The impact of financing schemes and income taxes on electricity generation costs

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The NEA carries out economic studies on a regular basis to assist member countries in their own assessments in support of decision making for the power sector. As part of the studies carried out under the NEA Nuclear Development Committee, several computer tools have been used to calculate the costs of electricity generation, their various elements and their sensitivity to different parameters. The model presented in this article was developed in order to assess the impact of financing schemes and income taxes on generation costs.

Electricity generation cost estimates reported in many national and international studies provide a wealth of data to support economic assessments, and eventually to guide choices on generation sources and technologies. However, although the electricity generating cost is the criterion generally selected to present results, it is calculated by various means in different studies because the chosen approach must be relevant to the context of the specific project (private vs. stated-owned investor, regional differences...).

The traditional constant-money levelised generation cost methodology is widely used by utilities, government agencies and international organisations to provide economic assessments of alternative generation options. It gives transparent and robust results, especially suitable for screening studies and international comparisons. However, the method, which is strictly economic, does not take into account all the factors influencing the choice of investors in liberalised electricity markets. In particular, it does not take into account financing schemes and income taxes which may have a significant impact on the capital cost to be supported by the investor.

The approach described below is based on the overall framework of average levelised lifetime cost evaluation, but it takes into account the financing scheme adopted by the investor and the income taxes supported by the plant operator/utility. It is similar to models which are used to analyse the economics of competing electricity generation sources in liberalised electricity markets, such as the merchant plant cash flow model adopted in the MIT study.[1]

The model, or computer tool, developed to implement the approach was used in sample calculations carried out for nuclear, coal and gas power plants to illustrate concretely the application of the methodology. The purpose of the sample calculations was to estimate the impact of financing and taxes on the relative competitiveness of different generation sources and technologies.

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The results provide detailed electricity generation costs estimated within different financing and income tax contexts; they show how the associated conditions affect generating costs, and how the impacts differ according to the generating source. In particular, they demonstrate that both factors have an impact on the capital component of generation costs which is not technology-neutral.

The assumptions adopted for input data, including unit costs and economic conditions, reflect the present situation but do not refer to any specific technology, reactor type or country. Two different financing contexts are considered: moderate and tight financing constraints. With input data corresponding to the condition applying in a given investor/utility project, the computer tool developed to implement the model may be applied to specific case studies on concrete choices of generation technologies.

Methodology

In order to put the adopted approach in perspective, it is worth highlighting the basic principle of the constant-money levelised cost method, used for example in OECD studies.[2] This method discounts the time series of expenditures to their present value in a specified reference year by applying a discount rate. A similar process is used for electricity generation to calculate its present value equivalent. The ratio of discounted expenditures versus discounted electricity generation provides the levelised lifetime cost of electricity, which is expressed in constant money of the reference year. This cost, often called "bus-bar cost", is generally split into its capital, fuel and operation and maintenance (O&M) components.

The approach used below differs from the constant-money levelised cost method mainly in the treatment of investment/capital costs. The calculations are performed in nominal/current money, meaning that all costs, starting from an initial value adopted for the base year, are escalated according to an assumed inflation rate; a positive or negative trend over time can be added to the inflation rate if needed. Loan paybacks are computed according to the loan interest rate which, in itself, includes inflation trends.

The annual outlays related to capital investment, fuel costs and O&M costs, as well as income tax payments, are calculated taking inflation into account. Outlays include waste management and disposal, and decommissioning costs as applicable (for example in the case of nuclear power plants). Capital investment is handled in two parts: the equity component and the loan component (outlays occurring during the pay-back period). Appropriate annual capital depreciation is also computed for tax calculation purposes, the income taxes being charged on the taxable income calculated by deducting asset depreciation from total net income.

The annual revenues are calculated by multiplying the annual electricity generation by the wholesale price of electricity. The electricity selling price escalates according to the inflation rate, but remains unchanged over the plant lifetime in constant money value.

The cash flow is then obtained by deducting expenses from revenues. From this cash flow, the internal rate of return (IRR) or return on equity (ROE) is calculated year by year, its value becoming positive when the cumulated cash flow becomes positive.

The model can be operated as a profitability or generating-cost calculator:

- **Profitability calculator.** The electricity price is an input value and the model computes the IRR. This IRR figure is available either for the plant's entire economic life or for any specific number of operating years, should the shareholders want their return on equity over a shorter period.
- **Generating-cost calculator.** The IRR after a certain number of operating years is an input, and the model computes the electricity selling price which allows this return. Since this selling price stays the same over the years in constant money, it can be assimilated to a levelised electricity generation cost corresponding to the pre-selected return on equity.

The additional capability of the model is that it includes, together with the cash flow-based estimation of IRR or electricity selling price, a calculation of discounted outlays estimated with a discount rate (including inflation) equal to the IRR. Starting from the outlay schedules computed in the merchant plant cash flow model, discounted outlays are calculated and the yearly power generation amounts are also discounted. This part of the model is similar to the classic economic model used in levelised generation cost calculation, with the exception that a nominal discount rate has to be used in order to discount outlays expressed in nominal values.

This additional capability allows a detailed assessment of the impact of financing schemes and income taxes on levelised costs of electricity generation. As shown in the sample calculations presented below, it is possible with the model to calculate the three components of levelised generation cost (capital, fuel and O&M) and to display the income tax separately from the capital cost component.

Assumptions

The calculation is performed for three generating sources: nuclear, gas-fired and coal-fired power plants operating in the context of liberalised markets corresponding to the average conditions prevailing in the United States. The technical and unit-cost assumptions (see Table 1) are not intended to reflect any specific design but are illustrative of state-of-the-art units currently available on the market.

Table 1. **Technical and cost data**

	Unit	Nuclear	Gas	Coal
Overnight capital cost	$/kW	2000	650	1400
Plant life	years	40	25	40
Construction time	months	60	24	48
Capacity factor	%	90	90	90
Thermal efficiency – LHV	%	33	58	44
Decommissioning	$ million	350	0	0
Fuel cost	$/MBtu or tonne	0.50/ MBtu	6.0/ MBtu	40/ tonne
Fuel cost escalation rate	%	0	0	0
Waste management	cents/kWh	0.1	0	0
O&M	$ per kW per year	50	25	50
O&M cost escalation rate	%	0	0	0
Annual incremental capital cost	$/kW	20	6	12

For convenience, the calculations are normalised to 1000 MWe capacity plants but the results are valid irrespective of the size of the plant, provided that the specific overnight capital costs assumed ($/kWe installed) are appropriate for the plants being considered. Input cost data and results, i.e., generation costs per kWh, are expressed in year 2007 US dollars ($).

As indicated above, calculations were performed in two contrasted economic and financing contexts (moderate and tight financial constraints) recognising that the financial parameters may change depending on the perception of risks by investors and banking institutions. The corresponding financial parameters are summarised in Table 2.

Table 2. **Financial parameters**

		Moderate			Tight		
	Unit	Nuclear	Gas	Coal	Nuclear	Gas	Coal
Inflation rate	annual %	3	3	3	3	3	3
Equity portion	%	30	30	30	60	60	60
Equity return	%	12	12	12	15	15	15
Equity recovery period	years	40	25	40	25	25	25
Debt portion	%	70	70	70	40	40	40
Debt interest rate	%	7	7	7	9	9	9
Debt term	years	15	15	15	15	15	15
Income tax rate	%	38	38	38	38	38	38
Depreciation term	years	15	15	15	15	15	15
Depreciation schedule		MACRS*			MACRS*		

* *MACRS = modified accelerated cost recovery system.*

The tight financial context corresponds to a low degree of investor confidence in electricity generation projects requiring a high ratio of equity versus debt, high return on equity and high interest rates. The moderate context assumes a higher confidence of potential investors in the economic viability of electricity generation projects leading to lower ratio of equity versus debt, lower return on equity and lower interest rates.

It has been assumed that financing conditions will be the same for the three technologies, i.e., nuclear, coal and gas. In some studies, this is not the case because it might be argued that some sources or technologies are perceived to be riskier than others by potential investors. With the model used, it would be easy to perform sensitivity analyses showing the impact of assuming different financial constraints for different technologies.

Impact of financing schemes

Tables 3 and 4 provide the electricity generation costs in the case of moderate and tight financial constraints respectively, calculated for coal, gas and nuclear power plants with the input data and financial parameters given in Tables 1 and 2. Figures 1 and 2 provide a graphic representation of those results.

Table 3. **Electricity generation costs ($/MWh) – Moderate financial constraints**

	Nuclear	Gas	Coal
Capital without income tax	2.49	0.79	1.63
Income tax	0.39	0.10	0.25
Capital including income tax	2.88	0.89	1.88
O&M	0.63	0.34	0.63
Fuel	0.62	3.92	1.33
Total without income tax	*3.74*	*5.05*	*3.59*
Total including income tax	**4.13**	**5.15**	**3.84**

Table 4. **Electricity generation costs ($/MWh) – Tight financial constraints**

	Nuclear	Gas	Coal
Capital without income tax	3.77	1.05	2.45
Income tax	1.08	0.26	0.69
Capital including income tax	4.85	1.31	3.14
O&M	0.63	0.34	0.63
Fuel	0.62	3.92	1.32
Total without income tax	*5.02*	*5.31*	*4.40*
Total including income tax	**6.10**	**5.57**	**5.09**

Figure 1. **Electricity generating costs – Moderate financial constraints**

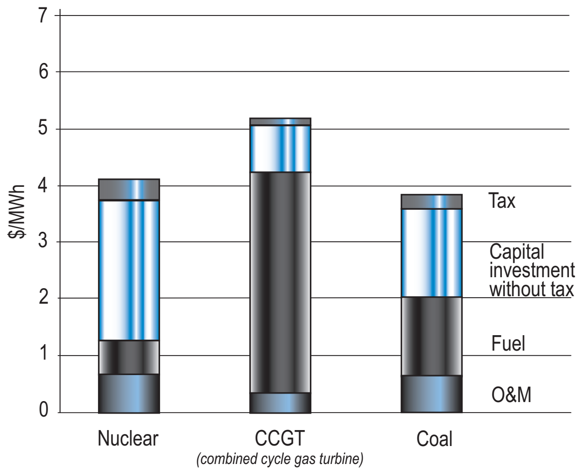
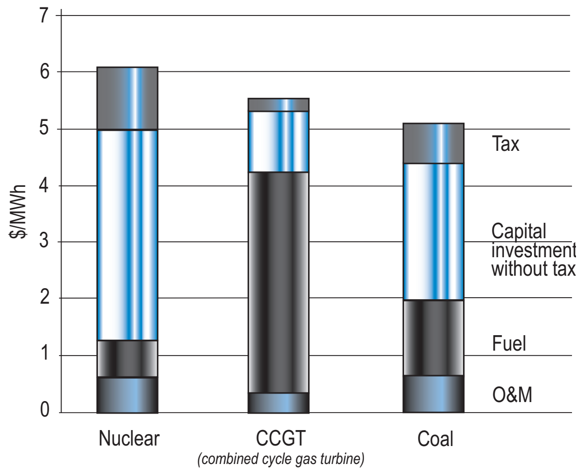


Figure 2. **Electricity generating costs – Tight financial constraints**



The different cost components, including income tax, illustrate that while generating costs increase for all three electricity generation technologies when income taxes are included in the calculation, the impacts of financing schemes and income taxes differ significantly from technology to technology. The reason for those differences is that the specific (per kWh) taxable income is very sensitive to the cost structure of the generation source considered.

The annual taxable income, which corresponds to the revenue that will be allocated to pay the expected return on equity, is equal to the revenue less operating expenses, including fuel and O&M costs, less interest payments and asset depreciation. As this taxable income depends on the capital investment required to finance the plant, on the equity/debt ratio and on the required return on equity, the specific annual taxable income will be higher for capital-intensive electricity generation sources such as nuclear, less so for coal, and lastly gas.

- Under moderate financial constraints, the generation cost increases by 10% for nuclear, 7% for coal and only 2% for gas.
- Under tight financial constraints, the gaps are even wider as the increase is 22% for nuclear, 16% for coal and 5% for gas.

Including income tax in the generating cost may change the relative competitiveness of electricity generation sources. For example, with the assumptions and input data adopted in the present study, under the tight financial constraints, nuclear is cheaper than gas when excluding tax, but gas is cheaper when taxes are included. This highlights the importance of presenting the detailed results together with all assumptions, input data and boundary conditions adopted in any cost estimation.

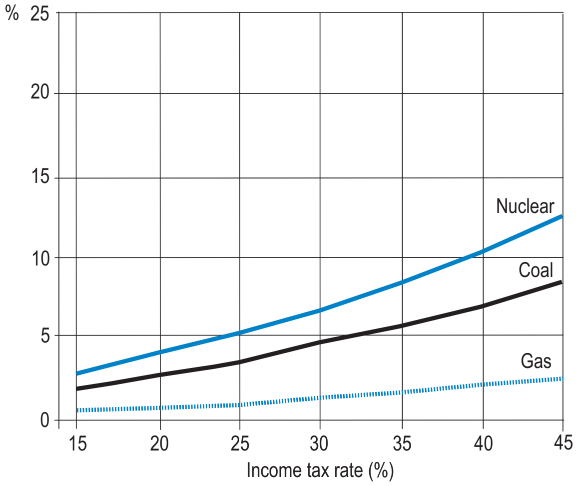


Figure 3. **Income tax/electricity generating cost ratio – Moderate financial constraints**

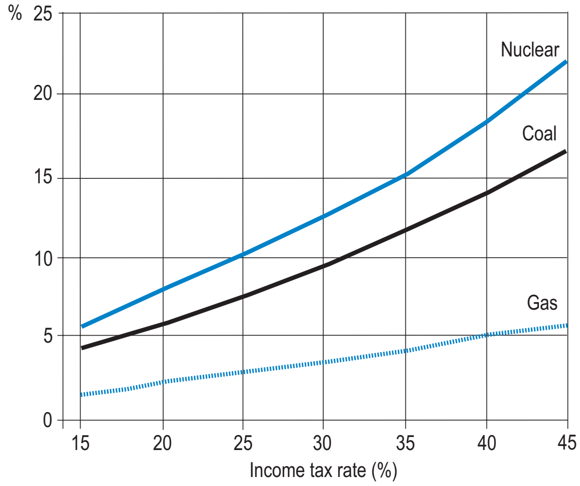


Figure 4. **Income tax/electricity generating cost ratio – Tight financial constraints**

Sensitivity to income tax rates

As previously noted, the base calculation was performed in the context of liberalised markets corresponding to the average conditions prevailing in the United States. Consequently, the income tax rate was estimated at 38%.

However this rate varies widely from country to country, ranging from some 15% to above 40%. It is therefore interesting to see how the results would be affected by such a variation, all other parameters remaining unchanged. The sensitivity calculation takes into account an income tax rate range of 15% to 45%.

As in the base case, the sensitivity calculation is performed for coal, gas and nuclear power plants. Figures 3 and 4 illustrate the impact of such a variation in income tax rate on the electricity generation cost, expressed in a percentage of this cost.

In the case of moderate financial constraints (Figure 3), the income tax/generating cost ratio varies from 2.9% to 12.4% for nuclear, from 0.6% to 2.5% for gas and from 1.9% to 8.4% for coal. In the case of tight financial constraints (Figure 4), the income tax/generating cost ratio varies from 5.8% to 22.4% for nuclear, from 1.3% to 6.0% for gas and from 4.3% to 17.3% for coal.

It should be stressed that the results presented in Figures 3 and 4 are valid in the framework of the assumptions and input data summarised in Table 1. Outside of this context, results may differ significantly, in particular in cases where the relative importance of capital cost versus fuel and O&M costs is different from the sample calculations. When capital cost is proportionally higher, the sensitivity of generation costs to tax rates is higher and vice versa.

Conclusions

Levelised generation costs estimated with the traditional approach, where financing schemes and income taxes are not taken into account, provide a relevant basis for screening studies and international comparisons. However, they do not reflect the full range of parameters that affect investor choices. Including financing constraints and taxes in the cost calculation provides estimates that are better adapted to understanding investor choices in liberalised electricity markets.

The illustrative calculations carried out for a range of income tax rates in two contrasted financial constraint frameworks show that taking those parameters into account may change the relative competitiveness of electricity generation sources. This highlights the importance of presenting detailed results together with all assumptions, input data and boundary conditions adopted in any cost estimation.

The results obtained show that tax regimes implemented by governments have an impact on generation costs which is not technology-neutral. Government policy makers may choose to take this into account in order to implement a tax regime consistent with national energy policy goals. ■

References

1. MIT (2003), *The Future of Nuclear Power*, MIT, Cambridge, MA.
2. NEA and IEA (2005), *Projected Costs of Generating Electricity – 2005 Update*, OECD, Paris.