

Net Cash Flow

**Economic Decision
Analysis in Engineering
Course notes**

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Net cash flow

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1 Net cash flow

Forecasts of cash flow are the foundation of almost all economic analysis carried out for investment decision making in industry. At one extreme, the forecasts can be very simple involving merely estimating the future cost and timing of an investment. At the other extreme, the forecasts can be very complicated and may involve estimating the cash flows of a complete project over a period of 20 years or more, together with detailed fiscal calculations for each year.

Definitions

Cash flow is simply the cash received and the cash expended over a defined period of time. Net cash flow is simply the cash received less the cash expended during a period.

Table 1 - Definition of net cash flow

	Cash received in the period
less	Cash spent in the period
equals	Net cash flow in the period

The derivation of the future net cash flow of an investment is essential if we are to determine whether that investment is economically viable.

As stated above, in its basic form, net cash flow is simply cash received in a period less cash spent during the same period. In most project appraisal, the period is usually one year. However, more rarely, and particularly with projects which are already underway, the period may be shorter (a month or a quarter, for instance).

In most investment appraisals, a projection of estimated future cash flows is made for the life of the project. In its simplest terms, the cash flow projection would be as shown in Table 1. In this table, year 1 is the first year of forecast cash flow.

Table 2 - Simple net cash flow projection

		Year 1	Year 2	Year 3	Year 4
	Cash received \$MM	500	420	330	230
less	Cash spent \$MM	25	25	25	25
equals	Net cash flow \$MM	475	395	305	205

In this table \$MM means million dollars.

This particular cash flow projection might be for a project in the middle or towards the end of its life.

We discuss the main elements of cash flow for oil and electric power projects below.

Gross revenue

Gross revenue from a project is derived from a project is essentially the result of multiplying production by price as is illustrated in Table 2 for (a) an oil field and (b) an electric power plant.

Table 2 - Gross revenue examples				
		Year 1	Year 2	Year 3 etc
	Crude oil production MMbbl	5	4	3
times	Crude oil price \$/bbl	50	50	50
equals	Crude oil revenue \$MM	250	200	150
	Electricity production MWh	300,000	300,000	300,000
times	Electricity Price \$/MWh	250	250	250
equals	Electricity revenue \$MM	75.0	75	75

In Table 2 above, the abbreviations have the following meanings -

\$MM = million dollars
 MMbbl = million barrels
 \$/bbl = dollars per barrel
 MWh = megawatt hours = 1,000 kilowatt hours
 \$/MWh = \$ per megawatt hour

Very often, production during any one year is expressed in terms of the average production rate per day during the year. In these cases, annual revenues are calculated by multiplying the average daily rates by 365 days, then by the fraction of the year for which there is production and then by the price. Typically, the daily production rates are expressed in the following symbols and units -

Bopd = barrels of oil per day
 Kbopd = thousand barrels of oil per day
 Mbopd = thousand barrels of oil per day

 MWh/d = Megawatt hours per day
 KWh/d = Kilowatt hours per day

When oil production is expressed in daily terms (kbopd or mbopd), we can calculate annual production and annual revenue as illustrated below.

daily production	= 10 Kbopd
multiplied by	365 days per year / 1,000
fraction of the year with production	= 100%
equals annual production of	3.65 MMbbl
multiplied by an oil price of	\$20 per bbl
equals annual gross revenue	\$73 MM

When electricity production is expressed in daily terms (MWh/d), we can calculate annual production and annual revenue as illustrated below.

daily production	= 100 MWh/d
multiplied by	365 days per year
fraction of the year with production	= 60% (capacity factor)
equals annual production of	21,900 MWh
multiplied by an electricity price of	\$0.20 per KWh
equals annual gross revenue	\$4.38 MM

Capital costs

The main feature of capital costs is that they are one-off costs, usually incurred at the beginning of a project. In many cases, they are large expenditures which must be incurred often several years before any revenue is obtained. For instance, offshore oil and gas developments typically involve capital expenditures of less than US\$100 million to several US\$1,000 million. Oil and gas capital expenditures (alternatively referred to as development or construction expenditures) consist of the costs of drilling, tankers, offshore platform construction and installation, process facilities, trunk pipelines which transport oil or gas, supply bases, camps and accommodation, storage vessels etc. Electric power investments consist of land acquisition, constructing buildings and roads, acquiring equipment.

“Tangible” capital costs are hardware, equipment, roads and other physical assets. “Intangible” capital costs are services, fees, legal charge and other non-physical costs.

Operating costs

The main characteristic of operating expenditures is that they occur periodically and are necessary to maintain production. This distinguishes them from capital expenditures which are one-off costs. In cash flow analysis, operating costs are usually expressed in terms of expenditure per year or expenditure per bbl or per KWh. Operating costs typically consist of labour costs, maintenance costs, office overheads etc. Operating costs are not normally incurred until production is underway. Operating costs can be fixed periodic/annual amounts or can be variable and determined as a function of production rate.

“Fixed” operating costs are those costs that are independent of the level of production. Variable operating costs those costs that are related to the level of production

Abandonment (or Decommissioning) costs

Abandonment costs are a special category of capital expenditure associated with making good or abandoning a project at the end of field life, once it has become uneconomic to continue producing. Abandonment costs can be a significant component of cash flow, particularly in the case of offshore developments as well as onshore in environmentally sensitivity areas. For offshore oil and gas or power projects, it is common for abandonment costs to be a significant portion of the original development costs.

Government Take

In addition to capital costs, operating costs and abandonment costs, a major item of net cash flow for all projects is income tax. Income tax is a form of “Government Take” or “State Take”, or “Fiscal Costs”. Income taxes can be 20% to 50% of net cash flow.

Major items of cash flow for most petroleum projects are royalties, profit sharing, as well as income taxes. Collectively, the total of all such imposts is "Government Take" or "State Take" or "Fiscal Costs". This is cash flow or other kinds of economic benefit received by Governments or States. In many petroleum projects worldwide, Government Take is over 50% of net pre-tax cash flow. There are many different forms of Government Take, but State royalties, State profit sharing, income taxes and secondary (or "surplus profits") taxes are common internationally.

Net cash flow summary

Figure 1 illustrates the typical net cash flow profile for an oil field investment.

The overriding economic characteristics of cash flow for oil and gas projects are typically large initial capital expenditures incurred sometimes over a period of years before production starts and therefore before revenues are obtained from oil and gas sales.

Annual operating costs are usually small by comparison with the initial capital outlays and are often, but by no means always, small also by comparison with the revenues obtained once production is underway.

Sometimes the largest component of net cash flow during the productive life of a field is "Government Take", or "State Take" or the total of "Fiscal costs". This is the portion of net cash flow which goes to the Government or the State in the form of taxes, royalties and so on.

The last components of net cash flow are abandonment costs. Usually these are incurred at the end of a project when it is no longer economic to continue. However, sometimes, wells and items of equipment are abandoned during field life.

The remaining net cash flow is sometimes called "discretionary", or "free" cash flow. This is the money available to the company to spend on other projects or to add to the balance sheet "reserves". This remainder is the basis on which the company decides whether or not the project is economically viable.

Figure 2 illustrates the typical net cash flow profile for an electric power plant investment. This is similar to Figure 1, except that revenue tends to be constant over the life of the project.

Figure 1 - Example oil project net cash flow profile

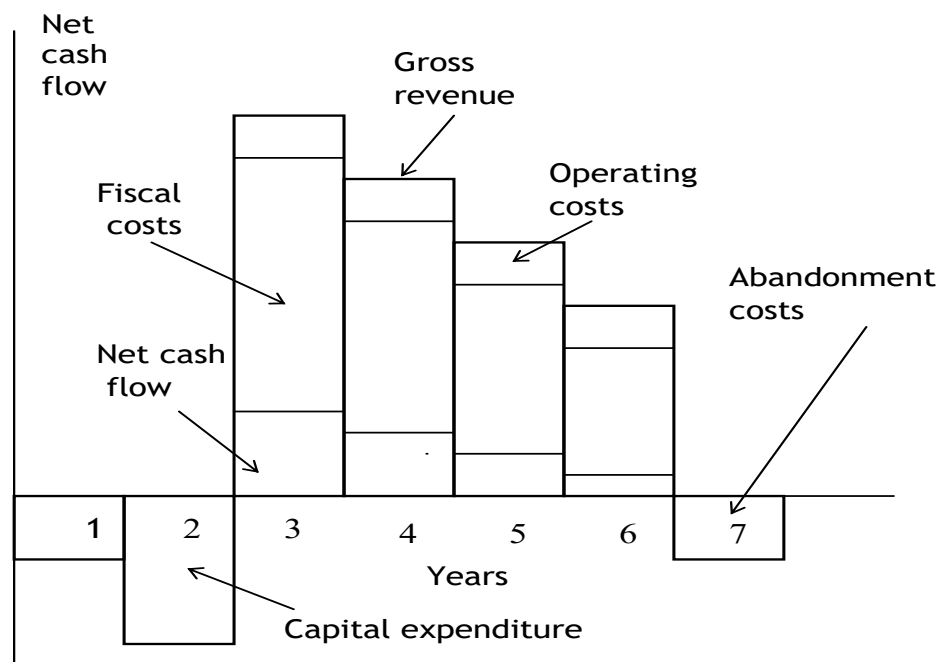
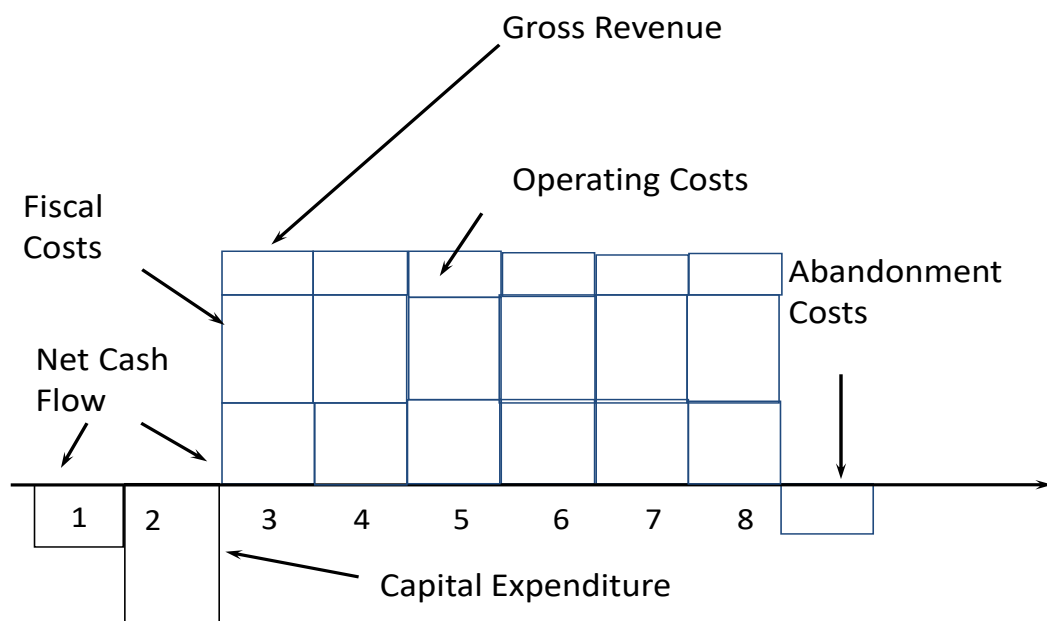


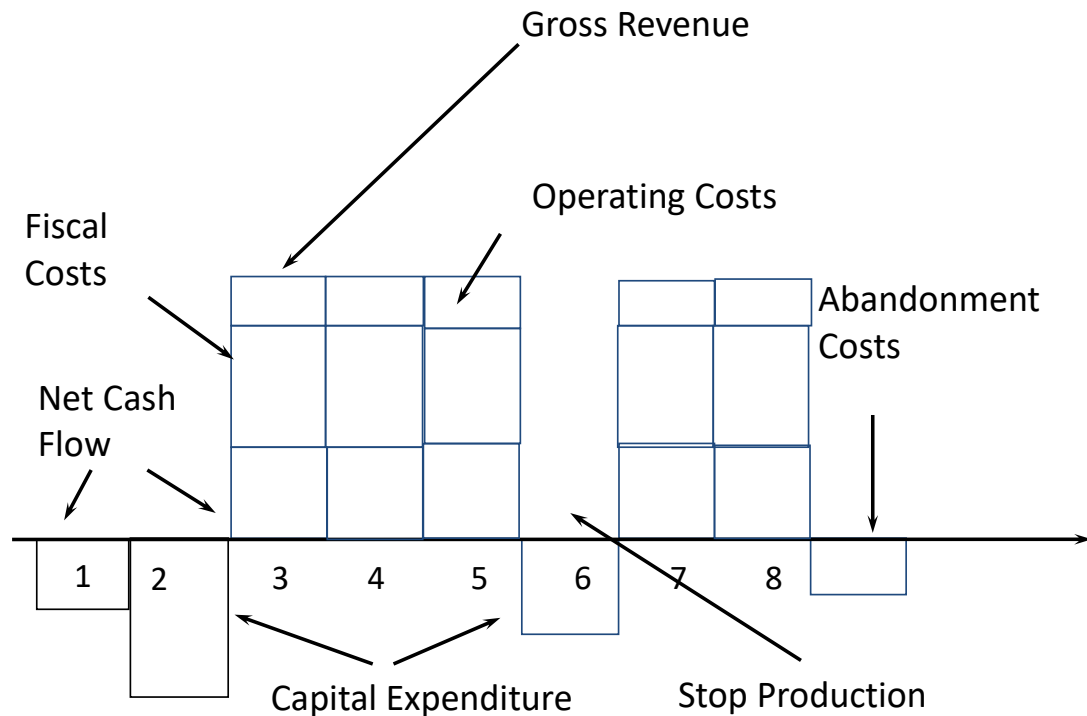
Figure 2 - Example electric power project net cash flow profile



There might be projects in which we make additional investments during the life of the project. This is illustrated in Figure 3 below. In this particular case, net cash flow is negative

during the life of the project. However, alternatively, we might continue production as in an expansion project.

Figure 2 - Example electric power project net cash flow profile



With the one exception of a section on loan financing, throughout these course notes we assume that we finance the project with equity. That is, we use our company's own money to fund the initial investment.

We also assume throughout these notes that we are dealing either with only one project or with incremental investments based on that project. However, it is a simple matter to extend the techniques to the consolidation of several projects.

Before-tax cash flow for oil

Calculate the before tax net cash flow for this project.

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prodn	Kbopd				60	50	40	30	20
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20

Gross revenue calculation

Prodn	Kbopd				60	50	40	30	20
Days per yr	No		365	365	365	365	365	365	365
Prodn	MMbbl								
Price	\$/bbl		20	20	20	20	20	20	20
Revenue	\$MM								

Before-tax net cash flow ("BTNCF")

Revenue	\$MM								
Capex	\$MM								
Opex	\$MM								
BTNCF	\$MM								

Before-tax cash flow for oil - Answer

Calculate the before tax net cash flow for this project.

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prodn	Kbopd				60	50	40	30	20
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20

Gross revenue calculation

Prodn	Kbopd				60	50	40	30	20
Days per yr	No		365	365	365	365	365	365	365
Prodn	MMbbl	73.0			21.9	18.3	14.6	11.0	7.3
Price	\$/bbl		20	20	20	20	20	20	20
Revenue	\$MM	1,460			438	365	292	219	146

Before-tax net cash flow ("BTNCF")

Revenue	\$MM	1,460			438	365	292	219	146
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20
BTNCF	\$MM	1,160	-50	-150	418	345	272	199	126

Before-tax cash flow for Hypothetical Power Plant - Question
Calculate the before tax net cash flow for this project.

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Production	MWh/year	3,066,000			613,200	613,200	613,200	613,200	613,200
Price	\$/MWh				250	250	250	250	250
Capex	\$MM	300	90	210					
Opex	\$MM	92			18.4	18.4	18.4	18.4	18.4

Gross revenue calculation

Prodn	MWh/year								
Price	\$/MWh								
Revenue	\$MM								

Before-tax net cash flow ("BTNCF")

Revenue	\$MM								
Capex	\$MM								
Opex	\$MM								
BTNCF	\$MM								

Before-tax cash flow for Hypothetical Power Plant - Answer
Calculate the before tax net cash flow for this project.

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Production	MWh/year	3,066,000			613,200	613,200	613,200	613,200	613,200
Price	\$/MWh				250	250	250	250	250
Capex	\$MM	300	90	210					
Opex	\$MM	92			18.4	18.4	18.4	18.4	18.4

Gross revenue calculation

Prod'n	MWh/year	3,066,000			613,200	613,200	613,200	613,200	613,200
Price	\$/MWh				250	250	250	250	250
Revenue	\$MM	767			153.3	153.3	153.3	153.3	153.3

Before-tax net cash flow ("BTNCF")

Revenue	\$MM	767			153	153	153	153	153
Capex	\$MM	300	90	210					
Opex	\$MM	92			18	18	18	18	18
BTNCF	\$MM	375	-90	-210	135	135	135	135	135

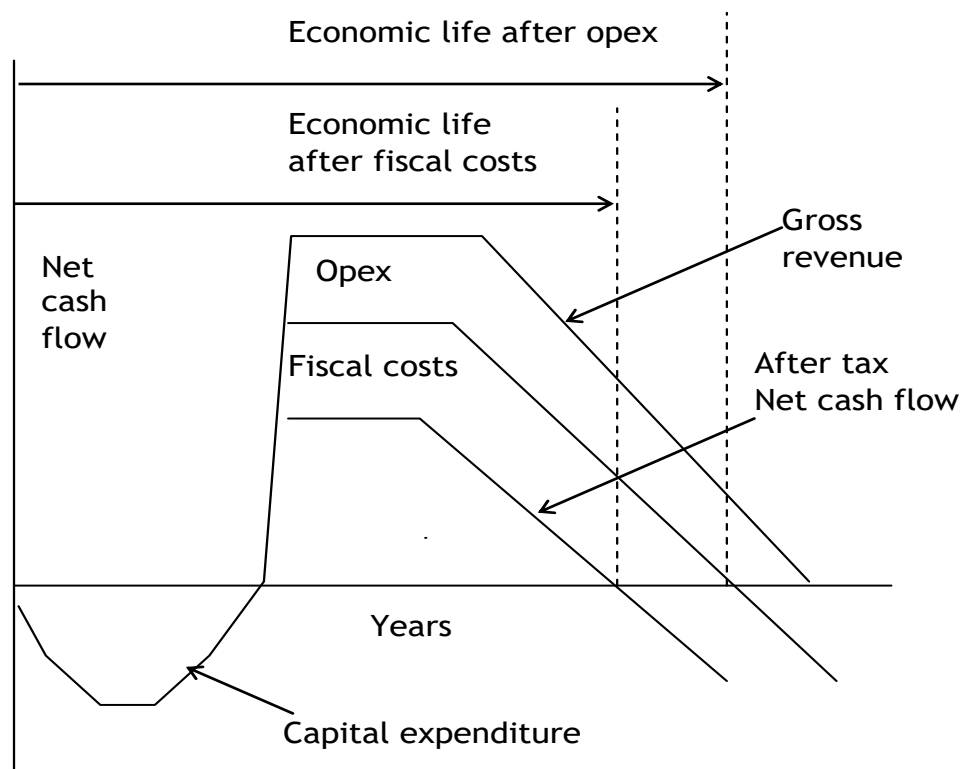
2 Economic life

A critical aspect of the cash flow profile of an oil and gas project is its role in determining the economic life of the field and the reserves.

As shown in Figure 1, if we ignore fiscal costs, it becomes uneconomic to continue operating the field when gross revenue less operating costs become zero. Under such circumstances the field would be shut in and the economic life of the field would be the period from the start of production to the year of shut in.

In practice, however, fiscal costs act as additional operating costs and typically reduce the economic life of the field, because they bring forward the time when it is uneconomic to continue production (see Figure 1).

Figure 1 - Economic life



Reserves

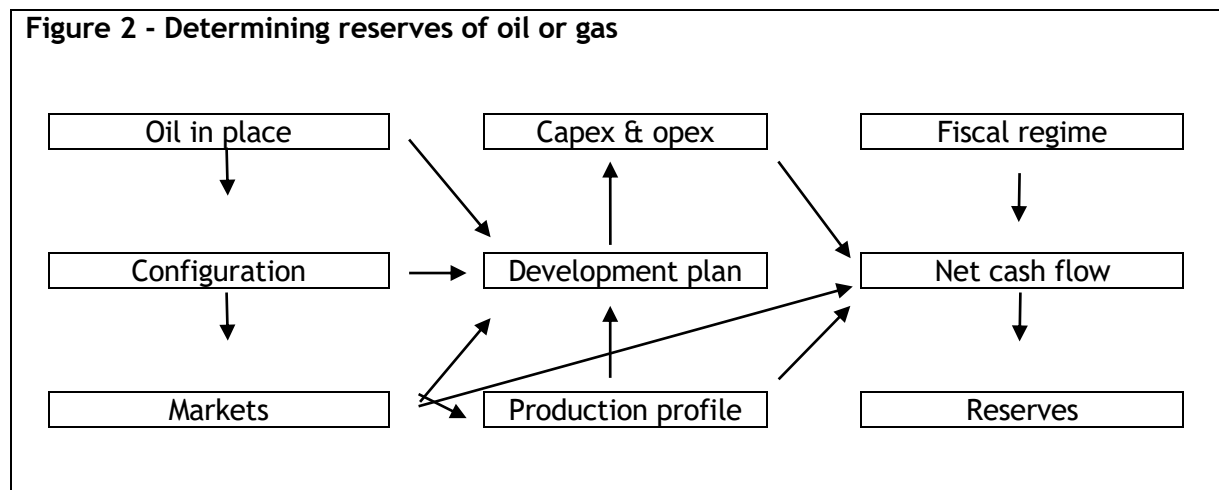
An important consequence of this is that the cumulative production from the field (that is, the reserves) is determined by economics. In other words, reserves are determined by fiscal regime, oil price and other economic factors as much as they are by geological and engineering parameters. If the oil price rises, then the gross revenue goes up, the field life is extended and the reserves of oil or gas increase. Lower operating costs also increase

reserves. In contrast, fiscal costs reduce reserves. This is true of fiscal terms in almost all countries. The same field in two different countries (if that was possible) would in general have different reserves because the fiscal term would be different.

We can deduce from the foregoing discussion of economic life that we cannot determine the reserves of an oil or gas field unless we make a cash flow projection. However, we cannot construct a cash flow projection unless we know the development plan and its associated production, revenue and costs. In turn, we cannot make a development plan unless we know the hydrocarbons in place, the configuration of the reservoir, its location and the market for the oil or gas we produce. In sum, in order to determine the reserves of an oil or gas field, we need to know the following (see also Figure 2).

- The oil or gas in place
- The configuration of the reservoir (which will affect the costs)
- The location of the reservoir (which will affect the costs)
- The market for the oil and gas produced (which will affect price and volume)
- A plan of development
- The production profile associated with that plan
- The capital and operating costs
- The fiscal costs.
- The net cash flow.

Figure 2 - Determining reserves of oil or gas

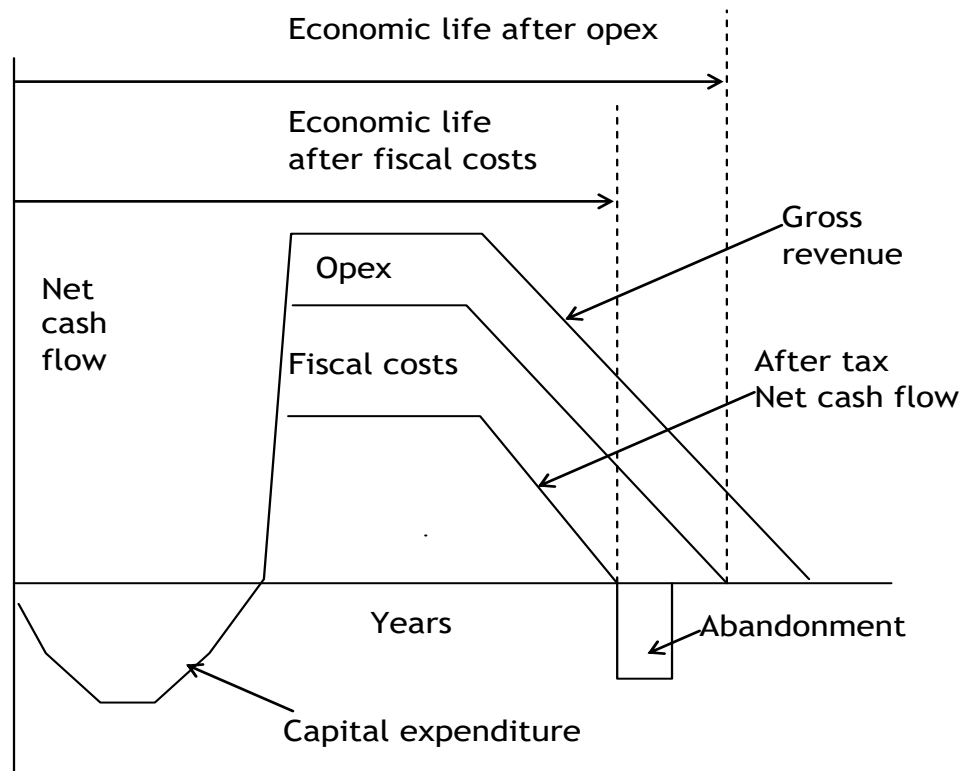


Abandonment

Once we have determined the economic life of a project we can include the costs of abandonment in the net cash flow projection. Abandonment will begin in the year after the last year of the project. To abandon the project any earlier would mean giving up some positive net cash flow towards the end of the development. To abandon the project later would mean incurring a loss. Therefore, beginning the abandonment in the year after the end of economic life optimises the value of the development.

Although the process of abandoning a field might take several years, in practice, as a simplification, we usually assume that the abandonment costs occur in the year after we reach the end of economic life. Figure 3 illustrates the full net cash flow projection including abandonment in a single year.

Figure 3 - Net cash flow including abandonment



Cash flow over economic life

Calculate the before tax economic life and the reserves for this field at different oil prices.

Before tax net cash flow (BTNCF) at \$20/bbl	Units	Units	Total	1	2	3	4	5	6	7	8	9	10
Daily production	Kbopd					30.0	15.0	10.0	5.0	4.5	4.0	3.5	3.0
Annual prodn (produce 365 days per yr)	MMbbl												
Price	\$/bbl	20		20	20	20	20	20	20	20	20	20	20
Revenue	\$MM												
Capex	\$MM		200	50	150								
Opex	\$MM	40	320			40	40	40	40	40	40	40	40
BTNCF without abandonment	\$MM												
Years of economic life	Year												
Ec life BTNCF without abandonment	\$MM												
Abandonment = \$50 MM	\$MM	50											
Ec life BTNCF with abandonment	\$MM												
Reserves	MMbbl												

Before tax net cash flow (BTNCF) at \$30/bbl	Units	Units	Total	1	2	3	4	5	6	7	8	9	10
Daily production	Kbopd					30.0	15.0	10.0	5.0	4.5	4.0	3.5	3.0
Annual prodn (produce 365 days per yr)	MMbbl												
Price	\$/bbl	30		30	30	30	30	30	30	30	30	30	30
Revenue	\$MM												
Capex	\$MM		200	50	150								
Opex	\$MM	40	320			40	40	40	40	40	40	40	40
BTNCF without abandonment	\$MM												
Years of economic life	Year												
Ec life BTNCF without abandonment	\$MM												
Abandonment = \$50 MM	\$MM	50											
Ec life BTNCF with abandonment	\$MM												
Reserves	MMbbl												

Cash flow over economic life - answer

Calculate the before tax economic life and the reserves for this field at different oil prices.

Before tax net cash flow (BTNCF) at \$20/bbl		Units	Total	1	2	3	4	5	6	7	8	9	10
Daily production	Kbopd					30.0	15.0	10.0	5.0	4.5	4.0	3.5	3.0
Annual prodn (produce 365 days per yr)	MMbbl		27			11.0	5.5	3.7	1.8	1.6	1.5	1.3	1.1
Price	\$/bbl	20		20	20	20	20	20	20	20	20	20	20
Revenue	\$MM		548			219	110	73	37	33	29	26	22
Capex	\$MM		200	50	150								
Opex	\$MM	40	320			40	40	40	40	40	40	40	40
BTNCF without abandonment	\$MM		28	-50	-150	179	70	33	-4	-7	-11	-14	-18
Years of economic life	Year	5		1	2	3	4	5					
Ec life BTNCF without abandonment	\$MM		82	-50	-150	179	70	33					
Abandonment = \$50 MM	\$MM	50	50						50				
Ec life BTNCF with abandonment	\$MM		32	-50	-150	179	70	33	-50				
Reserves	MMbbl		20.1			11.0	5.5	3.7					

Before tax net cash flow (BTNCF) at \$30/bbl		Units	Total	1	2	3	4	5	6	7	8	9	10
Daily production	Kbopd					30.0	15.0	10.0	5.0	4.5	4.0	3.5	3.0
Annual prodn (produce 365 days per yr)	MMbbl		27			11.0	5.5	3.7	1.8	1.6	1.5	1.3	1.1
Price	\$/bbl	30		30	30	30	30	30	30	30	30	30	30
Revenue	\$MM		821			329	164	110	55	49	44	38	33
Capex	\$MM		200	50	150								
Opex	\$MM	40	320			40	40	40	40	40	40	40	40
BTNCF without abandonment	\$MM		301	-50	-150	289	124	70	15	9	4	-2	-7
Years of economic life	Year	8		1	2	3	4	5	6	7	8		
Ec life BTNCF without abandonment	\$MM		310	-50	-150	289	124	70	15	9	4		
Abandonment = \$50 MM	\$MM	50	50									50	
Ec life BTNCF with abandonment	\$MM		260	-50	-150	289	124	70	15	9	4	-50	
Reserves	MMbbl		25.0			11.0	5.5	3.7	1.8	1.6	1.5		

Royalties, economic life and reserves

Calculate the economic life and the reserves before and after royalty.

Net cash flow before royalty	Units	Spare	Total	1	2	3	4	5	6	7	8	9	10
Daily production	Kbopd					30.0	15.0	10.0	5.0	4.5	4.0	3.5	3.0
Annual prodn (produce 365 days per yr)	MMbbl		27			11.0	5.5	3.7	1.8	1.6	1.5	1.3	1.1
Price	\$/bbl	30		30	30	30	30	30	30	30	30	30	30
Revenue	\$MM		821			329	164	110	55	49	44	38	33
Capex	\$MM		200	50	150								
Opex	\$MM	40	320			40	40	40	40	40	40	40	40
Net cash flow (NCF) without aband	\$MM												
Years of economic life	Year												
Ec life NCF without abandonment	\$MM												
Abandonment = \$50 MM	\$MM	50											
Ec life NCF with abandonment	\$MM												
Reserves	MMbbl												

Net cash flow after royalty	Units	Spare	Total	1	2	3	4	5	6	7	8	9	10
Daily production	Kbopd					30.0	15.0	10.0	5.0	4.5	4.0	3.5	3.0
Annual prodn (produce 365 days per yr)	MMbbl		27			11.0	5.5	3.7	1.8	1.6	1.5	1.3	1.1
Price	\$/bbl	30		30	30	30	30	30	30	30	30	30	30
Revenue	\$MM		821			329	164	110	55	49	44	38	33
Royalty at 20% of revenue	%	20%											
Capex	\$MM		200	50	150								
Opex	\$MM	40	320			40	40	40	40	40	40	40	40
Net cash flow (NCF) without aband	\$MM												
Years of economic life	Year												
Ec life NCF without abandonment	\$MM												
Abandonment = \$50 MM	\$MM	50											
Ec life NCF with abandonment	\$MM												
Reserves	MMbbl												

Royalties, economic life and reserves - answer**Calculate the economic life and the reserves before and after royalty.**

Net cash flow before royalty	Units	Spare	Total	1	2	3	4	5	6	7	8	9	10
Daily production	Kbopd					30.0	15.0	10.0	5.0	4.5	4.0	3.5	3.0
Annual prodn (produce 365 days per yr)	MMbbl		27			11.0	5.5	3.7	1.8	1.6	1.5	1.3	1.1
Price	\$/bbl	30		30	30	30	30	30	30	30	30	30	30
Revenue	\$MM		821			329	164	110	55	49	44	38	33
Capex	\$MM		200	50	150								
Opex	\$MM	40	320			40	40	40	40	40	40	40	40
Net cash flow (NCF) without aband	\$MM		301	-50	-150	289	124	70	15	9	4	-2	-7
Years of economic life	Year	8		1	2	3	4	5	6	7	8		
Ec life NCF without abandonment	\$MM		310	-50	-150	289	124	70	15	9	4		
Abandonment = \$50 MM	\$MM	50	50									50	
Ec life NCF with abandonment	\$MM		260	-50	-150	289	124	70	15	9	4	-50	
Reserves	MMbbl		25.0			11.0	5.5	3.7	1.8	1.6	1.5		

Net cash flow after royalty	Units	Spare	Total	1	2	3	4	5	6	7	8	9	10
Daily production	Kbopd					30.0	15.0	10.0	5.0	4.5	4.0	3.5	3.0
Annual prodn (produce 365 days per yr)	MMbbl		27			11.0	5.5	3.7	1.8	1.6	1.5	1.3	1.1
Price	\$/bbl	30		30	30	30	30	30	30	30	30	30	30
Revenue	\$MM		821			329	164	110	55	49	44	38	33
Royalty at 20% of revenue	%	20%	164			66	33	22	11	10	9	8	7
Capex	\$MM		200	50	150								
Opex	\$MM	40	320			40	40	40	40	40	40	40	40
Net cash flow (NCF) without aband	\$MM		137	-50	-150	223	91	48	4	-1	-5	-9	-14
Years of economic life	Year	6		1	2	3	4	5	6				
Ec life NCF without abandonment	\$MM		166	-50	-150	223	91	48	4				
Abandonment = \$50 MM	\$MM	50	50							50			
Ec life NCF with abandonment	\$MM		116	-50	-150	223	91	48	4	-50			
Reserves	MMbbl		21.9			11.0	5.5	3.7	1.8				

3 Net cash flow and profit

It is important to distinguish between two concepts which appear similar, but which in fact are radically different. These are the concepts of net cash flow and profit. Very often the terms are used loosely, and this can lead to confusion. It is essential therefore that we make a firm distinction between them at the outset.

Net cash flow

Net cash flow is a measure or estimate of money actually received and actually spent during a period. For an oil and gas project, expenditure may include capital costs, operating costs and fiscal costs. Therefore, in any one period, in its simplest terms net cash flow is as shown in Figure 1.

Figure 1 - Net cash flow

	Gross revenue
less	Capex
less	Opex
less	Royalties, taxes
equals	Net cash flow

Profit

Profit is an artificial measure used in annual accounts or in tax calculations. By definition, it is not the same as net cash flow, and will only be numerically the same as net cash flow accidentally. In its simplest form, profit is as shown in Figure 2.

Profit calculations are required to determine the financial health of a business or project. Once a project is underway, we can assess its profitability by assuming that only a portion of the costs of initial set-up or construction are deducted each year. Thus, calculating profit involves depreciating capital costs instead of incorporating them directly. Depreciation involves spreading capital costs over a period of time to reflect the fact that the assets are "used up" not in one period, but over the life of an asset.

In the period when capital costs are incurred, profit will be more than net cash flow because, for profit calculations, only a portion of capital costs are deducted in any one year. In a period when capital costs are not incurred, profit will be less than net cash flow. There are other aspects of the calculation of profit which make it even less likely to correspond to net cash flow. These include accounting concepts such as "work in progress" and "accruals", which are not discussed in these notes.

The way in which capital costs are depreciated or spread over time is usually determined by rules laid down in accounting or tax regulations. These attempt to spread the costs over the life of an asset. Some commonly used depreciation methods are described in detail later in these notes.

Figure 2 - Profit

	Gross revenue
less	Depreciation
less	Opex
less	Royalties, taxes
equals	Profit

In general, profit is an accounting concept used in reporting company accounts or in assessing tax liability. It is artificial in the sense that it does not correspond to actual money flows, but depends on depreciation schedules and rules laid down in regulations or by convention. In contrast, net cash flow represents actual money flows. It represents what we need to make investment decisions.

Illustration

We can illustrate the use of cash flow and profit concepts by a simple example.

Suppose a company is considering investing in a project which involves an initial outlay (capital expenditure) of \$100 million in the first year, and regular annual running (or operating) costs of \$10 million over a period of 4 years after the first year. The company anticipates that annual income generated by the business will be \$40 million in each of those four years. The derivation of net cash flow for this investment would be as shown in Table 3.

Table 3 - Example net cash flow projection

		Year 1	Year 2	Year 3	Year 4	Year 5
	Gross revenue \$MM	0	40	40	40	40
less	Capex \$MM	100				
less	Opex \$MM	0	10	10	10	10
equals	Net cash flow \$MM	-100	30	30	30	30

The company will decide whether or not to invest in the project on the basis of this projection of net cash flow. It represents an estimate of the actual net cash which will be received or lost in each year of the project.

Assume that the company decides to go ahead and invest in the project. In each year, the company's accountant will present the annual accounts of the project. In preparing the

accounts, the accountant may assume that the original capital outlay of \$100 million represents an asset which is used up over the life of the project (we assume 4 years). The asset might be depreciated evenly over the period. That is 25 million per year in this example. This is called "straight line" depreciation, or "prime cost" depreciation. However, depending on company policy, other depreciation methods might be employed. Assuming an even spreading of the capital costs over 4 years, for the purposes of preparing annual accounts the annual profit projection would be as shown in Table 4.

Table 4 - Example profit projection

		Year 1	Year 2	Year 3	Year 4	Year 5
	Gross revenue \$MM	0	40	40	40	40
less	Depreciation \$MM	0	25	25	25	25
less	Opex \$MM	0	10	10	10	10
equals	Profit \$MM	0	5	5	5	5

Therefore, from the annual accounts, the profit would be a constant \$5 million per year. In contrast, net cash flow shows a loss of \$100 million in the first year and a net receipt of \$30 million per year after that.

A profit projection is clearly an artificial construction. It depends on a method of depreciation that might be different for different companies. Therefore the same project might have different profit projections for different companies.

A profit projection would be inappropriate as a means to make an investment decision. The company would not in this example actually receive a net \$5 million per year. It would in practice incur a loss in year 1 and thereafter receive a net positive amount of \$30 million each year. That is, the net cash flow projection gives the forecasted actual money spent and received and correctly represents the size and timing of cash flow. While profit calculations have their uses once a project is underway (in annual reporting for instance), they are inappropriate for making investment decisions because they do not represent actual money flows.

Profit calculation

Calculate the before tax profit for this project.

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prod'n	Mbopd				60	50	40	30	20
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20

Revenue calculation

Prod'n	Mbopd				60	50	40	30	20
Days per yr	No		365	365	365	365	365	365	365
Prod'n	MMbbl	73			22	18	15	11	7
Price	\$/bbl		20	20	20	20	20	20	20
Revenue	\$MM	1,460			438	365	292	219	146

Before-tax net cash flow ("BTNCF")

Revenue	\$MM	1,460			438	365	292	219	146
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20
BTNCF	\$MM	1,160	-50	-150	418	345	272	199	126

Profit

Depreciate at 20% straight line from production start

Revenue	\$MM								
Depr'n at 20%	\$MM								
Opex	\$MM								
Profit	\$MM								

Profit calculation - answer

Calculate the before tax profit for this project.

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prodn	Mbopd				60	50	40	30	20
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20

Revenue calculation

Prodn	Mbopd				60	50	40	30	20
Days per yr	No		365	365	365	365	365	365	365
Prodn	MMbbl	73			22	18	15	11	7
Price	\$/bbl		20	20	20	20	20	20	20
Revenue	\$MM	1,460			438	365	292	219	146

Before-tax net cash flow ("BTNCF")

Revenue	\$MM	1,460			438	365	292	219	146
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20
BTNCF	\$MM	1,160	-50	-150	418	345	272	199	126

Profit

Depreciate at 20% straight line from production start

Revenue	\$MM	1,460			438	365	292	219	146
Deprn at 20%	\$MM	200			40	40	40	40	40
Opex	\$MM	100			20	20	20	20	20
Profit	\$MM	1,160			378	305	232	159	86

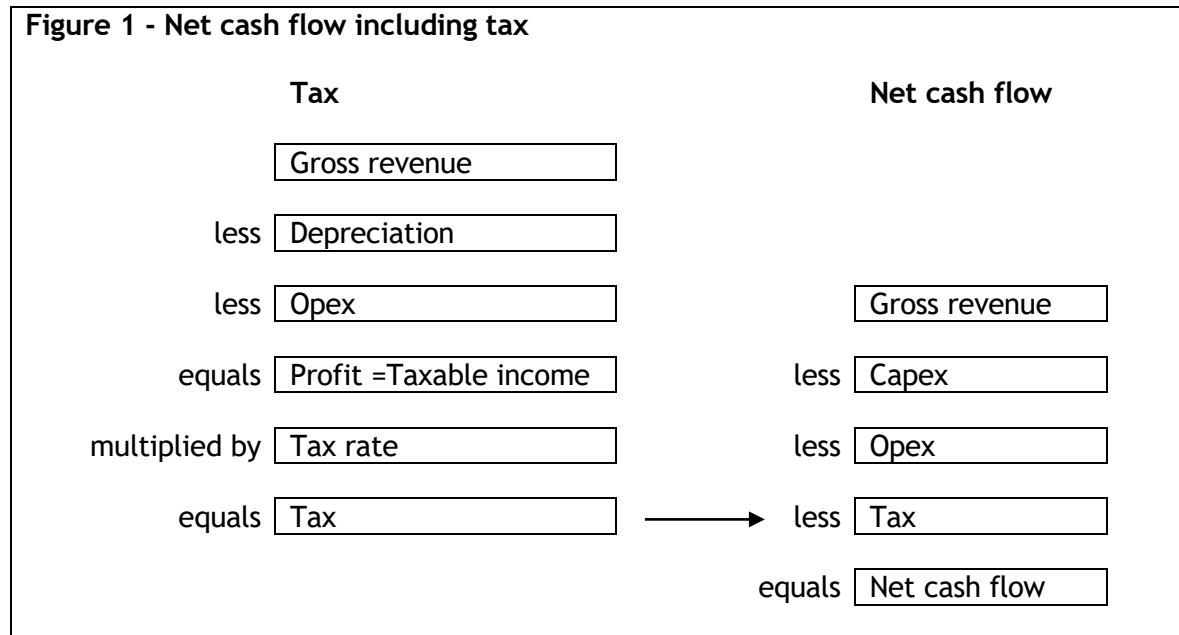
4 Income tax

In the section above we discussed the difference between the concepts of cash flow and profit. It was stressed that profit calculations are artificial and usually incorporate depreciation of capital costs. In contrast, cash flow calculations represent actual money flows and incorporate capital costs directly. Net cash flow projections are the essential basis for making investment decisions.

Net cash flow and tax

Having established this difference, it is nevertheless important to recognise that profit calculations are actually required as one of the elements of a cash flow projection. They are required because cash flows normally incorporate income tax calculations and usually these calculations involve a calculation of profit. For example, a cash flow projection which incorporated income tax might be as shown in Figure 1.

Figure 1 - Net cash flow including tax



In cases such as these, profit calculations are made as an intermediate step when deriving a final after-tax cash flow. However, the profit is often called "taxable income", reflecting the purpose for which we are calculating the profit. In other words, profit calculations can affect cash flow indirectly. However, they do not affect cash flow directly.

The example cash flow projection set out in an earlier section shows how before-tax net cash flow is derived in a simple case. We can include tax and derive an after-tax net cash flow projection by making additional assumptions about the tax payable on such a project. Suppose, for instance, that tax is payable at a rate of 40% of taxable income, that taxable income is derived by depreciating the capital costs of \$100 million evenly over 4 years (that is, \$25 million per year) from the year in which income starts, and that operating costs are expensed (that is, written off immediately without depreciation). In practice, the rules for depreciation for tax are set out in the tax legislation of the country hosting the project.

The derivation of income tax on the project under these circumstances would be as shown in Table 1.

Table 1 - Example tax calculation		Year 1	Year 2	Year 3	Year 4	Year 5
	Gross revenue \$MM	0	40	40	40	40
less	Depreciation \$MM	0	25	25	25	25
less	Opex \$MM	0	10	10	10	10
equals	Taxable income \$MM	0	5	5	5	5
multiplied by	Tax rate %	40%	40%	40%	40%	40%
equals	Tax liability	0	2	2	2	2
equals	Tax payment	0	2	2	2	2

In this example, the tax is payable in the same year as the tax liability. In practice, there may be a time lag between the liability to pay tax and the actual payment. It is not uncommon for the lag between liability and payment to be up to one year. In some cases, tax is payable in advance based on an estimate of the tax liability in the coming year.

We are assuming in this analysis that the company paying the tax has no other activities apart from this project. If it did have other activities, we would need to combine the finances of all of the company's projects in order to calculate the tax.

Using this derivation of tax payable, the projection of the after-tax net cash flow for the project would be as shown in Table 2.

Table 2 - Example net cash flow including tax		Year 1	Year 2	Year 3	Year 4	Year 5
	Gross revenue \$MM	0	40	40	40	40
less	Capex \$MM	100				
less	Opex \$MM	0	10	10	10	10
less	Tax	0	2	2	2	2
equals	Net cash flow \$MM	-100	28	28	28	28

Note that while depreciation is required for the calculation of tax, it nevertheless has no direct effect on the derivation of net after-tax cash flow. Depreciation never appears directly as a component of net cash flow.

Tax Relief on Costs

In the example tax calculations above, we calculate tax as a percentage of taxable income. Taxable income is gross revenue less tax deductions (depreciation and opex). We can also derive tax in a more detailed way by calculating the effect of tax on each individual element of the net cash flow separately. We can calculate separately the tax on gross revenue, the tax relief on depreciation (that is, the reduction in tax through deducting depreciation) and the tax relief on operating costs (that is, the reduction in tax through deducting operating costs). These calculations are set out below for the example shown in Tables 1 and 2.

In any single year during the example project in Tables 1 and 2,

$$\text{Tax} = (\text{Gross Revenue} - \text{Depreciation} - \text{Opex}) * \text{Tax Rate}$$

Example tax rate = 40%

Therefore, in this example, in any single year during the project,

$$\text{Tax} = \text{Gross Revenue} * 40\% - \text{Depreciation} * 40\% - \text{Opex} * 40\%$$

Or, in words,

$$\text{Tax} = \text{Tax on Gross Revenue} - \text{Tax Relief on Depreciation} - \text{Tax Relief on Opex}.$$

$$\text{The Before-Tax Net Cash Flow (BTNCF)} = \text{Gross Revenue} - \text{Capex} - \text{Opex}$$

$$\text{The After-Tax Net Cash Flow (ATNCF)} = \text{BTNCF} - \text{Tax}$$

$$\text{ATNCF} = \text{BTNCF} - (\text{Tax on Gross Revenue} - \text{Tax Relief on Depreciation and Opex})$$

$$\text{ATCNF} = \text{BTNCF} - \text{Tax on Gross Revenue} + \text{Tax Relief on Depreciation and Opex}$$

Table 3 shows how this would work for the example in Table 1.

Table 3 - Example tax calculation - Detailed Derivation in \$MM						
		Year 1	Year 2	Year 3	Year 4	Year 5
	Gross revenue (a)	0	40	40	40	40
less	Tax on gross revenue (a)	0	-40*40%	-16	-16	-16
=	Gross revenue after tax (a)	0	+40*(1-40%)	+24	+24	+24
	Capital costs (b)	-100				
less	Tax relief on depreciation (b)	0	+25*40%	+10	+10	+10
=	Capital costs after tax (b)	-100	+25*40%	+10	+10	+10
	Operating costs (opex) (c)	0	-10	-10	-10	-10
less	Tax relief on opex (c)	0	+10*40%	+4	+4	+4
=	Capital costs after tax (c)	-100	-10*(1-40%)	-6	-6	-6
	Tax (a + b + c)	0	-16+10+4	-2	-2	-2
	ATNCF (a + b + c)	-100	+40-10-2	+28	+28	+28

The tax and the ATNCF are the same as in Tables 1 and 2.

After-tax cash flow

Calculate the after tax cash flow for this project.

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prodn	Kbopd				60	50	40	30	20
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20

Revenue calculation

Prodn	Kbopd				60	50	40	30	20
Days per yr	No		365	365	365	365	365	365	365
Prodn	MMbbl								
Price	\$/bbl		20	20	20	20	20	20	20
Revenue	\$MM								

Before-tax net cash flow ("BTNCF")

Revenue	\$MM								
Capex	\$MM								
Opex	\$MM								
BTNCF	\$MM								

Income tax

Depreciate at 20% straight line from production start

Revenue	\$MM								
Deprn at 20%	\$MM								
Opex	\$MM								
Taxable income	\$MM								
Tax at 40%	\$MM								

After-tax net cash flow ("ATNCF")

Revenue	\$MM								
Capex	\$MM								
Opex	\$MM								
Tax	\$MM								
ATNCF	\$MM								

After-tax cash flow - answer

Calculate the after tax cash flow for this project.

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prodn	Kbopd				60	50	40	30	20
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20

Revenue calculation

Prodn	Kbopd				60	50	40	30	20
Days per yr	No		365	365	365	365	365	365	365
Prodn	MMbbl	73			22	18	15	11	7
Price	\$/bbl		20	20	20	20	20	20	20
Revenue	\$MM	1,460			438	365	292	219	146

Before-tax net cash flow ("BTNCF")

Revenue	\$MM	1,460			438	365	292	219	146
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20
BTNCF	\$MM	1,160	-50	-150	418	345	272	199	126

Income tax

Depreciate at 20% straight line from production start

Revenue	\$MM	1,460			438	365	292	219	146
Deprn at 20%	\$MM	200			40	40	40	40	40
Opex	\$MM	100			20	20	20	20	20
Taxable income	\$MM	1,160			378	305	232	159	86
Tax at 40%	\$MM	464			151	122	93	64	34

After-tax net cash flow ("ATNCF")

Revenue	\$MM	1,460			438	365	292	219	146
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20
Tax	\$MM	464			151	122	93	64	34
ATNCF	\$MM	696	-50	-150	267	223	179	135	92

5 Loss carry forward

In an earlier section, we discussed a simple tax calculation for an investment. In this section, we discuss an additional feature of tax calculations that usually has a critical effect on the decision to invest in an oil and gas project. This feature is the concept of a loss carry forward. The best way to discuss this is with an example.

Depreciation as costs are incurred

In the simple tax calculation made in an earlier section, we assumed that depreciation began from the year in which production and income started. The resulting taxable income calculation was a simple subtraction of opex and depreciation from the gross revenue.

We might for the same project make the alternative assumption that depreciation begins as soon as the costs are incurred. This is the method of depreciation in the tax legislation for oil and gas projects in some countries. In such cases, the calculation of tax will involve a loss carry-forward calculation. This is shown in Table 1 for the same example project as discussed in an earlier section.

Table 1 - Example tax calculation with loss carry forward (LCF)		Year 1	Year 2	Year 3	Year 4	Year 5
	Gross revenue \$MM	0	40	40	40	40
less	Depreciation \$MM	25	25	25	25	0
less	Opex \$MM	0	10	10	10	10
equals	Net revenue \$MM	-25	5	5	5	30
	With LCF \$MM	-25	-20	-15	-10	20
	Taxable income \$MM	0	0	0	0	20
multiplied by	Tax rate %	40%	40%	40%	40%	40%
equals	Tax payment \$MM	0	0	0	0	8

In this example, as far as the tax calculation is concerned a "loss" of \$25 million is made in the first year. This is carried forward to future years and is used to offset the positive net revenues which occur later. As a result, there is no liability to pay tax until year 5 when the liability is \$8 million. Note that the company pays the same total tax (\$8 million) as it would in the earlier example tax calculation. However, because of the effect of the loss carry forward, the tax payment is delayed.

Note that the losses in each year of Table 1 are not actual losses. They are "tax losses". They are "losses" only as far as the tax calculation is concerned.

Clearly, the company would prefer the method of depreciation illustrated in Table 1 to the method in which depreciation begins from production start. In both cases the company pays the same total tax (\$8MM). However, in this case, the company pays the \$8MM tax at the end of year 5. In the previous case, the company paid the \$8MM tax from the beginning of production at a rate of \$2MM per year for 4 years. The company would prefer the method in Table 1 because, by comparison with the earlier method, it is effectively saving the company \$2MM per year. The company could place this saving into a bank deposit account and earn interest. By the end of year 5 it would be able to take out of the bank its deposits (that is,

\$2MM per year for 4 years equals \$8MM) plus the bank interest earned on the deposits. In total, the amount saved would be more than the \$8MM it would pay in tax by depreciating as costs are incurred. This is illustrated in Table 2 in which we assume that the bank interest is 10% per year.

Table 1 - Comparison of tax with different depreciation methods

	End year 1	End year 2	End year 3	End year 4	End year 5
A - Tax in earlier example \$MM	0	2	2	2	2
B - Tax in this example \$MM	0	0	0	0	8
Deposit savings in bank \$MM	0	2	2	2	2
Interest on balance at 10% \$MM	0	0	0.2	0.42	0.66
Bank balance \$MM	0	2	4.2	6.62	9.28
Overall effect of saving (B vs A) \$MM	0	0	0	0	1.28

This example illustrates how important the timing of the start of depreciation can be to the timing of tax payments, and therefore to the net cash flow and the economics of the project.

The method of depreciation illustrated in Table 1 is particularly helpful for the economics of marginal field developments or generally when large capital expenditures are outlaid several years before production starts. In this context, marginal projects are, by definition, those with low / marginal net cash flows. They can be discoveries with low reserves, or low production, or high capital costs, or high operating costs. For instance, high capex and opex might be particularly true of deep water projects. Any delay in the payment of tax in such circumstances can make the difference between an economically viable and an economically unviable project.

Depreciation matrices

In the example discussed above, we depreciated only one year of capital expenditure as the costs were incurred. However, when we are depreciating a stream of capex spent over several years as costs are incurred, it is important to make sure the timing of depreciation is correct. In these circumstances, it is necessary to work out the depreciation schedule for each individual expenditure and then add the schedules together. A useful way of doing this is to set up a depreciation matrix.

Table 2 contains an example of such a matrix for a capital expenditure schedule which consists of \$100 million in year 1 and \$160 million in year 2, each depreciated over 4 years on a straight line basis. Here, we must depreciate each year's capex individually and then add the resulting depreciated amounts together.

Table 2 - Depreciation matrix

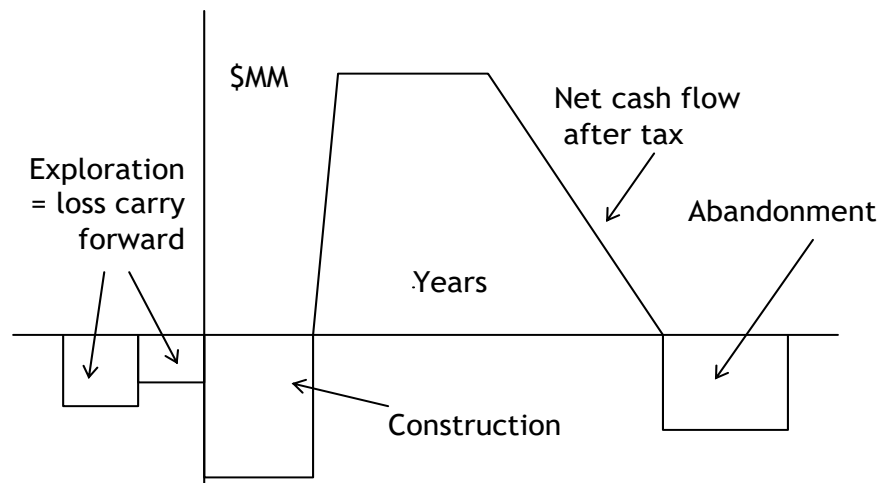
		Annual depreciation in \$MM				
Years	Annual capex	Year 1	Year 2	Year 3	Year 4	Year 5
1	\$100MM	25	25	25	25	0
2	\$160MM	0	40	40	40	40
3	etc	0	0	0	0	0
Total	\$260MM	25	65	65	65	40

The tax effect of past costs

In the example above, we illustrated the effect of a loss carry forward on project economics by assuming depreciation as costs are incurred.

However, there are other circumstances in which there might be a tax loss at the beginning of a net cash flow projection. These are circumstances in which we have incurred exploration or research costs in the past before the construction starts. This is illustrated in Figure 1. The exploration costs might be associated with seismic surveys, geological surveys or drilling exploration wells. In practice, it is highly likely that we would have incurred such costs in order to make the discovery we are evaluating. In many tax regimes, exploration costs can be carried forward as expenses without depreciation. They therefore often form a large tax deduction at the beginning of a project and might give rise to a tax loss. Such a tax loss will reduce the tax payable, and might delay the tax payable on the project (as illustrated in Table 1). The tax loss might even eliminate completely any tax otherwise payable on the project. This would be the case if the exploration costs were larger than the future before tax net cash flow of the project.

Because a loss carry forward can reduce and delay tax, it is effectively a benefit in the net cash flow and has positive value. Because past losses can be substantial, it is extremely important to include them in the net cash flow. They might make viable a project that would otherwise be uneconomic and they will always increase future net cash flow because they reduce the future tax payable.

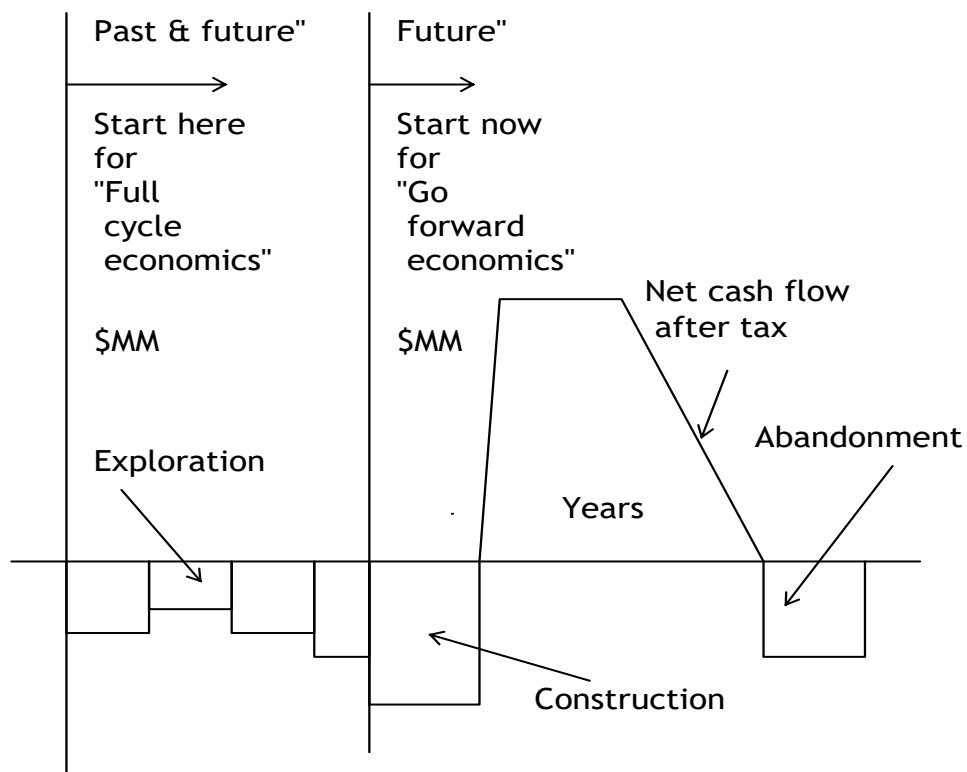
Figure 1 -Net cash flow with past exploration costs

Go forward and full cycle economics

In the vast majority of cases, we make cash flow projections on a "go forward" basis (see Figure 2). We prepare cash flows based on only future revenues, costs and taxes starting from today. This is because we wish to know whether or not the project is economically viable going forward. For such analyses, we are only interested in the past costs in so far as they affect the future taxes we will be paying. The past costs will reduce the tax payable because they are deductions in the tax calculations. They will therefore increase the future cash flows from what they otherwise would have been.

In this example, we project the net cash flow from the beginning of construction, because that coincides with the present time. However, in other situations, we might be in the middle of project life and then we would project the future new cash flow from the middle of the project. In this case, the "past" would include past construction costs and past revenues from previous production. Go forward economics requires us to look only to the future, wherever we are in the project cycle.

Occasionally, we might calculate "full cycle" economics and work out the net cash flow from the beginning of exploration (see Figure 2). Then the exploration costs are included directly in the net cash flow. Another name for this is "post-mortem" economics. When preparing such analyses, we are actually going back in time and asking ourselves the question "Looking from the beginning, did we make a profitable investment?" In fact, the investment might not have been profitable looking from the beginning. However, in most cases, that is no longer relevant. We cannot change the past. In most cases, the important question is "Looking from now, on a go forward basis, will the investment be profitable?"

Figure 2 -Go forward and full cycle economics

After-tax cash flow - depreciate as costs are incurred

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prodn	Mbopd				60	50	40	30	20
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20

Revenue calculation

Prodn	Mbopd				60	50	40	30	20
Days per yr	No		365	365	365	365	365	365	365
Prodn	MMbbl	73			22	18	15	11	7
Price	\$/bbl		20	20	20	20	20	20	20
Revenue	\$MM	1,460			438	365	292	219	146

Before-tax net cash flow ("BTNCF")

Revenue	\$MM	1,460			438	365	292	219	146
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20
BTNCF	\$MM	1,160	-50	-150	418	345	272	199	126

Income tax**Depreciate at 20% straight line as costs are incurred**

Revenue	\$MM								
Depr yr 1 capex	\$MM								
Depr yr 2 capex	\$MM								
Total deprn	\$MM								
Opex	\$MM								
Net revenue	\$MM								
With loss cf	\$MM								
Taxable income	\$MM								
Tax at 40%	\$MM								

After-tax net cash flow ("ATNCF")

Revenue	\$MM								
Capex	\$MM								
Opex	\$MM								
Tax	\$MM								
ATNCF	\$MM								

After-tax cash flow - depreciate as costs are incurred - answer

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prodn	Mbopd				60	50	40	30	20
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20

Revenue calculation

Prodn	Mbopd				60	50	40	30	20
Days per yr	No		365	365	365	365	365	365	365
Prodn	MMbbl	73			22	18	15	11	7
Price	\$/bbl		20	20	20	20	20	20	20
Revenue	\$MM	1,460			438	365	292	219	146

Before-tax net cash flow ("BTNCF")

Revenue	\$MM	1,460			438	365	292	219	146
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20
BTNCF	\$MM	1,160	-50	-150	418	345	272	199	126

Income tax

Depreciate at 20% straight line as costs are incurred

Revenue	\$MM	1,460			438	365	292	219	146
Depr yr 1 capex	\$MM		10	10	10	10	10		
Depr yr 2 capex	\$MM			30	30	30	30	30	
Total deprn	\$MM	200	10	40	40	40	40	30	
Opex	\$MM	100			20	20	20	20	20
Net revenue	\$MM	1,160	-10	-40	378	305	232	169	126
With loss cf	\$MM		-10	-50	328				
Taxable income	\$MM	1,160			328	305	232	169	126
Tax at 40%	\$MM	464			131	122	93	68	50

Now

464

151

122

93

64

34

Previously

After-tax net cash flow ("ATNCF")

-20

0

0

4

16

Difference

Revenue	\$MM	1,460			438	365	292	219	146
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20
Tax	\$MM	464			131	122	93	68	50
ATNCF	\$MM	696	-50	-150	287	223	179	131	76

Now

696

-50

-150

267

223

179

Previously

After-tax cash flow with loss carry forward from past

Data	Units	Future		Years						
		total	Past	1	2	3	4	5	6	7
Prodn	Mbopd					60	50	40	30	20
Price	\$/bbl			20	20	20	20	20	20	20
Past exploration	\$MM		50							
Future capex	\$MM	200		50	150					
Opex	\$MM	100				20	20	20	20	20

Revenue calculation

Prodn	Mbopd					60	50	40	30	20
Days per yr	No			365	365	365	365	365	365	365
Prodn	MMbbl	73				22	18	15	11	7
Price	\$/bbl			20	20	20	20	20	20	20
Revenue	\$MM	1,460				438	365	292	219	146

Before-tax net cash flow ("BTNCF")

Revenue	\$MM	1,460				438	365	292	219	146
Past exploration	\$MM		50							
Future capex	\$MM	200		50	150					
Opex	\$MM	100				20	20	20	20	20
Future BTNCF	\$MM	1,160		-50	-150	418	345	272	199	126

Income tax**Depreciate at 20% straight line from production start**

Revenue	\$MM									
Past exploration	\$MM									
Deprn at 20%	\$MM									
Opex	\$MM									
Net revenue	\$MM									
With loss cf	\$MM									
Taxable income	\$MM									
Tax at 40%	\$MM									

After-tax net cash flow ("ATNCF")

Revenue	\$MM									
Past exploration	\$MM									
Future capex	\$MM									
Opex	\$MM									
Tax	\$MM									
Future ATNCF	\$MM									

After-tax cash flow with loss carry forward from past - answer

Data	Units	Future		Years						
		total	Past	1	2	3	4	5	6	7
Prodn	Mbopd					60	50	40	30	20
Price	\$/bbl			20	20	20	20	20	20	20
Past exploration	\$MM		50							
Future capex	\$MM	200		50	150					
Opex	\$MM	100				20	20	20	20	20

Revenue calculation

Prodn	Mbopd					60	50	40	30	20
Days per yr	No			365	365	365	365	365	365	365
Prodn	MMbbl	73				22	18	15	11	7
Price	\$/bbl			20	20	20	20	20	20	20
Revenue	\$MM	1,460				438	365	292	219	146

Before-tax net cash flow ("BTNCF")

Revenue	\$MM	1,460				438	365	292	219	146
Past exploration	\$MM		50							
Future capex	\$MM	200		50	150					
Opex	\$MM	100				20	20	20	20	20
Future BTNCF	\$MM	1,160		-50	-150	418	345	272	199	126

Income tax**Depreciate at 20% straight line from production start**

Revenue	\$MM	1,460				438	365	292	219	146
Past exploration	\$MM		50							
Deprn at 20%	\$MM	200				40	40	40	40	40
Opex	\$MM	100				20	20	20	20	20
Net revenue	\$MM					378	305	232	159	86
With loss cf	\$MM		-50	-50	-50	328				
Taxable income	\$MM	1,110				328	305	232	159	86
Tax at 40%	\$MM	444				131	122	93	64	34

After-tax net cash flow ("ATNCF")

Revenue	\$MM	1,460				438	365	292	219	146
Past exploration	\$MM		50	Not directly included in future NCF						
Future capex	\$MM	200		50	150					
Opex	\$MM	100				20	20	20	20	20
Tax	\$MM	444				131	122	93	64	34
Future ATNCF	\$MM	716		-50	-150	287	223	179	135	92

6 Sunk costs

Sunk costs are costs incurred before the first period of a cash flow projection. They are historic cost or past costs. For instance, they might be previous exploration costs or research costs incurred before a development being analysed gets underway. However, they are literally any costs incurred in the past. Therefore, if we are in the middle of field life, sunk costs would include the costs of construction at the beginning of the project as well as the costs of operating the field in previous years.

Cash flow and sunk costs

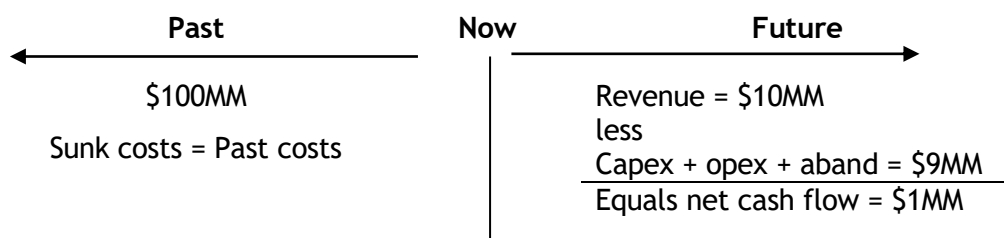
It is important that such prior costs or sunk costs do not appear directly in a projection of future cash flow. Investment decisions are based on future costs and revenues because we can choose whether or not to incur them. We cannot do anything about sunk costs. By definition they have already been spent, and therefore cannot directly affect future decisions in a financial sense.

Sunk costs can have an effect on future cash flow, but that effect is only indirect. That is, sunk costs can affect future tax and royalty calculations (for instance), because as a loss carry forward they can reduce the tax or royalty payable in the future. Sunk costs might in some circumstances also have an indirect effect on future cash flow if they in any way affect future loan repayments or loan interest.

Illustration

The following hypothetical example illustrates the point. Figure 1 depicts a situation in which exploration in a licence has so far cost a company \$100 million. As a result of this exploration, a small discovery of oil has just been made. We have estimated that the discovery will produce oil for only one year at a total cost (capex plus opex plus abandonment) of \$9 million and will yield gross revenue of \$10 million. Thereafter, the field will no longer produce. The net cash flow is therefore \$1 million

Figure 1 - Sunk costs illustration



No uncertainty or Government Take

There is no government in this example and therefore there are no taxation or PSC arrangements which would reduce the net cash flow of the company. Hypothetically, there is no uncertainty and therefore the company will receive a net cash flow of \$1 million for certain.

The question is - should the company go ahead and develop the discovery? If it does, it will certainly not recover the \$100 million spent in the past. Therefore, is it worth it?

The answer is yes. Under these circumstances, the company should go ahead and develop the discovery. By doing this it will gain \$1 million in the future (within a year). By not doing so, it will receive nothing. Nothing can be done about the loss of \$100 million. It is gone. In fact, by developing the discovery, the loss can be reduced to \$99 million. A loss of \$99 million is better than a loss of \$100 million.

Sunk costs and acquisition prices - 1

Having acknowledged that past costs are irrelevant to the investment decision, we should recognise the apparent contradiction to this, that there are many occasions when companies might base the price of a petroleum property acquisition on the past costs. Sellers of petroleum exploration properties often seek to set the price equal to the amount they have already spent on exploration up to the present. Ignoring fiscal effects, there is no economic logic to this practice.

For instance, a seller of a 50% working interest in an exploration permit might set the price at 50% of the past costs. Of course as mentioned above, ignoring fiscal effects, there is no economically rational basis for this. A company buying the interest would only pay such an amount if it believed that the future net cash flow was likely to be significantly more than 50% of the past costs. In this case, it is irrelevant to the buyer that the seller calls the price "past costs". To the buyer, it is simply the price of the acquisition and he will buy the property only if the expected future net cash flow is considerably more than the price.

Indirect effect on future net cash flow

If we remove the "no Government" assumption, then there are circumstances in which sunk costs can be very relevant to the investment decision. These circumstances include occasions where governments allow losses from the past to be deducted against future revenue for tax purposes, or where past costs can be recovered from future project revenue under cost recovery provisions. In such circumstances, past costs actually improve future cash flow because they effectively reduce the future tax payable or, in the case of a PSC regime, increase the revenue associated with cost recovery.

The latter point is illustrated in Table 1. In this example, the past costs are \$50 million, incurred on exploration in years 1 to 5 of a licence. A discovery was made at the end of year 5 and the future cash flow in years 6 to 8 is composed of future costs of \$10 million in each year and future revenue of \$100 million in year 8. By the time year 8 has been reached, the accumulated costs in the licence amount to \$80 million. This is composed of \$50 million from the past (that is, sunk costs) plus \$30 million from the future (that is, future costs).

We assume a simple case in which costs are not depreciated for costs recovery, but can be recovered immediately. In year 8, all of these costs can be recovered from project revenue because project revenue is \$100 million, which is in excess of the \$80 million costs. The excess (\$20 million) is profit oil which in this example is assumed to be split between the State and the company on a 50%-50% basis. Therefore the company receives \$10 million of the \$20 million profit oil, and the total company revenue in year 8 is \$80 million plus \$10 million equals \$90 million. The future net cash flow to the company (on which the

investment decision would be based) is therefore negative \$10 million in each of years 6 and 7, and \$80 million (equal to revenue of \$90 million less costs of \$10 million) in year 8.

Table 1 - Sunk costs and future net cash flow

	Past	Future		
		Year 6	Year 7	Year 8
Project data				
Project revenue \$MM				100
Past costs \$MM	-50			
Future costs \$MM		-10	-10	-10
Cumulative costs \$MM	-50	-60	-70	-80
Company cash flow				
Cost recovery \$MM				80
Profit oil \$MM				20
Company share of profit oil (50%) \$MM				10
Total company revenue				90
Future costs \$MM		-10	-10	-10
Future net cash flow \$MM		-10	-10	80

Sunk costs and acquisition prices - 2

The issue of sunk costs can be important in petroleum property acquisition decisions because they can influence the price. They can influence the price not as being the sole and direct determinant of price (as discussed above), but because they indirectly affect the future net cash flow of the property through the fiscal regime. They will reduce future taxes and/or increase future cost recovery. Then they will have the effect of increasing the value of the project to the buyer and the price it is willing to pay.

Summary

In summary -

- a) Sunk costs are simply and literally any costs incurred in the past
- b) They are irrelevant to the investment decision unless -
 - they affect future taxes, royalties etc and/or
 - they affect future cost recovery and profit oil.

7 Inflation

It is essential to incorporate estimates of future inflation in cash flow projections. This reflects an expectation that the different elements of cash flow will be larger in future years than they are now, because the prices of what we produce and the goods and services we buy will rise.

In principle, each item of cash flow will be affected differently by inflation. For instance, the future costs of building offshore platforms will be affected by future steel prices and construction yard labour costs. Similarly, the costs of drilling wells will be affected by the movement in rig rates and drilling hardware and consumables (casing, tubing, bits, drilling mud etc).

In practice, when we are constructing cash flow projections, simple assumptions about inflation are normally acceptable. We might assume for instance that all capital and operating costs will inflate at 5% per year. Therefore, the cash flow analysis would start by making estimates of capital and operating costs in today's terms (that is, as if they were all incurred in the current year) and then inflating or "escalating" them before inclusion in the cash flow for the years in which we forecast that they will be incurred. The following illustrates the process.

Illustration

Suppose that we estimate today's (this year's) costs of developing a crude oil discovery to be \$250 million phased over two years. Suppose also that today's costs of operating that discovery to be \$20 million per year once production is underway in three year's time. These amounts are estimates of the "real" costs. Real costs are the costs if they were incurred today. They are unaffected by inflation. If we assume that the level of inflation (in other words, the rate of escalation) for these costs is 5% per year, our forecast of the costs as they will be in the years when they will actually be incurred would be derived in Table 1.

Table 1 - Deriving escalated prices and costs					
	Year 1	Year 2	Year 3	Year 4	Year 5
Real oil price \$ per bbl	20	20	20	20	20
Capex \$MM	100	150			
Opex \$MM			20	20	20
Escalation rate %	5%	5%	5%	5%	5%
Escalation factor	1.05	1.103	1.157	1.216	1.276
Escalated oil price	21.00	22.05	23.15	24.31	25.53
Escalated capex \$MM	105.00	165.38			
Escalated opex \$MM			23.15	24.31	25.53

In Table 1 the escalation factor is given by the calculation shown below.

$$\text{Escalation factor} = (1 + \text{escalation rate})^n$$

where n = the year the cost is incurred or price received

Thus, for instance, in year 3, the escalation factor is $(1+0.05)^3$, which is equal to 1.157. Therefore, operating costs in that year are estimated to be today's costs of \$20 million times 1.157 equals \$23.15 million.

When greater accuracy is required, escalation rates might be derived for part-years. In addition, depending on the degree of sophistication of the forecast, escalation rates might be projected for different items of capital and operating costs and the rates might be varied from year to year.

Depreciation and escalation

It is important to note that, once a capital expenditure has been depreciated, it is not valid to escalate the annual depreciation amounts. Depreciation is a way of spreading a given capital expenditure in a given year over a period of time depending on what is contained in the accounting/tax/royalty regulations. In cash flow analysis, we estimate the actual capital costs in future years by escalating them. This process determines the estimated actual capital expenditure in any given year.

Once the actual capital expenditure in any year is known, then the regulations determine what the depreciation is in each subsequent year. A general principle of depreciation is that the sum of the annual depreciated amounts equals the actual capital expenditure being depreciated. This would not be the case if we escalated the annual depreciation amounts.

Jargon

The escalated costs, prices and cash flow discussed above are referred to as "inflated", "nominal", or "money-of-the-day" costs, prices. These are distinguished from "today's", "real" or "deflated" costs, and prices. Real or deflated quantities represent a measure of the purchasing power of a future amount of money in today's terms. Refer to Table 2 for a summary of the jargon used in the industry to describe situations in which inflation is included or excluded.

Perhaps the best, but least used word to describe a price or cost that has been escalated is the "actual", or "estimated actual" price or cost. This is because it represents our estimate of what a price or cost will actually be in money terms in the future.

Table 2 - Jargon

With inflation / escalation	Without inflation / escalation
Money of the day	Real
Nominal	Deflated
Escalated	Unescalated
Inflated	Purchasing power
Actual	

Perhaps the best, but least-used word to describe a price or cost that has no escalation is the "purchasing power" of the actual price or cost. This is because it represents how much we can buy with the actual monetary amount.

In a sense, the purchasing power should not be measured in dollars, but what the dollars will buy. We buy goods and services ("G&S") with our dollars. Suppose that each G&S that we buy costs \$1 today. Then the purchasing power of a monetary amount received or spent in the future is how many G&S we can buy in the future with that monetary amount. In this calculation we would need to know by how much G&S have increased in price (that is, the escalation rate). Therefore, in this example, strictly speaking we should not measure purchasing power in dollars, but in G&S. That is, we should ideally measure purchasing power in terms of something physical rather than dollars. Despite this, in practice, people usually use dollars to represent purchasing power.

Nominal net cash flow

Nominal net cash flow is the net cash flow which results from an analysis based on escalated costs and prices. It therefore has inflationary expectations embedded in it. It is the estimated actual net cash flow we will receive in dollars.

Real cash flow

Real net cash flow is the future net cash flow expressed in terms of its purchasing power in the future. It is equivalent to nominal cash flow deflated by projected inflation rates (that is by "deflators" or "deflation rates" when used in this context). These deflation rates will not necessarily be the same as the rates used to escalate capital costs, operating costs or oil prices. They might, correspond more to general levels of inflation as measured, for instance, by the Consumer Price Index or some similar indicator. Individual companies may determine deflators for their own operations. Real net cash flow is the amount of goods and services we can buy in the future with our future nominal net cash flow.

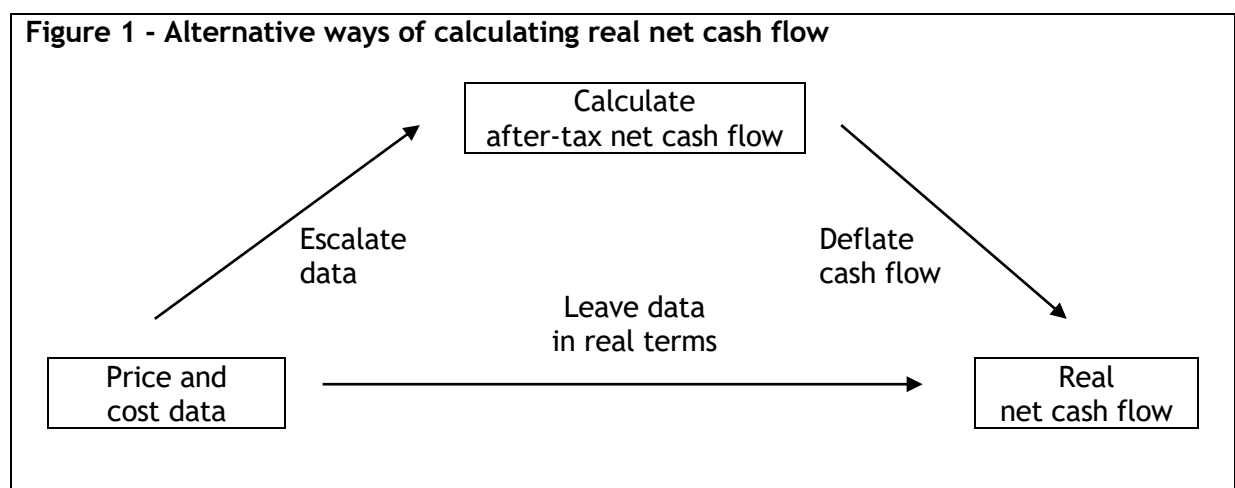
An illustration of the conversion from nominal net cash flow to real net cash flow is shown in Table 3.

Table 3 - Nominal and real net cash flow		
	Year 1	Year 2 etc
Nominal net cash flow \$MM	105	110
Deflation rate %	5%	5%
Deflation factors (numbers)	1.05	1.10
Real net cash flow G&S	100	100

The derivation of real net cash flow discussed above is based on the use of escalated costs and prices, calculating nominal net cash flow and then deflating the resulting nominal net cash flow.

Calculating real after-tax net cash flow

An alternative derivation of real net cash flow different from the derivation shown above is often used in the industry. This alternative is derived simply by using real, unescalated costs and prices at the outset, thus apparently removing the need to deflate the net cash flow which results. The two approaches to the derivation of real net cash flow are illustrated in Figure 1.



The two approaches do not in general give the same resulting net cash flow and, in fact, would only yield the same results in special circumstances. There are two reasons for this.

The first is that the escalation rates which are applicable to costs, prices and the escalation rates applicable to net cash flow are not necessarily the same, which they would need to be for the two approaches to be equivalent.

The second is that the effect of tax and particularly a phenomenon called "fiscal drag" almost always intervenes to ensure that real net cash flows derived by deflating nominal cash flows are lower than real net cash flows based on costs and prices which remain

unescalated. This is best illustrated by means of example tax calculations as shown in the following.

Suppose a project has components of cash flow in real terms as shown in Table 4 below. The "real" tax derived given these assumptions is shown in the same table.

Table 4 - Real tax calculation - version 1						
		Year 1	Year 2	Year 3	Year 4	Year 5
Real data						
	Gross revenue G&SMM	0	40	40	40	40
	Capex G&SMM	100				0
	Opex G&SMM	0	10	10	10	10
Real tax calculation						
	Gross revenue G&SMM	0	40	40	40	40
less	Depreciation G&SMM	25	25	25	25	0
less	Opex G&SMM	0	10	10	10	10
equals	Net revenue G&SMM	-25	5	5	5	30
	Loss carry forward G&SMM	-25	-20	-15	-10	
	Taxable income G&SMM	0	0	0	0	20
multiplied by	Tax rate %	40%	40%	40%	40%	40%
equals	Tax payment G&SMM	0	0	0	0	8

We can derive the real tax a different way by escalating income and costs by 5% per year, working out the nominal tax liability and deflating the resulting using a deflator of 5% per year. The calculation is shown in Table 5.

A comparison between the two calculations of the real tax liability shows that the approach shown in version 1 gives a lower real tax liability (that is, \$8 million) than the approach shown in version 2 (which gives \$11.7 million). In other words, the correct real tax is almost 50% more than the incorrect real tax calculated in version 1.

It is not valid to derive real net cash flow simply by basing it on unescalated costs and prices. This generally leads to an understatement of the tax payable. The correct way to derive real net cash flow is to escalate costs and prices, calculate royalties and taxes, and then deflate the resulting net cash flow. This approach also allows different escalation rates to be applied to different components of cash flow.

Another way of looking at the difference between version 1 and version 2 is that the two would give identical results if the depreciated amounts of \$26.3 million in version 2 were escalated at the same rate (5%) as the other elements of the tax calculation. Then the real tax liability would be \$8 million as in version 1.

Table 5 - Real tax calculation - version 2

		Year 1	Year 2	Year 3	Year 4	Year 5
Escalated data						
	Gross revenue \$MM	0	44.1	46.3	48.6	51.1
	Capex \$MM	105				0
	Opex \$MM	0	11.0	11.6	12.2	12.8
Nominal tax calculation						
	Gross revenue \$MM	0	44.1	46.3	48.6	51.1
less	Depreciation \$MM	26.3	26.3	26.3	26.3	0
less	Opex \$MM	0	11.0	11.6	12.2	12.8
equals	Net revenue \$MM	-26.3	6.8	8.5	10.2	38.3
	Loss carry forward \$MM	-26.3	-19.4	-10.9	-0.7	
	Taxable income \$MM	0	0	0	0	37.6
multiplied by	Tax rate %	40%	40%	40%	40%	40%
equals	Nominal tax payment \$MM	0	0	0	0	15.0
Real tax calculation						
divided by	Deflator (number)	1.05	1.10	1.16	1.21	1.28
equals	Real tax payment G&SMM	0	0	0	0	11.7

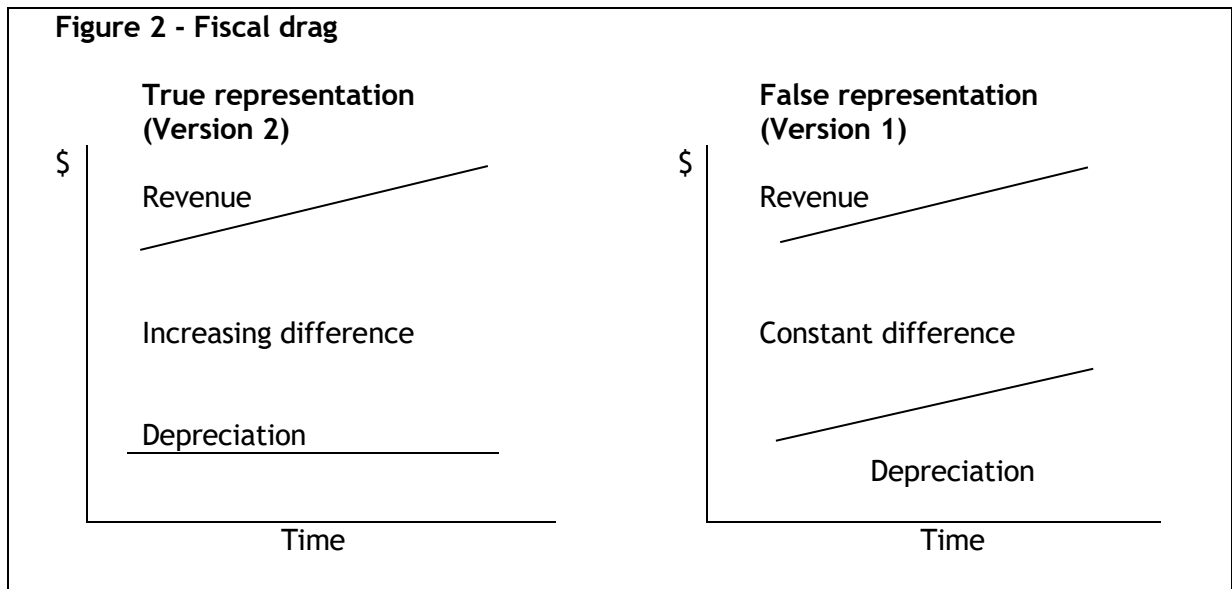
However, the depreciation in version 2 is not escalated - it would be invalid to do this. This has the effect of increasing the real tax liability above what it otherwise would be. The effect is known as "fiscal drag". Fiscal drag is the effect of tax increasing over time because at least one of the deductions in the tax calculation (in this case, depreciation) does not keep pace with inflation.

These points are illustrated in Figure 2. The left hand side of this figure shows that if inflation affects the cash flows, then revenues increase over time. However, one of the deductions in the tax calculation - depreciation - remains constant over time. Therefore there is an ever increasing difference between revenues and costs. The gap gives rise to ever increasing tax in real terms. This is the true representation of the situation and illustrates version 2 above.

The right hand side of Figure 2 shows what would occur if depreciation increased over time. In this case, the difference between revenues and the deductions remains constant and therefore the tax remains unaffected by inflation. This is implicitly what is happening in version 1 and does not represent reality. It is a false representation.

In fact, version 1 underestimates tax because it overstates the real depreciation used as a deduction in the tax calculation. Version 1 uses nominal depreciation amounts instead of deflated or real amounts. Version 2 correctly uses nominal depreciation as part of a nominal tax liability calculation and then at the end converts nominal tax to real tax.

Another example of fiscal drag is the case where tax scales used in assessing income tax on individuals do not increase with inflation even though income does. Because of this, the real (and nominal) tax liability increases with time.



Working in real terms

In the analyses above we demonstrated that, if we want to derive real net cash flow, the correct way to derive the real net cash flow is to escalate the data, work out the nominal net cash flow and then deflate the result. It is not correct simply to work entirely in real terms from the start.

A common misconception is that working in real terms removes the effects of inflation. This is simply not true. It is impossible to remove the effects of inflation when calculating real net cash flow. The real net cash flow is always dependent on the rate of inflation / deflation we assume. Different inflators / deflators give different real net cash flow. It is easy to demonstrate this.

Table 6 contains a calculation of real tax (that is, version 3) similar to that calculated in Table 5 (version 2). However, this version 3 is different from version 2 in that we assume escalation and deflation rates of 2% instead of 5%.

In this version 3 based on 2% escalation and deflation, the real tax paid is \$9.7MM compared to \$11.7MM derived in version 2 with 5% escalation and deflation.

Table 6 - Real tax calculation - version 3

		Year 1	Year 2	Year 3	Year 4	Year 5
Escalated data						
	Gross revenue \$MM	0	41.6	42.4	43.3	44.2
	Capex \$MM	102.0				0
	Opex \$MM	0	10.4	10.6	10.8	11.0
Nominal tax calculation						
	Gross revenue \$MM	0	41.6	42.4	43.3	44.2
less	Depreciation \$MM	25.5	25.5	25.5	25.5	0
less	Opex \$MM	0	10.4	10.6	10.8	11.0
equals	Net revenue \$MM	-25.5	5.7	6.3	7.0	33.1
	Loss carry forward \$MM	-25.5	-19.8	-13.5	-6.5	
	Taxable income \$MM	0	0	0	0	26.6
multiplied by	Tax rate %	40%	40%	40%	40%	40%
equals	Nominal tax payment \$MM	0	0	0	0	10.7
Real tax calculation						
divided by	Deflator (number)	1.02	1.04	1.06	1.08	1.10
equals	Real tax payment G&SMM	0	0	0	0	9.7

Escalating components of cash flow

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prod'n	Mbopd				60	50	40	30	20
Price	G&S/bbl		20	20	20	20	20	20	20
Capex	G&SMM	200	50	150					
Opex	G&SMM	100			20	20	20	20	20

Escalation rates and factors

Cost/price esc	% pa		5%	5%	5%	5%	5%	5%	5%
Esc factors	No.		1.050						

Data in money-of-the-day terms

Prod'n	Mbopd								
Price	\$/bbl								
Capex	\$MM								
Opex	\$MM								

Escalating components of cash flow - answer

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prod'n	Mbopd				60	50	40	30	20
Price	G&S/bbl		20	20	20	20	20	20	20
Capex	G&SMM	200	50	150					
Opex	G&SMM	100			20	20	20	20	20

Escalation rates and factors

Cost/price esc	% pa		5%	5%	5%	5%	5%	5%	5%
Esc factors	No.		1.050	1.103	1.158	1.216	1.276	1.340	1.407

Data in money-of-the-day terms

Prod'n	Mbopd				60	50	40	30	20
Price	\$/bbl		21.00	22.05	23.15	24.31	25.53	26.80	28.14
Capex	\$MM	218	52.5	165.4					
Opex	\$MM	128			23.15	24.31	25.53	26.80	28.14

Work out the correct real tax payable for the project below assuming escalation of 10% per year and a tax rate of 40%. The first calculation is the incorrect calculation of real tax.

Incorrect calculation

In real terms	Units	Totals	1	2	3	4	5
Revenue	G&SMM		0	40	40	40	40
Capex	G&SMM		100				
Opex	G&SMM			10	10	10	10
Revenue	G&SMM			40	40	40	40
Depreciation	G&SMM			25.00	25.00	25.00	25.00
Opex	G&SMM			10	10	10	10
Taxable income	G&SMM			5.00	5.00	5.00	5.00
Tax	G&SMM	8		2.00	2.00	2.00	2.00

Correct calculation

Escalation = 10% Escalator for year 1 = 1.1

	Totals	Totals	1	2	3	4	5
Escalated data							
Revenue	\$MM						
Capex	\$MM						
Opex	\$MM						
Tax calculation							
Revenue	\$MM						
Depreciation	\$MM						
Opex	\$MM						
Taxable income	\$MM						
Nominal tax	\$MM						
Deflator							
Real tax	G&SMM						

Work out the correct real tax payable for the project below assuming escalation of 10% per year and a tax rate of 40%.
The first calculation is the incorrect calculation of real tax.

Incorrect calculation

In real terms	Units	Totals	1	2	3	4	5
Revenue	G&SMM		0	40	40	40	40
Capex	G&SMM		100				
Opex	G&SMM			10	10	10	10
Revenue	G&SMM			40	40	40	40
Depreciation	G&SMM			25.00	25.00	25.00	25.00
Opex	G&SMM			10	10	10	10
Taxable income	G&SMM			5.00	5.00	5.00	5.00
Tax	G&SMM	8		2.00	2.00	2.00	2.00

Correct calculation

Escalation = 10% Escalator for year 1 = 1.1

	Totals	Totals	1	2	3	4	5
Escalated data							
Revenue	\$MM			48.40	53.24	58.56	64.42
Capex	\$MM		110				
Opex	\$MM			12.10	13.31	14.64	16.11
Tax calculation							
Revenue	\$MM			48.40	53.24	58.56	64.42
Depreciation	\$MM			27.50	27.50	27.50	27.50
Opex	\$MM			12.10	13.31	14.64	16.11
Taxable income	\$MM			8.80	12.43	16.42	20.82
"Nominal" tax	\$MM	23.4		3.52	4.97	6.57	8.33
Deflator			1.10	1.21	1.33	1.46	1.61
"Real" tax	G&SMM	16.3		2.91	3.74	4.49	5.17

After-tax cash flow with escalation and deflation

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prodn	Mbopd				60	50	40	30	20
Price	G&S/bbl		20	20	20	20	20	20	20
Capex	G&SMM	200	50	150					
Opex	G&SMM	100			20	20	20	20	20

Escalation rates and factors

Cost/price esc	% pa		5%	5%	5%	5%	5%	5%	5%
Esc factors	No.		1.050	1.103	1.158	1.216	1.276	1.340	1.407

Data in money of the day terms

Prodn	Mbopd				60	50	40	30	20
Price	\$/bbl		21.00	22.05	23.15	24.31	25.53	26.80	28.14
Capex	\$MM	218	52.5	165.4					
Opex	\$MM	128			23.2	24.3	25.5	26.8	28.1

Before-tax net cash flow ("BTNCF")

Revenue	\$MM								
Capex	\$MM								
Opex	\$MM								
BTNCF	\$MM								

Income tax**Depreciate at 20% straight line from production start**

Revenue	\$MM								
Deprn at 20%	\$MM								
Opex	\$MM								
Taxable income	\$MM								
Tax at 40%	\$MM								
Deflation rate	%								
Deflator	No								
Real tax	G&SMM								

After-tax net cash flow ("ATNCF")

Revenue	\$MM								
Capex	\$MM								
Opex	\$MM								
Tax	\$MM								
ATNCF	\$MM								
Deflation rate	%								
Deflator	No								
Real ATNCF	G&SMM								

After-tax cash flow with escalation and deflation - answer

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prodn	Mbopd				60	50	40	30	20
Price	G&S/bbl		20	20	20	20	20	20	20
Capex	G&SMM	200	50	150					
Opex	G&SMM	100			20	20	20	20	20

Escalation rates and factors

Cost/price esc	% pa		5%	5%	5%	5%	5%	5%	5%
Esc factors	No.		1.050	1.103	1.158	1.216	1.276	1.340	1.407

Data in money of the day terms

Prodn	Mbopd				60	50	40	30	20
Price	\$/bbl		21.00	22.05	23.15	24.31	25.53	26.80	28.14
Capex	\$MM	218	52.5	165.4					
Opex	\$MM	128			23.2	24.3	25.5	26.8	28.1

Before-tax net cash flow ("BTNCF")

Revenue	\$MM	1,822			507	444	373	293	205
Capex	\$MM	218	53	165					
Opex	\$MM	128			23	24	26	27	28
BTNCF	\$MM	1,476	-53	-165	484	419	347	267	177

Income tax**Depreciate at 20% straight line from production start**

Revenue	\$MM	1,822			507	444	373	293	205
Deprn at 20%	\$MM	218			44	44	44	44	44
Opex	\$MM	128			23	24	26	27	28
Taxable income	\$MM	1,476			440	376	304	223	134
Tax at 40%	\$MM	591			176	150	121	89	53
Deflation rate	%	0	5%	5%	5%	5%	5%	5%	5%
Deflator	No	9	1.050	1.103	1.158	1.216	1.276	1.340	1.407
Real tax	G&SMM	476			152	124	95	67	38

After-tax net cash flow ("ATNCF")

Revenue	\$MM	1,822			507	444	373	293	205
Capex	\$MM	218	53	165					
Opex	\$MM	128			23	24	26	27	28
Tax	\$MM	591			176	150	121	89	53
ATNCF	\$MM	886	-53	-165	308	269	226	177	124
Deflation rate	%	0	5%	5%	5%	5%	5%	5%	5%
Deflator	No	9	1.050	1.103	1.158	1.216	1.276	1.340	1.407
Real ATNCF	G&SMM	684	-50	-150	266	221	177	132	88

8 Loan financing

In the earlier sections of this chapter, the question of the source of funding for petroleum projects was ignored. Everything we have looked at so far assumes that the company carrying out an exploration/development project funds that project itself. That is, the project is financed by equity, or, in other words, shareholders' funds.

This is not always the case. In some instances, the company might go to a bank or banking syndicate to borrow all or part of the money for a development. In such cases, the project is said to be "loan financed", "bank financed", "geared" or some equivalent term.

Non-recourse loans

In some cases, borrowed money for project development may come from funds borrowed against the company's balance sheet. If something goes wrong with the project, or for that matter the company, then the bank can take charge of the company's assets. For these loans therefore, the banks have recourse to the assets of the company - i.e. the company itself.

However, in many instances in the petroleum industry, non-recourse loans have been negotiated. These are loans which rely solely on the project itself for security and loan repayment. If something goes wrong with the project, then the banks can attempt to recover their loans from whatever is left of the project, but they have no recourse to any other assets of the company.

In other instances, the banks may negotiate limited recourse loans, for which they have restricted access to the other assets of the company if something goes wrong with the project.

Usually, the banks attempt to reduce their exposure to project risks by specifying in the loan agreement how risks will be dealt with. The banks normally require a return on their loans which is only a few percentage points above the risk-free rate. They therefore argue that they should not take on the kind of risks which shareholders do. Shareholders take on risks in the anticipation of high rewards and provide funds to companies with this understanding. Banks take on relatively little risk, but require returns lower than shareholders.

Reservoir engineering assessments and the assessment of risks in connection with loan financing are usually required for non-recourse loans. These are required to determine a proposed development's reserves and production performance. Non-recourse loans are normally provided based on what the project can repay from proven reserves. That is, reserves which have a high degree of certainty. In other words, reserves associated with a low degree of risk.

When looking at the economics of different projects, it is critical to know whether the cash flows have been calculated assuming 100% equity financing (which, so far, we have always assumed) or assuming some degree of loan financing. It is not valid to compare the economics of two projects, one of which assumes equity financing and one which has any component of loan financing.

Gearing

Financing, or gearing, always radically improves the economics of a project as compared to the equivalent 100% equity financed case. The illustration in Table 1 demonstrates this (in this table, interest on loans is assumed to be 10% per year).

This is why loan financing is said to "gear-up" a project - alternatively, the project is "leveraged". The risk to the company is increased, because it must pay back the funds loaned to it even though there is a possibility that the project might not yield the A\$120 MM after the first year. However, the rate of return to equity is much bigger, because all or part of the cash flow need only return a low percentage return to the bank.

Another way in which loan financing assists project economics is in its effects on income tax. In many countries round the world, interest on loans is allowed as a deduction against income tax. Since interest payments on multi-million dollar loans are considerable, this can have a significant effect on project economics

Table 1 - The effect of gearing

	Time = 0	Time = end 1 year	Return to Company
a) Equity financed project Project cash flow	-\$100	+\$120	20%
b) 50% loan financed project Project cash flow	-\$100	+\$120	
Financing (loan, repayment)	+\$50	-\$55	
Net cash flow to company	-\$50	+\$65	30%
c) 100% loan financed project Project cash flow	-\$100	+\$120	
Financing	+\$100	-\$110	
Net cash flow to company	\$0	+\$10	Infinite

Net cash flow with financing example

Table 2 illustrates how project financing can be incorporated into an example project cash flow analysis.

We assume in this table that all capital expenditure for the project is borrowed, and that interest during years of zero income is accrued and capitalised. Repayments of principal are in equal amounts over 4 years starting in the first year of income. The tax calculations assume a tax rate of 40% and depreciation over 4 years starting from the year the expenditure is incurred.

There are many different forms of project financing and only one example is shown in the analysis. The analysis assumes, for instance, that all development costs will be bank financed. In practice, this may not be possible and only a portion of the costs might be financed this way.

The analysis also incorporates a fixed repayment schedule. In practice, repayments might be linked to revenues generated by the development. For instance, repayments might be a

certain percentage of gross revenue less operating costs and royalties. In practice, many different repayment methods apply.

Note that in this analysis, interest on borrowing is allowed as a deduction against income tax. This is typically the case for income tax regimes worldwide

Table 2 - Example net cash flow with project financing					
	Year 1	Year 2	Year 3	Year 4	Year 5
Field data					
Income		100.0	100.0	100.0	100.0
Capex	100.0				
Opex		10.0	10.0	10.0	10.0
Net cash flow	-100.0	90.0	90.0	90.0	90.0
Financial calculations					
Loan	100.0				
Balance at start	100.0	110.0	82.5	55.0	27.5
Interest during year	10.0	11.0	8.3	5.5	2.8
Repayment of principal		25.0	25.0	25.0	25.0
Repayment of year 1 interest		2.5	2.5	2.5	2.5
Balance at end	110.0	82.5	55.0	27.5	0.0
Tax calculation					
Income		100.0	100.0	100.0	100.0
Depreciation	25.0	25.0	25.0	25.0	
Opex		10.0	10.0	10.0	10.0
Interest paid		11.0	8.3	5.5	2.8
Interest in repayment		2.5	2.5	2.5	2.5
Net revenue	-25.0	51.5	54.2	57.0	84.8
Loss carry forward	-25.0				
Taxable income		26.5	54.2	57.0	84.8
Tax payment (40%)		10.6	21.6	22.8	33.9
Net cash flow calculations					
Income from project		100.0	100.0	100.0	100.0
Funds borrowed	100.0				
Total cash in	100.0	100.0	100.0	100.0	100.0
Capex	100.0				
Opex		10.0	10.0	10.0	10.0
Loan repayment		25.0	25.0	25.0	25.0
Repayment of year 1 interest		2.5	2.5	2.5	2.5
Loan interest		11.0	8.3	5.5	2.8
Tax		10.6	21.6	22.8	33.9
Total cash out	-100.0	-59.1	-67.4	-65.8	-74.2
Net cash flow	0.0	40.9	32.6	34.2	25.8

After-tax cash flow with debt financing

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prodn	Mbopd				60	50	40	30	20
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20

Example bank financing

Borrow \$50 & \$150 MM at 10% and repay debt in 5 equal installments from year 3

Drawdown at start of year	\$MM								
Interest calculations									
Debt at start of year	\$MM								
Interest owed at end yr	\$MM								
Interest paid at end yr	\$MM								
Unpaid interest bef prodn	\$MM								
Unpaid interest repaid later	\$MM								
Total interest paid	\$MM								
Debt calculations									
Debt at start of year	\$MM								
Unpaid interest bef prodn	\$MM								
Unpaid interest repaid later	\$MM								
Loan debt repaid	\$MM								
Total debt at end of year	\$MM								

Income tax

Depreciate at 20% straight line from production start

Revenue	\$MM								
Deprn at 20%	\$MM								
Opex	\$MM								
Total interest paid	\$MM								
Taxable income	\$MM								
Tax at 40%	\$MM								

After-tax net cash flow ("ATNCF")

Revenue from production	\$MM								
Loan									
Total cash in									
Capex	\$MM								
Opex	\$MM								
Total interest paid	\$MM								
Loan debt repaid	\$MM								
Tax paid	\$MM								
Total cash out	\$MM								
ATNCF	\$MM								

After-tax cash flow with debt financing - answer

Data	Units	Total	Years						
			1	2	3	4	5	6	7
Prodn	Mbopd				60	50	40	30	20
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20

Example bank financing

Borrow \$50 & \$150 MM at 10% and repay debt in 5 equal installments from year 3

Drawdown at start of year	\$MM	200.0	50.0	150.0					
Interest calculations									
Debt at start of year	\$MM		50.0	205.0	225.5	180.4	135.3	90.2	45.1
Interest owed at end yr	\$MM	93.2	5.0	20.5	22.6	18.0	13.5	9.0	4.5
Interest paid at end yr	\$MM	67.7			22.6	18.0	13.5	9.0	4.5
Unpaid interest bef prodn	\$MM	25.5	5.0	20.5					
Unpaid interest repaid later	\$MM	25.5			5.1	5.1	5.1	5.1	5.1
Total interest paid	\$MM	93.2			27.7	23.1	18.6	14.1	9.6
Debt calculations									
Debt at start of year	\$MM		50.0	205.0	225.5	180.4	135.3	90.2	45.1
Unpaid interest bef prodn	\$MM	25.5	5.0	20.5					
Unpaid interest repaid later	\$MM	25.5			5.1	5.1	5.1	5.1	5.1
Loan debt repaid	\$MM	200.0			40.0	40.0	40.0	40.0	40.0
Total debt at end of year	\$MM		55.0	225.5	180.4	135.3	90.2	45.1	0.0

Income tax

Depreciate at 20% straight line from production start

Revenue	\$MM	1,460			438.0	365.0	292.0	219.0	146.0
Deprn at 20%	\$MM	200			40.0	40.0	40.0	40.0	40.0
Opex	\$MM	100			20.0	20.0	20.0	20.0	20.0
Total interest paid	\$MM	93			27.7	23.1	18.6	14.1	9.6
Taxable income	\$MM	1,067			350.4	281.9	213.4	144.9	76.4
Tax at 40%	\$MM	427			140.1	112.7	85.3	58.0	30.6

After-tax net cash flow ("ATNCF")

Revenue from production	\$MM	1,460			438.0	365.0	292.0	219.0	146.0
Loan			50.0	150.0					
Total cash in			50.0	150.0	438.0	365.0	292.0	219.0	146.0
Capex	\$MM	200	50.0	150.0					
Opex	\$MM	100			20.0	20.0	20.0	20.0	20.0
Total interest paid	\$MM	93			27.7	23.1	18.6	14.1	9.6
Loan debt repaid	\$MM	200			40.0	40.0	40.0	40.0	40.0
Tax paid	\$MM	427			140.1	112.7	85.3	58.0	30.6
Total cash out	\$MM	1,020	50.0	150.0	227.8	195.9	164.0	132.1	100.2
ATNCF	\$MM	640	0.0	0.0	210.2	169.1	128.0	86.9	45.8

9 Incremental cash flow analysis

Introduction

Many investments in the oil and gas industry are modifications or increments to existing investments. We might be considering drilling an additional well on an existing field to increase production, or acquiring new equipment to replace existing equipment, to increase production or to lower operating costs. In such cases, the analysis should proceed as follows -

- (a) Forecast the after-tax net cash flow of the existing investment - the base project.
- (b) Forecast the after-tax net cash flow of the base project plus the incremental project.
- (c) Take the difference between the after-tax net cash flow of (a) and (b). This is the incremental after-tax net cash flow.

Example incremental analysis

The following analysis gives a simple example of the way in which we could assess the economics of an incremental investment. Table 1 shows an analysis of the after-tax net cash flow for the base project. In this example we assume that depreciation for tax is straight line depreciation over 4 years starting in year 2 when gross revenue begins.

Table 1 - After-tax net cash flow for base project

	Year 1	Year 2	Year 3	Year 4	Year 5
Base project = Project A					
Gross revenue \$MM		80	70	60	50
Capital costs \$MM	100				
Operating costs \$MM		20	20	20	20
Base tax					
Gross revenue \$MM		80	70	60	50
Depreciation \$MM		25	25	25	25
Operating costs \$MM		20	20	20	20
Taxable income \$MM	-	35	25	15	5
Tax \$MM		14	10	6	2
Base after-tax net cash flow					
Gross revenue \$MM		80	70	60	50
Capital costs \$MM	100				
Operating costs \$MM		20	20	20	20
Tax \$MM		14	10	6	2
After-tax net cash flow \$MM	-100	46	40	34	28

Suppose we are considering a modification to this project which has an incremental net cash flow as shown in Table 2.

Table 2 - Before tax net cash flow for incremental project

	Year 1	Year 2	Year 3	Year 4	Year 5
Incremental project					
Extra revenue \$MM		5	20	15	10
Extra capital costs \$MM	20				
Extra operating costs \$MM		0	0	0	0

On its own and ignoring timing effects, we might consider the incremental project to be attractive because the total extra revenue (\$50 MM) exceeds the total extra costs (\$20 MM), giving an extra before tax net cash flow of \$30 MM. However, to analyse the incremental project properly, we need to add together the cash flows for the base and the incremental project and recalculate the tax and the after-tax net cash flow of the combined projects. Table 3 shows the calculations.

Table 3 - After-tax net cash flow for base and incremental projects combined

	Year 1	Year 2	Year 3	Year 4	Year 5
Combined project = Base plus increment					
Gross revenue \$MM		85	90	75	60
Capital costs \$MM	120				
Operating costs \$MM		20	20	20	20
Combined tax					
Gross revenue \$MM		85	90	75	60
Depreciation \$MM		30	30	30	30
Operating costs \$MM		20	20	20	20
Taxable income \$MM		35	40	25	10
Tax \$MM		14	16	10	4
Combined after-tax net cash flow					
Gross revenue \$MM		85	90	75	60
Capital costs \$MM	120				
Operating costs \$MM		20	20	20	20
Tax \$MM		14	16	10	4
After-tax net cash flow \$MM	-120	51	54	45	36

Table 3 shows that when we combine the cash flow of the base and the increment and recalculate the tax, the tax timing of the combined project remains the same as for the base project. The incremental project has not changed the start of paying tax.

Finally, we can calculate the incremental after-tax net cash flow of the incremental project by taking the difference between the after-tax net cash flow in Table 3 and that in Table 1. The result is shown in Table 4.

Table 4 - Incremental after-tax net cash flow (ATNCF)

	Year 1	Year 2	Year 3	Year 4	Year 5
ATNCF of base project \$MM	-100	46	40	34	28
ATNCF of combined project \$MM	-120	51	54	45	36
Incremental ATNCF \$MM	-20	5	14	11	8

The total incremental after-tax net cash flow is now \$18 MM. This compares with an incremental net cash flow of \$30 MM before tax. Of course, over the whole of project life, tax at a rate of 40% has reduced the incremental after-tax net cash flow by 40% of the incremental before tax net cash flow.

Short cut incremental analysis

In this particular example, it is possible to take a short cut to the incremental analysis described above. If we know that the incremental project will not change the timing of tax payments or other components of the fiscal regime, then we can simplify the analysis and work only with the incremental net cash flow.

We illustrate the process with the same example as above.

The analysis is shown in Table 5. In this table we work only with the incremental net cash flow. The analysis is similar to the analyses above. The tax calculations in Table 5 are calculations of the change in tax from the base project to the combined project. They are not calculations of the absolute tax payments. In this analysis, we need to know that the base project starts paying tax in Year 2. As mentioned above, we also need to know that the incremental project does not change the year in which we start paying tax.

The incremental after-tax net cash flow shown in Table 5 is identical to the incremental after-tax net cash flow we would obtain by taking the difference between the after-tax net cash flows of the base project and the combined project.

The total incremental after-tax net cash flow of the incremental project in Table 5 is \$18 MM. This is that same as the total incremental before tax net cash flow of \$30 MM less the total incremental tax of \$12 MM. The total incremental tax is 40% of \$30 MM.

Table 5 - Short cut incremental analysis

	Year 1	Year 2	Year 3	Year 4	Year 5
Incremental project					
Extra gross revenue \$MM		5	20	15	10
Extra capital costs \$MM	20				
Extra operating costs \$MM		0	0	0	0
Incremental tax					
Extra gross revenue \$MM		5	20	15	10
Extra depreciation \$MM		5	5	5	5
Extra operating costs \$MM		0	0	0	0
Extra taxable income \$MM		0	15	10	5
Extra tax \$MM		0	6	4	2
Incremental after-tax net cash flow					
Extra gross revenue \$MM		5	20	15	10
Extra capital costs \$MM	20				
Extra operating costs \$MM		0	0	0	0
Extra tax \$MM		0	6	4	2
Extra ATNCF \$MM	-20	5	14	11	8

Message

The key message of this section is that, in carrying out incremental economic analyses, in general it is very important to calculate -

- (a) the after-tax cash flow of the base project and
- (b) the after-tax cash flow of the combined base plus incremental project and
- (c) then take the difference between the two after-tax net cash flows.

If this is not done, then the timing effects of the fiscal regime will not be taken into account correctly and the investment decision might be flawed.

However, if we are sure that the incremental project will not change the timing of fiscal payments, then we can take a short cut and calculate the incremental net cash flow directly.

In addition, we can calculate the individual components of the incremental net cash flow as illustrated in Table 5. This might be useful because it gives a breakdown of the way in which the incremental project affects the project.

Many, even most, investments we analyse will be projects that are increments to an existing project. Even when we are analysing a new project, it will be an increment to the existing cash flow of the company. To analyse such an investment properly, we should -

- (a) obtain the after-tax cash flow of the company as a whole and
- (b) the after-tax cash flow of the combined company cash flow plus the incremental project and
- (c) then take the difference between the two after-tax net cash flows.

In other words, we often need a total company cash flow to analyse the effect of the new project properly.

9 Incremental cash flow analysis

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Incremental net cash flow analysis

(1) Calculate the after tax cash flow for the base plus the incremental case. Then take the difference. Show that a short cut incremental analysis gives the same result in this case because the increment does not change the timing of tax.

(2) Change the data for the incremental case. Enter zero incremental production and zero incremental capex. Enter \$10MM for incremental opex in year 5. Note the incremental before tax and after tax net cash flow totals. Explain the difference between them.

		Years							
1.1 Data for base case	Units	Total	1	2	3	4	5	6	7
Prodn	Mbopd				60	50	40	30	20
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20
1.2 Before-tax net cash flow for base case									
Revenue	\$MM				438	365	292	219	146
Capex	\$MM		50	150					
Opex	\$MM				20	20	20	20	20
BTNCF	\$MM		-50	-150	418	345	272	199	126
1.3 Income tax for base Depreciate at 20% straight line from revenue start									
Revenue	\$MM				438	365	292	219	146
Deprn at 20%	\$MM				40	40	40	40	40
Opex	\$MM				20	20	20	20	20
Taxable income	\$MM				378	305	232	159	86
Tax at 40%	\$MM				151	122	93	64	34
1.4 After-tax net cash flow for base case									
Revenue	\$MM				438	365	292	219	146
Capex	\$MM		50	150					
Opex	\$MM				20	20	20	20	20
Tax	\$MM				151	122	93	64	34
ATNCF	\$MM		-50	-150	267	223	179	135	92
2. Data for incremental case									
Prodn	Mbopd	15			10	9	8	7	6
Capex	\$MM	20	0	20					
Opex	\$MM	0			0	0	0	0	0

3.1 Data for combined case		Total	1	2	3	4	5	6	7
Prodn	Mbopd								
Price	\$/bbl								
Capex	\$MM								
Opex	\$MM								
3.2 Before-tax net cash flow for combined case									
Revenue	\$MM								
Capex	\$MM								
Opex	\$MM								
BTNCF	\$MM								
3.3 Income tax for combined case Depreciate at 20% straight line from revenue start									
Revenue	\$MM								
Deprn at 20%	\$MM								
Opex	\$MM								
Taxable income	\$MM								
Tax at 40%	\$MM								
3.4 After-tax net cash flow for combined case									
Revenue	\$MM								
Capex	\$MM								
Opex	\$MM								
Tax	\$MM								
ATNCF	\$MM								
4. After-tax net cash flow (ATNCF) for combined case minus base case									
Incremental ATNCF	\$MM								
5.1 Short cut incremental before-tax net cash flow									
Incremental revenue	\$MM								
Incremental capex	\$MM								
Incremental opex	\$MM								
Incremental BTNCF	\$MM								
5.2 Short cut incremental income tax Depreciate at 20% straight line from revenue start									
Incremental revenue	\$MM								
Deprn of incremental capex	\$MM								
Incremental opex	\$MM								
Incremental taxable income	\$MM								
Incremental tax at 40%	\$MM								
5.3 Short cut incremental after-tax net cash flow									
Incremental revenue	\$MM								
Incremental capex	\$MM								
Incremental opex	\$MM								
Incremental tax	\$MM								
Incremental ATNCF	\$MM								

9 Incremental cash flow analysis

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Incremental net cash flow analysis - answer

(1) Calculate the after tax cash flow for the base plus the incremental case. Then take the difference. Show that a short cut incremental analysis gives the same result in this case because the increment does not change the timing of tax.

(2) Change the data for the incremental case. Enter zero incremental production and zero incremental capex. Enter \$10MM for incremental opex in year 5. Note the incremental before tax and after tax net cash flow totals. Explain the difference between them.

Years									
1.1 Data for base case	Units	Total	1	2	3	4	5	6	7
Prodn	Mbopd	73			60	50	40	30	20
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20
1.2 Before-tax net cash flow for base case									
Revenue	\$MM	1,460			438	365	292	219	146
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20
BTNCF	\$MM	1,160	-50	-150	418	345	272	199	126
1.3 Income tax for base Depreciate at 20% straight line from revenue start									
Revenue	\$MM	1,460			438	365	292	219	146
Deprn at 20%	\$MM	200			40	40	40	40	40
Opex	\$MM	100			20	20	20	20	20
Taxable income	\$MM	1,160			378	305	232	159	86
Tax at 40%	\$MM	464			151	122	93	64	34
1.4 After-tax net cash flow for base case									
Revenue	\$MM	1,460			438	365	292	219	146
Capex	\$MM	200	50	150					
Opex	\$MM	100			20	20	20	20	20
Tax	\$MM	464			151	122	93	64	34
ATNCF	\$MM	696	-50	-150	267	223	179	135	92
2. Data for incremental case									
Prodn	Mbopd	15			10	9	8	7	6
Capex	\$MM	20		20					
Opex	\$MM	0			0	0	0	0	0

3.1 Data for combined case	Units	Total	1	2	3	4	5	6	7
Prodn	Mbopd	88			70	59	48	37	26
Price	\$/bbl		20	20	20	20	20	20	20
Capex	\$MM	220	50	170					
Opex	\$MM	100			20	20	20	20	20
3.2 Before-tax net cash flow for combined case									
Revenue	\$MM	1,752			511	431	350	270	190
Capex	\$MM	220	50	170					
Opex	\$MM	100			20	20	20	20	20
BTNCF	\$MM	1,432	-50	-170	491	411	330	250	170
3.3 Income tax for combined case Depreciate at 20% straight line from revenue start									
Revenue	\$MM	1,752			511	431	350	270	190
Deprn at 20%	\$MM	220			44	44	44	44	44
Opex	\$MM	100			20	20	20	20	20
Taxable income	\$MM	1,432			447	367	286	206	126
Tax at 40%	\$MM	573			179	147	115	82	50
3.4 After-tax net cash flow for combined case									
Revenue	\$MM	1,752			511	431	350	270	190
Capex	\$MM	220	50	170					
Opex	\$MM	100			20	20	20	20	20
Tax	\$MM	573			179	147	115	82	50
ATNCF	\$MM	859	-50	-170	312	264	216	168	119

4. After-tax net cash flow (ATNCF) for combined case minus base case									
Incremental ATNCF	\$MM	163	0	-20	45	41	37	32	28

5.1 Short cut incremental before-tax net cash flow									
Incremental revenue	\$MM	292			73	66	58	51	44
Incremental capex	\$MM	20	0	20					
Incremental opex	\$MM	0			0	0	0	0	0
Incremental BTNCF	\$MM	272	0	-20	73	66	58	51	44
5.2 Short cut incremental income tax Depreciate at 20% straight line from revenue start									
Incremental revenue	\$MM	292			73	66	58	51	44
Deprn of incremental capex	\$MM	20			4	4	4	4	4
Incremental opex	\$MM	0			0	0	0	0	0
Incremental taxable income	\$MM	272			69	62	54	47	40
Incremental tax at 40%	\$MM	109			28	25	22	19	16
5.3 Short cut incremental after-tax net cash flow									
Incremental revenue	\$MM	292			73	66	58	51	44
Incremental capex	\$MM	20	0	20					
Incremental opex	\$MM	0			0	0	0	0	0
Incremental tax	\$MM	109			28	25	22	19	16
Incremental ATNCF	\$MM	163	0	-20	45	41	37	32	28

10 Depreciation

In earlier sections, we discussed the difference between calculations of net cash flow and calculations of profit. We emphasised that net cash flow is strictly cash received less cash spent including capital expenditure. In contrast, profit is calculated by depreciating capital expenditure - that is, spreading it over a period of years. Depreciation has no direct part in determining net cash flow. However, depreciation does have an indirect effect in that in general it is required to determine taxes, royalties, and cost recovery.

For this reason, it is important to know the different methods of depreciation used in the calculation of royalties, tax and cost recovery in the oil and gas industry internationally. In this section we review the following depreciation methods -

1. Straight Line.
2. Declining balance.
3. Double declining balance.
4. Double declining balance - straight line switch.
5. Units-of-production.
6. Sum-of-the-years-digits.

Straight line depreciation

"Straight line" (or "prime cost") depreciation is a way of spreading capital expenditure evenly over a specified period of time. In other words, the capital expenditure is distributed linearly. The best way of describing this is with an example.

Suppose that \$100 million is spread evenly over 4 years on a straight line basis. The following shows the calculation of the annual depreciation amounts -

Annual depreciation = \$100 million/4 years = \$25 million per year

The basic algebraic formula used in deriving straight line depreciation is:-

$$D_i = K/N$$

where -

D_i = Depreciation in year i

K = Initial capital investment

N = Number of years over which asset is depreciated

Sometimes the calculation is expressed in terms of an annual rate of depreciation -

$$D_i = K \cdot R$$

where - R = Rate of depreciation as a percentage

therefore - $R = 1/\text{Number of years over which asset is depreciated}$

In the above numerical example where the number of years over which an asset is depreciated is 4, the annual depreciation rate is 25% (equal to 1 divided by 4).

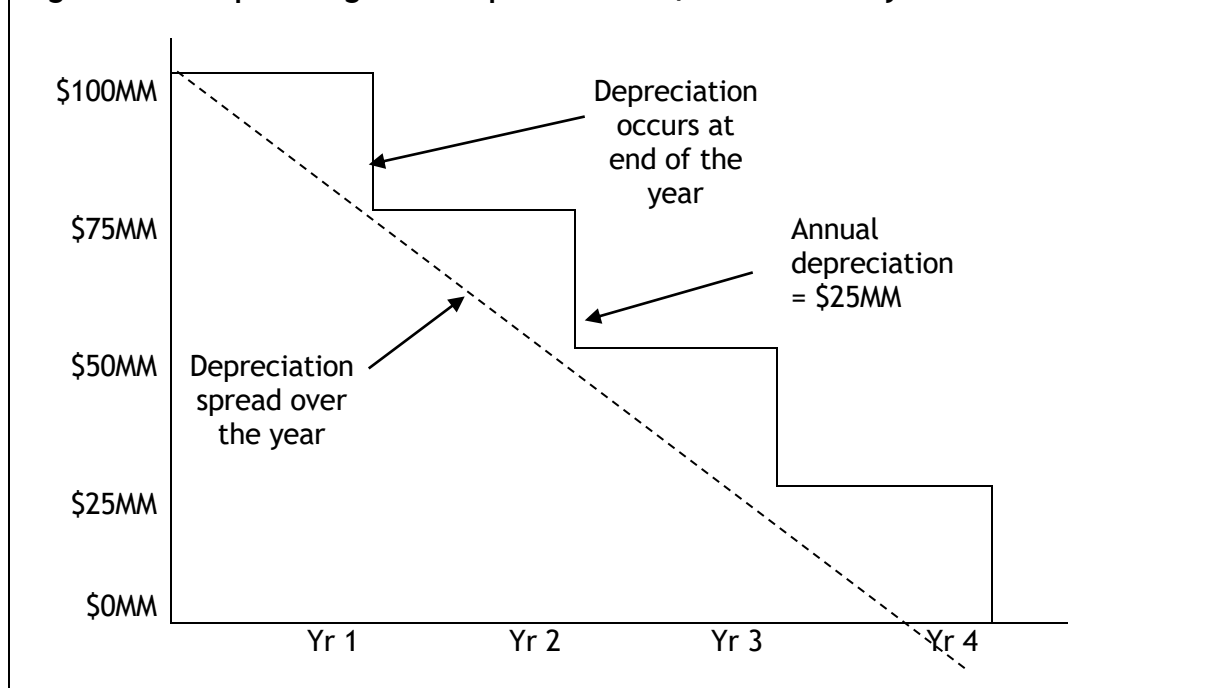
An alternative way of looking at the derivation of the annual depreciation calculation is in terms of a balance at start and balance at end year as shown in Table 1 and Figure 1. While

in this case the calculation is more complicated than simply dividing by the number of years of depreciation, it will help later when looking at other methods of depreciation.

Table 1 - Example straight line depreciation of \$100MM over 4 years

	Year 1	Year 2	Year 3	Year 4
Balance at start of year \$MM	100	75	50	25
Annual depreciation \$MM	25	25	25	25
Balance at end of year \$MM	75	50	25	0

Figure 1 - Example straight line depreciation of \$100MM over 4 years



It can be seen from the table and the figure that straight line depreciation has the following properties -

- (a) The remaining, undepreciated balance reduces linearly - i.e. in a straight line
- (b) The annual depreciation is the same in each year
- (c) All the initial capital expenditure is depreciated - i.e. there is nothing left over, and the balance after the depreciation period (4 years here) is zero.

In all the above calculations, we have assumed that the asset has no salvage value. That is, it has no value at the end of its life, which the stipulated depreciation period attempts to approximate.

Declining balance depreciation

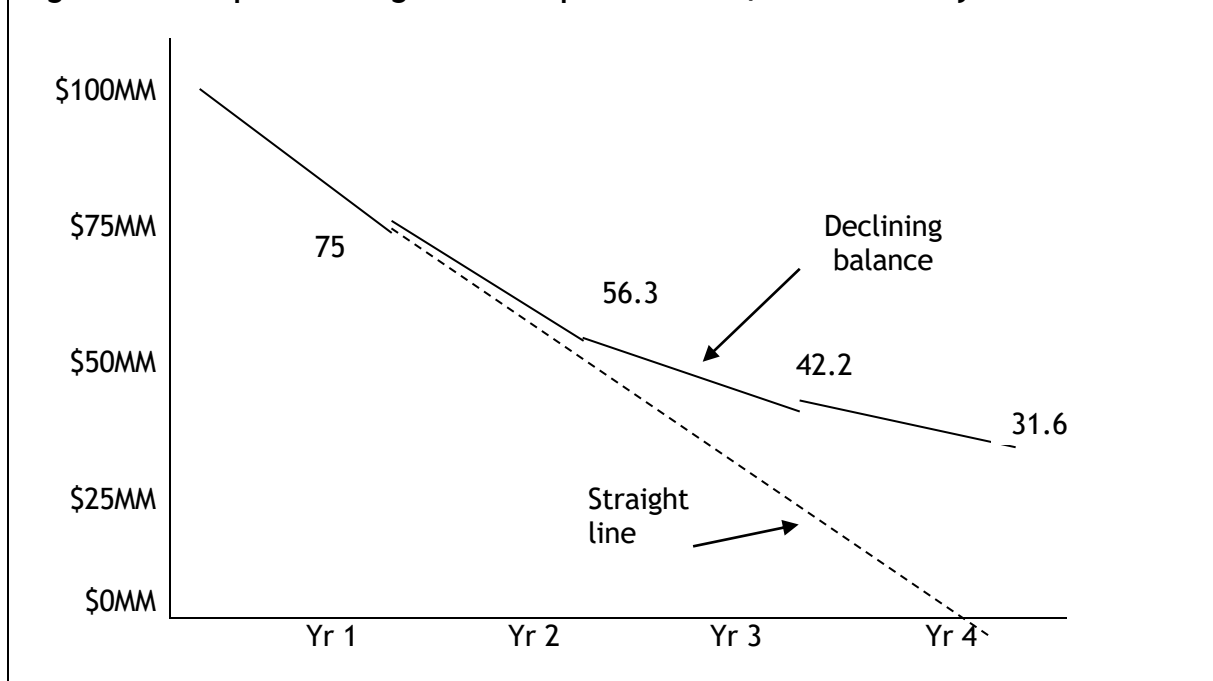
“Declining balance” depreciation (or “diminishing value” depreciation) is a way of spreading capital expenditure such that the annual depreciation declines each successive year. This is achieved by making the annual depreciation a constant proportion of the starting (and

declining) balance in each year. It is best demonstrated with the example shown in Table 2 and Figure 2.

Table 2 - Example declining balance depreciation of \$100MM over 4 years

	Year 1	Year 2	Year 3	Year 4
Balance at start of year \$MM	100	75	56.3	42.2
Annual depreciation \$MM	25	18.8	14.1	10.5
Balance at end of year \$MM	75	56.3	42.2	31.6

Figure 2 - Example declining balance depreciation of \$100MM over 4 years



In this example \$100 million is depreciated on a declining balance basis over 4 years (a 25% depreciation rate). This is similar to the example used previously, except that it is declining balance as opposed to straight line.

The algebraic formula used in deriving declining balance depreciation is -

$$D_i = B_i / N$$

where -

D_i = Depreciation in year i

B_i = Balance at the start of year i

N = Number of years over which asset is depreciated

The calculation can also be expressed in terms of an annual rate of depreciation -

$$D_i = B_i * R$$

where - R = Rate of depreciation as a percentage

and - $R = 1 / \text{Number of years over which asset is depreciated}$

An alternative formula can be derived by repeating the table above in algebraic form as shown in the table below (as before, K is the initial capital investment) -

	Year 1	Year 2	Year 3	Year 4
Balance at start of year	K	$K(1-R)$	$K(1-R)^2$	$K(1-R)^3$
Annual depreciation	KR	$KR(1-R)$	$KR(1-R)^2$	$KR(1-R)^3$
Balance at end of year	$K(1-R)$	$K(1-R)^2$	$K(1-R)^3$	$K(1-R)^4$

The general term for depreciation in year i is -

$$D_i = K \cdot R \cdot (1-R)^{i-1}$$

This equation is equivalent to the previous equation for declining balance, since B_i , the balance at the start of year i, is given by -

$$B_i = K \cdot (1-R)^{i-1}$$

Therefore -

$$D_i = B_i \cdot R$$

It can be seen from the graph in Figure 2 that declining balance depreciation has the following properties-

- The remaining, undepreciated balance reduces by a smaller and smaller amount each year.
- The annual depreciation declines each year.
- Not all the initial capital expenditure is depreciated - i.e. there is something left over after the depreciation period (4 years here).

Double declining balance depreciation

One variant of declining balance depreciation is so-called double declining balance depreciation. The two are similar, but double declining balance is simply declining balance depreciation in which the rate of depreciation is doubled. In this case the depreciation in any one year, i, is given by the formula -

$$D_i = B_i \cdot 2R$$

alternatively:-

$$D_i = K \cdot 2R \cdot (1-2R)^{i-1}$$

Taking the example used earlier, double declining balance depreciation of \$100 million over 4 years is given in Table 3 and Figure 3.

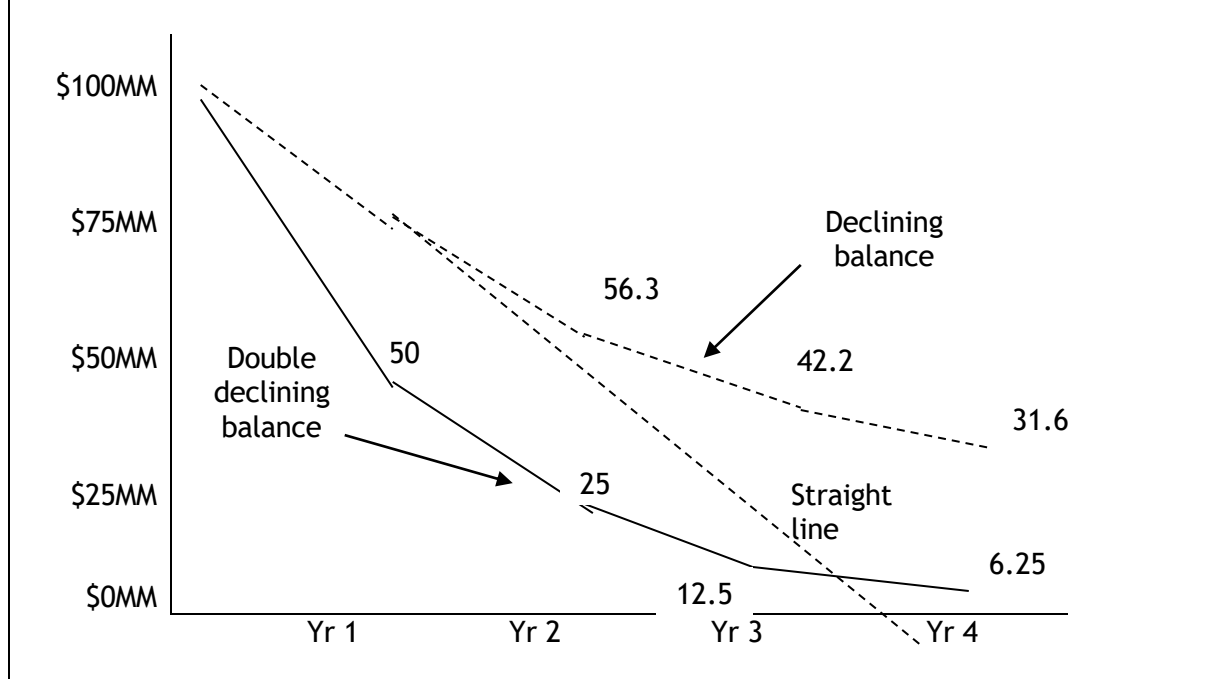
Table 3 - Example double declining balance depreciation of \$100MM over 4 years

	Year 1	Year 2	Year 3	Year 4
Balance at start of year \$MM	100	50	25	12.5
Annual depreciation \$MM	50	25	12.5	6.25
Balance at end of year \$MM	50	25	12.5	6.25

In this example, the effective depreciation rate is 50% (equal to 2 times 25%) of the balance at the beginning of each year.

Double declining balance depreciation has the same properties as declining balance depreciation as set out above. In particular, although the remaining balance at the end of the depreciation period is less than for declining balance depreciation (\$6.25 million with double declining balance as opposed to \$31.6 million with declining balance depreciation), the remaining balance is still positive and will remain positive no matter how long the depreciation period.

In general, we can multiply the depreciation rate by any depreciation factor to speed up the rate at which a capital expenditure is written off. With double declining balance depreciation, the depreciation factor is 2. Another depreciation factor in use in some taxation regulations is 1.5. However, whatever the depreciation factor, an inherent feature of the declining balance method is that, no matter what the depreciation factor, there will always be an undepreciated balance remaining at the end of the depreciation period

Figure 3 - Example double declining balance depreciation of \$100MM over 4 years

Declining balance depreciation with balloon payment

As discussed above, one of the features of declining balance depreciation is that not all of the initial capital expenditure is depreciated. No matter how long the depreciation period, a residual undepriciated balance of expenditure always remains. In the declining balance example, an undepriciated balance of \$31.6 million remains at the end of the depreciation period of 4 years. In the double declining balance example, an undepriciated balance of \$6.25 million remains at the end of the depreciation period of 4 years.

One way in which we can ensure that all the capital expenditure is depreciated is to allow the undepriciated balance as a lump-sum or a "balloon" payment in the year following the end of the depreciation period. Taking the example declining balance depreciation above, the depreciation schedule with a balloon payment is shown in Table 4.

In this example, the balloon payment is \$31.6 million in the 5th year. This payment ensures that the sum of the depreciated amounts is equal to the initial capital expenditure. With the double declining balance depreciation example, the balloon payment in the 5th year would be \$6.25 million.

Table 4 - Declining balance depreciation with balloon payment

	Year 1	Year 2	Year 3	Year 4	Year 5
Balance at start of year (\$MM)	100	75	56.3	42.2	31.6
Annual depreciation (\$MM)	25	18.8	14.1	10.5	31.6
Balance at end of year (\$MM)	75	56.3	42.2	31.6	0

Double declining balance depreciation with straight line switch

In the previous section, we discussed one way in which we can ensure that all the capital expenditure is depreciated when using the declining balance depreciation method. Another option which is frequently used is to switch to straight line depreciation at some point during the depreciation period. The switch to a straight line depreciation is made when a straight line method gives a more advantageous (that is, larger) depreciation. Table 5 contains an example of the technique.

Suppose that \$100 million is depreciated on a double declining balance basis over 4 years with a switch to straight line when that is advantageous to the company. The double declining balance calculations are as shown in Table 5.

Table 5 - Example double declining balance - straight line switch depreciation

	Year 1	Year 2	Year 3	Year 4
Double declining balance				
Balance at start of year \$MM	100	50	25	12.5
Annual depreciation \$MM	50	25	12.5	6.25
Balance at end of year \$MM	50	25	12.5	6.25
Straight line				
Remaining years	4	3	2	1
Balance at start of year \$MM	100	50	25	12.5
Annual depreciation \$MM	25	16.7	12.5	12.5
Balance at end of year \$MM	75	33.3	12.5	0
Optimum depreciation				
Largest depreciation \$MM	50	25	12.5	12.5

In the calculations above, the starting balance in any year is the balance left after the optimum depreciation is taken. The double declining balance depreciation in any one year is the starting balance multiplied by two times the depreciation rate. The straight line depreciation in any one year is the balance at the start of that year divided by the remaining years.

For example, in year 3, the starting balance is 25 which gives a double declining balance depreciation of \$12.5 million (equals 25 times 2 divided by 4) and the straight line depreciation also gives \$12.5 million (equals 25 divided by 2). From this year onwards, the straight line method gives the higher annual depreciation. With a starting balance of \$12.5 million in year 4, the double declining balance method gives an annual depreciation of \$6.25 million (equals 12.5 times 2 divided by 4) and the straight line method gives an annual depreciation of \$12.5 million (equals 12.5 divided by 1).

We can derive a general formula which can be applied to determine the year in which the switch from declining balance to straight line should be made. The derivation is shown below:-

In any year, i , declining balance depreciation is given by -

$$D_i = F \cdot R \cdot B_i$$

where:-

D_i = Depreciation in year i

F = Depreciation factor (which is 2 for double declining balance)

R = Rate of depreciation as a percentage = $1/N$

B_i = Undepreciated balance at the start of year i

Similarly, in the year i , straight line depreciation is given by -

$$D_i = B_i / \text{Remaining years}$$

where:-

Remaining years = $N - (i - 1)$

and N = Depreciation period

Therefore, straight line depreciation is adopted when it is more than declining balance depreciation. That is, when -

$$\frac{B_i}{N - (i - 1)} \text{ is greater than or equal to } (F \cdot B_i / N)$$

$$\text{or, rearranging, when } i \text{ is greater than or equal to } \frac{F(N+1) - N}{F}$$

$$\text{Therefore, the year of switch is given by } i = \frac{F(N+1) - N}{F}$$

In the example above, $F=2$ and $N=4$. Therefore, the year in which the switch to straight line is made is $(2 \text{ times } (4+1) - 4)$ divided by 2, which is equal to 3. This was also established numerically in the example calculation above.

Note that when F is equal to 1, the year of switch is always equal to 1. In other words, when the declining balance depreciation factor is 1, straight line depreciation is always better than declining balance depreciation after the first year. When the declining balance depreciation factor is 1, the two methods give the same result for the first year of depreciation.

Units of production depreciation

Units of production depreciation is sometimes applied in natural resource projects to reflect an assumption that capital assets for these projects are used up in proportion to the degree to which the resource base is used up in any one year. In petroleum projects, units of production depreciation in any one year would be proportionate to the ratio of

production of petroleum in a year to total estimated oil or gas reserves extracted over the life of a project.

Table 6 contains an example of the derivation of units of production depreciation of a capital expenditure of \$100 million for an oil field with reserves of 50 million barrels (MMbbl) and a forecast productive life of 4 years :-

Table 6 - Units of production depreciation				
	Year 1	Year 2	Year 3	Year 4
Production (MMbbl)	20	15	10	5
Production/reserves ratio (%)	40%	30%	20%	10%
Depreciation rate (%)	40%	30%	20%	10%
Depreciation (\$MM)	40	30	20	10

In petroleum projects, it is usually the case that production is high initially and declines towards the end of field life. Correspondingly, with this method of depreciation, the assets used to produce the field are depreciated significantly early in the productive life of the field and only to a small extent towards the end of field life.

In algebraic form, the formula for Units of Production depreciation is as follows -

$$D_i = K \cdot P_i / \text{Reserves}$$

where -

D_i = Depreciation in year i

P_i = Production in year i

One issue with units of production depreciation is that it relies on an inherently uncertain estimate of reserves at the beginning of the depreciation period. If subsequently the estimate of reserves changes, then adjustments to the annual depreciation figure must be made.

This issue is easily dealt with by using an alternative, but equivalent, calculation for the depreciation in each year. The equation we employ is -

$$D_i = \frac{\text{Production during year } i \cdot \text{Remaining balance of capital after depreciation}}{\text{Remaining reserves at start of year}}$$

The application of this equation for the example in Table 6 is shown in Table 7

Table 7 - Units of production depreciation

	Year 1	Year 2	Year 3	Year 4
Remaining reserves from previous year MMbbl	50	30	15	5
Reserves revisions in previous year MMbbl	0	0	0	0
Revised remaining reserves at start MMbbl				
Production MMbbl	20	15	10	5
Production/reserves ratio %	40%	50%	67%	100%
Depreciation rate %	40%	50%	67%	100%
Remaining capital from previous year \$MM	0	60	30	10
Capital additions in previous year \$MM	0	0	0	0
Remaining balance of capital at start \$MM	100	60	30	10
Depreciation (\$MM)	40	30	20	10

This is the same result as in Table 6.

In practice, the company might revise its estimates of reserves during field life. If so, then the remaining reserves would change from that indicated in Table 7. Similarly the company might incur additional capital costs during the previous year which might revise the balance of capital at the start of the year.

This method of depreciation is used frequently in the profit calculation in oil company annual accounts. In such cases it is often referred to as a calculation of the "depletion allowance". The depreciation rate in Table 7 is referred to as the "depletion coefficient"

Sum-of-the-years digits depreciation

Sum-of-the-years digits depreciation has a similar effect to units-of-production depreciation in that it gives higher annual depreciation early in the life of an asset than that late in the asset's life. Again, the workings of the method are best conveyed with an example.

Assuming that \$100 million is to be depreciated over 4 years using the sum-of-the-years digits method, the calculations would be made as shown in Table 8.

Table 8 - Sum-of-the-years-digits depreciation

	Year 1	Year 2	Year 3	Year 4
Sum of years (=1+2+3+4)	10			
Years remaining	4	3	2	1
Years left/sum of years (%)	40%	30%	20%	10%
Depreciation rate (%)	40%	30%	20%	10%
Annual depreciation (\$MM)	40	30	20	10

In this method of depreciation, the depreciation rate is equal to the years remaining divided by the sum of the years. Clearly, the annual depreciation will be weighted towards the beginning of the project because this is when remaining life is larger.

The equation used to derive annual depreciation under this method is as follows -

$$D_i = K * \text{Years remaining} / \text{Sum of years}$$

Therefore -

$$D_i = \frac{K * 2(N - (i-1))}{N(N+1)}$$

where -

D_i = Depreciation in year i

K = Initial capital expenditure

N = Number of years over which the asset is depreciated

Depreciation methods**Depreciate \$200 by different methods starting in year 2 (prod start)**

		Years						
Straight line at 20%		Total	1	2	3	4	5	6
Balance at start	\$MM			200.0				
Depreciation	\$MM							
Balance at end	\$MM							

Declining balance at 20% with ballon in year 7**7**

Balance at start	\$MM			200.0				
Depreciation	\$MM							
Balance at end	\$MM							

Double declining balance at 20% with ballon in year 7**7**

Balance at start	\$MM			200.0				
Depreciation	\$MM							
Balance at end	\$MM							

Double declining balance with straight line switch**(a) Double declining balance (20% * 2 = 40%)**

Balance at start	\$MM			200.0				
Depreciation	\$MM							
Balance at end	\$MM							

(b) Straight line

Remaining yrs								
Balance at start	\$MM							
Depreciation	\$MM							
Balance at end	\$MM							

(c) Optimum

Double dec bal	\$MM							
Straight line	\$MM							
Optimum	\$MM							

Units of Production (or "Depletion Allowance")

Production	MMbbl			9.1	21.9	18.3	14.6	11.0
Prod / reserves	%							
Deprn rate	%							
Depreciation	\$MM	200						

Depreciation methods - answer**Depreciate \$200 by different methods starting in year 2 (prod start)**

		Years						
Straight line at 20%		Total	1	2	3	4	5	6
Balance at start	\$MM			200.0	160.0	120.0	80.0	40.0
Depreciation	\$MM	200		40.0	40.0	40.0	40.0	40.0
Balance at end	\$MM	400		160.0	120.0	80.0	40.0	0.0

Declining balance at 20% with balloon in year 7**7**

Balance at start	\$MM			200.0	160.0	128.0	102.4	81.9	65.5
Depreciation	\$MM	200		40.0	32.0	25.6	20.5	16.4	65.5
Balance at end	\$MM	538		160.0	128.0	102.4	81.9	65.5	0.0

Double declining balance at 20% with balloon in year 7**7**

Balance at start	\$MM			200.0	120.0	72.0	43.2	25.9	15.6
Depreciation	\$MM	200		80.0	48.0	28.8	17.3	10.4	15.6
Balance at end	\$MM	277		120.0	72.0	43.2	25.9	15.6	0.0

Double declining balance with straight line switch

(a) Double declining balance (20% * 2 = 40%)									
Balance at start	\$MM			200.0	120.0	72.0	43.2	21.6	
Depreciation	\$MM			80.0	48.0	28.8	17.3	8.6	
Balance at end	\$MM			120.0	72.0	43.2	25.9	13.0	
(b) Straight line									
Remaining yrs				5	4	3	2	1	
Balance at start	\$MM			200.0	120.0	72.0	43.2	21.6	
Depreciation	\$MM			40.0	30.0	24.0	21.6	21.6	
Balance at end	\$MM			160.0	90.0	48.0	21.6	0.0	
(c) Optimum									
Double dec bal	\$MM			80.0	48.0	28.8	17.3	8.6	
Straight line	\$MM			40.0	30.0	24.0	21.6	21.6	
Optimum	\$MM	200		80.0	48.0	28.8	21.6	21.6	

Units of Production (or "Depletion Allowance")

Production	MMbbl	75		9.1	21.9	18.3	14.6	11.0
Prod / reserves	%	100%		12.2%	29.3%	24.4%	19.5%	14.6%
Deprn rate	%	100%		12.2%	29.3%	24.4%	19.5%	14.6%
Depreciation	\$MM	200		24.4	58.5	48.8	39.0	29.3

11 Cash flow summary

The following is a summary of the main points in the net cash flow section.

Net cash flow

NCF is strictly money.

NCF is cash received when we receive it less cash spent when we spend it.

NCF is gross revenue less capex less opex less taxes.

Capex is one-off, upfront and usually large.

Opex is periodic, spread over field life and relatively small each year.

Abandonment costs usually occur at the end of project life. They might be significant compared to initial development costs.

Government Take is periodic and it usually the a large component of NCF.

Economic life

Economic life is the period up to the point when revenue is less than operating costs for the last time.

Economic life helps determine reserves of oil or gas.

Economic life and reserves are a function of economic parameters like oil price, operating costs and Government Take as much as they are a function of geology, engineering and physical parameters.

We abandon the field after its economic life. We cannot know when to abandon the field until we know the economic life.

Profit

Profit is not the same as net cash flow.

Profit includes depreciated capex. Net cash flow includes capex directly.

Profit is an artificial construction calculated for accounts.

Net cash flow is actual money and is needed to make investment decisions.

We need to calculate profit because tax and production sharing contract terms require us to do so. Otherwise, we would not need to calculate profit to make investment decisions.

Tax

Income tax is payable on almost all projects.

Tax is based on a calculation of taxable income, which is effectively a profit calculation and therefore involves depreciating capex.

Usually, we start depreciation when production starts or when we spend the money, whichever is later.

Sometimes (not very often) we start depreciation when we spend the money. This can help the economics considerably.

Depreciation delays tax deductions for capex. This tends to hurt marginal developments more so than profitable developments.

Loss carry forward

A loss carry forward is a tax loss that can be deducted in the future. It is not an actual loss.

A loss carry forward can (a) reduce tax payments in early years, (b) delay tax payments or (c) eliminate tax payments completely depending on the circumstances.

Tax losses arise in different ways - eg from prior exploration expenditure, from low revenue in early field life, from high deductions early in field life.

Tax losses improve the value of the project because they can delay and possibly reduce future tax.

Sunk costs

Sunk costs are any costs incurred in the past.

Sunk costs are irrelevant to future net cash flow unless they are deductible against tax or are cost recoverable.

Sunk costs usually increase future net cash flow because they reduce and can delay future tax or increase cost recovery in the early years of production.

Nominal and real cash flow

Nominal net cash flow is actual money

Real net cash flow is the purchasing power of the money. Ideally purchasing power should be measured in physical units (eg goods and services). However, in practice we measure it in today's money.

Fiscal drag

Fiscal drag is the effect on real net cash flow of taxes increasing over time. It arises because something in the fiscal calculations does not keep pace with inflation - for instance, depreciation.

If you want real after-tax net cash flow you must escalate the data, calculate the nominal after-tax net cash flow and then deflate the result.

You cannot obtain the correct real after-tax net cash flow without first escalating the data.

Real after-tax net cash flow is a function of the rate of escalation / deflation. You get different real after-tax net cash flow with different escalation / deflation assumptions.

You can never eliminate the effect of inflation.

Debt financing

Most net cash flow analyses assume equity financing - that is, we use shareholders' money.

We might instead assume that all or part of the project is financed by debt - by a loan from a bank.

If we assume debt financing, there are 3 extra elements in the net cash flow - the loan (income), loan repayments (costs) and loan interest (costs).

Loan interest is deductible against tax. However, the loan and loan repayments do not form part of the tax calculation.

Some PSCs allow cost recovery of loan interest. Some do not.

Incremental net cash flow

Almost all projects are incremental projects because they are adding to an existing net cash flow.

The correct way to handle incremental projects is -

- Obtain the existing after-tax net cash flow (base).
- Re-calculate the net cash flow including the new project (base plus increment).
- Take the difference.
- Make a decision.

Otherwise you could take the wrong decision.

Depreciation

We need to depreciate in order to calculate taxable income or cost recovery.

There are several depreciation methods used in fiscal regimes round the world -

- Straight line
- Declining balance
- Double declining balance
- Units of production