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Improved methodology for determining the value of energy from distributed renewables using statistical analysis combined with normative scenarios

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Abstract

The financial benefits of a distributed electric generation facility cannot be calculated without an expectation of the electricity's market value. Prediction of long-term future prices is a difficult but mandatory task, which is often reduced to constant annual prices with steady annual growth rates. This study provides a methodology for predicting electricity prices at an hourly resolution for long-term analysis, using the Swedish case as an example. It includes a statistical examination of historical data inspired by the meteorology sector to create a "typical year" of hourly price values. Future prices are calculated by applying annual rate changes to the typical year curve, using a monthly resolution to allow for seasonal variations. Rate changes are predicted using historical trends and current market conditions for near-term prices, and a normative scenario for mid- to long-term prices. The resulting methodology can be used in part or whole for any market in which historical data is available and a normative scenario created.

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Keywords: Methodology, prices, long-term forecast, investment analysis, renewable energy, normative scenario

1. Introduction

For building owners considering a renewable energy installation, investment analysis requires predicting future electricity prices. It is common to assume a constant price of electricity throughout the year that grows steadily over the life of the system [1-4]. This method can lead to overestimations of prices in the mid- to long-term and does not consider seasonal variations or a time-of-day pricing option. This paper presents a methodology for long-term forecasting of hourly prices using the Swedish market as an example. The process has two steps: establishing a neutral annual price curve that represents a "typical year" and then projecting the curve out for the lifetime of the investment.

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2. Annual price curve generation

The process begins by deriving the hourly prices for a typical year from historical data. Nord Pool, the deregulated spot market in the Nordic region, has the largest influence on wholesale electricity prices in Sweden [5]. Since joining Nord Pool in 1996, prices have been notably inconsistent with no discernible pattern. Approximately half of the years (most before 2001) have flat curves with slightly lower summertime prices, and the others have distinctly unique and random profiles. This is attributed largely to the high proportion of hydropower and electric heating in the Nordic electricity system [6], however it is preferred to avoid weather inputs for long-term analysis and therefore this method relies on statistics.

2.1. Overview of methodology

To handle the inconstant behavior of the spot market and create a representative curve for long-range analysis, the typical meteorological year (TMY) method for weather data is applied. TMY data sets are created by selecting specific months of data based on how representative they are of the long-term average month, and then stitched together to create the annual weather profile [7].

To apply this technique to electricity prices, each hour of the day within a month is considered its own data set. For each data set, a statistical analysis (described in detail below) is performed to determine the most representative price. This value is then used to calculate a normalized root mean square (NRMS) from all prices in each hour. The 24 NRMS values from each day are averaged together to represent that month, and the month that has lowest NRMS from all years is selected. The inflation adjusted, hourly pricing data for the selected months is then used to build the final typical year curve. To ensure that the prices are relevant to the current market, the difference between the average annual prices of the most recent year's curve and typical year is added to create the final typical year curve.

2.2. Statistical analysis alternatives and example

The statistical analysis to determine the most representative price is a critical feature of the method, therefore several alternatives have been reviewed; highest probability, mean and median. Fig. 1 shows the hourly prices for representative days in June and December using each of the selection criteria. It shows that the high probability curves are unstable, which is due to the prices not following a normal distribution. For example, histograms for hours two and three in June show that the data sets are similar, but have wide, even distributions with multiple peaks, making highest probability an unsuitable method. The mean and median values are very similar, and two selection options are proposed. One is to use the lower average annual NRMS, which in this case favors the median. However, the mean values will be used because the average monthly prices match the curve patterns of several past years.

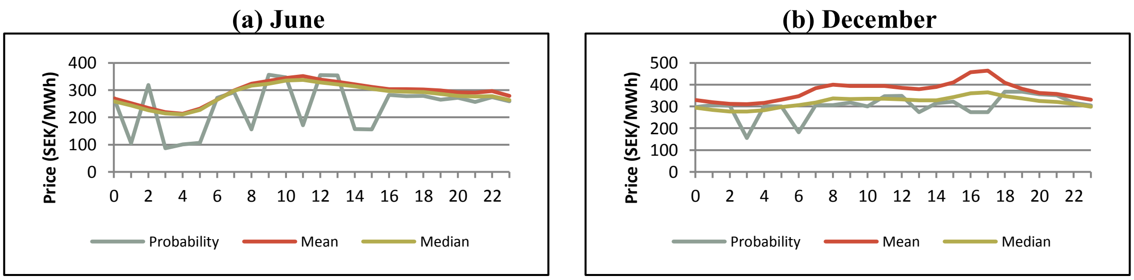

Fig. 1. Most representative days for (a) June and (b) December

3. Long range forecast

Long-range forecasting is an imprecise but necessary task. Smil [8] recites a long list of forecast errors in energy prices and demand in several sectors, and suggests increased use of normative scenarios rather than prediction. Hamm and Borison [9] note that forecasters bias their input sources from the past and present, and suggest merging financial and engineering data with a future focused approach. These suggestions are applied here in a methodology for projecting an annual price curve for the lifetime of an investment.

3.1. Near-term trends

To determine near-term (5-10 years) electricity price trends, historical data is examined and combined with current market dynamics. Monthly averages are calculated using Nord Pool clearing prices from 1996-2013. Each month is then plotted across all of the years and a linear regression used to find the average annual rate change. This long-term average can then be compared to the current market conditions and industry predictions to determine near-term pricing trends.

3.2. Normative scenario and back casting

Normative scenarios can be developed internally, extracted from regional government documents or a combination of both. Once developed, the expected path taken by government, industry and consumers is back casted to the near-term trend. Prices are then derived from the back casted events. While only one scenario is presented here, it is good practice to develop several to capture a range of possible outcomes.

3.3. Methodology and example

To project prices into the future, year-on-year rate changes are specified for every year, which permits non-linear changes in price. Rate changes are applied to each month separately to capture potential seasonal variations. Monthly resolution is relevant for electric systems, present or planned, with seasonal renewable generation that cannot be dispatched on demand.

In this example, the expected near-term trend is that prices will continue to increase but at a steadily decreasing rate as consumers seek alternatives and the market calibrates. The normative scenario is based on several reports and policies that indicate the development direction for Sweden [10-14]. Increased installation of renewable energy and transmission networks result in continued high prices in the mid-term but will eventually decrease as the cost of renewables decrease. Nord Pool prices since 2000, the 30-year projections, and the 2013 average price with a 4% annual growth rate are compared in Fig. 2.

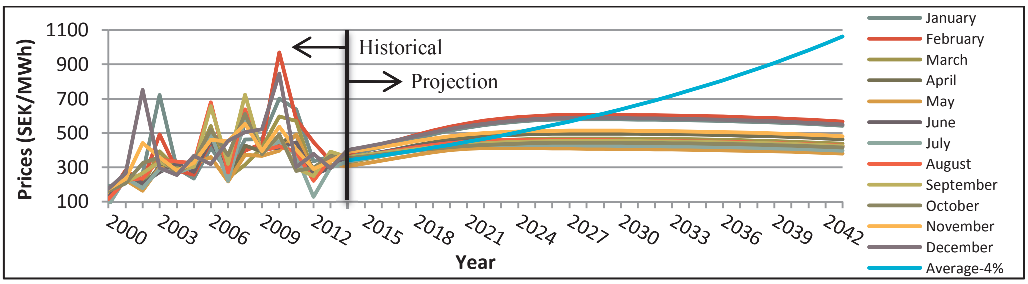

Fig. 2 - Price forecast for each month, projected out 30 years (in real 2012 SEK)

4. Conclusion

A methodology for determining hourly prices for use in renewable energy investment analysis has been described and demonstrated using the Swedish market. This technique can be used in any market with available data and has advantages over simple linear forecasting methods, such as; consideration of time-of-day pricing, a monthly resolution that can capture seasonal pricing effects, and dynamic annual growth rates. Future work will demonstrate the affect this methodology has on the financial analysis of distributed solar systems.

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Biography

Nelson Sommerfeldt is a PhD candidate at the KTH School of Industrial Technology and Management (ITM) researching the techno-economic conditions of solar photovoltaic systems in Swedish multi-family housing. Hatef Madani received his PhD in Energy Technology from KTH Royal Institute of Technology, Sweden. He currently works as a Post-Doctoral researcher and teacher at KTH School of ITM.