A Modified Levelized Cost of Energy Model to Provide Purchase Prices and Price Schedules to Power Purchase Agreement

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Introduction

The use of Power Purchase Agreements (PPAs) has been increasing around the world and 29,632 MW in 343 signed or planned PPAs for wind farms existed as of January 2014. The cost of energy is an increasingly important issue in the world as renewable energy resources are growing in demand. Performance-based energy contracts are designed to keep the price of energy as low as possible, while controlling the risk for both parties (i.e., the Buyer and the Seller). Price and risk are often balanced using complex PPAs. Since wind is not a constant supply source, to keep risk low, wind PPAs contain clauses that require the purchase and sale of energy to fall within reasonable limits. However, the existence of those limits also creates pressure on prices causing increases in the Levelized Cost of Energy (LCOE). Based on variation of performance parameters such as capacity factor (CF) and economic parameters such as the inflation rate, the power generator (the Seller) may find that the limitations on power purchasing given by the utility (the Buyer) are not favorable and will result in higher costs of energy than predicted. In this research, a new cost model is developed to evaluate the price of electricity from wind energy under a PPA contract that addresses those variations and uncertainties mentioned earlier. In particular, in this paper, the pricing and price schedule of a wind project under a PPA contract is studied.

Approach

Existing cost models do not take into account energy purchase limitations or variations in energy production when calculating an LCOE, where the LCOE is the sum of costs over the lifetime of the project, *Equation 1*. The costs in the LCOE equation include initial investment (*I*), operations and maintenance (*OM*), fuel cost (*F*), production tax credit (*PTC*), depreciation (*D*), tax levy (*T*), and royalties or land rent (*R*).

$$LCOE = \frac{\sum_{i=1}^{n} \frac{I_i + OM_i + F_i - PTC_i - D_i - T_i + R_i}{(1+r)^i}}{\sum_{i=1}^{n} \frac{E_i}{(1+r)^i}} \qquad (1)$$

To find an accurate LCOE for wind farms under a PPA, the standard LCOE equation should be modified to include the uncertainties in energy production and fit the energy delivery parameters within a given PPA. This includes creating parameters in the equation (e.g., expected power production, etc.) that can be adjusted to fit each wind farm's unique PPA. The equation is modified to include common terms maximum energy purchase penalties and minimum energy purchase penalties. Using the LCOE of the contract, a single purchase price can be found that either includes a projected inflation rate or includes an increasing price schedule with the expected inflation rate. This involves finding the necessary LCOE to break even, finding the total revenue from energy that is purchased and then discounting the total revenue from each kWh

produced over the lifetime of the project according to the expected inflation rate. Using this model, a new price schedule is developed that either increases according to inflation or remains constant during the project.

Main body of abstract

PPAs attempt to create a fair agreement between the power generator (the Seller) and the utility purchasing the power (the Buyer). This includes creating terms that share the risks to the project that can generate extra costs. In a renewable energy contract, this typically involves the uncertainty of energy production. A Buyer, when entering a new energy contract, expects to receive roughly the same amount of energy every year. The amount of energy specified by the contract is crucial for the utility to have a sufficient supply to be able to meet their projected consumer demand. However, renewable energy sources are not always certain of the energy production and they can produce either too little energy for the Buyer to be able to meet demand or more energy than the Buyer wants to purchase. PPAs solve this problem by creating annual energy purchase limits in which energy will not be purchased after a certain amount and/or a requirement where the Seller will have to pay for energy that was under-produced. A typical LCOE model reviews all costs associated in the project, but does include the costs from creating energy purchase limits.

Calculating the closest estimate of LCOE is crucial for the success of a wind farm. The results from an earlier work on developing a new LCOE model for PPAs show that there is a difference between the actual LCOE calculated without penalties and the LCOEs that have penalties, As seen in Figure 1. If the LCOE is too low and does not reflect a close to perfect break-even cost, the wind farm could fail. This study looks at actual wind farm data to calculate the costs created by PPA's power purchase limits and determines LCOE according to each wind farms own PPA and limits. The actual onshore/offshore wind farm data of Germany and Denmark, from 2013 to 2015 are used for this study. Using the LCOE, a power purchase price can be determined from the LCOE that includes the costs from penalties. The price for energy then can be either a constant price accounting for a future inflation rate or a price that increases every year according to the determined inflation rate.

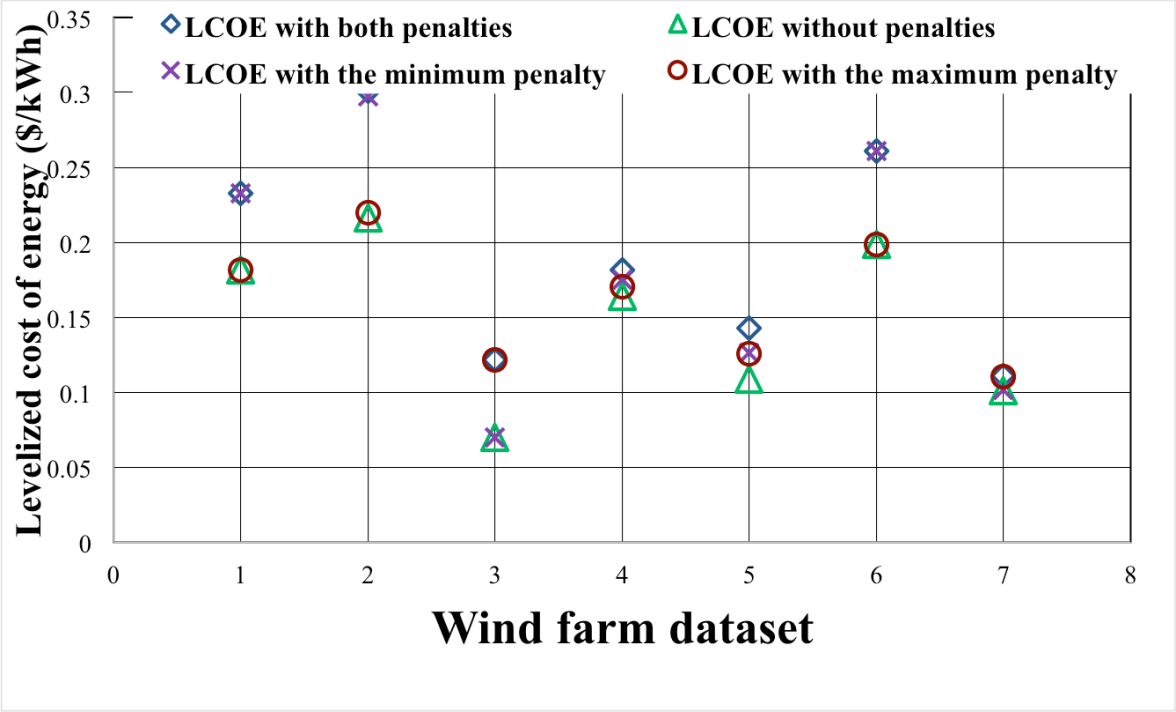

Figure 1 – LCOE for PPA comparison

Conclusion

The mechanisms that PPAs use to reduce the risk of additional, unforeseen costs create a paradox of increased costs for the Seller in the contract. Maximum and minimum annual energy delivery quantities increase the actual LCOE for wind farms. Depending on the contractual terms agreed upon for annual energy, the Seller can project LCOEs from expected future costs and the projected CF to help determine the best options for a price schedule and cost of energy for each kWh. Often, a PPA is bid on in which the price is already stated in the bid. Formulating a feasible PPA price and schedule that reflects at least a break-even price for the wind farm is critical to the success of the wind farm. Without a correctly calculated LCOE, the project could fail, negatively affecting both the Seller and the Buyer as the Buyer is expecting to meet consumer needs using the Seller's generated energy. Using this model, PPAs will come close to their goal of creating a fair contract.

Learning objectives

- To provide a new LCOE model that allows for better negotiation of PPA prices and bids
- To provide a method to create a fair contract between the Buyer and Seller
- To provide a modified pricing and price schedule of wind projects under PPA contracts considering the penalties for under-delivery or over-delivery limits