Measuring the Costs and Benefits of New Technology: a framework for photovoltaics

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MEASURING THE COSTS AND BENEFITS OF NEW TECHNOLOGY:

A FRAMEWORK FOR PHOTOVOLTAICS*/

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ABSTRACT

Existing benefit-cost evaluations of photovoltaic technology use inappropriate discount rates as well as accounting-based benefit measures which ignore some of the technology's important attributes. This paper outlines the application of finance theory to the evaluation of Photovoltaics including estimation of benefits, risks and discount rates. The resulting KWH cost estimates for PV power are lower than previous analyses suggest.

INTRODUCTION

The economic potential of photovoltaics (PV) is frequently evaluated using benefit/cost (B-C) methods which discount future costs and benefits into present values. A growing body of literature is beginning to identify the limitations of traditional B-C techniques as applied to new technology. Increasingly, academic accountants and economists are suggesting that myopic applications of project evaluation techniques, generally coupled with the use of accounting-based cost information, have repeatedly failed to identify promising new technologies thereby leading to widespread disinvestment policies among American industries. Photovoltaics present an opportunity to evaluate a new technology using broader, more appropriate measures that better reflect the technology's economic attributes.

Current photovoltaic project evaluations, which suggest that PV is "not yet" cost-effective, contain flaws similar to those identified in the literature [e.g. see Kaplan, 1986] and therefore continue the U.S. dilemma: in various cases where it appeared that investment in new technology was "not yet" cost-effective foreign competitors proceeded, often gaining important global advantage.

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*/ Forthcoming: Proceedings, Solar World Congress 1991, Denver: International Solar Energy Society; Pergamon Press.

This research partly supported by the Massachusetts PV Center, the University of Lowell PV Center, Sandia National Labs and the Solar Energy Research Institute.

6. **New Technology Eliminates Old Dichotomies:** Traditional production theory held that product quality and manufacturing cost were directly related: raise quality and costs must rise. This paradigm is based on an accounting model which tracks the average cost of all units produced without identifying the cost of producing and repairing defectives. In contrast, it is now widely held that manufacturing quality does not necessarily cost more. This significant innovation of thought is enabled by new technologies and approaches to manufacturing.

New technology thus enables former dichotomies to be turned into joint-products: e.g. you can reduce automobile emissions <u>and</u> improve a car's gasoline mileage with micro-processor technology in the carburetor. Fuel efficiency and clean air become joint products of the technology.

PV likewise obviates old paradigms and dichotomies. It generates clean energy thus eliminating the need for subsequent clean-up or add-on emission control. If the lessons of the new manufacturing hold, this is the least-cost option as compared to fossil-based generation alternatives.

7. **Failing to recognize the benefits of low marginal-costs operation:** New technology generally operates with low marginal cost which allows for pricing flexibility. This issue is not well understood since it is easy to confuse accounting with economic costs. Some authors [e.g. Berliner and Brimson, 1988] suggest that capital intensive technologies are risky by virtue of their potentially high debt service requirements yet this confuses asset risk with financing risk. Debt service relates to financing risk, not the asset's operating leverage risk.

APPLYING THE LESSONS TO PV -- DISCOUNT RATES

A proper framework for evaluating PV technology addresses all of these issues [see Awerbuch, 1991]. In this paper we focus on the issue of discount rate estimation.

The basis of project evaluation is to discount future costs and benefits into present values. Larger discount rates produce smaller present values. More importantly, high discount rates favor expense-intensive technologies (e.g. combustion turbines) over capital intensive ones.

Discount rate estimation is based on theoretical approaches to risk measurement using the Capital Asset Pricing Model (CAPM). The discount rate must correct for the risk-differentials among generation alternatives being evaluated. It is incorrect to compare several generation alternatives using the same discount rate. Using classical risk definitions PV-based generation is less risky than fuel-based generation which suggests that its net cash

AN APPLICATION -- ESTIMATING THE KWH COST OF PV

Consider a firm whose sole business is the sale of PV-generated electricity to a utility under an IPP agreement. In addition to the initial outlays for PV systems and land, the major factor affecting the estimate of KWH power is the firm's cost of capital. An analysis of such a firm was recently made in order to develop a "proxy" IPP bid for PV-generated electricity.

The cost of capital estimates are predicated on the following assumptions: i) Capital markets are perfectly competitive; ii) PV cells are sold in competitive markets; iii) PV cells have a 30-year technological life -- there is no decay in output efficiency until the end of their life; iv) Manufacturing costs for PV cells fall over time according to a pre-specified learning curve; v) The utility buys all of the firm's energy output.

The firm's cost of capital can be estimated using the CAPM which relates required return on the PV project to investment risk: $R_p = R_f + \beta_p(R_m - R_f)$, where R_p is the required return on the PV project; R_f is the prevailing risk-free rate of return (generally the yield on government obligations); R_m is the required return on a diversified market portfolio; β_p, the project's beta, is the covariance of the firm's return with those of a broadly diversified portfolio [see, for example, Seitz 1990]. Beta measures systematic risk relative to a diversified portfolio.

The range of expected returns for the proxy bidding firm indicates beta estimates in the range of $-0.1 \leq \beta \leq 0.1$. This supports the notion that the risk of PV as defined[1] is uncorrelated to broad market risk so that its introduction to a diversified portfolio will not increase risk significantly. This means that the required return for this firm's shares is quite low -- the correct cost of capital ranges around 6.3% to 7.7%. This rate is applied to the firm's initial investment, assumed to be $7,000/kw of capacity.

The remainder of the cost analysis is done by disaggregating the cash flows and discounting each at its own risk-adjusted rate which may be different than the cost of capital. The present value of the operating flows is added to the initial system cost (less investment tax credit). The result is divided by the hours of production (2190 per year) to get a present-value cost per KWH, which is then annuitized over the 30-year period to develop a levelized cost per KWH.

KWH cost estimates were made for three Beta values: -0.1. 0.0, and 0.1 which correspond to discount rates of 6.3%, 7.0% (risk-free) and 7.7%. The KWH cost estimates for these discount rates are $.180, $.194 and $.207 per KWH.

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1. Other risks such as technical failures, discontinuities in the price of PV cells or the introduction of some other, more efficient technology have been ignored.