# Financial Performance of Alternative Energy Firms

By Kenji Hewitt
Supervised by Dr. Alexey Rubtsov
Department of Mathematics, Ryerson University

## Motivation

According to Bloomberg NEF, global markets saw a 3 percent growth in clean energy investments to over $330 billion in 2017. The demand for green energy investments is growing but there is still a major hurdle to overcome before its potential can be realized: performance. Boulatoff and Boyer[1] found that green firms underperformed comparable to Nasdaq firms by 9 percent over a five-year period ending in October 2008. Additionally, the green firms experience more volatility. Institutional investors are becoming more inclined to make socially responsible investments but do not wish to sacrifice returns in the process. Is it possible to have their cake and eat it too? Increasing returns while lowering risks is the ultimate goal of every investor, but can it be achieved by incorporating alternative energy firms into the portfolio?

## Overview

Two portfolios were constructed: a "black" portfolio of companies who generate energy using non-renewable sources (coal, petroleum, etc), and a "green" portfolio of companies who generate a majority of their energy through the use of renewable energy sources (geothermal, solar, biomass, etc). The exact composition of each portfolio and a short description of their assets are shown below:

| Black Portfolio | |
|---|---|
| Firm | Operations |
| Anadarko Petroleum Corp. | Crude oil, petroleum |
| Devon Energy Corporation | Crude oil, petroleum |
| Chevron Corp. | Chemicals, petroleum |
| NextEra Energy | N Crude oil, petroleum |
| Noble Energy Inc. | Crude oil, petroleum |
| Pioneer Natural Resources | Petroleum, natural gas |
| Valero Energy Corp. | Crude oil, petroleum |
| Exxon Mobil Corp. | Crude oil, petroleum |

| Green Portfolio | |
|---|---|
| Firm | Operations |
| Ormat Technologies, Inc. | Geothermal, solar |
| Renewable Energy Group, Inc. | Renewables |
| Ballard Power Systems | Fuel Cells |
| Enphase Energy | Photovoltaics |
| First Solar Holding, LLC. | Photovoltaics |
| Green Plains Renewable Energy, Inc. | Ethanol |
| Ocean Powers Technology, Inc. | Wave |
| SunPower Corporation | Photovoltaics |

Initially, the efficient frontier will be computed using the historical data from 1/04/2012 to 1/04/2013 which consists of 251 data points of stock adjusted close prices, then assume the investor is highly risk averse and chooses the global minimum variance portfolio. To generate the efficient frontier, one must resort to numerical optimization techniques to find a solution to the problem

$$\begin{aligned} \underset{w}{\text{minimize}} \quad & \{CVaR_{1-\epsilon}(w^T R)\} \\ \text{subject to} \quad & w_i \geq 0, i = 1, \ldots, n, \\ & w^T \mu \geq \bar{\mu}_p, \\ & w^T \mathbf{1} = 1 \end{aligned} \tag{1}$$

The constraint $w_i \geq 0$ restricts short selling within the portfolio. Then next step it to perform an out-of-sample test of the portfolios and backtest them from January 2013 to July 2018, rebalancing and recording performance data on a monthly basis.

## Portfolio Optimization

Since no analytic solution for (1) exists, one must resort to optimization techniques which are often difficult to apply in practice. Krokhmal et al.[2] suggested a scenario-based optimization based on the approximation

$$\mathbb{E}[-R_p | R_p \leq -VaR_{1-\epsilon}(R_p)] \approx \frac{1}{q\epsilon} \sum_{i=1}^{q} w^T R^i$$

where $R^i = (R_1^i, \ldots, R_n^i)^T$ is the $i$th scenario for asset returns and $R_p$ is portfolio return. The portfolio optimization process is summarized by the following flow chart:

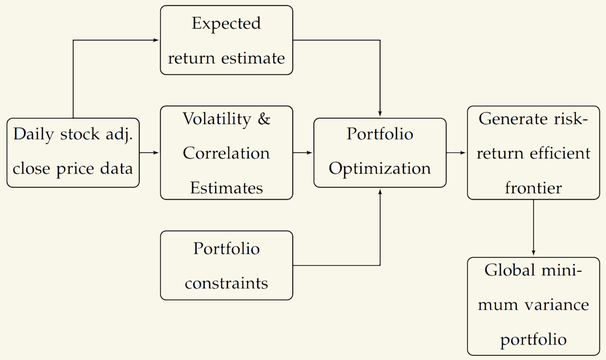


Fig. 1: Portfolio Optimization Process

Both the Mean-Variance and CVaR optimization approach are used to create the efficient frontiers.

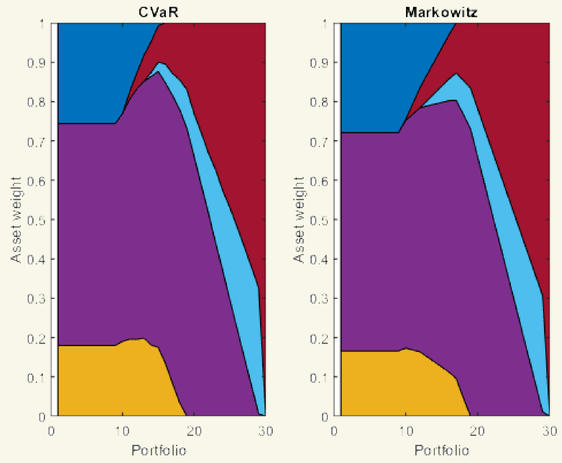


Fig. 2: Optimal Portfolio weights

## Results

| Sharpe Results | | |
|---|---|---|
| Portfolio | Monthly Sharpe | Annualized Sharpe |
| Black | 0.435 | 1.506 |
| Green | 0.358 | 1.240 |

Observe that the annualized Sharpe ratio is 21% higher in the case of the black portfolio. Given this information, investors will be more likely to invest in the black portfolio when comparing their risk-adjusted returns.

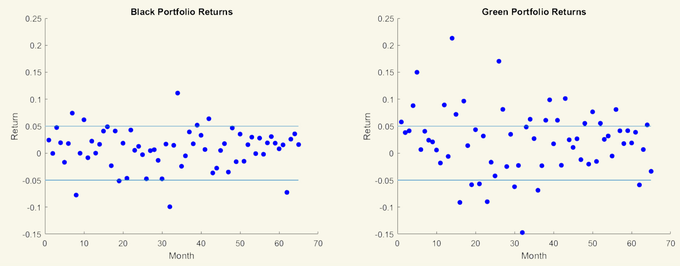


Fig. 3: Scatterplot of returns

## Conclusions

Institutional investors are becoming more inclined to make socially responsible investments but do not wish to sacrifice returns in the process. To address this potential conflict, the implementation of a carbon tax in combination with carbon mitigation policy may provide a financial incentive to invest in firms with a relatively low carbon footprint. In December 2016, the Government of Canada along with most provinces and territories have agreed to the Pan-Canadian Framework on Clean Growth and Climate Change. The key mission of the framework is to reduce greenhouse gas (GHG) emissions by putting a price on carbon pollution. In effect, firms that produce high amounts of GHG will pay more in taxes than a firm that produce lesser amounts of GHG, creating an incentive to reduce emissions. A similar framework could be implemented across the U.S, as it is one of the few large industrialized nations that does not have a carbon tax. A simple solution could be to implement a federal carbon emissions tax. This would create a financial incentive to reduce carbon emissions while imposing a cost to firms that produce high levels of GHG.

## References

[1] C. Boulatoff and C. M. Boyer. *Green recovery: How are environmental stocks doing?* The Journal of Wealth Management, 2009, p. 20.

[2] Uryasev S. Krokhmal P. Palmquist J. *Portfolio Optimization with Conditional Value-At-Risk Objective and Constraints.* 2001, pp. 17–25.

[3] Frank J. Fabozzi Sergio M. Focardi. "The Mathematics of Financial Modeling and Investment Management". In: 1 (2004), pp. 20–71.