Renewable Portfolio Selection

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Introduction

Due to government incentives such as the investment and production tax credits, on-site power generation from renewable sources is an economically feasible option with a decent return on investment. For example, General Motors, our industrial partner, is using solar panels on several assembly plants and distribution centers; the football stadium of the Philadelphia Eagles is installing a mixture of wind and solar generation. A vital question in such circumstances is the correct selection and quantity of the various renewable sources. It is well known that the peak wind turbine output occurs usually at different times from the peak solar output and thus, if possible, a mixture of both is a viable option.

Such large industrial sites face the problem of making an investment decision on on-site renewable generation while still engaging with power markets through spot purchases and power purchase agreements. This research developed an analytical tool for long term financial planning of renewable installations. The web-based system provides financial assessments of various contractual options. The site owner can own the installation, it can lease the roof, or a combination of the two where it would lease the space in initial years and then repurchase the installation. For each option we provide a thorough assessment including a Monte-Carlo simulation considering uncertainties such as the price of renewable energy credits (RECs) and electricity rates.

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The net present value (NPV) of a contract is expressed as

$$\sum_{t=1}^{T} \frac{P_t}{(1 + r)^t},$$

where $r$ is the discount rate and $T$ denotes the number of years in the planning horizon. In year $t$, the general expression for the cash flow is

$$P_t = [\text{revenue from REC}] - [\text{grid electricity cost}] - [\text{renewable electricity cost}] - [\text{renewable operational cost}] + [\text{annual tax benefit of depreciation of the installation}].$$

The revenue from REC and the renewable operational cost is zero if the site owner does not own the installation in the incumbent year $t$, which can be indicated by setting the per-REC price and O&M cost to zero. The electricity cost vanishes if the owner owns the installation and consumes the energy produced. The appeal of this model is that it can capture all of the three aforementioned variants of a contract.

Usually, the NPV is treated as a single number based on single-value predictions (point forecasts). The assumptions lying beneath are rarely reported or even understood. In this project we shed light on four key input parameters and offer a simulation based approach to obtain confidence intervals of NPV. The four parameters are

1. the grid rate escalation,
2. the degradation rate of the renewable installation,
3. the renewable energy rate escalation, and
4. the renewable operating cost escalation.

Samples are generated based on three choices of distributions: normal, triangular, and log-normal.

Often a firm is considering several possible installation projects with a limited initial capital investment. This NPV calculation is combined with optimization to select the best subset of projects. The objective function of the underlying so-called knapsack problem is to maximize the overall NPV while capping the total investment below the budget limit.
The Renewable Portfolio Standard (RPS) usually places an obligation on electricity supply companies to produce a specified fraction of their electricity from renewable energy sources. In this project, we apply the RPS concept to a portfolio of projects where the selected projects must derive at least a certain percentage of the overall energy from renewable installations. This requirement add an extra constraint to the optimization model.