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New discounted cash flow method: Estimating plant profitability at the conceptual design level while compensating for business risk/uncertainty

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ABSTRACT

Conceptual design of a new plant involves the evaluation of alternative plant configurations to determine physical feasibility (does each achieve desired production levels within the required quality limits?) and economic viability (is sufficient profit generated each year of a multiyear projected lifetime while requiring an acceptably low initial capital investment?). In testing alternatives, designers require both an absolute measure and a normalized measure in order to make a definitive evaluation. In recent years *NPV* (*Net Present Value*) has often been chosen as the absolute metric and *IRR* (*Internal Rate of Return*) as the normalized one. But these two measures provide insufficient information to develop an optimum design that can be guaranteed suitably profitable, i.e., with optimum design profits high enough to justify investment . . . more importantly, high enough to warrant taking on the risk/uncertainty characteristics of a particular product/plant with the business environment in which the constructed plant must operate.

In this paper a relook at discounted cash flow procedures motivates a new metric based on a *normalized and annualized* value of *NPV*, designated $NPV_{\%}$. In line with traditional analysis, a required minimum value – $NPV_{\%}^{required}$ (%/year) – once found via ad hoc and/or first principles methods, is assumed to represent suitably the Enterprise's profitability expectations plus the "premium" needed to justify intrinsic business risk/uncertainty. The ability to achieve a value that justifies anticipated risk, however that property is calculated or characterized, is a major element in determining whether projected returns from a particular design are high enough to justify proceeding with the project.

Surprisingly, a close analysis of spreadsheet methodology used for discounted cash flow calculations, such as in calculating *NPV*, reveals unexpected underlying linearities, e.g.,

$$NPV = a(Profit_{BT}) + b(FixedCapital)$$

when "factored estimates" are used (usually the case at the conceptual design stage), as well as

$$ROI_{BT} = e(NPV_{\%}) + f$$

Thus maximizing either ROI_{BT} or $NPV_{\%}$ is equivalent to minimizing the time to achieve return of invested capital (exposure to risk). *NPV* measures the effect on a company's balance sheet that will result from a decision to design/construct/operate. Thus once an appropriate risk premium for a plant is agreed upon, a rigorous design procedure can utilize a constrained optimization procedure in which *NPV* (absolute profitability) and $NPV_{\%}$ (inverse of time exposed to the risk of capital loss) are jointly optimized, subject to the constraint $NPV_{\%} > NPV_{\%}^{required}$. How much to weight the long-term profitability vs. speed of capital return is essentially a decision for the designers/investors.

1. Introduction

In the past two to three decades, the methodology for evaluating plant economics at the conceptual design stage has converged to use of just a few main approaches and metrics. The use of discounted cash flow (DCF) methods has assumed a primary importance, with the *Net Present Value* (*NPV*) of a proposed project most often used as the primary *absolute* metric. If the constructing Enterprise's overall *Rate of Return* (the annual year-over-year growth of its net assets or "book value") is used as the *Discount Factor* in the DCF calculations, *NPV* essentially measures the potential increase in the Enterprise assets or book value above this "expected return that would result from constructing and operating the proposed plant over the entire construction and operations period. Of course, all design and market assumptions must hold true for this interpretation to be valid. With this measure, positive *NPV* denotes

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