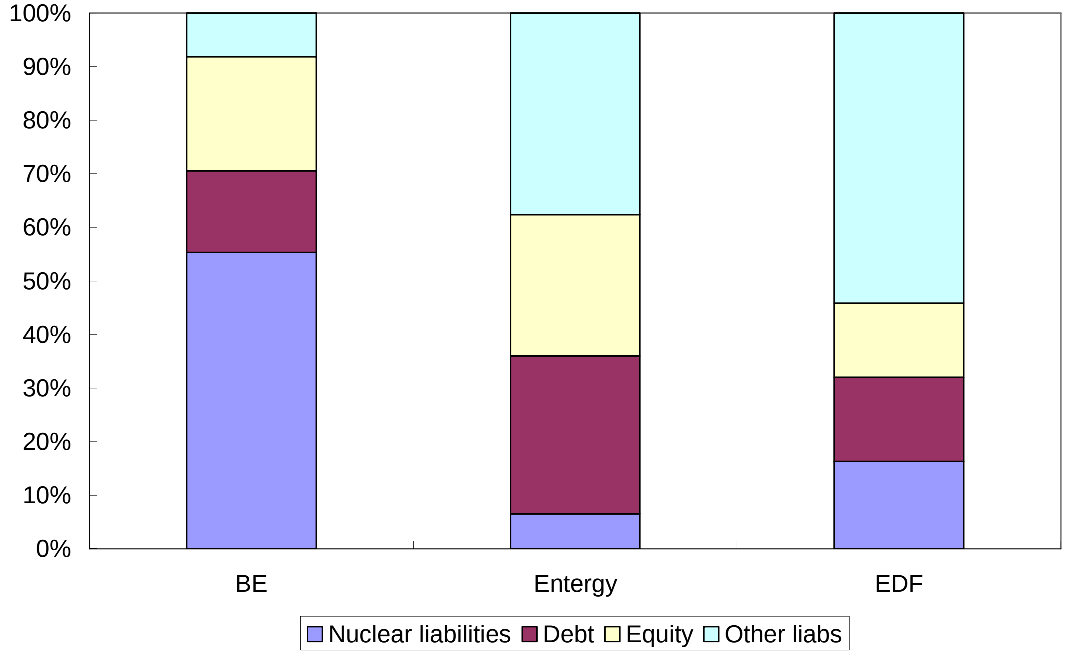
## 1. UK GAAP

The UK framework is distinctive in three respects. First there is only one privately owned nuclear power company, British Energy. The other nuclear power stations are owned by a public limited company, Magnox Electric, which is ultimately owned by the UK government. Second, government policy since the privatisation of British Energy in 1996 has been that the nuclear liabilities must follow the assets, so the company should have full responsibility for all liabilities. This principle would apply to any future nuclear build too (UK Government 2008, para 3.1).

Thirdly, the UK has followed a policy of reprocessing nuclear spent fuel, that is treating it to separate potentially re-useable fissile uranium and plutonium (a by product of fission) from the pure waste material. Reprocessing entails significant additional costs which are set against the economic value of the fuel saved. Early decisions to reprocess were heavily influenced by the view that the plutonium had significant value both as weapons material and for a future series of breeder reactors, which are now unlikely to be built (Taylor 2007 p.12). As of 2008 France and Japan continue to reprocess fuel but Germany is phasing reprocessing out. The US stopped in 1977 on concerns of nuclear weapon proliferation. Future nuclear power plants in the UK would not have their spent fuel reprocessed.

The effect of points two and three is to make the back end fuel costs a significantly larger liability for British Energy than for nuclear generators in the US for example. Figure 2 shows the relative balance sheet proportions made up of nuclear liabilities for British Energy, Entergy (a leading US nuclear generator) and EDF, the world’s largest nuclear company. Each company uses a different accounting framework but these are close enough that the figures are representative.

*Figure 2: Balance Sheet Structure for British Energy plc, Entergy Inc and EDF Group*




Source: Company annual report and accounts (BE, EDF); Form 10-K (Entergy)

The UK GAAP (generally accepted accounting principles) approach to nuclear liabilities was first put into practice with the creation of British Energy plc in 1995. Unlike the previous public sector accounts, BE needed a full and rigorous set of figures to form the basis of a prospectus for the public offering that took place in 1996 (HM Treasury, 1996). The key principles were:

- the decommissioning liability was fully recognised on the balance sheet but at a discounted rate
- back end fuel liabilities were recognised as the fuel was used; a large part of the liability accrued at 1996 covered fuel burnt several years previously but stored and awaiting reprocessing; these accruals were discounted also.
- the discount rate was chosen as 3% real, reflecting the fact that the majority of the back end fuel liabilities were covered by long term contracts with the state-owned nuclear reprocessing company BNFL, and these contracts were indexed to the retail price index. The real rate of interest implied by index-linked government bonds at the time was approximately 3%.

Appraisal of UK GAAP principles

The principles used for and disclosure of British Energy's nuclear liabilities were largely consistent with economic logic. This was essential given the sceptical investor attitude to the flotation of the company and the need to satisfy them that the well publicised problems of British nuclear power in the public sector days had been fully addressed.

First, the accounting recognised from the start the unavoidable nature of the decommissioning obligation and the need to fully reflect it as an liability. Second it chose a defensible discount rate, the return on index-linked gilts, in effect the real risk free rate. Third, the company disclosed in considerable detail the expected long term future cash outflows, allowing investors to value the liabilities using their own chosen discount rates.

Why might investors not simply take the accounting value of the liabilities? The use of a risk free rate is too conservative if there is a non-trivial possibility of the company defaulting on the liabilities (credit risk). Credit risk exists for any corporate entity and would only shrink to zero if the liabilities were fully funded. Although British Energy's decommissioning costs were backed by a segregated fund of assets, the company invested them largely in equities (consistent with pension fund asset allocation in the 1990s - Sutcliffe, 2005 p.60). So there was a significant mis-match between assets and liabilities. It would not be possible to claim the decommissioning liabilities were fully funded at that stage and so a credit-risk adjusted discount rate would be justifiable for an investor to use.

A second reason for investors not using the accounting value of the liabilities would be if there is some optionality that allows the company to influence the value of the obligation (e.g. delaying the date of decommissioning). This is hard to assess and depends largely on the clarity and credibility of government policy.

The choice of index-linked gilt returns as a discount rate has the great merit that it is a market-based number. But since the mid-1990s, real gilt returns have fallen owing to the hugely increased demand by pension funds for assets to match their liabilities more closely, reflecting the introduction of the Minimum Funding Rule in the Pensions Act of 1995 and the shift of opinion among actuaries and pension fund trustees towards more liability-driven investment (McGrath and Windle, 2006). In 2008 British Energy still discounted its liabilities at 3% real but the real return on index-linked gilts in January 2008 had fallen to around 1.2% for twelve year maturities and below 1.0% for maturities of over twenty years (JPMorgan 2008).

2. US GAAP

US policy differs from the UK significantly in that fuel reprocessing stopped in 1977 and the federal government takes responsibility for all back end fuel storage and disposal costs. Nuclear operators pay a levy of 0.1c per kWh of power produced, which discharges any further fuel-related obligation. What is for British Energy a long term liability is for US operators simply a normal current cost.

Only the decommissioning liability remains on the balance sheet and the accounting treatment of this changed in 2003. Previously US GAAP treated nuclear decommissioning in line with other long term deferred costs and benefits: the cost of decommissioning was, in effect, a negative salvage value and was added to the value of the asset when first created and amortised over the life of the power station.

This meant an accounting treatment at odds with economic substance because it failed to treat time value explicitly at all.

Amid concerns that nuclear operators were insufficiently well funded to meet their future decommissioning obligations, in 2001 SFAS143 "Accounting for Asset Retirement Obligations" introduced a treatment much closer to UK GAAP. The decommissioning liability now had to be fully recognised at value discounted by an interest rate which would reflect the company specific credit risk (FASB 2001 para.8).

Appraisal of US GAAP principles

SFAS143 is a significant improvement over its predecessor. It differs from UK GAAP in the choice of discount rate. The UK requires a risk-free rate whereas in the US a company can use a credit-adjusted discount rate. The US is closer to the economic reality in capturing the credit risk of default.

The difference between the two comes out starkly in British Energy's reconciliation of its UK GAAP accounts to US GAAP in 2003. Under the US rule British Energy had to apply a discount rate reflecting its credit rating, which at time was very poor, the company being in the middle of a complex restructuring after its near-insolvency in 2002. So under UK GAAP the liabilities were discounted at 3% real but under US GAAP the rate was 12.2% real. This cut the present value of the liabilities by £2.4 billion! The paradox emerges that the less likely a company is to be able to pay its liabilities, the lower the burden shown on the balance sheet. Under mark to market accounting this would have appeared as a £2.4 billion boost to the company's profitability.

3. International Accounting Standards

International financial reporting standards (IFRS) have become increasingly important since their adoption by all large European Union companies since 2005 and widespread adoption internationally. IAS37 "Provisions, Contingent Liabilities and Contingent Assets" in September 1998 appeared to establish that decommissioning liabilities should be fully recognised, thereby following UK practice. But a lack of clarity over exactly how the rule should be applied led to a subsequent interpretation by the International Financial Reporting Interpretations Committee (IFRIC) in 2004. This states that there should be full recognition of the decommissioning cost at the current best estimate, discounted at a "current market-based rate" (IASB, 2004)

In June 2005 the International Accounting Standards Board (IASB) published an Exposure Draft proposing modifications to IAS37 (and a change of name to "Non-Financial Liabilities") that would move it closer to US GAAP. In particular the IASB suggested that:

> a non-financial liability should be measured at the amount that an entity would rationally pay to settle the present obligation or to transfer it to a third party on the balance sheet date (IASB, 2005)

The French electricity company EDF uses IFRS and discounts its liabilities at a 3% real rate, the same as British Energy in the UK. But this is apparently a coincidence; index linked French government bond yields were in the range 1.5% to 2.2% in early 2008 (JPMorgan 2008) and at interest rates in 2007-08 3% real is close to an AA rated corporate bond, which is the conventional benchmark for discounting pension liabilities (see below section 4).

Note that IFRS requires a company to record a liability only when the obligation can be estimated reliably (IASB 1999. It is questionable whether the obligation to dispose of spent nuclear fuel can be estimated reliably when there is no working prototype and unlikely to be one for some years. But the alternative is to omit any quantification of the obligation, which is unlikely to command public acceptance.

4. US Government Accountability Office

A fourth point of reference is the US Government Accounting Office (GAO), which was asked by the US Congress to investigate whether nuclear power operators were adequately funding their obligations to decommission their power stations. In a series of reports (US Government Accounting Office 1999, 2003) and in subsequent publications by Williams (2007), the main author of the GAO analysis, the GAO used two quite different approaches to valuing the decommissioning liabilities. One was to discount them at the US government treasury bond rate (the risk free rate), which appeared to reflect the view that US utilities could borrow at that rate or something similar. The other approach was to discount the liabilities at the same rate as the expected return on the assets in the associated trust fund, a much higher rate because these assets were typically mostly equities.

Both approaches seem flawed. Utilities are typically lower than average risk companies but are not risk-free, especially since in some parts of the US wholesale power markets have been deregulated. The regulated network business may be very low risk because of the implicit guarantee that the regulator will assure a reasonable rate of return but the generation business faces a significant commercial risk. The likelihood of default on the decommissioning liability is therefore not zero.

Using the return on assets is also flawed. It appears to have been chosen in GAO (2003) mainly to avoid the companies making a profit on their decommissioning activities (as would be the case if the expected return on assets exceeded the discount rate used to value the liabilities). But this expected profit would reflect the risk that the assets failed to grow to meet the liabilities, so there is no reason why the two should be the same. As we argue below in section 4 in the context of pension liabilities, there is no economic basis for using the asset return as the discount rate for the liabilities.

To summarise, the accounting treatment of nuclear liabilities has converged somewhat over the last decade between US, UK and International principles. Decommissioning liabilities must be recognised in full at their present value, using an appropriate market-based discount rate. But there is no agreement on what that rate should be. Since the liabilities are not that large for non-UK nuclear companies the issue has not been of great practical significance. To try to resolve the question we now turn to the debate over the correct discount rate to use in pension liabilities.

## 4. Comparison with pension liabilities

Nuclear liabilities closely resemble the liabilities of corporate pension funds. Each is a long term obligation of a company that must be: i) accounted for in the company's financial statements; and ii) valued appropriately by investors. Since pension liabilities affect most large companies in the North American and western European economies, there is a substantial literature on them, which gives some helpful guidance on how to account for and value nuclear liabilities.

When companies offer a retirement pension they make a long term promise to pay. Over the years this promise has become increasingly enforceable by law as the implicit promise has been made more explicit (Dept of Work and Pensions, 2006). The asset counterpart is the employee/retiree's claim on the company. The higher the quality of the company's promise to pay, the higher the value of the asset ie the lower the discount rate used to value it, and so the higher the value of the liability to the company. Like nuclear liabilities therefore, pension liabilities represent future long term obligations of the company that have no current cash cost or interest rate.

The literature on pension funds addresses three questions:

- What is the economic value of the liability?
- How should the liabilities and assets be accounted for?
- How should the assets be invested so as to ensure the liabilities are fully discharged?

The first question is of interest to economists and investors. The second is a matter for the accounting profession. The third is the domain of actuaries and is not considered further in this paper. A fourth question which has not received much attention is how investors and analysts treat pensions in their valuation of companies.

<u>1. Valuation.</u>

Liabilities should be valued as the discounted present value of future obligations.

The economist's interpretation of pension liabilities is that they are a claim on the firm and its shareholders and should be valued as such. Treynor (1977) argued that the "the appropriate discount rate is the riskless interest rate" because if not then the claimant would only receive their full return if the assets were invested a aggressively, with some risk of loss (p.627). But he also argued that the shareholders, having limited liability, had a put option in the form of the right to put the value of the company to the pension claimants (and other creditors) in the event that their claims exceeded the company's assets. Correct economic valuation of the company's pension arrangements required the liability to be discounted at the risk free rate and the recognition of an asset in the form of the put option.

Treynor's point (and similar arguments were made by Sharpe (1976) and Bulow (1982) was that the liabilities are a claim on the company, not just the pension assets, and that the discount rate was quite unrelated to the return on assets. Actually valuing the put option was problematic, given the lack of any market transactions. By implication a company in significant financial distress should use a much higher discount rate, since the value of the option would be greater.

The introduction of pension guarantees changes this argument. Bodie and Merton (1993) argue that where there is no funding and no government guarantee then the value of the pension promise to employees must be less than certain because there is some risk that the firm goes bust and defaults. If the government then guarantees the pension this restores the value of the pension promise to the employees but leaves the company still with the default option, the gap being met by the government. The introduction of the Pension Benefit Guarantee Corporation with the 1974 ERISA Act closes the circle. Assuming that the PBGC charges an accurate credit-related insurance premium to the company, the shareholders once again face the full cost of the liability discounted at the risk free rate. This is a strong assumption since the PBGC, though technically separate from the government, is in effect backed by the federal government and on some accounts is significantly underfunded (US Government Accountability Office, 2004). So some degree of optionality may remain with shareholders, implying that the appropriate discount rate is not the risk free rate after all.

Another argument for using the risk free rate or something even lower rests on either risk aversion by the claimants or on the view that the liabilities are non-diversifiable by the company. If claimants are risk averse then they would use a lower discount rate to value them than the risk free rate. Equivalently they would require a higher certainty equivalent future amount discounted at the risk free rate. It is plausible to assume that individual employees are indeed risk averse given the huge personal importance of pension payments to them and the near impossibility of finding other ways to create a retirement income if a pension fund defaults close to the point of retirement.

For companies, pension liabilities cannot be perfectly hedged in financial markets. As has now been widely recognised, equities are an imperfect hedge for wage inflation and longevity is not hedgeable at all (though some investment banks are trying to create a market for longevity risk – OECD, 2007). If companies could purchase a perfect hedge portfolio then they could remove all remaining risk to shareholders, at a price. "The economic cost of pension liabilities is the buy-out cost of pension liabilities on the market" (Orszag and Sand 2005). But in practice there is no well defined market and the only way to offload fully the pension liability risk is to sell it to a life insurance company. Partial hedging is available from investment banks in the form of inflation swaps and long term interest swaps. A few longevity hedge transactions have also been done (reference).

Some financial economists have also disputed the projected unit method. Bulow (1982) argues that future salary increases are not a liability of the firm. If the firm were wound up now, it would not have to pay pensions reflecting those future salary increases. Accountants have preferred to include them on the argument that not to do so is inconsistent with the going concern concept. One can go further and argue that there is some optionality in pension fund schemes, because firms may be able to negotiate lower benefits as part of broader pay and employment negotiations.

## 2. Accounting.

Pension liabilities should be discounted using the interest rate on AA rated bonds.

International, US and UK accounting treatment of pension liabilities were broadly harmonized by 2000, when the UK adopted FRS17. All three standards require pension liabilities to be valued using the projected unit method (i.e. including future wage increases) and discounted using the interest rate on an AA-rated corporate bond. There remain differences in the treatment of deficits and the calculation of the return on assets but these are not relevant to this paper.

The consensus on using AA bond rates, which follows the practice adopted by the FASB in the US in December 1985 (FASB 1985a para.44) lacks firm foundations (Whittington, 2005 in Clark et al (ed.) 2005). FASB 1985 argued for market related interest rates but in the absence of actual transfers of ownership of pension liabilities, opted for high quality corporate bonds as a compromise that captured some credit risk, but not too much.

3. Stock market treatment of pension liabilities

Evidence on how investors value the liabilities is limited. Exley et al (1997) cite the classic investment text Graham and Dodd's "Security Analysis" (1934) as arguing that pension funds should be treated as combinations of investments at market value, less a debt on the firm (ie the liabilities). The debt is off balance sheet (or at least was in 1934) but no less a claim on the firm. Orszag and Sand (20005) cite evidence including Li et al (2005) that investors do take pension liabilities and deficits into account when valuing companies but imperfectly.

Summary of issues from pension fund literature.

Future pension promises are a liability of the company. Employees value these promises highly and want to value them at the risk free rate or lower. Shareholders may have some scope to avoid the full cost because of limited liability and the potential to renegotiate the terms of payments. The liabilities recognised by accountants include future salary increases that some economists argue should be excluded. Use of the rate of return on an AA-rated corporate bond has emerged as a widely accepted compromise that accepts a small degree of credit risk in the value of the liabilities. The value to employees may be higher because of explicit or implicit government guarantees to bail them out if the firm defaults.

### 5. Nuclear & pension liabilities compared

The key questions emerging for the application of principles to pension liabilities are:

- Is the obligation involved in nuclear liabilities similar in kind to that of pension promises?
- What significance is there in the fact that the counterpart asset belongs to the state rather than individuals?
- What optionality is there for companies?
- How well diversifiable are nuclear liability risks?

Table 3 summarises the key differences between nuclear and pension liabilities.

*Table 3: Nuclear and pension liabilities compared*

| | | Decommissioning | | Back end |
|---|---|---|---|---|
| | Pension | Funded | Unfunded | fuel |
| Duration (yrs) | 20-30 | 50-100 | 50-100 | 5-1000 |
| Counterparty | Employees | Govt | Govt | BNFL/Govt |
| Optionality | Some | No | Some | No |
| Credit risk | Yes | None | Yes | Yes |
| Risk aversion | Possibly | No | No | No |
| Discount rate | AA or better | Real gilt | AA | AA |
| Unhedged risk | Longevity | Technical/ Political | Technical/ Political | Political |

<u>Difference in counterparty</u>

The obligation to clean up nuclear sites and store and dispose of waste fuel creates an asset for the state i.e. all taxpayers. A failure to discharge the liability would entail costs for the government, since it would fall to the state to pay for the clean up.

This is not hypothetical. British Energy was on the brink of administration in September 2002 when it was given emergency loans by the British government which allowed it to keep operating pending a long and complex financial restructuring. The government, as senior creditor, drove the process and provided guarantees for the company's nuclear liabilities in exchange for a share of the company's future cashflow, a form of non-voting equity. The equity shareholders were in effect exercising a put option over their long term nuclear obligations. Since there could be no possibility of the obligations being allowed to lapse the government had to take them on. The restructured company rejoined the stock market in January 2005 with partial guarantees still in place. Ironically by 2006 the government made a £2.5 billion (book) profit on the transaction because the equity of the new company was substantially more valuable owing to higher electricity prices (NAO 2006, table 3).

Optionality

Any options the company has to reduce or delay the liability payments is an asset, which cuts the value of the liability. The main possibility here is delaying the timing of spending, since that reduces its present value at any positive real discount rate. This amounts to a battle between the company and the government. Governments, through legislation, can force the company to decommission the stations earlier or later, depending on the state of technical knowledge and on the costs and benefits. Earlier decommissioning frees up the site for other uses and removes a hazard to the local community, as well as a potential sources of terrorist material. But later decommissioning will probably be cheaper because the site is less radioactive, as well as the time value.

But since the company's operations may have ceased long before these decisions are taken, the question of optionality may be irrelevant. Who would be the beneficiary of any surplus in the segregated fund? It could remain a tradeable claim on stock market. Or it could be taken by government, which then acquires the option value to wait to decommission until the fund is large enough. But knowing that would reduce the pressure on the company in the first place, so the moral hazard remains in part in place.

Back end fuel costs are largely contracted with the government owned company BNFL (or Cogema in France). There is therefore far less scope for changing decisions, though the BNFL contracts were renegotiated as part of British Energy's financial restructuring in 2002/03. We conclude there is minimal option value connected with nuclear liabilities other than the normal credit default risk.

Credit risk

The credit risk arising in decommissioning costs is so obvious – the company may not even exist when the costs arise – that only a segregated fund of assets can make sense. If the liabilities were fully funded then the risk is zero and a risk free rate would be the correct discount rate. This is most unlikely in practice since the assets can only be said to be funding the liabilities if assumptions about long term returns are made, which must be subject to error. To the extent that the assets do fund the liabilities, that part of the liabilities could and should be valued at the real risk free rate.

For back end fuel costs, many of the cash payments will arise during the period the company is still operating. In present value terms most of the cashflows are of this type. There is therefore a good case for using a credit adjusted discount rate to value these, as with the use of AA corporate bonds for pension liabilities.

Risk aversion

The government is the counterparty to the liabilities and is not risk averse, nor does it face liquidity constraints. This weakens the case for using a rate lower than the risk free rate.

Appropriate discount rate

Taking the pension liability case as comparison, an AA rated corporate bond rate would be the right discount rate for unfunded decommissioning liabilities and for back end fuel costs. For funded decommissioning costs there is a case for using the risk free rate, since these liabilities are, in effect, unavoidable. Any option value by the company in varying the terms of the liabilities is potentially offset by the ability of the counterparty – the government – to respond by changing the law.

Unhedged risks

The case for valuing pension liabilities more onerously, that is at or even below the risk free rate, was that they cannot be hedged fully and the undiversifiable risk is unwelcome even to risk neutral shareholders. The main problem is longevity risk, though even wage inflation is a problem to hedge accurately (Exley et al, 1997, Sutcliffe, 2005).

For nuclear liabilities the main uncertainty is technical. Over the long timescales till decommissioning, technical change is likely to be substantial. Improvements in knowledge could make decommissioning much cheaper. But it could make it feasible to decommission earlier, which would raise the value of the liabilities, possibly sharply.

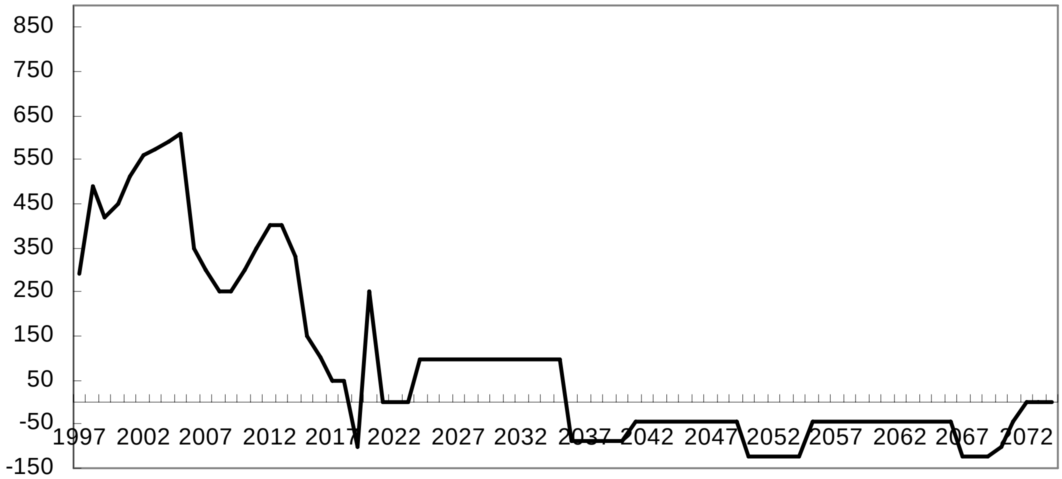
The other uncertainty is political. A dramatic change in public acceptance of nuclear power could make the liabilities larger (through pressure for earlier or more thorough clean up) or smaller (owing to less pressure for dismantling early, with the benefit of any delay reducing the present value).

## 6. Case study: valuation of British Energy plc

This section reports on research into the way investment analysts valued the company British Energy at and after its privatisation in 1996. BE was unique at the time in being a wholly nuclear investor owned generator. The scale of nuclear liabilities was far more important than for foreign investor owned nuclear companies because it was all-nuclear and because of British policy on back end fuel obligations, including the requirement that fuel be reprocessed. Nuclear power being new to the British stockmarket, equity analysts had to value the liabilities. The evidence is that they generally used mistaken methods.

The importance of valuing the liabilities is shown in figure 3, which shows the time path of cashflows for British Energy, as forecast by the government's financial advisor BZW.

*Figure 3 BZW Forecast of Net Free Cashflows 1997-2074, 1996 prices (£m)*




Source: BZW, 1996

The company consisted of eight nuclear power stations; seven British designed advanced gas cooled reactors (AGRs) and one modified US pressurised water reactor (PWR), Sizewell B. Sizewell B only began operations in 1995 and was scheduled to run for forty years. The other stations, which were built in the 1960s and 1970s were all scheduled to close as they reached their design lives in the early part of the next decade.

The company's expected cashflows therefore consisted of a "block" of positive net cashflows through the first few decades of the next century, followed by several decades of negative cashflows corresponding to the back end fuel costs and the early decommissioning costs. The very long term decommissioning costs would fall after 2060 and were excluded from BZW's forecast on the assumption that they would be met from the returns on the segregated decommissioning fund assets. In present value terms they were relatively unimportant in any case.

The choice of discount rate would be critical to the estimated value of the whole company. Too high a discount rate for the liabilities would inflate the value of the equity. Too low a rate would make it appear worthless and make privatisation impossible.

Equity analysts used one of three approaches to valuing the company, all of them flawed according to the principles discussed so far in this paper:

- Discount all cashflows at the weighted average cost of capital (WACC)
- Use a discounted cashflow (DCF) valuation at the WACC but with a terminal value after ten years
- Use an enterprise value (EV) to earnings before interest, tax, depreciation and amortisation (EBITDA) multiple.

<u>Discounting all cashflows at the WACC – example BZW</u>

BZW was the investment bank advising the government on the sale of British Energy and was the lead underwriter and sponsor of the flotation. It's research was the most thorough and detailed and one would expect the authors to be encouraged to emphasise the upside potential of the shares, since the bank was paid on a percentage of the sale proceeds.

BZW emphasised DCF valuation because of the unusually complex relationship between accounting profit and cashflows at British Energy and because of the importance of the long term liabilities (BZW 1996). But in discounting all future cashflows at the WACC, their valuation made no distinction between deferred costs and committed liabilities. We have argued earlier that committed liabilities represent a form of non-interest bearing debt that should be discounted at a lower rate of interest. BZW's valuation therefore understated the value of the liabilities and overvalued the company's equity.

But at least BZW's forecasts explicitly took account of the time value of the long term cash outflows. Given investor uncertainty over the future of the company's operations (especially the operating load factor and the path of power prices) the margin of error in the forecasts and in the choice of WACC was already significant.

<u>DCF plus terminal value example - HSBC James Capel</u>

A second approach was that taken by one of the leading UK broking houses of the time, HSBC James Capel (hereafter HSBC). In a long, detailed piece of research, HSBC opted like BZW for a DCF approach but decided to use a terminal value after ten years of explicit forecasts (HSBC James Capel 1996 p.86). This is conventional practice in broking research, reflecting the normal assumption that the company will have some going concern value into the indefinite future.

This was a very questionable assumption for British Energy though, because the company's eight power stations all had a finite life and there were no good grounds for believing the company would be able to invest in other assets, either nuclear or otherwise.

Normal practice for calculating a terminal value is to use a perpetuity calculation of the form:

$$\frac{FCF_{t+1}}{WACC - g}$$

where $FCF_{t+1}$ is the forecast of free cashflows to the firm in the year after the last year of explicit forecasts, WACC is the weighted average cost of capital and g is the long term growth rate of free cashflows (see for example Damodaran, 1996, chapters 10, 11 and 12 and Brealey, Myers & Allen, 2006, p.510-511).[1] The value of g is given as the combination of the reinvestment rate of future cashflows and the return on investment:

$$g = ROIC * (1 - b)$$

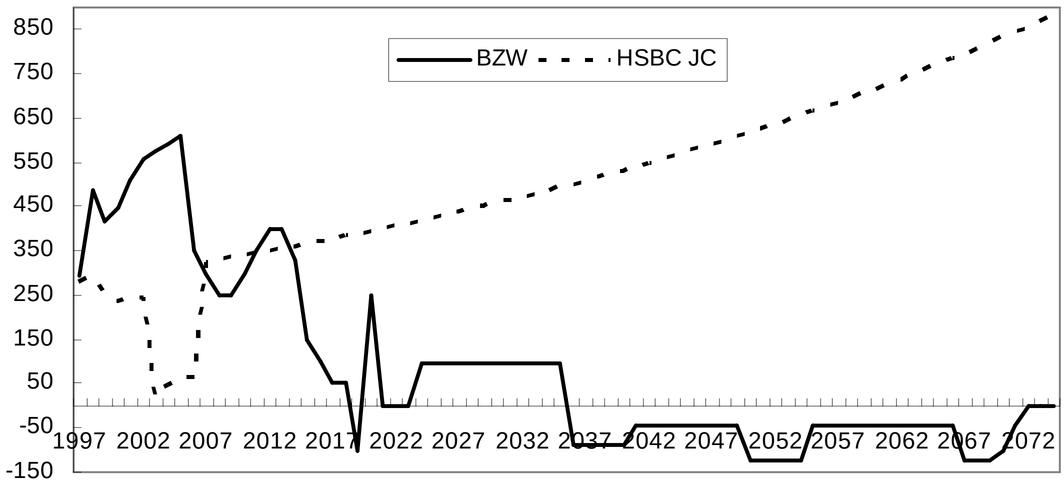
where ROIC is the return on invested capital and b is the payout ratio, so (1-b) is the retention rate (Copeland et al 2000, chapter 8). For British Energy to have a positive terminal value implied a continuing programme of reinvestment, but just where this investment would go was unclear.

[1] Damodaran refers to the "value of stable growth" and Brealey, Myers & Allen refer to "horizon value".

For the ten years of explicit cashflow forecasts, HSBC took into account the expected flows of cash out of the company to pay for fuel storage and reprocessing, treating them as ordinary cash costs.

Figure 4 plots BZW's cashflow forecasts with those of HSBC, showing after ten years the latter's implicit cashflow forecast embodied in the terminal value assumption of a long term growth rate of 2%.

Figure 4: BZW and HSBC James Capel Forecasts of Net Free Cashflow 1997-2074, 1996 prices (£m)




Source: BZW (1996), HSBC (1996); author's estimates

Figure 4 suggests that HSBC's valuation was seriously flawed as guide to British Energy's continuing business value. The valuation implicitly assumed that the company found a stream of new investment opportunities that gave it perpetual growth after 2006, sufficient to more than offset the declining cashflows from closing nuclear power stations. To the extent that it captured the liability value at all, this approach collapsed the future value of the nuclear liabilities into a single free cash flow number in the perpetuity value. This method was most unlikely accurately to value the company.

Multiples-based valuation – Morgan Stanley

HSBC at least adopted a cashflow based valuation approach. Several brokers, including the influential US investment bank Morgan Stanley Dean Witter (hereafter Morgan Stanley), chose instead to use the EV/EBITDA multiple as their main valuation method.

Multiples are commonly used in investor valuations, partly for simplicity and speed of communication, compared with other more complex approaches such as DCF. A multiple collapses a lot of information into a single ratio that can be compared with the multiple for other similar companies or for the whole market. But multiples implicitly embody assumptions about growth and risk, just like DCF valuations[2]. Moreover the most commonly used multiples such as price earnings (P/E) ratios and EV/EBITDA are based on accounting profit data, not cashflow data.

Morgan Stanley (1997) adopted EV/EBITDA as their main valuation approach and compared the multiple for British Energy with that of other quoted British electricity companies. This raises three serious objections.

First, any multiple has the same problem of a terminal value mentioned above, that it implicitly assumes a perpetual continuing growth of free cashflows, which was unwarranted for British Energy.

Second, to compare the company with other electricity companies was questionable because their risk and growth characteristics were very different. The regulated monopoly regional electricity companies were stable, low risk companies. British Energy was, in

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[2] The EV of a firm is the market value of its equity and debt, which should equal the DCF value of future cashflows. Assuming for simplicity that the EV could be captured by a single permanent growth model (equivalent to the Gordon growth model (Gordon 1962)) then: EV = $FCF_t$/(WACC-g), where $FCF_t$ is the perpetual free cash flow to the firm and WACC and g are as defined above. EV/EBITDA is then equivalent to: $FCF_t$/(WACC-g)x(1/EBITDA) or ($FCF_t$/EBITDA)x(1/(WACC-g)). The first term can be thought of as a conversion ratio for turning EBITDA into free cashflow. The point is that in a steady state equilibrium, the EV/EBITDA ratio is a function of the same parameters as a DCF valuation.

effect, a commodity manufacturer subject to far more earnings volatility and much higher operating leverage (Taylor 2008, p.161).

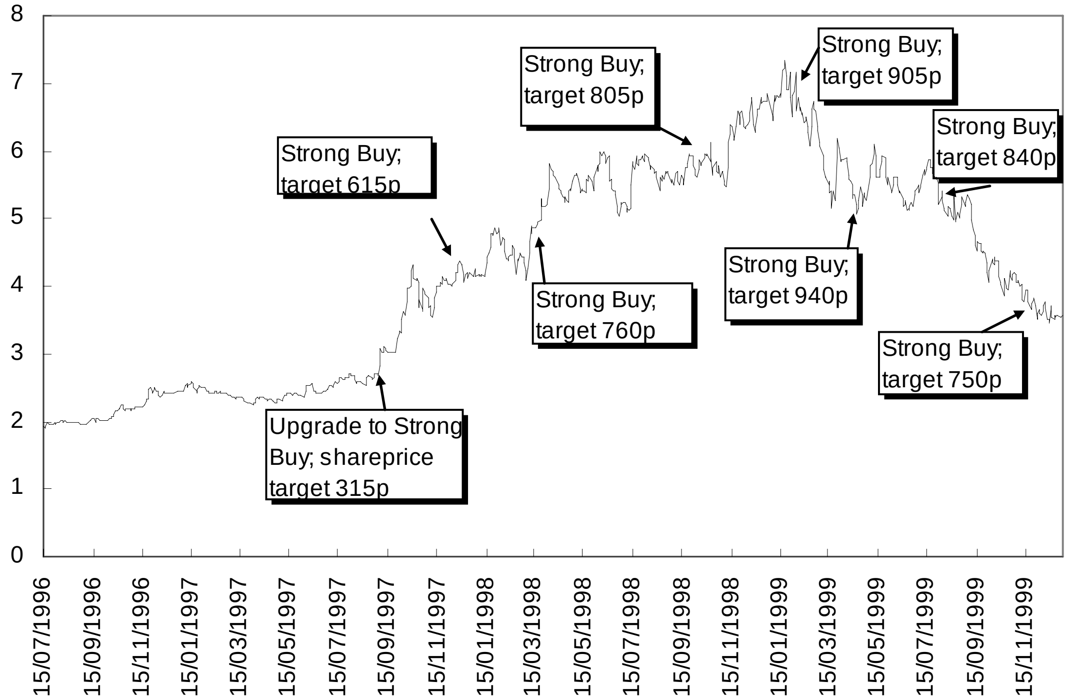
Thirdly EBITDA was an especially poor guide to the underlying cashflows of the company. British Energy's operating profit was derived after a complex set of provisions and accruals reflecting the company's transactions with the nuclear processing company BNFL. In any one year the EBITDA could diverge sharply from the underlying cashflows. In the financial year 1997 operating profit exceeded operating cashflow by nearly £100m but by 2002 operating profit was nearly £100m higher than operating cashflow. EBITDA, essentially operating profit with depreciation added back, was therefore a poor guide to the underlying cashflows (Taylor 2007 p.163).

It is not even clear that Morgan Stanley's definition of EBITDA was accurate, though this not a standard accounting item. British Energy's own calculation of EBITDA for the financial year 2001/2002 is £459m, compared with operating cashflow of £323m, a gap of £136m (British Energy 2005 p.167)

For the method to have any chance of success it the EV of the company would need to include the present value of the liabilities, alongside the market value of the equity and debt. But Morgan Stanley left out the liabilities and attempted to capture their value through the annual accrual for nuclear provisions in the EBITDA. This was imprecise and ignored the time value, as well as the obligations aspect of the future cashflows.

Morgan Stanley published a series of reports that rated British Energy's shares "buy", then "strong buy", with increasing target prices. Figure 5 shows the timing of these reports set against the share price.

Figure 5 British Energy Shareprice 1996-1999 (£); Timing of Morgan Stanley Research Reports




Source: Datastream; Taylor 2007 chapter 11.

Taylor 2007 argues that Morgan Stanley's research contributed significantly to the rise in British Energy shares in the period 1997-1998 by providing a valuation argument that the shares were undervalued, a view shared by one former British Energy executive (Taylor 2007, p.167).

Conclusions on analyst practice

This sample of equity analyst valuation methods is discouraging for those who expect analysts to police the financial markets and keep them efficient. But in mitigation one might argue that British Energy was a new sort of company and that the importance of the liabilities was not fully understood. Equally one has to point out the very detailed level of information disclosed by the company itself, data which was largely ignored by analysts.[3]

[3] One former investment bank advisor to British Energy suggested to this author that the liabilities were ignored partly because they most lay in "creditors", not provisions, because the majority was accounted for

Adjusting the liabilities in line with pension practice

The valuation methods of HSBC and Morgan Stanley all but ignored British Energy's liabilities and therefore were likely to over value the company's equity. BZW explicitly included the liabilities but, we argue, discounted them at too high a discount rate namely the company's WACC.

Using the detail disclosed in British Energy's accounts we can estimate the magnitude of the error in using the wrong discount rate.

Table 4 shows the calculation. British Energy published forecasts of its future nuclear cashflows, net of the expected cash returns on the segregated decommissioning fund. Only part of these cashflows were liabilities, the rest represented expected cashflows that would arise only as the fuel was burnt. So it is the "accrued" liabilities (column 2) that represent obligations of the company, even if it were to cease trading immediately.

*Table 4 British Energy' Nuclear Liabilities, at Varying Discount Rates (31 March, 1998 £million)*

| Discount period | Total Liabilities (1) | Accrued to date (2) | Midpoint (yrs) | Accrued only 3% | 4% | 10% |
|---|---|---|---|---|---|---|
| Within 5 yrs | 1,613 | 939 | 2.5 | 872 | 851 | 740 |
| 6-10 yrs | 1,295 | 754 | 8 | 595 | 551 | 352 |
| 11-25 yrs | 2,857 | 1,663 | 18 | 977 | 821 | 299 |
| 26-50 yrs | 884 | 515 | 38 | 167 | 116 | 14 |
| 51 yrs and over | 2,917 | 1,698 | 60 | 288 | 161 | 6 |
| Total | 9,566 | | | 2,900 | 2,500 | 1,410 |

Source: British Energy annual report and accounts 1997-98; author's estimates

by contractual payments to the nuclear reprocessing company BNFL. Analysts are used to considering provisions as potentially debt-like liabilities but typically treat creditors as working capital items.

The company's own balance sheet records the accrued liabilities at £2,900m, discounted at 3% real, the return on index linked gilts. If we adopt the pension liability rule and discount at the AA rated corporate bond rate, this was roughly one percentage point higher in the mid-1990s. We estimate that the liabilities in this case would have a present value of £2,500m, or £400m less. BZW's use of a WACC of ten percent real meant the liabilities were implicitly valued at £1,410m. BZW's approach therefore understated the liabilities by some £1,100m compared to the use of a AA bond rate, or about £1.50 per share. At the time the balance sheet data above were published, the shares were trading at about £5.50. It is therefore possible that misevaluation of the liabilities led to a significant overvaluation of the shares. Taylor (2007 chapter 11) argues that an inflated share price was a direct contributor to the flawed financial strategy that led the company into near insolvency in 2002.

## 7. Conclusions

We conclude with three sets of observations.

<u>Nuclear liabilities should be valued in a way similar to pension liabilities</u>

Nuclear liabilities are similar to pension liabilities but without the complication of longevity risk and with a looser legal framework. The principles established by financial economists and now more or less reflected in accounting rules should broadly apply to nuclear liabilities, namely:

- funded unavoidable liabilities should be valued at the risk free rate of interest;
- unfunded obligations should be valued at the AA corporate bond rate; use of the AA bond rate is as much a pragmatic compromise as it is for pensions. It remains to be seen whether the continuing research by the IASB produces a better benchmark.
- there is a case for valuing nuclear liabilities at a higher discount rate when the company's credit rating is low; economics suggests that the value of the obligations is lower when there is a materially higher risk of default and that this

should be matched by a lower value of the liability; whether this should be reflected in the accounting profitability is more questionable.

Accounting, economics and investor valuation

The valuation of long term nuclear liabilities was not a subject that investors and analysts were conceptually well prepared for in the UK stock market of the mid-1990s. But from 2000 many investors, especially those working in the pension fund industry, were forced to get to grips with the implications of FRS17 and the debate over the correct discount rate for pension liabilities. Had this debate happened a few years earlier, equity analysts might have recognised that the same questions applied to nuclear liabilities, and made better valuation decisions on the company British Energy. Conceivably this might in turn have caused better financial discipline at the company and avoided the financial crisis of 2002.

The liabilities should be treated as a form of non-interest bearing debt

Wittington (2005) argues that pension liabilities are akin to zero coupon debt. Graham and Dodd (1934) long ago argued that pension liabilities were essentially like any other debt. Companies with nuclear liabilities should therefore take a broader view of their capital structure and dividend payouts by including nuclear liabilities in their definition of capital structure. Equity analysts are now more likely to treat pension liabilities as debt, mainly because the accounting disclosure has encouraged them to do so (Bader, 2003). If this principle had been applied in the late 1990s to British Energy then the company might not have got into financial distress.

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