Annex 2

COMPARISON BETWEEN INVESTMENT APPRAISAL AND FINANCIAL APPRAISAL

1. Introduction

The evaluation of a fuel cycle cost is clearly sensitive to the methodology adopted. The aim of this annex is to describe the different methodologies required for investment appraisal and financial appraisal. From a utility's viewpoint, a "fixed price" is required from the service provider in order to carry out its appraisals. In this annex the reference prices from the main part of the report have been taken as the "fixed prices" to be used. This also allows the effect of using different discount rates to be clearly seen since discount rate is the only variable parameter in the examples shown. For convenience, these prices are shown in Table 2.1 below:

Table 2.1. **Reference prices**

Component	**Reference unit price (1991 mv)**
Uranium purchase	$50/kg U (in 1990) ($19.2/lb) U_3O_8 escalation 1.2% p.a.
Conversion	$8/kg U
Enrichment	$110/SWU
Fabrication	$275/kg U
Reprocessing option: - Spent fuel transport - Reprocessing - VHLW disposal	 ECU 50/kg U ECU 720/kg U ECU 90/kg U
Direct disposal option: - Spent fuel transport & storage - Encapsulation & disposal	 ECU 230/kg U ECU 610/kg U

Note: A long-term exchange rate of ECU 1 = $1 has been assumed.

These prices have been used consistently throughout the calculations in this annex.

2. Investment appraisal

Investment appraisal requires the examination of all the costs through time of a particular project and involves discounting these costs to a base date. In the case of projects for the generation of electricity the levelised unit cost is determined by the method described in Annex 1. This methodology is appropriate when one is considering whether to make an investment in a particular type of power station, when a number of different options e.g. coal, oil, gas or nuclear are available. The discount rate used is set by the rate of return on capital employed that the investment is required to make. The scarcer the capital or the more risky the project, the higher the required return, and hence discount rate used.

As part of the investment appraisal for a nuclear power station, the fuel costs have to be treated in exactly the same way. This involves setting out the entire fuel cycle costs over time based on market price projections or prices derived from plant cost estimates (e.g. Annex 3). The entire fuel cycle cost stream in the form of cash flows for the reprocessing and direct disposal options are set out in Figures 2.1 and 2.2, respectively. From these cash flows, lifetime levelised fuel cycle costs can be obtained as described in Annex 1.

3. Financial appraisal

Once the type of power station to be built has been decided using investment appraisal, the utility will also be interested in *financial appraisal* because it has to make money available ahead of generation for the front-end components, and it has to put money aside to meet all back-end fuel cycle cash outflow as the electricity is generated. The electric utility has to account to its owners and/or its regulators on its financial performance on a regular basis. In doing this the company is obliged to recognise both costs that have been incurred and costs that will occur in the future due to the electricity generated during the period under review.

The expenditure on front-end costs occurs before the electricity is generated as the utility has to buy the uranium ore, enrich it, and then fabricate it into fuel assemblies, all of which can take a year or more. In financial and investment appraisal the front-end is treated in the same way, i.e. when the actual money was paid out for the material and services.

All back-end costs, i.e. storage, reprocessing, encapsulation and waste disposal, occur some time after the electricity has been produced and, therefore, a different approach has to be taken. The costs are treated as liabilities and are covered by making a financial provision in the accounts.

Provisioning is done because an electric utility must be certain that it has amassed sufficient funds during the operating lifetime of a reactor to be able to meet its future liabilities. It is usual practice for a sum of money to be levied on each unit of electricity produced and for that money to be invested, such that a financial return is secured at such a level that future liabilities will be met in full.

The rate of return assumed on this investment has to be risk free: this is done by adopting a prudent interest rate. In view of the long timescales involved, this is typically around a few percent per annum in real terms. This is consistent with historic returns seen in practice on investments over the past 50-100 years. The money thus put aside may be invested either for the utility's own projects or else external to the company.

A *financial appraisal* thus considers the annual charges being made in the profit and loss account of the utility, as the fuel is used in a reactor and defined on the basis of a prudent interest rate, lower than the discount rate used for investment appraisal. An illustration of the annual profit and loss accounting charges that would be made to cover costs associated with the reprocessing or direct disposal options are shown in Figures 2.3 and 2.4, respectively. Here, a real interest rate of 2 per cent per annum has been assumed.

If it is examined how the provisions fund balance changes with time for the reprocessing option (Figure 2.5) several distinct phases can be seen:

– During the first five years of station operation the fund grows at a fast rate since money is being set aside and interest accrued, but there is no expenditure for reprocessing services.

– During the next 25 years of station operation, income is received, money is still being set aside, interest is being accrued but transport and reprocessing expenses have to be met. Therefore the fund's growth rate is reduced and, when electricity generation ceases, income to the fund falls but expenditure continues until all the spent fuel has been reprocessed. The value of the fund falls particularly rapidly when the final core is reprocessed in 2033/34.

– Thereafter, whilst the high level waste is being stored prior to ultimate disposal, the balance of the fund grows slowly at an annual rate of 2 per cent less the annual storage charge.

– During the HLW disposal period, the balance of the fund falls as disposal expenses are met. The funds value falls to zero when payment is made for the disposal of the last batch of waste.

The direct disposal option has a different profile for the provisions fund balance with time (Figure 2.6). Here, early expenditure is for storage only and this is at a much lower level compared with the reprocessing option. Hence, the balance of the fund rises to a much greater value before the relatively larger expenses are incurred, later, for the encapsulation and disposal of spent fuel.

Based on experience in the United Kingdom, a long-term interest rate of 2 per cent per annum (real), the rate assumed in the illustrations given, would be consistent with short-term pre-tax rates of return in the range 6 per cent to 8 per cent per annum. If much higher short-term rates were experienced, then it is possible that a long-term rate higher than 2 per cent per annum may be more appropriate. However, no attempt has been made here to assess provision interest rates that might apply at these higher levels and the 2 per cent figure has been applied throughout merely for illustrative purposes.

4. Front-end costs

For both appraisal methods the cash outflow occurs ahead of generation and, hence, costs are compounded forward over the appropriate "lead time" at the discount rate used. The unit fuel cycle cost (mills/kWh) is the value which must be obtained for each unit of electricity generated, such that the net present value of the revenues is equal to the net present value of the costs.

The unit front-end fuel cost derived from either appraisal methods will be the same.

5. Back-end costs

For back-end unit fuel costs, the financial appraisal will usually give a *higher* unit cost compared with investment appraisal. This can be seen for both the reprocessing and direct disposal options in Figures 2.7 and 2.8, respectively.

Here the back-end unit cost depends on the rate of return assumed for the provision fund. The unit cost will be the same irrespective of the discount rate chosen. This is not the case in the investment appraisal case (see Figures 2.7 and 2.8).

Tables 2.2 to 2.6 bring together the total set of results and these are shown in Figures 2.7 and 2.8. Using only the reprocessing option for purposes of illustration, the effect of increasing the assumed rate of interest earned by the provisions fund from 2 per cent per annum to 5 per cent per annum is shown in Figure 2.9 and Table 2.4.

6. Conclusions

The value of the unit front-end cost will be the same regardless of whether financial or investment appraisal is used. The value will only depend on the discount rate selected.

The unit back-end cost, will depend on the type of appraisal performed, the assumed interest rate applicable to the provision fund and the discount rate selected.

Unit fuel cycle costs are a combination of front-end and back-end unit costs and therefore they too will be dependent on the type of appraisal carried out. The prudent use of low interest rates for provision funding results in financial appraisal producing generally higher unit fuel costs than investment appraisal. It is only when the discount rate is lower than the assumed interest rate that financial appraisal results in lower costs. Clearly, when the interest rate equals the discount rate, the same unit cost results whether financial or investment appraisal is used.

The magnitude of the difference between the unit cost derived by financial appraisal and that derived by investment appraisal increases as the difference between the assumed interest rate and the discount rate increases.

It is important to clearly identify the type of appraisal and the assumed interest rate/discount rate that has been used when presenting the results of unit fuel cycle cost calculations.

Table 2.2. **Fuel cycle levelised unit cost (reprocessing option); assumes back-end prices constant at 5 per cent reference values**

	Cost (mills/kWh)						
Discount Rate	**0%**	**2%**	**5%**	**8%**	**10%**	**12%**	**15%**
Front-end	4.15	4.35	4.70	5.08	5.36	5.66	6.14
Back-end	2.73	2.23	1.79	1.50	1.34	1.20	1.04
Credit	-0.42	-0.34	-0.26	-0.19	-0.17	-0.14	-0.11
Total	**6.46**	**6.24**	**6.23**	**6.39**	**6.53**	**6.72**	**7.07**

Table 2.3. **Fuel cycle levelised unit cost (reprocessing option) showing the effect of provisioning at 2 per cent p.a.**

	Cost (mills/kWh)						
Discount Rate	**0%**	**2%**	**5%**	**8%**	**10%**	**12%**	**15%**
Front-end	4.15	4.35	4.70	5.08	5.36	5.66	6.14
Back-end (Cash flow)	2.73	2.23	1.79	1.50	1.34	1.20	1.04
Credits	-0.42	-0.34	-0.26	-0.19	-0.17	-0.14	-0.11
Total (Cash flow)	**6.46**	**6.24**	**6.23**	**6.39**	**6.53**	**6.72**	**7.07**
Back-end (Provisioned)	2.23	2.23	2.23	2.23	2.23	2.23	2.23
Total (Provisioned)	**5.96**	**6.24**	**6.67**	**7.12**	**7.42**	**7.75**	**8.26**

Table 2.4. **Fuel cycle levelised unit cost (reprocessing option) showing the effect of provisioning at 5 per cent p.a.**

	Cost (mills/kWh)						
Discount Rate	**0%**	**2%**	**5%**	**8%**	**10%**	**12%**	**15%**
Front-end + Credits	3.73	4.01	4.44	4.89	5.19	5.52	6.03
Back-end (Provisioned 5%)	1.79	1.79	1.79	1.79	1.79	1.79	1.79
Total	**5.52**	**5.80**	**6.23**	**6.68**	**6.98**	**7.31**	**7.82**

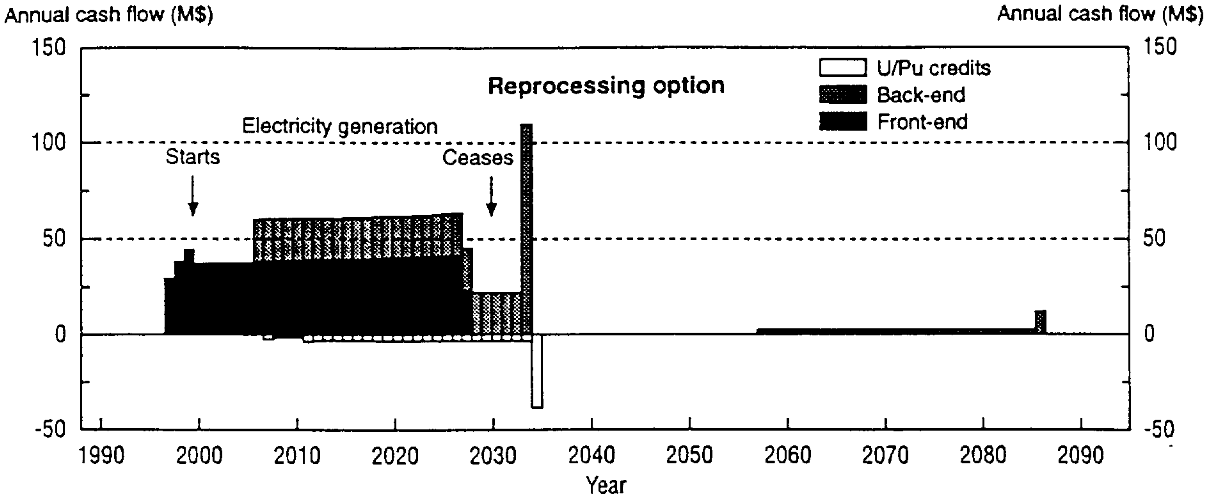
Table 2.5. **Fuel cycle levelised unit cost (direct disposal option); assumes back-end prices constant at 5 per cent reference values**

	Cost (mills/kWh)						
Discount rate	**0%**	**2%**	**5%**	**8%**	**10%**	**12%**	**15%**
Front-end	4.15	4.35	4.70	5.08	5.36	5.66	6.14
Back-end	2.63	1.46	0.76	0.51	0.43	0.37	0.31
Total	**6.78**	**5.81**	**5.46**	**5.59**	**5.79**	**6.03**	**6.45**

Table 2.6. **Fuel cycle levelised unit cost (direct disposal option) showing the effect of provisioning at 2 per cent p.a.**

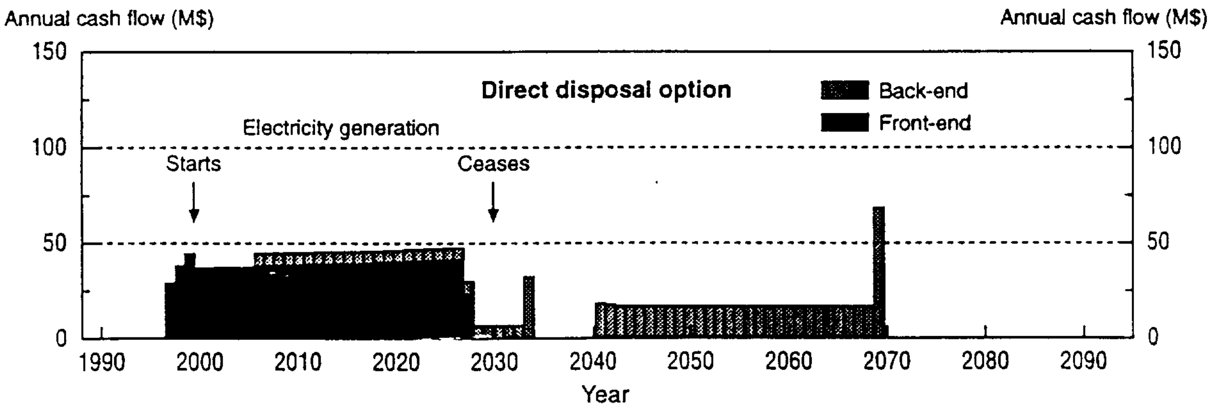
	Cost (mills/kWh)						
Discount Rate	**0%**	**2%**	**5%**	**8%**	**10%**	**12%**	**15%**
Front-end	4.15	4.35	4.70	5.08	5.36	5.66	6.14
Back-end (Cash flow)	2.63	1.46	0.76	0.51	0.43	0.37	0.31
Total (Cash flow)	**6.78**	**5.81**	**5.46**	**5.59**	**5.79**	**6.03**	**6.45**
Back-end (Provisioned)	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Total (Provisioned)	**5.61**	**5.81**	**6.16**	**6.54**	**6.82**	**7.12**	**7.60**

Figure 2.1 **Indicative front and back-end cash flows for PWR**
(1 400 MWe)



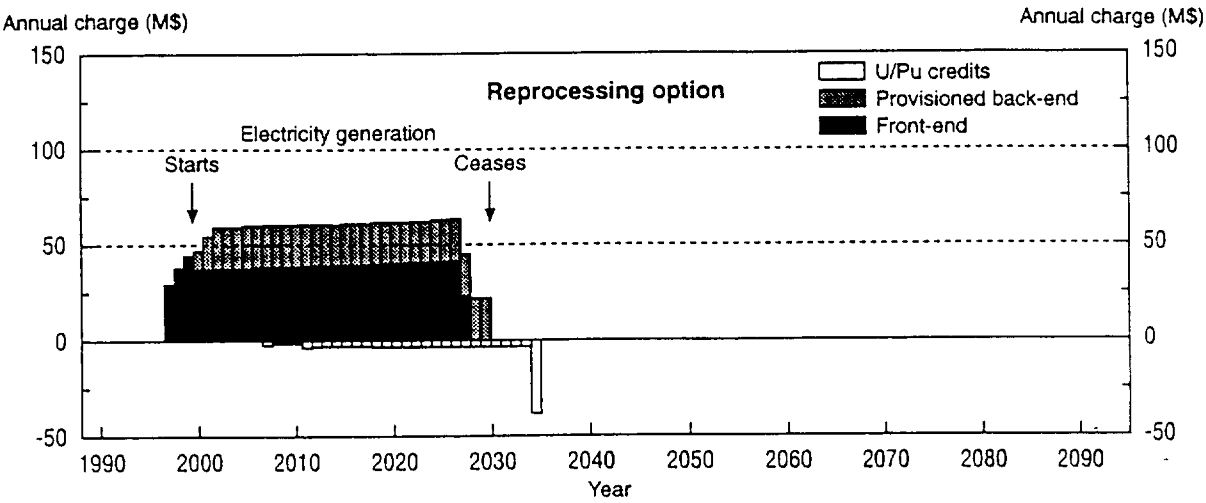
Cost (mills/kWh)	0%	2%	5%	8%	10%	12%	15%
Front-end	4.15	4.35	4.70	5.08	5.36	5.66	6.14
Back-end	2.73	2.23	1.79	1.50	1.34	1.20	1.04
Credits	-0.42	-0.34	-0.26	-0.19	-0.17	-0.14	-0.11
Total	6.46	6.24	6.23	6.39	6.53	6.72	7.07

Figure 2.2 **Indicative front and back-end cash flows for PWR**
(1 400 MWe)



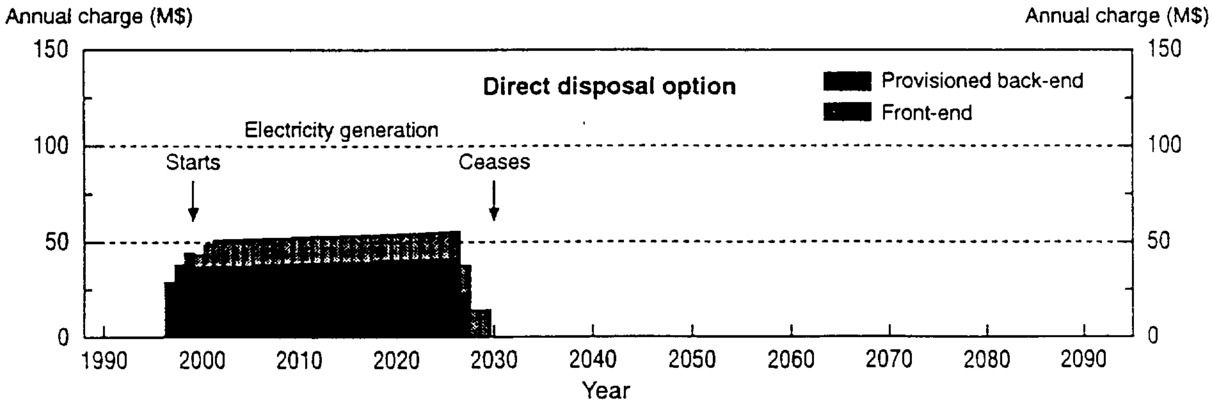
Cost (mills/kWh)	0%	2%	5%	8%	10%	12%	15%
Front-end	4.15	4.35	4.70	5.08	5.36	5.66	6.14
Back-end	2.63	1.46	0.76	0.51	0.43	0.37	0.31
Total	6.78	5.81	5.46	5.59	5.79	6.03	6.45

Figure 2.3 **Indicative front and back-end accounting charges for PWR**
(1 400 MWe)



Cost (mills/kWh)	0%	2%	5%	8%	10%	12%	15%
Front-end	4.15	4.35	4.70	5.08	5.36	5.66	6.14
Back-end	2.23	2.23	2.23	2.23	2.23	2.23	2.23
Credits	-0.42	-0.34	-0.26	-0.19	-0.17	-0.14	-0.11
Total	5.96	6.24	6.67	7.12	7.42	7.75	8.26

Figure 2.4 **Indicative front and back-end accounting charges for PWR**
(1 400 MWe)



Cost (mills/kWh)	0%	2%	5%	8%	10%	12%	15%
Front-end	4.15	4.35	4.70	5.08	5.36	5.66	6.14
Back-end	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Total	5.61	5.81	6.16	6.54	6.82	7.12	7.60

Figure 2.5 **Back-end provisions fund variations with time**
(reprocessing option)

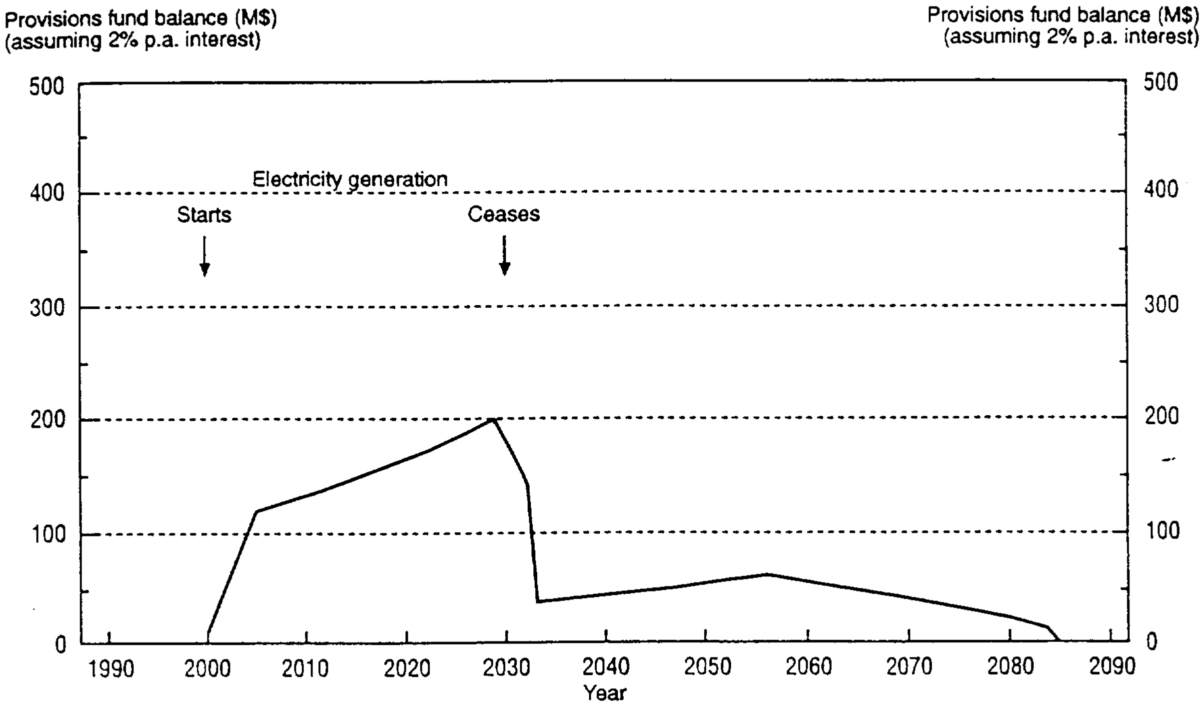


Figure 2.6 **Back-end provisions fund variations with time**
(direct disposal option)

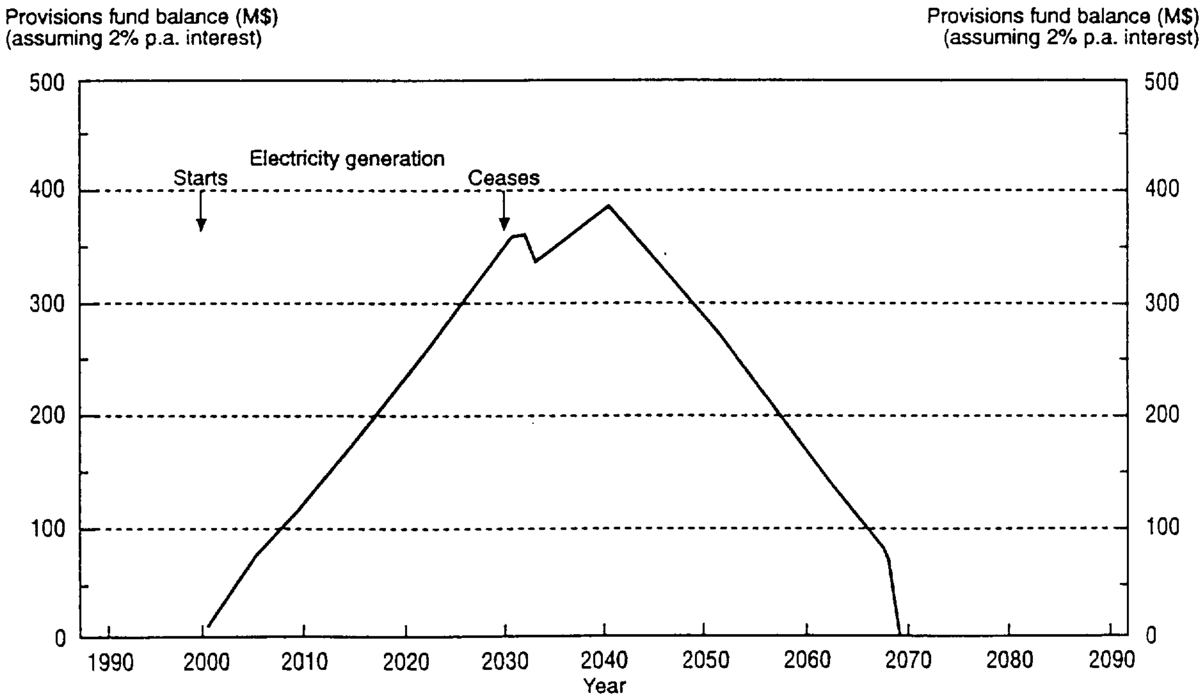


Figure 2.7 **Levelised fuel cycle cost appropriate to investment and financial appraisal**
(reprocessing option)

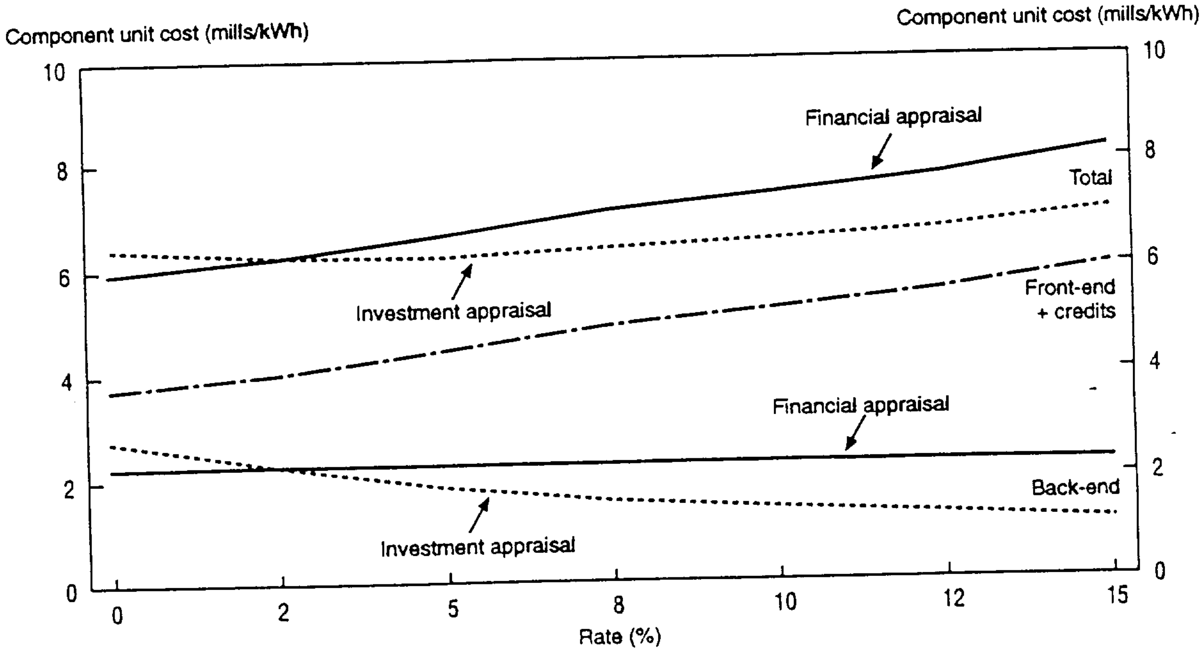


Figure 2.8 **Levelised fuel cycle cost appropriate to investment and financial appraisal**
(direct disposal option)

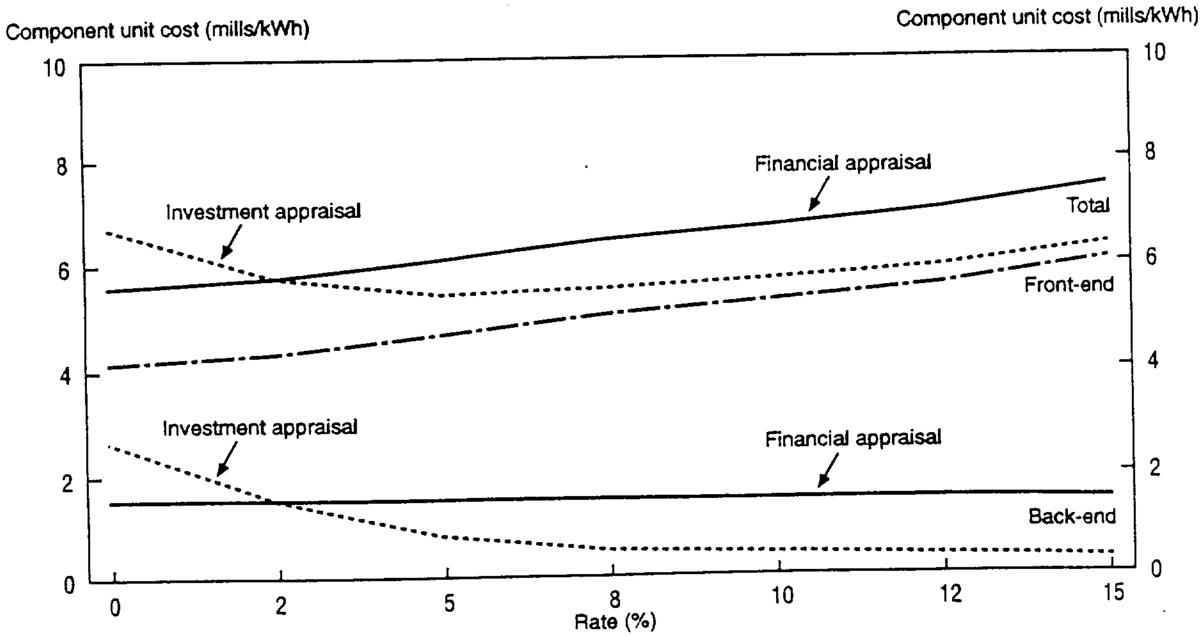


Figure 2.9 **Levelised fuel cycle cost appropriate to investment and financial appraisal**
(reprocessing option)