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# STOCHASTIC LCOE AND RISK/COST TRADE-OFF IN ELECTRICITY GENERATION PORTFOLIO SELECTION

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## Overview

Investment decisions and investment assessment in electricity production are usually supported by a Levelized Cost Of Electricity (LCOE) analysis, where the LCOE is obtained as the deterministic solution of an algebraic equation, in which fuels prices and CO2 costs are included as dynamic deterministic variables (expected values of future prices and costs). LCOE is then the break-even cost over which an investment becomes profitable.

Promoting fuels and CO2 costs dynamics from deterministic to stochastic processes, for which parameters can be estimated from market data, promotes LCOE from deterministic to stochastic, with a distribution, a variance and an average value. This makes the new definition of LCOE sensitive to market risk, since its variance can be used as a market risk indicator. Moreover, in this new stochastic frame, the generation plants of a generation company can be collectively seen as a portfolio, for which a risk-cost (i.e. variance-cost) Markowitz analysis can be performed, helping investors and property assessors to include uncertainty on fuel and CO2 price dynamics in their LCOE analysis for any given fuels mix. Since it can be shown that in this frame most of the risk comes from thick and asymmetric LCOE distribution tails, the variance-cost Markowitz analysis can in turn be replaced by a more apt risk trade-off measure, the CVaR (Conditional Value at Risk), which is very sensitive to tail risk. The utility of the stochastic LCOE theory is highlighted applying it to the case in which the addition of a nuclear plant to an existing fossil fuels portfolio is considered. In this case, it is shown that investment risk is reduced in the variance-cost scheme, but not necessarily in the CVaR-cost scheme. Then, using the stochastic LCOE methodology, companies or public planners can explore risk-cost trade-offs taking into account a variety of risk attitudes.

## Method

The methodology is discussed for the case of an US investment, using typical US prices and costs. A stochastic dynamic frame to model fossil fuel prices (gas and coal) and CO2 price is set up by means of a system of stochastic differential equations (sde). The coal price is modeled by means of a mean reverting process, the gas price is modeled by a mean reverting process with jumps, and the CO2 price by a geometric Brownian motion. Not only one, but three possible CO2 price sde dynamics are explored, using three different volatilities. The case of a company owning a gas, a coal and a nuclear plant is used as an example. For the variance-cost approach, all possible portfolios for the three CO2 scenarios are plotted in the mean-standard deviation Markowitz plane, and optimal portfolios are discussed. The results are compared to the case in which the company starts without the nuclear plant. For the CVaR approach, only the case in which the company owns a coal and a gas plant is studied. In this case, the CVaR-(expected)cost curve for all possible portfolios is computed, and it is mapped to the same variance-cost plane found in the variance-cost approach for the no-nuclear case.

## Results

In the case of the variance-cost approach, for all three CO2 scenarios the addition of a nuclear plant makes the portfolios less risky than the portfolios in which the nuclear asset is not present, for any given level of expected cost. In the highest CO2 volatility scenario, it turns out that it is not even convenient to include the coal plant. For the CVaR-cost approach, one specific CO2 volatility scenario is chosen in order to simplify the comparison. Using the CVaR-cost mapping to the variance-cost plane, the analysis shows that the optimal portfolio is very different from the portfolio found in the variance-cost approach, and that the optimal portfolio of the variance-cost approach is suboptimal in this case.

## Conclusions

The stochastic LCOE methodology is useful to assist assessment and investment decisions in electricity portfolios, and extends the existing deterministic LCOE methodology to include risk attitude in the decision. It is flexible, in the sense that it can include different risk measures, to take into account different risk attitudes.

## References

Mari, C. (2014) ‘’Hedging Electricity Price Volatility using Nuclear Power’’, Applied Energy, 113: 615-621.