Norwegian University of Life Sciences

Master's Thesis 2017 30 ECTS
School of Economics and Business

Investing in Alternative Energy Companies

An analysis of risk, return, and the price drivers for solar, wind, hydro and nuclear power companies through exchange traded funds

Ida Byre and Linda Engebakken Kverneng
Master in Business Administration

Preface

This thesis marks the end of our two-year Master's Degree in Business Administration at the Norwegian University of Life Sciences.

We thank our supervisors Ole Gjølberg and Marie Steen for introducing us to this topic, and for helpful comments and suggestions throughout the writing process.

Neither the institution, nor our supervisors are responsible for weaknesses in either the methods or conclusions drawn in this thesis.

Ida Byre *Linda Engebakken Kverneng*

Ås - May 11, 2017

Investing in Alternative Energy Companies

An analysis of risk, return and the price drivers for solar, wind, hydro and nuclear power companies through exchange traded funds

Abstract

Increasing new investment in alternative energy suggests that investors increase their share of holdings that promote cleaner energy and fewer emissions. This paper examines the performance of six exchange-traded funds (ETFs) that invest globally in alternative energy companies in the period January 2009 to January 2017. Our results show that all the funds except the fund in hydropower underperformed the market in the years following the financial crisis. We also analyse the relationship between the prices of the ETFs, oil, clean technology stocks, natural gas, and the market by using a multi-factor asset pricing model. We find strong influence of the S&P Global 1200 index and clean technology stocks; however, the influence of WTI Crude Oil and Henry Hub Natural Gas show no significant impact in the multi-factor model. Furthermore, we study the volatility development of the ETFs and look into global policies regarding the alternative energy sector. Our findings suggest that the ETFs have become less risky compared to the market throughout the period despite globally unstable policies.

Table of Contents

Ida Byre: Tel: +47 99586032. Email address: ida.byre@gmail.com

Linda Engebakken Kverneng: Tel: +47 47807072. Email address: linda.engebakken@hotmail.com

Introduction

The alternative energy sector[1] has experienced substantial growth over the last years, and new investments in the sector keep growing. New investment in clean energy reached a record in 2015 of 349 billion US dollars ($bn), which was an increase of 11% from 2014, and 30% from 2013 (BNEF 2016). The increasing awareness of climate change and concerns of global warming have made industries worldwide more focused on decarbonizing. Businesses like Google, Apple and Facebook race towards a 100% renewable energy target to reduce their companies' carbon footprint (Moodie 2016). However, as Sabbaghi (2011b) pointed out in his research on green exchange traded funds, these kinds of investments are considered to be highly volatile.

This thesis evaluates how alternative energy companies have performed during the period of 2009 to 2017 through exchange-traded funds (ETFs). We analyse six ETFs invested in solar power, wind power, hydropower and nuclear energy. We are investigating ETFs because they are financial instruments where most of them are set to replicate an index to assure cheap and simple fund management. This type of investment is popular because of its low costs and the easy access.

The very first ETF in alternative energy launched in 2005, and the market for ETFs in alternative energy has grown rapidly since. This paper investigates the relationship between returns in the funds in alternative energy and the broad-based market index, S&P Global 1200 (S&P 1200). We hypothesize that the funds in alternative energy have underperformed the S&P 1200 in the years following the financial crisis, because the sector has been troubling with high costs and is highly dependent on substitutes from the government.

We also investigate the role of clean technology stock returns and changes in oil and natural gas prices on the returns of the alternative energy ETFs. Previous studies by Kumar et al. (2012), Sadorsky (2012) and Inchauspe et al. (2015) find evidence for a positive relationship between the stock returns of clean energy companies and changes in the oil price. We assume that the relationship between the prices changes of oil and the returns of alternative energy ETFs are positive, as increasing oil prices encourage a substitution from oil to alternative energy.

Companies in the alternative energy sector rely on improving technology to become more efficient and affordable. More projects can be implemented because the technology improves and the costs of installing alternative energy facilities declines. We believe this leads to a positive effect between the returns of clean technology stocks and the funds in alternative energy. Another part of the energy sector is natural gas, which

[1] There are multiple common terms used to describe the alternative energy sector. We will consistently use the term alternative energy when describing our data, but terms as renewable, clean or green might appear when we refer to other studies or sources.

we consider as a substitute for renewables. Natural gas stands for about one third of the electricity generation in the U.S., and the EIA (2017b) expect the trend to continue. We hypothesize that positive price changes in natural gas leads to positive returns in alternative energy companies.

An obstacle in the expansion of the alternative energy sector has been the high costs, but because the technology improves, alternative energy is getting cheaper, and projects manage to survive even without subsidies from the government. According to the IEA (2016), wind and solar are the fastest growing sources of electricity globally, and in their 2016 report they state that "Between 2008 and 2015, the average cost of land-based wind decreased by 35 % and that of solar photovoltaics by almost 80%" (IEA 2016). The climate conference in Paris (COP21) in December 2015 shed new light on the importance of renewable energy. And, as of April 2016, 175 countries had signed the Paris Climate Agreement. There is still insecurity about the future of alternative energy, and the EIA (2013) states that fossil fuels will be the dominant energy source regarding energy consumption until 2040. However, when oil prices fell in 2014, the stock prices of alternative energy companies managed to stay stable. We believe increased focus on climate change and decreasing costs in the alternative energy sector have made the ETFs in alternative energy less volatile from 2009 to 2017 compared to the market.

To study the ETFs in alternative energy, we will try to answer three research questions:

H_1: *The alternative energy ETFs underperformed the market in the years following the financial crisis*

H_2: *The returns of clean technology stocks, oil and natural gas have significant explanatory value on the ETFs beyond what is reflected in the market index.*

H_3: *The alternative energy ETFs have become less risky since the financial crisis compared to the market index*

Literature Review

Previous research has examined the performance and the relationship between the price of alternative energy companies and the prices of oil, technology stocks, and market indices. There have been documented effect of oil prices, but the empirical evidence is not clear.

Henriques and Sadorsky (2008) use a four-variable vector autoregression (VAR) model to study the relationship between stock prices of alternative energy companies and the price of oil, technology stock prices, and interest rate. They find evidence for stating that oil prices, technology stock prices, and interest rate each have some explanatory value for companies in alternative energy using data from 2001 to 2007. The authors suggest that oil price movements may not be as important as they anticipated, because they find little or no significant evidence on the impact of oil price shocks on the stock prices of alternative energy. After these findings, there have been contradicting results regarding the impact of oil prices on the price of alternative energy companies.

Managi and Okimoto (2013) studied the relationship among oil prices, clean energy stock prices and technology stock prices from the period 2001 to 2010. They controlled for structural changes in the market, which is an economic condition that occurs when there is a significant change in the time series data, and found a positive relationship between clean energy stock prices and oil prices after structural breaks. However, the authors suggest that extending the data and applying a VAR model evidences a positive relationship between the price of oil and alternative energy stocks, supporting the importance of alternative analytical techniques. They also suggest that structural changes affect the relationship between the prices of oil prices, technology stock, and alternative energy stocks.

Kumar et al. (2012) also used a vector autoregression model to study the impact of rising oil prices on the stock price of clean energy firms from 2005 to 2008. The authors find evidence that past movements in the oil prices explain stock prices in clean energy firms. Also, past movements in the stock prices of high technology firms and the interest rate seems to explain stock prices of clean energy firms. Carbon price return was not a significant factor for price movements in clean energy firms. They suggest that carbon prices have not created a stimulus for the switch from conventional fossil fuels to renewables.

Sadorsky (2012) wrote a paper about volatility spillovers between oil prices and the stock prices of alternative energy companies. He find evidence that stock prices of alternative energy companies correlate better with technology than with oil prices. The author used a generalized autoregressive conditional heteroscedasticity (GARCH) process to look at the conditional correlations and to analyse the volatility spillovers from 2001 to 2010.

Inchauspe et al. (2015) studied how the stock market and technology stock prices played a role on renewable energy stock prices between 2001 and 2014. Using a multi-factor asset pricing model with time-varying coefficients, the authors find evidence for a strong influence of the MSCI World Index and technology stock prices on renewable energy stock prices. They find low influence of oil prices on the stock price of renewable energy companies, but suggest that oil prices have become more influential since 2005 because of its increased beta factor. They also find evidence for saying that the renewable energy sector underperformed the market index after the financial crisis, and suggest that the sector did not recover from the losses in this period.

Mallett and Michelson (2010) do not find any significant difference between green funds and index funds in the period of 1998 to 2007. Examining the performance of green funds for parametric and non-parametric tests, they suggest that there is no significant difference between the performance of green funds and other mutual funds during the nine-year period. However, Sabbaghi (2011b) finds evidence that a green portfolio outperformed the S&P 500 before the market collapse of 2008, but that it underperformed in the years following the financial crisis using data from 2005 to 2010. He also suggests that green ETFs are highly volatile after investigating the volatility dynamics and finds strong evidence of volatility persistence (Sabbaghi 2011a).

Data

Selection of the ETFs in Alternative Energy

We define alternative energy as any source of energy that is an alternative to fossil fuels, and we include ETFs in the nuclear-, solar-, wind-, and hydropower market. Updated portfolio holdings, investment weighting in sectors and countries are available on the homepages of the funds, and since they trade on an exchange all prices are available and easy to find. You find a presentation of the ETFs in Table 1, with official names, ticker codes and sectors. We present a thorough description of the ETFs' investment objectives, reference indices and inception dates in Appendix I.

Table 1: Description of the Alternative Energy ETFs

ETF Name	Ticker Code	Sector
First Trust NASDAQ Clean Edge Green Energy Index Fund	QCLN	Broad
iShares Global Clean Energy ETF	ICLN	Broad
Guggenheim Solar ETF	TAN	Solar power
First Trust Global Wind Energy ETF	FAN	Wind power
Guggenheim S&P Global Water ETF	CGW	Hydropower
VanEck Vectors Uranium + Nuclear Energy ETF	NLR	Nuclear energy

Two of the ETFs in alternative energy (ICLN and QCLN) are funds that invest broadly in the alternative energy sector. They invest in companies involved in energy production as well as companies investing in improving technologies and utilities for the alternative energy sector. QCLN is a US-based fund while ICLN is a globally diversified fund with its main investments in China and the U.S. The rest of the ETFs invest in a sub category of the alternative energy sector: solar power, wind power, nuclear energy and hydropower. The sub ETFs are not broadly invested in the alternative sector, but they each hold around 20 to 40 companies, which make them diversified within the sector.

To see how the ETFs have performed we compare them to a conventional broad index, the S&P Global 1200. This index will work as our benchmark because it gives a global exposure to the equity market by investing in seven major indices based in the U.S., Europe, Japan, Canada, Australia, Asia and Latin America. In addition, we will use the WTI Crude Oil Spot Price, Henry Hub Natural Gas Spot price and a Clean Technology Index (CTIUS) in our multi factor model. The Cleantech Index is developed by the Cleantech Group and is described as "the leading global index for publicly traded cleantech companies" (Cleantech Group). It tracks 53 publicly traded cleantech companies across a broad range of industry sectors from alternative energy and energy efficiency to advanced materials, air & water purification, eco-friendly agriculture/nutrition and power transmission among others.

We downloaded daily closing prices for the ETFs, adjusted for dividends, in US Dollars from the Yahoo! Finance database and converted them into weekly prices by extracting the price on the first trading day of the week. Daily prices for the S&P Global 1200 index, the Cleantech index and daily spot prices of WTI Crude Oil and Henry Hub Natural Gas was downloaded from the S&P Dow Jones Indices database, the Cleantech Group, Thomson Reuters Eikon Datastream and U.S. Energy Information Administration (EIA), respectively. We also obtained 3-month US Treasury Bill at the U.S. Department of the Treasury homepage to analyse the excess returns of the investments. To synchronize these data with the ETFs we had to remove all U.S. Holidays from the dataset as the alternative energy funds does not trade these days. In our analysis, we use weekly data, and the period is set from January 2009 to January 2017 to exclude the extreme impact of the financial crisis.

Description of the Alternative Energy ETFs

First Trust Nasdaq Clean Edge Green Energy Index Fund (QCLN)

This fund tracks the Nasdaq Clean Edge Green Energy Index and invest around 90% of its assets in stocks from the reference index. They mainly invest in clean-energy technologies like solar photovoltaics, biofuels and advanced batteries, and all the investments are publicly traded in the United States. The fund has $54 million in total net assets and charges a fee of 0.60% a year. The product holds 38 companies where top five holdings account for over 40% of the overall investment. Tesla Motor is the top investment with 10.4% of total net assets (as of March 20, 2017). See top three holdings in Box 1.

Box 1: Description of the top three companies for QCLN

Tesla Motor (10%) is an automotive company focusing on electric cars, but they also "install, operate and maintain solar and energy storage products" (Annual Report, Tesla Inc. 2017). The company has yielded negative earnings per share (EPS) since the beginning of 2009 with a mean of $-4,6 the last three years (Nasdaq 2017).

ON Semiconductor (10%) is a technology company, the second largest investment in the fund and offers energy efficient innovations (Corporate Fact Sheet ON Semiconductor, 2017). They are working towards reducing global energy use by supplying semiconductor- based solutions for customers and organizations and by reducing its own carbon footprint. The company yielded positive EPS in 2016, with an average of $0,29 since 2009 (ON Semiconductor 2016).

Hexcel Corporation (8%) is a "technology-driven company and a global leader in advanced composite technology"(Hexcel Corporation 2017). They offer products to the global market, especially for the commercial aerospace and the industrial, space and defense market. Earnings per

iShares Global Clean Energy ETF (ICLN)

The iShares Global Clean Energy ETF is a broad fund tracking the S&P Global Clean Energy Index and is therefore exposed to the global equity market (iShares by BlackRock 2016). The portfolio consists of 28 companies, mainly in solar and wind, but also in companies producing equipment for the sector, and in technology companies. The fund trade on the Nasdaq stock exchange, has $80 million in net assets and an expense ratio of 0.47% (as of March 20, 2017). The fund is also market-cap-weighted and seeks to invest in large and liquid companies. Most of the holdings are in Chinese-based companies, followed by the U.S. Top three company holdings lies in the countries of Brazil, China and Spain and represent 20 % of the investment universe.

Figure 1: ICLN - country holdings

Box 2: Description of the top three companies for ICLN

Companhia Energetica de Minas Gera (7.6%) is a power company located in Brazil, and is an important electrical energy provider. The company generates energy through hydroelectric plants and transports electric power from the facilities to the distribution networks for the end users. It is listed on three different exchanges in Brazil (BM&F Bovespa), New York (NYSE) and Spain (BME).

China Everbright International LTD (6.3%) is a company in Hong Kong that specialize in environmental resource management in China. It is listed on the "Hong Kong Exchange" and is the "first one-stop integrated environmental solution provider in the country"(China Everbright International Limited 2016).

Gamesa Corporation Tecnologica S.A (5.8%) is a technology company in the wind industry for the markets in Spain, China, India and Brazil, and is the world leader in developing wind farms (Gamesa 2017). The company is listed on the Bolsa de Madrid exchange (BME) in Spain.

Solar Power: Guggenheim Solar ETF (TAN)

The Solar ETF follows the “MAC Global Solar Energy Index” and gives global exposure to all parts of the solar industry (Guggenheim Investments 2017b). It is investing in companies involved in the full value chain in the solar sector, from material production to energy production. It has $202 million in total managed assets and an expense ratio of 0.71%. The fund is rebalanced quarterly and holds 28 companies (as of December 31, 2016). TAN has its top holdings in the U.S., followed by China and Hong Kong. All the top five companies are directly involved in the solar industry by producing photovoltaics or building and managing solar power plants.

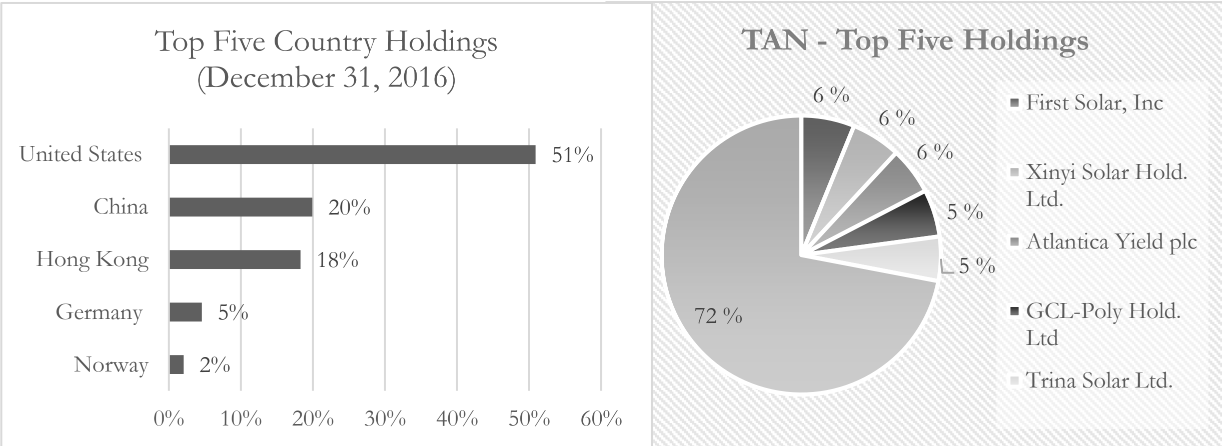

Figure 2: TAN - top 5 holdings and countries

Wind Power: First Trust Global Wind Energy ETF (FAN)

The Wind power ETF seeks to replicate the “ISE Global Wind Energy Index”, and gives exposure to businesses actively engaged in the wind energy industry and companies engaged in the development of a wind farm or production of electricity generated by wind power. Companies that provides goods and services exclusively to the wind energy sector are given an aggregated portfolio weight of 66.67%, and companies that are participating in the industry without being exclusive to the industry are given and aggregate portfolio weight of 33.33% (First Trust 2017). This ETF has $78 million in total net assets, and an expense ratio of 0.60%. It is rebalanced semi-annually, and holds 44 companies (as of December 30. 2016).

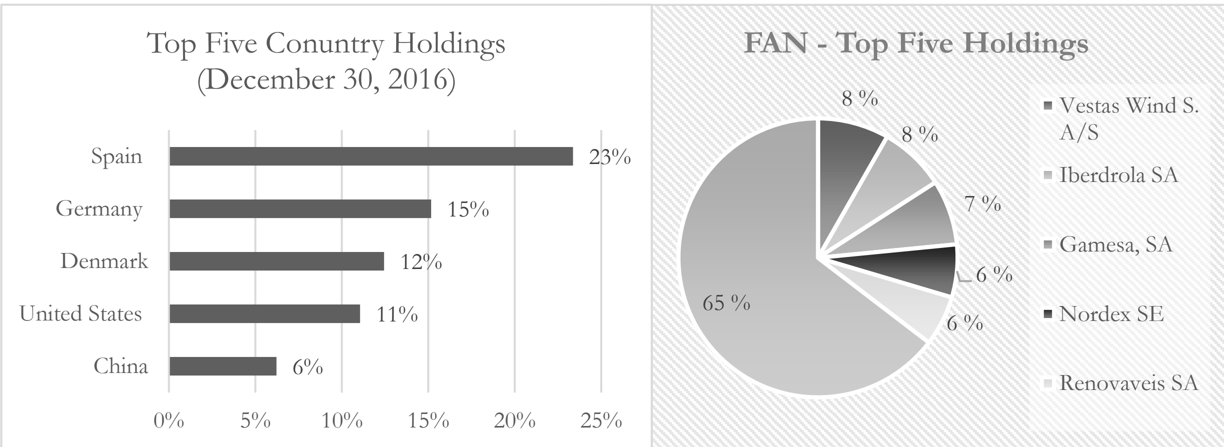

Figure 3: FAN - top 5 holdings and countries

Nuclear Power: VanEck Vectors Uranium+Nuclear Energy ETF (NLR)

NLR seeks to follow "MVIS Global Uranium and Nuclear Energy Index" and is exposed to companies investing in construction, engineering and maintenance of nuclear power facilities as well as the production of electricity from nuclear sources (VanEck 2017). It is also exposed to uranium mining and companies that provide equipment, technology or services to the nuclear power industry. This ETF has $35.21 million in total net assets and an expense ratio of 0.61%. NLR is rebalanced quarterly and has 26 holdings (as of February 20, 2017). All the top five companies are U.S. based diversified energy and gas providers.

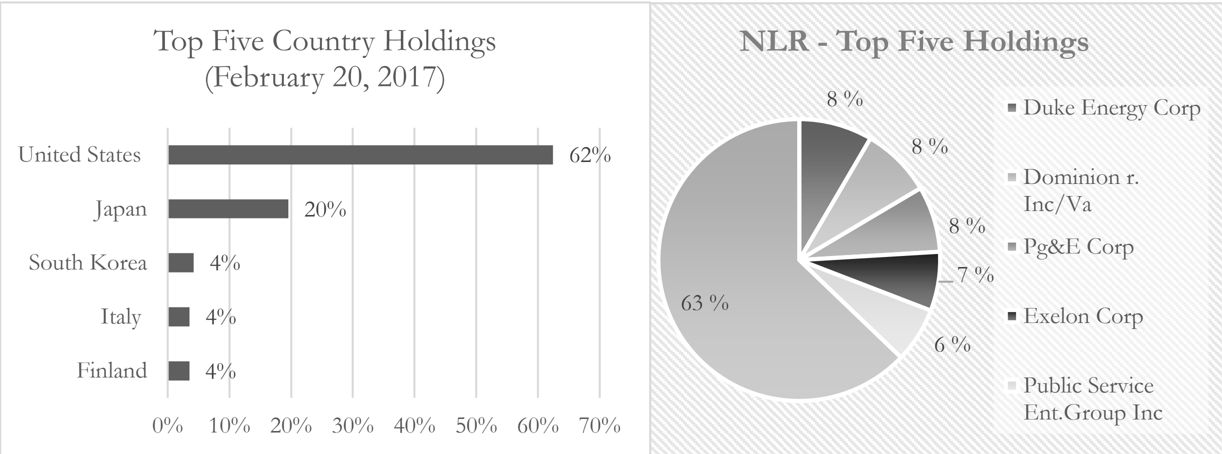

Figure 4: NLR - top 5 holdings and countries

Hydropower: Guggenheim S&P Global Water Index ETF (CGW)

CGW follows the "S&P Global Water Index". It is globally exposed to businesses that are investing in hydropower, water utilities, infrastructure, equipment, and materials used in the water sector (Guggenheim Investments 2017a). Their total net assets are $77 million and the fund has an expense ratio of 0.64%. This ETF is rebalanced semi-annually and has 53 holdings as of December 31, 2016 (Guggenheim CGW Factsheet). Out of the five biggest holdings, Xylem Inc. is the only company focusing on generating hydropower. Many of the companies that CGW invest in are working for sustainable fresh water, preserving the marine ecosystem and improving the sanitary technologies. We will keep studying this ETF, as there are still a few holdings involved in the hydropower sector.

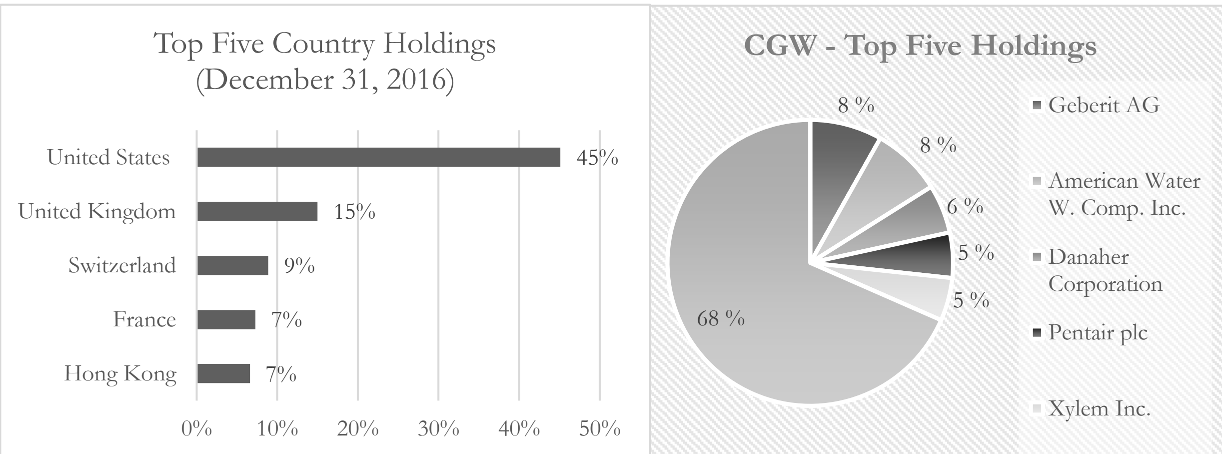

Figure 5: CGW - top 5 holdings and countries

Descriptive Statistics

Since the ETFs trade like stocks, we use the theory of the efficient market hypothesis (EHM). EHM states that in an efficient market, the stock prices follow a random walk, and reflect all available information at any given time (Fama 1970). This suggests that historical prices of the funds cannot explain the future prices, but may give an idea of how they respond to various factors. We use simple arithmetic returns to analyse the data, since this is a good approach when data follows a random walk.

Table 2: Descriptive statistics in excess returns for all the ETFs, the Cleantech Index, WTI Crude Oil, Henry Hub Natural Gas, and S&P 1200 from, January 2009 to January 2017.

Ticker Code	Annualized Excess Return	Standard Deviation	Excess Kurtosis	Skewness	Range	Min	Max
Solar (TAN)	-0.10	0.47	0.78	0.04	0.46	-0.20	0.26
Wind (FAN)	-0.01	0.25	1.54	-0.08	0.30	0.16	0.14
Nuclear (NLR)	-0.01	0.25	3.88	-0.21	0.31	-0.19	0.12
Hydro (CGW)	0.07	0.20	2.46	-0.08	0.22	-0.13	0.09
QCLN	0.04	0.32	1.78	-0.12	0.36	-0.20	0.16
ICLN	-0.09	0.32	2.35	0.01	0.40	-0.19	0.21
Cleantech	0.05	0.24	2.43	-0.15	0.28	-0.16	0.13
WTI	0.04	0.37	3.55	0.46	0.51	-0.23	0.29
Natural Gas	0.05	0.61	9.48	1.14	0.96	-0.34	0.62
S&P 1200	0.06	0.17	1.66	-0.37	0.17	-0.09	0.08

The Cleantech Index, WTI Crude Oil, Henry Hub Natural Gas, Hydro, the broad fund QCLN and the market are the investments yielding positive returns from 2009 to 2017. Solar has the overall lowest mean return of -10% and the highest standard deviation of the funds in alternative energy of 47%. Out of all the assets, natural gas has the highest standard deviation of as much as 60% and the highest range of 0.96, suggesting that there are big spreads in the data set. However, range can be misleading because it only depends on the minimum and maximum value, and not on how often they appear. Hydro is the only fund with a higher return than the market, but it has a slightly higher standard deviation, suggesting that it might be more risky than the market. It is natural that a broad and well-diversified market portfolio such as the S&P 1200 has a lower standard deviation than other investments.

All the assets have positive excess kurtosis', which indicates less clustering around the mean and large spreads. This gives higher chances for either extremely large or extremely small returns in the future. The skewness is relatively close to zero in all the funds, which indicate symmetrical data and a normal distribution, however a Jarque-Bera test shows that none of the data are normally distributed.

Analysis

This part starts with an analysis of the relationship between returns of the alternative energy ETFs and the S&P 1200 index. We will look at the performance of the ETFs in alternative energy compared to the market to analyse how the sector has performed since the financial crisis. Secondly, we conduct a multi-factor asset pricing model to see if the returns of clean technology stocks, oil and natural gas have significant explanatory value on the ETFs beyond what is reflected in the market index. At last, we study the volatility development of the alternative energy funds in comparison to the market. We look at rolling betas, development of the standard deviations, and the risk measures Sharpe and Information ratio to see if the ETFs in alternative energy have become less risky since the financial crisis compared to the market index.

The Performance of the Alternative Energy ETFs 2009-2017

We use a least squares regression to estimate the impact of the market index S&P 1200 on the ETFs. The model is presented below, the results from the regression are presented in Table 3 and further discussed below.

$$r_i = \alpha_i + \beta_{S\&P} r_{S\&P} + \varepsilon_i$$

$r_i = ETF\ i's\ return$
$\alpha_i = Intercept$
$r_{S\&P} = Return\ from\ the\ market\ index$
$\beta_{S\&P} = the\ sensitivity\ of\ ETF\ i's\ return\ with\ respect\ to\ the\ market\ index$
$\varepsilon_i = error\ term$

Table 3: Annualized mean return (standard deviation in paranthesis), Sharpe ratio, R^2(standard error in paranthesis), market beta and alpha (with t-values in paranthesis) for all the ETFs and S&P 1200 from 2009 to 2017.

	Annualized Excess Return	Sharpe Ratio	Adjusted R^2	Market Beta	Alpha
Solar (TAN)	-0.10	-0.22	0.39	1.77*	-0.21
	(0.47)		(0.05)	(16.54)	(-1.63)
Wind (FAN)	-0.01	-0.03	0.56	1.15*	-0.08
	(0.26)		(0.02)	(23.14)	(-1.30)
Nuclear (NLR)	-0.01	-0.04	0.49	1.03*	-0.07
	(0.25)		(0.02)	(19.97)	(-1.16)
Hydro (CGW)	0.07	0.35	0.65	0.95*	0.01
	(0.20)		(0.02)	(27.81)	(0.26)
QCLN (broad)	0.05	0.14	0.48	1.34*	-0.04
	(0.32)		(0.03)	(19.86)	(-0.43)
ICLN (broad)	-0.09	-0.29	0.49	1.34*	-0.17*
	(0.32)		(0.03)	(20.14)	(-2.18)
S&P 1200	0.06	0.37	1.00	1.00	0.00
	(0.17)				

The market has good explanatory power in all the alternative energy ETFs since all of the funds have high R square values between 39% and 65%. Hydro, the broad fund QCLN, and the benchmark are the only assets with positive Sharpe ratios, indicating that they all have positive risk-adjusted returns. Their standard deviations are higher than the benchmark, but their returns are lower, which is why the S&P 1200 has the highest Sharpe ratio. Evaluating the risk together with the returns is important in order to determine which fund gained the highest return considering its risk.

Hydro is the only fund that has beaten the market in terms of excess return, but an alpha value of approximately zero indicates that the fund has not added nor lost any value compared to the market. Hydro also has a higher standard deviation than the benchmark, and a lower Sharpe ratio. This indicates that the market index has a better risk-adjusted return over the period.

Solar has the highest market beta of 1.77 in the period, suggesting that if the market changed by 1%, Solar would change by 1.77%. A high market beta and a high standard deviation for Solar tell us that this fund is more volatile than the market, and could be considered an extremely risky fund to invest in. We see that Nuclear and Hydro have beta values close to one, which suggest that both have fluctuated in line with the market over the period.

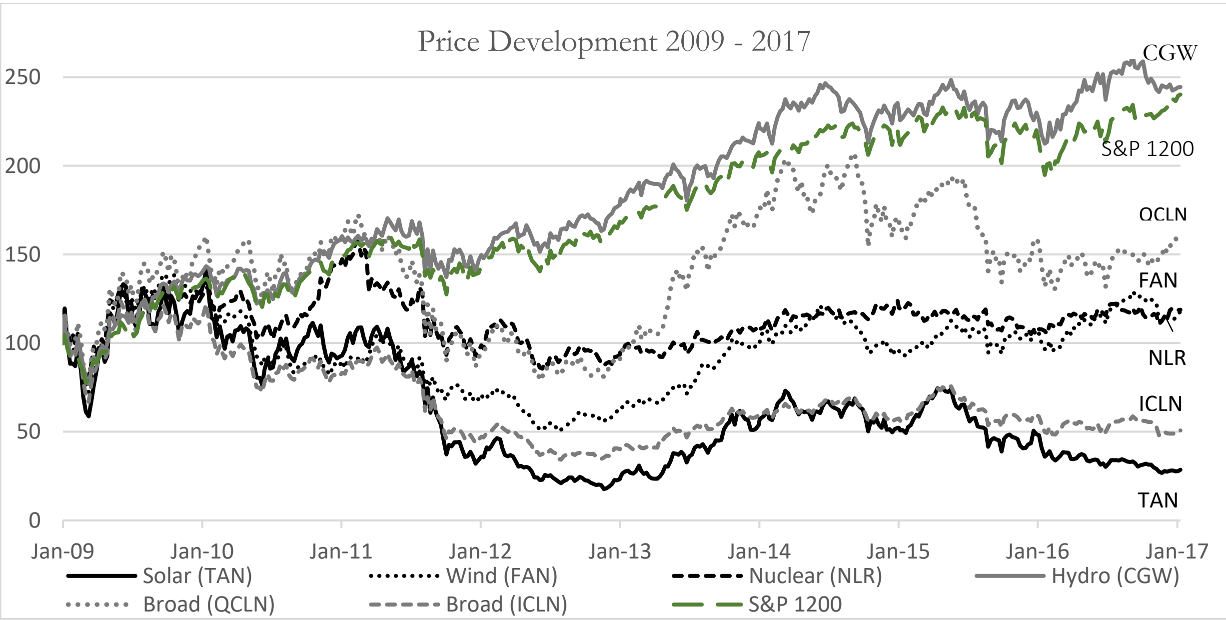

Figure 6: Price development for the ETFs and the S&P 1200 index, 2009 – 2017

From Figure 6, we see how the prices for the funds and the benchmark have developed from January 2009 to January 2017. To make it easy to compare, each series is set equal to 100 at the beginning of each time series in January 2009. We observe that between 2009 and 2010 all the funds move in the same direction, as they all try to recover from the financial crisis in late 2008. The graph shows that in the years following 2010, the funds move in different directions. Solar and ICLN have negative price development in the period reflecting the degreasing prices in the solar sector. Hydro show the most substantially growth rate, and is the only fund that outperforms the market in terms of price development.

Table 4: Correlation matrix for all the ETFs and S&P 1200 on excess returns, 2009 – 2017. All correlations are significant on a 5% level.

	TAN	FAN	ICLN	QCLN	NLR	CGW
Solar (TAN)	1					
Wind (FAN)	0.73	1				
Nuclear (NLR)	0.89	0.85	1			
Hydro (CGW)	0.88	0.77	0.86	1		
QCLN	0.64	0.74	0.73	0.73	1	
ICLN	0.69	0.85	0.80	0.81	0.80	1
S&P 1200	0.63	0.75	0.70	0.70	0.70	0.80

From Table 4 we see how the market correlates with the funds in alternative energy. We observe that the market correlate the least with Solar and the most with Hydro. Table 4 also tell us that Solar correlates highly with the broad funds ICLN and QCLN, as expected, as both the broad funds have a high percentage invested in solar power companies. We also see a high correlation between Wind and ICLN, as they also share some of the same holdings. However, why Wind correlates as much as 85% with Hydro is more surprising. They share no holdings, but both correlate highly with the broad-based market S&P 1200. This could tell us that even though there is a strong correlation between them, there may not be any significant effect. A correlation matrix can be misleading this way, but it is still a good supplement to the price development in Figure 6, where we see how the Wind and Hydro funds perform differently.

Summary of the Performance of the Alternative Energy ETFs

To answer the first hypothesis;

"Alternative energy ETFs underperformed the market in the years following the financial crisis"

All the alternative energy ETFs, except Hydro, underperformed the benchmark in terms of annualized returns and price development between January 2009 and January 2017. However, the returns between Hydro and S&P 1200 are not statistically significant different from each other on a 5% level, and we cannot conclude that Hydro has a significant higher return than the market. Hydro also has a higher standard deviation and lower Sharpe ratio, making it a riskier investment than the market.

Factors Affecting the Returns of the Alternative Energy ETFs

The price of alternative energy, as an electricity source, is mainly a function of market supply and demand. The weather is also a major contributor, as the amount of sunlight will affect the production of solar photovoltaics, as an example. However, other factors can also be price drivers for companies in alternative energy. Previous literature by Kumar et al. (2012), Sadorsky (2012), Managi and Okimoto (2013) and Inchauspe et al. (2015) find a positive relationship between the price of renewable energy stocks and the price of oil, technology stocks and market indices. We are investigating if there are some common factors influencing the returns of the ETFs in alternative energy. Our factors are inspired by the previous research mentioned, and include the following: Price changes of oil and natural gas, and returns from a clean technology index and the market index. The impact of the market is measured by the benchmark S&P Global 1200. We chose the included factors from the belief that they have a positive impact on the returns of the alternative energy funds. The price changes in oil and natural gas will hereafter be mentioned as returns.

We start by explaining the chosen price drivers and show the impact from each explanatory variable when conducting a single regression. Then we present the multi-factor asset pricing model, identify challenges in the model and discuss solutions to these challenges. Finally, the results of the regressions are given and further discussed.

The first independent variable we include in the model is the Cleantech Index. Since it is difficult to know the "true price" of improving technology, previous research have investigated technology indices that invest in publicly traded technology companies. We use the Cleantech Index (CT) in this analysis, to better capture the technology improvements directly related to the alternative energy sector. The index follows publicly traded cleantech companies and correlates highly with the funds in alternative energy as we see from Figure 7. This gives us reason to believe that the index is a possible price driver.

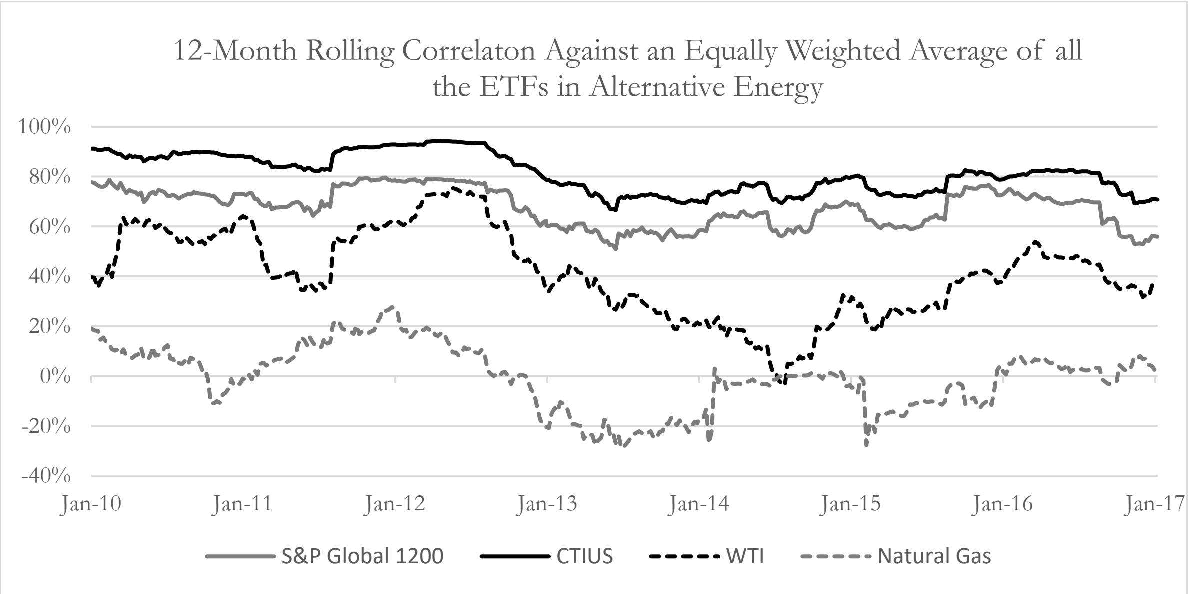

Figure 7: 12-month rolling correlation between an equally weighted portfolio of the alternative energy ETFs against the S&P 1200, the Cleantech Index, WTI Crude Oil and Natural Gas

Since both alternative energy and oil are involved in the energy market, the price of oil is a natural factor to include when looking at possible price drivers for the funds in alternative energy. We can see from Figure 7 that the correlation between the returns of WTI Crude Oil and the returns of the funds in alternative energy varies widely between -4% and 74%. There are contradicting findings about the relationship between the price of oil and alternative energy, but studies like Kumar et al. (2012) and Inchauspe et al. (2015), show that the oil price influences the price of clean energy companies positively. This leads us to the belief that the return of oil has a positive effect on the prices of the alternative energy ETFs. We use the spot price of WTI Crude Oil in our model as it is considered a benchmark for oil pricing.

Natural gas is another part of the energy sector, and may be seen as a substitute for renewables. Because natural gas is taking more of the energy demand from oil and coal, as it has lower CO_2 emissions than other fossil fuels, we believe that natural gas will affect the returns of alternative energy companies positively. From Figure 7, we see that there is low and mostly negative correlation between the returns of natural gas and the returns of the funds. This indicates that we might not see a strong impact from natural gas returns on returns of the funds. We use the Henry Hub Natural Gas spot price in our model.

Before explaining the multi-factor asset pricing model, we present the independent variables in a single regression against the returns of the alternative energy ETFs to see the impact from the single variables. Table 5 shows a single regression where the returns of the funds are the dependent variable and the returns of the Cleantech Index, WTI Crude Oil, and Henry Hub Natural Gas are the single explanatory variables.

*Table 5: Single regression for all the ETFs on the Cleantech Index, WTI Crude Oil and Henry Hub Natural Gas returns 2009 to 2017. Standard error and t-values in parenthesis under coefficients, * indicates significance on a 5% level.*

	The Cleantech Index (CT)			**WTI Crude Oil (WTI)**			**Henry Hub Natural Gas (NG)**		
	$r_i = \alpha_i + \beta_{CT} r_{CT} + \varepsilon_i$			$r_i = \alpha_i + \beta_{WTI} r_{WTI} + \varepsilon_i$			$r_i = \alpha_i + \beta_{NG} r_{NG} + \varepsilon_i$		
	Adj. R^2	α	β	**Adj. R^2**	α	β	**Adj. R^2**	α	β
Solar (TAN)	0.60	-0.22*	1.53*	0.13	-0.10	0.46*	-0.0021	-0.06	0.01
	(0.04)	(-2.09)	(25.39)	(0.06)	(-0.65)	(8.04)	(0.07)	(-0.38)	(0.31)
Wind (FAN)	0.76	-0.05	0.94*	0.18	0.02	0.29*	0.0011	0.04	0.02
	(0.02)	(-1.16)	(36.76)	(0.03)	(0.24)	(9.55)	(0.04)	(0.45)	(1.21)
Nuclear (NLR)	0.65	-0.04	0.82*	0.17	0.02	0.27*	0.0049	0.03	0.03
	(0.02)	(-0.87)	(27.83)	(0.03)	(0.21)	(9.38)	(0.03)	(0.41)	(1.75)
Hydro (CGW)	0.85	0.04	0.76*	0.20	0.10	0.23*	0.0036	0.12	0.02
	(0.01)	(1.62)	(49.14)	(0.02)	(1.62)	(10.24)	(0.03)	(1.70)	(1.59)
Broad (QCLN)	0.78	-0.03	1.18*	0.16	0.06	0.35*	0.0001	0.09	0.03
	(0.02)	(-0.55)	(38.90)	(0.04)	(0.60)	(9.03)	(0.04)	(0.78)	(1.02)
Broad (ICLN)	0.73	-0.16*	1.13*	0.16	-0.08	0.34*	0.0009	-0.05	0.03
	(0.02)	(-2.83)	(33.82)	(0.04)	(-0.75)	(8.88)	(0.04)	(-0.47)	(1.18)

We observe from the R square values in Table 5 that between 60% and 85% of the returns in the funds can be explained by the changes in the stock returns of clean technology companies, but only 13% to 20% can be explained by the returns of oil. This indicates that other factors than the oil returns explains 80% or more of the returns in the funds. The Henry Hub Natural Gas returns show no statistically significance in any of the funds in alternative energy. The Cleantech index is the only explanatory variable showing significant alpha values that differ from zero in Solar and ICLN with -0.22 and -0.16, respectively. This indicates that they will underperform the Cleantech index when the index returns are flat. When the independent variable is zero in the regression, the variables for the funds will be equal to the intercept.

We also observe that the Cleantech index and oil have significant beta values in all the funds. Solar, QCLN, and ICLN are on average more volatile than the Cleantech index, and the rest of the funds are less volatile than the index. This suggests that Solar, QCLN and ICLN will outperform the Cleantech index in strong market periods, and underperform in weak periods. All the funds are less volatile than WTI Crude Oil, as the betas are below 1.

The Multi-Factor Asset Pricing Model

To investigate if any of the factors have explanatory power beyond the market, we use a multi-factor asset-pricing model. The factors mentioned above are set as the explanatory variables and the funds as the dependent variable.

$$r_i = \alpha_i + \beta_{S\&P} r_{S\&P} + \beta_{CT} r_{CT} + \beta_{WTI} r_{WTI} + \beta_{NG} r_{NG} + \varepsilon_i$$

$r_i = ETF\ i's\ weekly\ arithmetic\ return$
$\alpha_i = intercept$
$r_{S\&P}, r_{CT}, r_{WTI}, r_{NG} = weekly\ arithmetic\ returns\ of\ the\ market, technology\ index, oil\ and\ natural\ gas$
$\beta_{S\&P,}, \beta_{CT}, \beta_{WTI}, \beta_{NG} = the\ sensitivity\ of\ ETF\ i's\ return\ with\ respect\ to\ the\ factors$
$\varepsilon_i = error\ term$

Challenges in the Model

The Cleantech index correlates as much as 80% with the returns of the S&P 1200. This suggests that we might be facing a problem with near multicollinearity. Multicollinearity is a problem because it can give high values of R square and few significant t-values, resulting in large variances and standard errors, and wide confidence intervals from the OLS estimators. We can also experience wrong signs for the regression coefficients and have trouble in assessing the single contribution from the explanatory variables. The parameters in our multi-factor model will also be highly sensitive to changes in the specification of the model and the sample coverage. To avoid this problem, we conduct a residual regression, as explained in Graham (2003), to remove the shared contribution from the two independent variables. We regress the Cleantech index against the S&P 1200 and assign the market index the priority over the shared contribution:

$$r_{CT}^{res} = \alpha_{CT} + \beta_{S\&P} r_{S\&P} + \varepsilon_i$$

We obtain the residuals from this regression and use them in the multi-factor model as the impact from the Cleantech index that is not reflected in the S&P 1200. The updated model is presented below:

$$r_i = \alpha_i + \beta_{S\&P} r_{S\&P} + \beta_{CT}^{res} r_{CT}^{res} + \beta_{WTI} r_{WTI} + \beta_{NG} r_{NG} + \varepsilon_i$$

We run a Breusch-Pagan-Godfrey (BPG) test to check for heteroscedasticity in our data set. This is to test whether the errors increase across the explanatory variables or not. We conduct the BPG test by regressing the squared residuals from the multi-factor regression on the original regressors. There is only evidence of heteroscedasticity in the Nuclear ETF on a 5% significance level. A consequence of this is that the estimators might longer be efficient in the multi-factor model. However, the F-value from the test on Nuclear is not significant on a 1% level. To further investigate this problem, we run a Glejser test, a Whites test and a Harvey test. As we can see from Table 6, the tests show contradicting results. Even though there is a chance of heteroscedastic data in the Nuclear ETF, we continue the analysis as this does not seem like a severe problem.

*Table 6: Results from heteroscedasticity-tests. *indicates significance on a 5% level.*

Nuclear				
Test	BPG	Harvey	White	Glejser
F-Value	2.41*	0.15	2.69*	1.01

A Durbin-Watson d-test shows no sign of autocorrelation in any of our data.

Results from the Multi-Factor Asset Pricing Model

*Table 7: Adjusted R^2 (standard error in paranthesis), alpha and beta values from the multi-factor asset model regression for all ETFs (t-stats in parenthesis). * indicates significance on 5% level.*

	Adjusted R^2	**Alpha**	**S&P 1200**	**Cleantech**	**WTI**	**Natural Gas**
Solar (TAN)	0.60*	-0.26*	1.74*	1.53*	0.025	-0.029
	(0.04)	(-2.54)	(18.06)	(14.79)	(0.58)	(-1.23)
Wind (FAN)	0.77*	-0.09*	1.13*	0.82*	0.017	-0.001
	(0.02)	(-2.08)	(28.05)	(18.99)	(0.92)	(-0.09)
Nuclear (NLR)	0.66*	-0.08*	0.98*	0.69*	0.035	0.011
	(0.02)	(-1.60)	(21.06)	(13.81)	(1.63)	(0.94)
Hydro (CGW)	0.86*	0.005	0.93*	0.63*	0.011	0.004
	(0.01)	(0.33)	(39.40)	(24.97)	(1.06)	(0.70)
Broad (QCLN)	0.78*	-0.06	1.31*	1.22*	0.008	-0.005
	(0.02)	(-1.24)	(27.22)	(23.60)	(0.37)	(-0.43)
Broad (ICLN)	0.73*	-0.20*	1.31*	1.09*	0.010	-0.001
	(0.02)	(-3.52)	(24.55)	(19.02)	(0.40)	(-0.04)

Table 7 shows how the high R squares indicates that the factors have explanatory power of the funds in alternative energy. There are big differences between the funds, as the model explains 60% of the returns in Solar, while it explains as much as 86% of the returns in Hydro. All the adjusted R squares are significant on a 5% level. This indicates that at least one of the beta values in the regression significantly differ from zero. The R squares increased from the single regressions in Table 3, which suggest that the new variables have explanatory power beyond the market. We also observe that all the beta values for the market and the Cleantech index are significant at a 5% level.

The alpha values are significantly different from zero in Solar, Wind, Nuclear and ICLN and suggests that when all the factors yield a return of zero the funds will yield a slightly negative return. Hydro is the only fund with a positive value, but it is not significant at a 5% level, and we cannot conclude that the fund will outperform the factors if the independent variables are zero in the regression.

Influence of the Market (S&P 1200)

We observe from Table 7 that the S&P 1200 seems to have good explanatory value in the funds, as all the beta values are statistically significant. This suggests that the returns of S&P 1200 affect the returns of the funds in alternative energy. The estimated beta coefficients of the market returns indicates that Solar, Wind, and the two broad funds QCLN and ICLN are more volatile than the market, while Nuclear and Hydro are about as volatile as the market.

Influence of the Cleantech Index (CT)

The returns of clean technology stocks have strong impact on the returns of the funds in alternative energy, indicating that the Cleantech index is an important pricing factor for the funds. Some of the funds invest in companies that the Cleantech index also invests in, and this could lead to similar behaviour patterns for the funds and the index. You will find an overview of these shared holdings in Appendix II. These shared holdings affect the beta values as they will move towards 1. This means that the beta values might have been even higher if the Cleantech index and the particular funds did not share any holdings. Our findings suggest that returns of the clean technology index are a key pricing factor in addition to the global equity index S&P 1200, which is important information when investing in the alternative energy sector. This result is in line with previous studies by Henriques and Sadorsky (2008), Kumar et al. (2012), Sadorsky (2012), and Inchauspe et al. (2015).

Influence of WTI Crude Oil (WTI)

All the beta values for oil returns are close to zero, and not statistically significant. This indicates that returns of oil have little impact on the returns of the funds. Recall, when we conducted a single regression on the returns of oil prices we found small R square values in all the funds, which gives reason to believe that the returns of oil have little influence on the returns of alternative energy funds. A possible reason for the low beta values is that oil and renewables operate in different markets, except for a few places where there are a small number of oil-fired electricity plants. Oil operates in the transport sector, while renewables operate in the electricity sector. In addition, when oil prices dropped in 2014, many countries took the opportunity to cut subsidies in fossil fuels, making renewable energy more attractive. We cannot conclude that the returns of oil have any significant impact on the returns of the funds in alternative energy beyond the market and the

Cleantech index. This result goes into the previously unclear research on the relationship between the price of oil and alternative energy stocks. It is consistent with the study by Henriques and Sadorsky (2008), which suggested that the price of oil have little or no impact of the prices of clean energy companies. This contradicts with the study by Inchauspe et al. (2015), who suggested that the price of oil gets more influential from 2007 to 2014.

Influence of Henry Hub Natural Gas (NG)

The beta values for natural gas are also close to zero, and some of them are even negative, which indicates a negative relationship between the returns of natural gas and the returns of Solar, Wind, and the two broad ETFs. The beta values are not statistically significant, and we cannot conclude that the funds are statistically dependent on natural gas. We were expecting the return of natural gas to have a positive effect on the returns of the funds, because natural gas and coal are substitutes with alternative energy, as they are the main sources of electricity. A possible reason why the returns of natural gas are not affecting the returns of the funds is that natural gas is cheap, and even if the price of natural gas would increase, it would be difficult and costly for households to change their electric system. In theory, the price of natural gas and renewables are substitutes, but this may not be true in real life.

Summary of the Factors Affecting the Returns of the Alternative Energy ETFs

To answer the hypothesis:

"The returns of clean technology stocks, oil and natural gas have significant explanatory value on the ETFs beyond what is reflected in the market index"

Our results show that the impact of oil and natural gas returns are not statistically significant in the multi-factor model, and suggest that they have little or no impact on the returns of the funds in alternative energy. However, when conducting a single regression with oil returns as the explanatory variable on the returns of the ETFs, all the funds show significant values for the impact of oil returns. When we add the price of oil to a multi-factor model, the significance impact disappears and the result suggests that the market and the Cleantech index have strong explanatory power of the funds. This may be because the oil price is reflected in the market index, but there are also other possible explanations.

We therefore conclude that there is a positive relationship between the returns of clean technology, the market and the returns of the alternative energy funds. We cannot conclude that the returns of oil or natural gas have any significant impact on the returns of the funds.

The Volatility Development of the Alternative Energy ETFs

In this section, we investigate the risk development of the funds in alternative energy to see if they have become less risky since the financial crisis compared to the market index. First, we examine the annualized standard deviations in two periods following the financial crisis, 2009-2012 and 2013-2016. Then, we look at the 24-month rolling market betas, before we analyse the risk measures to see how the funds have developed in terms of risk-adjusted returns. At last, we will discuss how global government policies and new investments in the alternative energy sector can be reasons for the funds' performances.

Development of the Standard Deviation

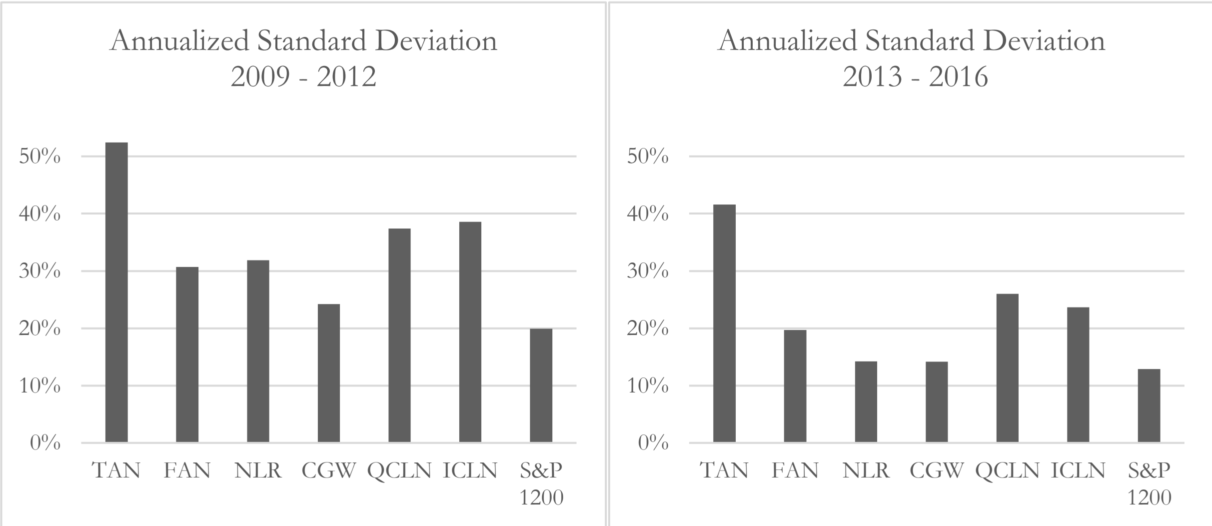

Figure 8: Annualized standard deviations for Solar (TAN), Wind (FAN), Nuclear (NLR), Hydro (CGW) and broad funds ICLN, and QCLN, 2009 – 2012 and 2013 – 2016

Table 8: % Change in standard deviation between the periods 2009-2012, and 2013-2016 for all the ETFs and the S&P 1200

	TAN	FAN	NLR	CGW	QCLN	ICLN	S&P 1200
Difference	-21%	-36%	-55%	-41%	-30%	-39%	-35%

Most of the standard deviations for the funds are higher than the market's in 2009 – 2012, but we observe that some of the funds are at the same level as the market in 2013 – 2016. It looks like the alternative energy sector has moved from a synchronized high-risk sector to vary more between the sub-sectors. All standard deviations have decreased between the two periods, including the market's standard deviation. We see that Nuclear has the largest decrease between the two periods, while Solar has the smallest decrease.

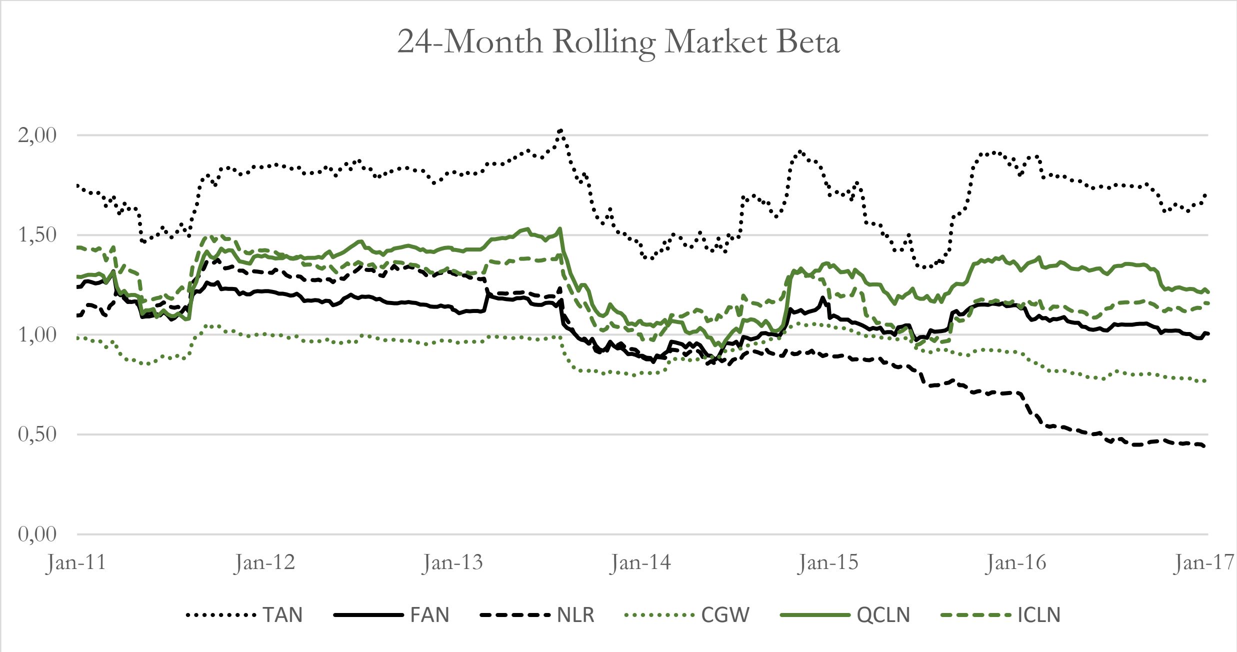

Figure 9: Two Year Rolling Market Beta against the S&P 1200 for Solar (TAN), Wind (FAN), Nuclear (NLR), Hydro (CGW) and two broad ETFs (QCLN and ICLN) from 2009 to 2017

Development of the Market Beta

Figure 9 shows how the six funds' market betas are developing in terms of volatility from January 2011 to January 2017. We can see that even though the market betas between the funds vary, they move simultaneously up and down from 2011 to mid-2015. In the middle of 2013, all the market betas dropped rapidly. A possible reason for the sudden drop can be the declining costs in the alternative energy sector this year. Companies finally started to gain profitable income since the funds in alternative energy had a booming year in 2013. This also made the standard deviations higher relative to the market, causing some of the market betas to rise again in 2015. From the end of 2015, all the market betas moved in various directions, suggesting that the volatility for the funds is getting more sub-sector dependent. Solar is still the most volatile fund with a beta of 1.7, followed by the two broad ETFs. Nuclear and Hydro shows a declining trend with a market beta lower than 1, indicating that they are less volatile than the market, while Wind has a beta close to 1.

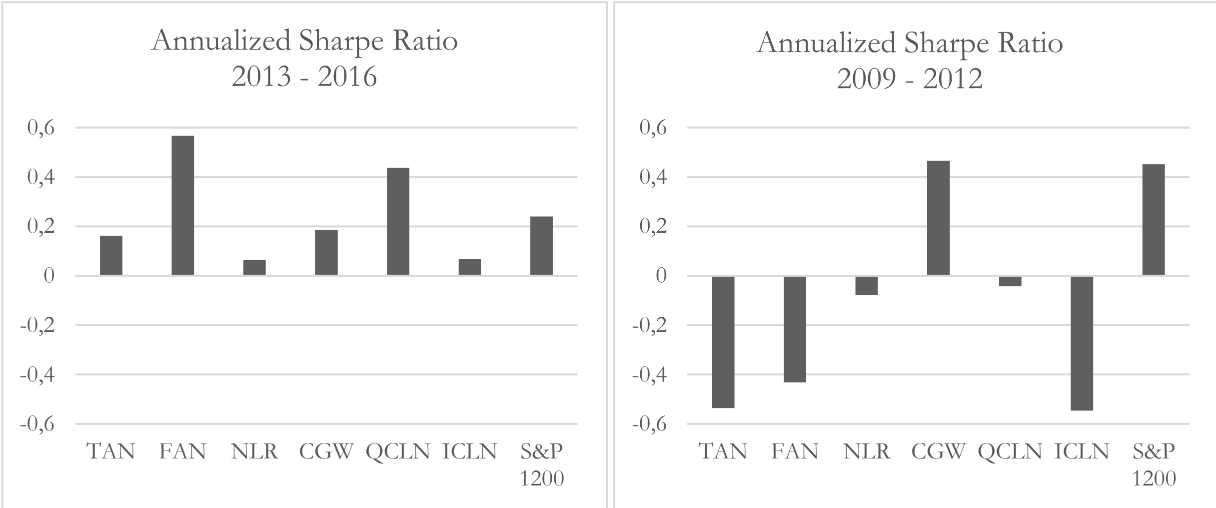

Figure 10: Annualized sharpe ratios for Solar (TAN), Wind (FAN), Nuclear (NLR), Hydro (CGW) and broad funds ICLN, and QCLN, 2009 – 2012 and 2013 – 2016

Development of the Sharpe Ratio

To get a better understanding of the risk development in the funds, we look at the risk and returns together. The Sharpe ratios show the annual risk-adjusted returns. Generally, a Sharpe ratio above 1 is considered acceptable. Most of the funds start with negative values in 2009 – 2012. Only the market index and Hydro has positive risk-adjusted returns in this period. In 2013 – 2016, all the funds, and the market index have positive Sharpe ratios. Even though the ratios are small, the risk-adjusted returns improved for most of the funds between the two periods. Only Hydro and the market index ended up with a decreased Sharpe ratio in the last period.

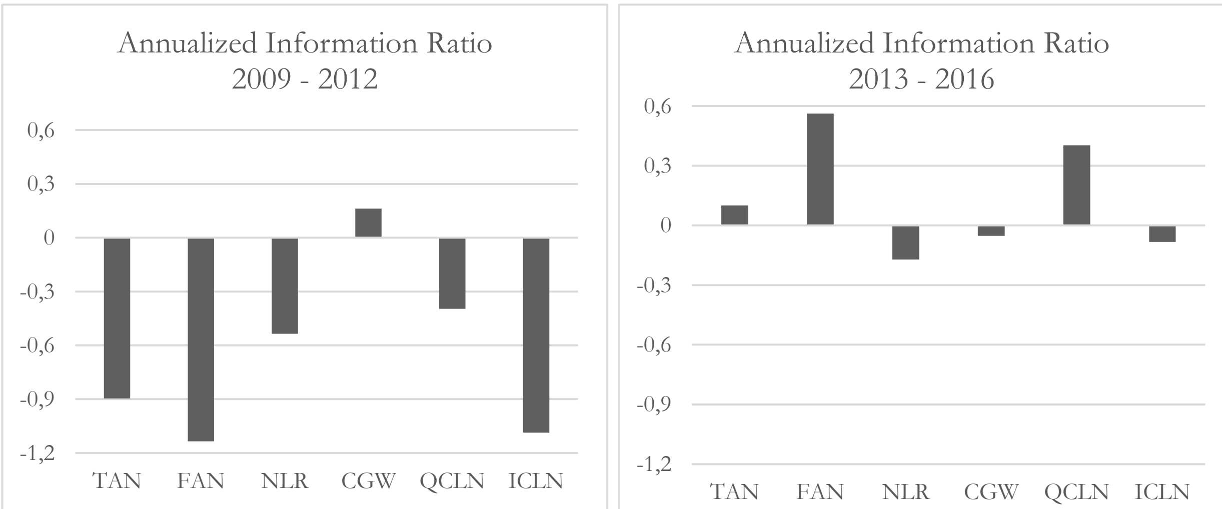

Figure 11: Annualized information ratios for Solar (TAN), Wind (FAN), Nuclear (NLR), Hydro (CGW) and broad funds ICLN, and QCLN, 2009 – 2012 and 2013 – 2016

Development of the Information Ratio

The information ratio (IR) differs from the Sharpe ratio because it measures the risk-adjusted return in relation to the benchmark instead of a risk-free investment. Most of the IRs shows great improvements between the two periods. All the funds start out negative in 2009 – 2012, except for Hydro, which means they have a negative risk-adjusted return in relation to the benchmark. In the last period, 2013 – 2016, Solar, Wind and QCLN end up with positive risk-adjusted returns. This means that they have performed well compared to the market.

Government Policies and New Investments in Alternative Energy

We cannot rely solely on the risk measures when investments decisions are made; it can give us a good indication of the risk we are facing, but as a supplement we want to look further into what is driving the prices of the alternative energy companies. The costs of installing and producing alternative energy have fallen dramatically since the financial crisis, and sources like solar and wind are now cost-competitive with fossils. Today, the biggest obstacle for investors in renewable energy might no longer be the costs, but the uncertainty regarding polices (The Guardian 2014). According to REN21 (2016), the support policies for renewable energy gained increased interest after the global agreement of COP21 in Paris in 2015. At the end of 2015, 173 countries had renewable energy targets and about 146 of these countries established renewable energy policies.

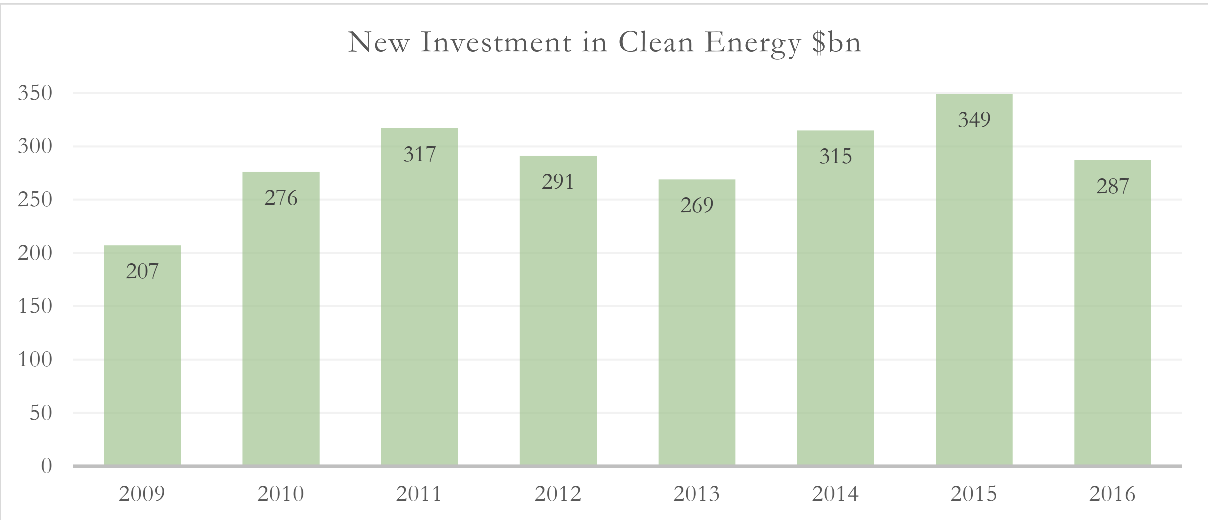

Figure 12: New investment in clean energy $bn from 2009 – 2016. Data from BNEF (2017a)

The best years for the funds in alternative energy, in terms of annualized returns, was the year of 2009 and 2013. Investors who had invested in alternative energy stocks finally saw profitable returns, and new investment in the years following increased as expected. However, investments in 2012 and 2013 went down because unstable policy regimes made investors unsecure about the future for clean energy. The sector was also experiencing increasing competition from developing countries who had cheaper materials. This led to decreasing new investment in developed countries, while investment rose with as much as 19% in developing countries from 2011 to 2012 (UNEP 2013). A possible reason for the reduction in new investments in 2013 was the declining costs for the renewable sector. This made the prices of alternative energy drop, because of the increased capacity for less money. The reduced costs also made it possible to build new locations for onshore wind and solar photovoltaics projects without subsidy support (UNEP 2014). Policy support still remains unstable in many countries during 2014 and 2015, but the new investments in alternative energy kept increasing. Even when the price of oil fell in mid-2014, new investments increased because of its cost-competitiveness, the new government policies and the assumed better economy for renewable energy.

Moving into the year of 2016, new investments fell 18% from the prior year. Setbacks in China and Japan can be the possible reasons for the low investment. Justin Wu, head of BNEF in the Asia Pacific, states that: "After years of record-breaking investment driven by some of the world's most generous feed-in tariffs, China and Japan are cutting back on building new large-scale projects and shifting towards digesting the capacity they have already put in place" (BNEF 2017b). However, the Chinese government are still trying to reform the energy sector to fulfil the potential for renewables. The unstable environmental policies can be another possible reason, especially in the U.S. as the presidential election was ongoing. The Bloomberg New Energy Finance forecast for 2017, proposes a rising demand in India, the Middle East, and South America that will offset the slowdown in China. There will still be declining costs because of technology improvement and increased competition, but we might be facing 2016-levels in regarding new investments (Ryan 2017). Even though policy support is still crucial for the alternative energy sector, its ability to raise money, the improving technology, and the decreasing material and production costs leads to optimism for the sector.

Summary of the Volatility Development of the Alternative Energy ETFs

To answer Hypothesis 3:

"*The alternative energy ETFs have become less risky since the financial crisis compared to the market index*"

All the funds' market betas are on a lower level in 2016 than in 2009, suggesting that the sector for alternative energy have been getting less volatile compared to the market. Also, the standard deviations are significant lower in 2013-2016 than in 2009-2012, but also the standard deviation for the market is significant lower. The ETFs in Wind, Nuclear, Hydro, and ICLN also show a larger decline in their standard deviations than the market, indicating that they have become less risky since the financial crisis compared to the market.

All the funds, except Hydro, have negative Sharpe ratios in 2009 to 2012. From 2013 to 2016, all the funds show positive ratios, indicating that most of the risk-adjusted returns have become significant better. All the funds, except Hydro, show a higher increase in the Sharpe ratios between the two periods, compared to the market. In addition, the information ratios show that all the funds, except Hydro, have increased their information ratios, indicating that the risk-adjusted returns in relation to the market is higher in the most recent period. However, the result shows that the IR values are still negative for Nuclear, Hydro and ICLN. It seems to be a positive change in the alternative energy sector regarding risk and return, but our short time horizon might not give a correct picture of how the sector is developing in the long term.

In terms of new investments, the sector rose until 2015 before declining again in 2016. Policies are unstable, and with low prices of fossil fuels, many countries have no reason to increase their policy support in alternative energy. However, cheaper materials, improving technologies and strengthening of the economics in the alternative energy sector could be reasons why we still see solid new investments in the alternative energy sector.

Summary and Concluding Remarks

This paper contributes to the existing literature in alternative energy investments by analysing the performance and the price drivers of six ETFs invested in companies involved in solar, wind, hydro and nuclear power. Our findings are helpful for investors whom are looking to include alternative energy companies, or ETFs, in their portfolio and to understand the essentials of this market.

There has been increased focus on alternative energy and new investments have grown with almost 40% since 2009. However, we find that all the ETFs in alternative energy, except Hydro, underperformed the market from 2009 to 2017. Hydro seems to have outperformed the market, but we cannot conclude that their annualized mean returns are significantly different from each other.

We also use a multi-factor asset pricing model to study the impact of price drivers in the alternative energy sector. Inspired by previous studies like Sadorsky (2012), Managi and Okimoto (2013), Inchauspe et al. (2015), we choose a clean technology index, oil and natural gas prices to be the explanatory variables in our model, along with the market index. The results show that the variations in the returns of all the six ETFs are best explained by returns in the clean technology index and the S&P 1200 index. We also find that the price changes of oil and natural gas are not significant factors influencing the returns of the funds in alternative energy.

Consistent with Sabbaghi (2011b) we find that the alternative sector is highly volatile. However, as the sector has experienced lower costs and improved technology we believe that the volatility has decreased since the financial crisis. We analyse rolling market betas, standard deviations, policies and other risk measures for the ETFs in alternative energy compared to the market. Our findings show a decreasing trend in the sector in terms of volatility, but when we look at risk-adjusted returns, the picture gets more unclear. It seems to be a positive trend, but our short time horizon might be a weakness. After the Paris Agreement shed new light on the importance of policies, more countries are working towards a common emission target. However, policy support is still unstable and investors should pay close attention to the development, as this might affect the returns of the companies in the alternative energy sector.

Readers whom are interested in conducting further research on the topic may want to consider the economics of the underlying companies in the funds. This can give a deeper insight of the performance and the price drivers of the ETFs and the underlying companies. To get a better understanding of how the alternative energy markets reacts to its price drivers, looking at lagged variables or price shocks can be interesting. In addition, it might be worthwhile analysing policies, on a global and on a national level, to see how they affect the returns of alternative energy companies and funds.

Criticism

To get a good picture of the alternative energy market we wanted to include an ETF in all the sub-sectors, including a hydropower ETF (CGW). However, the CGW is highly involved in sectors like water utilities, wastewater and infrastructure, while it has only a few holdings in the hydropower market. This might give a wrong impression on how hydropower companies are performing. But when looking at the average price development of three of the companies invested in hydropower, we find consistent performance with the price development of the ETF. Therefore, we suggest that the ETF gives a good presentation of the hydropower market. The Figure can be found in Appendix III.

A high correlation between the S&P 1200 and the Cleantech Index indicates multicollinearity. To solve this problem, we performed a residual regression to remove the shared contribution from the two independent variables. To avoid this problem completely, we could have removed the Cleantech index from the dataset, and replaced it with another factor that is not as highly correlated with the other independent variables. However, clean technology is an important price driver in the alternative energy sector, and removing this factor would exclude important results. Also, the impact of natural gas could have been excluded from our multi-factor model as the variable does not contribute in explaining the variance of the returns of the ETFs.

We also assume that the beta values are constant, as our model is not time varying. Over a longer time-period, beta values are not constant and this can give our multi-factor model misleading results. Another reason that could give misleading results is the short time-period of our data, as most of the ETFs were established around mid-2008. Because the time-period is no longer than 7 years, our results can give a wrong image of how the alternative energy market reacts to the variables included in our model.

Bibliography

BNEF. (2016). Clean Energy Investment in 2016 Undershoots Last Year's Record.

BNEF. (2017a). Global trends in clean energy investment.

BNEF. (2017b). Record $30bn year for offshore wind but overall investment down. *Bloomberg New Energy Finance*. Available at: https://about.bnef.com/blog/record-30bn-year-offshore-wind-overall-investment/.

China Everbright International Limited. (2016). *Corporate Fact Sheet 2016*. Available at: http://www.ebchinaintl.com/en/company/fs/20161H/fs2016_1h.pdf (accessed: 03.25.2017).

Cleantech Group. Available at: http://www.cleantech.com/indexes/the-cleantech-index-ctius/ (accessed: 04.02.2017).

EIA. (2013). Annual Energy Outlook 2013.

EIA. (2017a). *Natural Gas*. Available at: https://www.eia.gov/dnav/ng/hist/rngwhhdd.htm (accessed: 03.21.2017).

EIA. (2017b). Short-Term Energy Outlook (STEO).

Fama, E. F. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. *The Journal of Finance*, 25 (2): 383-417.

First Trust. (2017). *Factsheet - First Trust Global Wind Energy ETF*. Available at: https://www.ftportfolios.com/Common/ContentFileLoader.aspx?ContentGUID=7ed74027-1285-4def-88ac-2ac152007d7b (accessed: 03.20.2017).

Gamesa. (2017). *Gamesa*. Available at: http://www.gamesacorp.com/en/gamesaen/ (accessed: 03.22.2017).

Graham, M. H. (2003). Confronting Multicollinearity in Ecological Multiple Regression. *Ecology*, 84 (11): 2809-2815.

Guggenheim Investments. (2017a). *Factsheet - Guggenheim S&P Global Water Index ETF*. Available at: http://gugg.marketpowerweb.com/showpdf.cfg?pid=587389&pdfid=1487515 (accessed: 03.20.2017).

Guggenheim Investments. (2017b). *Factsheet - Guggenheim Solar ETF*. Available at: http://gugg.marketpowerweb.com/showpdf.cfg?pid=587452&pdfid=1488783 (accessed: 05.20.2017).

Henriques, I. & Sadorsky, P. (2008). Oil prices and the stock prices of alternative energy companies. *Energy Economics*, 30 (3): 998-1010.

Hexcel Corporation. (2016). *Annual Report 2009 - 2016*. Available at: http://phx.corporate-ir.net/phoenix.zhtml?c=75598&p=irol-reportsAnnual (accessed: 03.25.2017).

Hexcel Corporation. (2017). *Hexcel*. Available at: http://www.hexcel.com/ (accessed: 03.21.2017).

IEA. (2016). Next Generation Wind and Solar Power. From cost to value.: International Energy Agency. 182 pp.

Inchauspe, J., Ripple, R. D. & Trück, S. (2015). The dynamics of returns on renewable energy companies: A state-space approach. *Energy Economics*, 48: 325-335.

iShares by BlackRock. (2016). *iShares Global Clean Energy ETF Fact Sheet 2016*. Available at: https://www.ishares.com/us/products/239738/ishares-global-clean-energy-etf/1467271812594.ajax?materialType=Fact+Sheet&fileType=pdf (accessed: 03.20.2017).

Kumar, S., Managi, S. & Matsuda, A. (2012). Stock prices of clean energy firms, oil and carbon markets: A vector autoregressive analysis. *Energy Economics*, 34 (1): 215-226.

Mallett, J. E. & Michelson, S. (2010). Green Investing: Is it Different from Socially Responsible Investing? *International Journal of Business*, 15 (4): 395-410.

Managi, S. & Okimoto, T. (2013). Does the price of oil interact with clean energy prices in the stock market? *Japan and the World Economy*, 27: 1-9.

Moodie, A. (2016). Google, Apple, Facebook race towards 100% renewable energy target. *The Guardian*. Available at: https://www.theguardian.com/sustainable-business/2016/dec/06/google-renewable-energy-target-solar-wind-power (accessed: 05.08.2017).

Nasdaq. (2017). *Tesla, Inc. Revenue & Earnings Per Share (EPS)*. Available at: http://www.nasdaq.com/symbol/tsla/revenue-eps (accessed: 03.22.2017).

ON Semiconductor. (2016). *ON Semiconductor Reports Fourth Quarter and Annual Results 2009 - 2016*

REN21. (2016). Renewables 2016 Global Status Report. Paris.

Ryan, J. (2017). Clean Energy Spending Drops Most on Record as China Slows Growth. *Bloomberg*. Available at: https://www.bloomberg.com/news/articles/2017-01-12/clean-energy-spending-drops-most-on-record-as-china-slows-growth (accessed: 05.01.2017).

S&P Dow Jones Indices. (2017). Available at: http://eu.spindices.com/indices/equity/sp-global-1200 (accessed: 03.20.2017).

Sabbaghi, O. (2011a). The behavior of green exchange-traded funds. *Managerial Finance*, 37 (5): 426-441.

Sabbaghi, O. (2011b). Do Green Exchange-Traded Funds Outperform the S&P500? *Journal of Accounting and Finance*, 11 (1): 50.

Sadorsky, P. (2012). Correlations and volatility spillovers between oil prices and the stock prices of clean energy and technology companies. *Energy Economics*, 34 (1): 248-255.

The Guardian. (2014). 10 things you should know about investment in renewable energy. Available at: https://www.theguardian.com/sustainable-business/investment-renewables-10-things-climate-change (accessed: 04.22.2017).

Thomson Reuters Datastream. (2017). *Datastream*. Available at: Subscription Service (accessed: 03.21.2017).

Treasury.gov. *U.S Department of the Treasury*. Available at: https://www.treasury.gov/Pages/default.aspx (accessed: 01.25.2017).

UNEP. (2013). Global Trends in Renewable Energy Investment 2013. Frankfurt: Frankfurt School - UNEP Centre/BNEF. 12-44 pp.

UNEP. (2014). Global Trends in Renewable Energy Investment 2014. Frankfurt: Frankfurt School - UNEP Centre/BNEF. 11-19 pp.

VanEck. (2017). *Factsheet - VanEck Vectors Uranium+Nuclear Energy ETF*. Available at: https://www.vaneck.com/library/vaneck-vectors-etfs/nlr-fact-sheet-pdf/ (accessed: 03.21.2017).

Table of Tables

Table of Figures

Appendices

Appendix I

Table 9: Presentation of the ETFs in alternative energy

Name	Ticker	Reference Index	Start date	Investment Object
iShares Global Clean Energy ETF	ICLN	MVIS Global Uranium & Nuclear Energy Index	24.06.2008	Gives global exposure to companies that produce energy from renewable resources
First Trust NASDAQ Clean Edge Green Energy Index Fund	QCLN	NASDAQ® Clean Edge® Green Energy Index℠	17.11.2006	Investing in clean energy companies that are publicly traded in the U.S. Includes companies engaged in manufacturing, development, distribution and installation of emerging clean-energy technologies including, but not limited to, solar photovoltaics, biofuels and advanced batteries.
Guggenheim S&P Global Water ETF	CGW	S&P Global Water NR Index	14.05.2007	Consists of companies investing in water utilities, infrastructure, equipment, instruments and materials.
VanEck Vectors Uranium+Nuclear Energy ETF	NLR	MVIS Global Uranium & Nuclear Energy Index	13.08.2007	Designed to track overall performance of companies involved in uranium mining or mining projects, engineering and maintaining nuclear power facilities, production of electricity from nuclear sources or provision of equipment etc. to the industry.
Guggenheim Solar ETF	TAN	MAC Global Solar Energy Index	15.04.2008	Consists of companies involved in different parts of the solar sector. Solar power equipment producers and suppliers of materials or services to solar equipment producers among others.
First Trust Global Wind Energy ETF	FAN	ISE Global Wind Energy Index	16.06.2008	66.67% of this index consists of companies that provides goods and services exclusively to the wind energy industry, while 33.33% is built of companies participating in the wind energy industry despite not being exclusively involved.

Appendix II

Table 10: The ETFs shared holdings with the Cleantech index

	Cleantech Index	Solar power	Wind power	Hydro power	Broad	Broad
	CTIUS	TAN	FAN	CGW	ICLN	QCLN
Company name	**% of total assets**					
Advanced Energy	2,01			0,38		3,92
Aegion	0,97			0,45		
Badger Meter	1,18			0,54		
Cree	2,21					3,78
Gamesa	2,74		8,37		5,80	
Hannon Armstrong	1,17	4,51				1,34
Hexcel	2,64					7,40
Itron	2,01					3,60
Ormat Technologies	2,34					4,27
Power Integrations	1,67					3,07
Lindsay	1,00			0,47		
Meyer Burger Tech.	0,70	4,81				
Siemens	3,12		1,91			
Silver Spring Networks	0,88					1,14
SMA Solar Technology	0,80				0,80	
SolarEdge ADR	0,75	3,52				
SunPower	0,77				1,40	1,75
Vestas Wind Systems	3,22		9,72		5,30	
Woodward	2,62		0,66			
Xylem	2,96			0,25		
TOTAL	**35,76**	**12,84**	**20,66**	**2,09**	**13,30**	**30,27**

Holdings as of March 20, 2017

Appendix III

Price development of equally weighted portfolio of Xylem Inc, Veolia Environment SA and Idex Corp (hydropower companies), and the hydropower ETF (CGW).

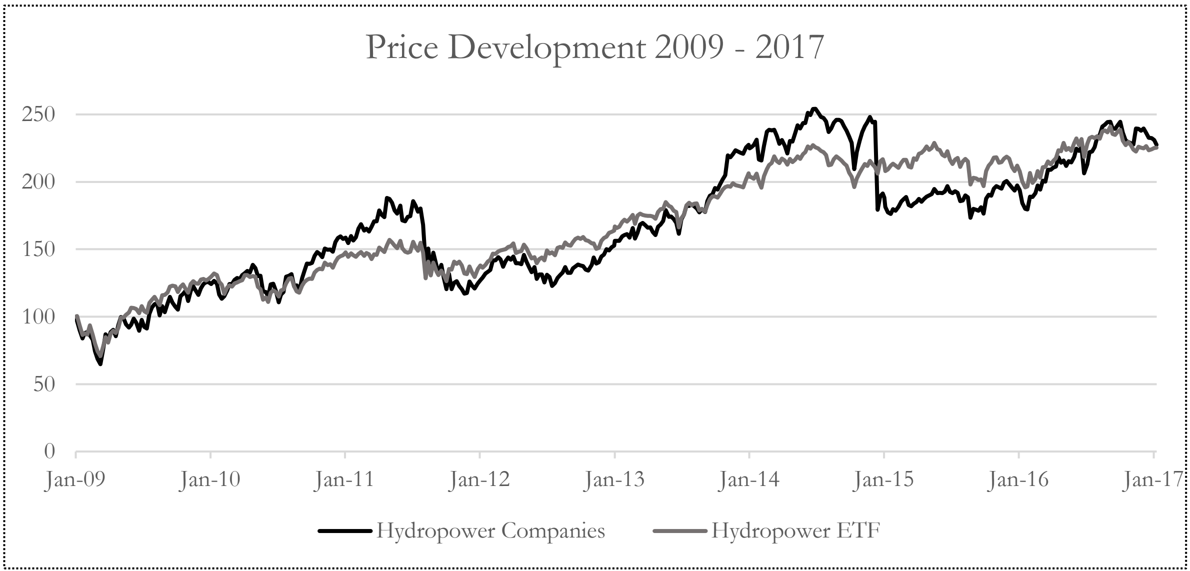

Figure 13: Price developement of the hydropower ETF (CGW) and equally weighted average of hydropower companies.

Norges miljø- og biovitenskapelig universitet
Noregs miljø- og biovitskapelege universitet
Norwegian University of Life Sciences

Postboks 5003
NO-1432 Ås
Norway