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Exploring Value Investing in Renewable Energy

Master thesis

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Preface

I would like to thank my thesis supervisor Mehtap Kiliç. During the Energy Finance course in the Economics bachelor, she sparked my interest for energy economics. Also she gave me the chance to become familiar with the challenges and opportunities that lay in the energy sector. Because of these experiences, I look forward to working in the renewable energy sector after finishing my studies.

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Abstract

As renewable energy is expected to fulfil an important role in the future, it is important to assess the performance, potential and risks of the different renewable energy technologies as well as of the renewable energy sector as a whole. Private investment in renewable energy is required, but it is difficult to convince investors to allocate their resources to new technologies that can't guarantee returns in the short run. In this thesis it is found that mature and proven technologies with higher book-to-market ratios are represented more in a value portfolio. Expected future growth of growth companies does not always materialize, causing newer renewable energy technologies in the growth portfolio to have a lower return over the 10 year sample. This thesis tries to link the underlying characteristics of the companies in the value portfolio to the higher return for value stocks in the long run. The premium can partially be explained by higher systematic risk of the stocks in the value portfolio in times of crises.

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Introduction

As acknowledged by the global community, carbon dioxide (CO_2) emissions are at least partly responsible for global climate change and the increase in global temperature. To limit global warming and to combat climate change, countries joined an international treaty, the United Nations Framework Convention on Climate Change (UNFCCC). Together they strive to present a response to climate change, leading to the adoption of the Kyoto protocol in 1997. This protocol legally binds developed countries to emission reduction targets. In 2015, a new agreement was signed in Paris. The Paris agreement's central aim is to accelerate and intensify the actions and investments needed for a sustainable low carbon future in order to keep global temperature rise below 2˚C above pre-industrial levels (UNFCCC, 2016).

During the last decades, governments have been trying to design efficient climate change policies. In Europe for example, this has led to the setting of the 20-20-20 targets by the European Union in 2007. Which essentially imposes a 20% cut in greenhouse gas emissions compared to 1990 levels, 20% of EU energy being generated by renewable energy sources and a 20% improvement in energy efficiency by 2020 (Bohringer, Rutherford, & Tol, 2009). In China, where 5 year plans are the most influential policy plans, there has been increasing attention for the decarbonisation of the country. From lowering the energy consumption per unit of GDP in the period 2006-2010 and increased hydropower in 2011-2015 to an extensive development plan for the environmental technology industry in 2016-2020. Given that a third of the world's carbon emissions come from China, important steps are taken in the fight against greenhouse gas emissions. In 2009, China issued the 'China Sustainable Development Strategy Report' in which the low-carbon strategy is addressed (Jiang, et al., 2013). The strategy contains explicit goals like the increase of the share of renewable energy in the total primary energy supply to 15%, increase on-grid wind capacity to 30 GW and to have installed 30 million square meters of solar power generation in 2020 (Wang, 2009). China's newest plans hint towards producing 25% of total energy supply from renewable sources in 2030 (The Guardian, 2016).

Besides the public support in various countries like public investments in R&D, investment incentives, tax benefits, incentive schemes, voluntary programs, obligations and tradable certificates, it will be hard, if not impossible, to achieve the ambitious emissions reduction targets without the diffusion of low-carbon technologies (Sanden & Azar, 2005). Diffusion of renewable energy technology could be the basis of long term mass reductions in CO_2 emissions. Still only a small part of the world's energy supply comes from renewable energy sources. The decarbonisation of our energy supply requires important investments to be successful.

One reason for the current limited renewable energy capacity is the relatively small marginal role of private investment in the renewable energy industry (Masini & Menichetti, 2013). Getting investors to invest in renewable energy technology is hard. Especially regarding the economic climate of the past 10 years, it is difficult to convince investors to allocate their resources to new technologies that can't guarantee returns in the short run. The majority of high-tech investors prefer to invest in technologies with low-risk low-return profiles and "seem to be steering clear of risky green investments, suggesting that clean-tech companies for a variety of reasons don't work" (Economist, 2011). At the 2010 World Economic Forum it was estimated that investments need to be increased up to 500 USD Billion in 2030 in order to attain the Kyoto reduction targets (World Economic Forum, 2010).

Other's concern about climate change and its risk for portfolios is the intensifying interest in socially responsible stocks. Since climate change is widely recognized as the most significant environmental issue facing the global economy, investor demand is growing for portfolio opportunities in clean and green technology (SIF, 2007). In a paper by (Galema, Plantinga, & Scholtens, 2008) it is argued that there is a trade-off between financial performance and non-financial performance causing excess demand for social responsible stocks and shortage of demand for irresponsible stocks leading to the overpricing of certain SRI stocks and under-pricing of irresponsible stocks.

Research question

There is a general consensus that there is a trade-off between sustainability and returns (Renneboog, Ter Horst, & Zhang, 2008). Therefore it is important to seek for profitable strategies to make investing in sustainable and renewable energy sources attractive for private investors. There has been an increase in investing and financing activities for renewable energy, but the trade-off between risk and return in the renewable energy sector is uncertain.

Energy security issues, climate change, fossil fuel depletion and new technologies are expected to provide new and exciting investment opportunities for renewable energy. But the renewable energy sector will probably be a risky place to invest for some time. To counter these issues, it is recommended for managers, investors and policy makers to have a good understanding of the determinants of risk in the renewable energy sector (Sadorsky, 2010).

It is interesting to identify profitable investment strategies. It is generally accepted among researchers that value investing achieves superior returns[1]. And so the goal of this thesis is to investigate 'value

[1] (Basu, 1977), (Chan, Yasushi, & Lakonishok, 1994), (Davis, 1994), (De Bondt & Thaler, 1985), (De Bondt & Thaler, 1987), (Fama & French, 1992), (Jaffe, Keim, & Westerfield, 1989), (Lakonishok, Shleifer, & Vishny, 1994), (Rosenberg, Reid, & Lanstein, 1984).

investing' in renewable energy stocks and to identify the cause of a company's high book-to-market ratio. And as investors benchmark the returns to the market, The research question therefor will be:

Can a value investing strategy in renewable energy stocks outperform the market?

Hypotheses

To answer this research question an analysis of the valuation of renewable energy stocks is required. When it is known how the market values risks, returns and social responsibility, we can apply the value investing theory to renewable energy stocks.

The literature supports a view that due to a trade-off between financial and non-financial performance, socially responsible stocks are overvalued (Galema, Plantinga, & Scholtens, 2008). By assessing the relative valuation of the renewable energy companies, it becomes clear how investors value the non-financial aspects of renewable energy stocks. It could also very well be that due to investor's risk aversion, there is a lack of demand for renewable energy stocks because of the risky nature of the technology, leading to an undervaluation of the sector (Sadorsky, 2010). So the hypothesis is tested: *Renewable energy stocks are overvalued relative to conventional energy stocks.*

According to the (Economist, 2011), most of the capital invested in the renewable energy sector has been channelled toward more mature renewable energy technologies that are more secure and closer to grid parity, like on-shore wind and hydro. Differences in book-to-market ratio's between different renewable energy technologies should differentiate the safer and proven technologies from the more uncertain and newer technologies. Using the literature's view on the riskiness of certain technologies combined with companies stock data, this statement is investigated by testing the hypothesis: *Stocks of mature and proven technology companies are value stocks and stocks of newer technology companies are growth stocks.*

Once we have established a view on the relative valuation of the stocks, it is interesting to investigate what causes this over/under-valuation. Growth stocks are believed to have higher expected future earnings (Lakonishok, Shleifer, & Vishny, 1994), these growth options must be visible in the form of more R&D activities. The renewable energy value chain spans from researching new technologies to the generation of electricity. The company activities and the value chain position should say something about its opportunities to grow. R&D activities provide less stable cash flows than energy generating firms but do create more growth options for future revenues. To see how this influences the book-to-market ratios the following hypothesis is tested: *Growth companies undertake more R&D activities than value companies.*

A lot of research has been done looking for possible explanations for the difference in book-to-market values of different companies. A paper by (Zhang, 2005) concludes that so called 'value stocks' are more risky than 'growth stocks' because assets in place are more risky than growth options in economic bad times. If value stocks were to perform better in economic good times and worse in economic bad times, the market beta of value stocks must be higher than the market beta of growth stocks. The fourth hypothesis therefore is: *Value stocks have more systematic risk than growth stocks.*

Literature Review

Since renewable energy might posit the solution to achieving the greenhouse gas emissions reduction target, it increasingly attracts the attention from academic, managerial, investing and policy making entities. First to gain an understanding of the renewable energy sector, a literature review is performed, analysing recent studies into renewable energy. After this, the link is made to investing in renewable energy and is evaluated how to understand various metrics that can provide us with information about the position of renewable energy technology.

Renewable energy

There is an increasing demand for energy due to population expansion, increasing wealth and economic growth. At the same time, energy supply suffers from both short- and long term uncertainty in combination with resources being unevenly distributed across world regions. This is because currently more than 80% of global energy supply depends on finite fossil fuels and thus the existing energy systems are not sustainable (Wustenhagen & Menichetti, 2012). Also, the use of fossil fuels for energy production has negative externalities like the emission of carbon dioxide and other environmental pollution. Nuclear energy is not believed to posit the solution to energy supply certainty, especially since the recent nuclear disaster in Fukushima (Wittneben, 2012).

This has caused the general consensus to shift in favour of renewable energy resources. Renewable energy is defined as energy that is generated from resources that are naturally refilled on a human timescale. This is done directly from the sun (such as concentrated solar and photo-voltaic), indirectly from the sun (such as wind, hydro and photosynthetic energy stored in biomass), or from other natural movements of the environment (geothermal and tidal energy) (Ellabban, Abu-Rub, & Blaadjerg, 2014). In order achieve public policy objectives to increase the share of renewable energy in the global energy mix and to prevent dangerous human-caused climate change, substantial private investment is needed (Mathews, Kidney, Mallon, & Hughes, 2010).

Already private investment in renewable energy has seen a rise. Ten years ago, government funding was the most important source of financing. Nowadays, private investment is the largest source of capital for renewable energy. According to (Wustenhagen & Menichetti, 2012) this is the result of two factors. Firstly, advancement of renewable energy technology resulted in increased reliability and declining costs of many renewable energy options. Secondly, because increased market opportunities created by public renewable energy policies drive private sector investments. This led renewable energy investments to total $328.9bn in 2015 (Bloomberg New Energy finance, 2016). For the future, costs are expected to decrease further as a result of technology development, deployment and economies of scale (Chu & Majumdar, 2012).

To convince private investors to invest their money in renewable energy companies, it is vital to make an assessment of the risks of each renewable energy technology and to keep uncertainties affecting investments in the energy sector in mind (Fuss, Szolgayova, Khabarov, & Obersteiner, 2010). An important feature of the renewable energy sector compared to other investment areas is the influence of regulation by governments and policy makers, a great deal of renewable energy technologies still is dependent on incentive schemes to be able to compete with fossil fuels (Burer & Wustenhagen, 2009). A commitment change by policy makers towards renewable energy might entail a no longer viable future for some renewable energy firms, having a direct effect on the renewable energy companies' returns.

The trade-off between risk and return in the renewable energy sector is uncertain and renewable energy companies are among the riskiest types of companies. In addition it is found that company sales growth has a negative impact on company risk but increasing oil prices have a positive impact on company risk (Sadorsky, 2010). (Henriques & Sadorsky, 2008) find that the renewable energy sector has more in common with the technology sector than with the energy sector. They find market beta values around 2, which are closer to technology companies than to energy companies.

In a paper by (Fuss, Szolgayova, Khabarov, & Obersteiner, 2010) the renewable energy sector uncertainty is explained as the technological uncertainty. This is the uncertainty about which technologies will become available at what cost and in what timeframe. A study performed by (Eleftheriadis & Anagnosopoulou, 2015) finds that due to this technology uncertainty, the mobilization of financial resources is among the most important barriers in the diffusion of renewable energy sources.

The Value Premium

Asset pricing is based upon the assumption that investors demand a higher return when they are confronted with higher undiversifiable risk. So, corrected for risk, all assets should have the same average return. (Banz, 1981) found that stocks of companies with a relative lower market capitalization (small stocks) seem to have higher returns on average than large market capitalization stocks, this is often referred to as the 'small firm premium'. There has been a lot of research into the completeness and accuracy of the CAPM model resulting in several anomalies, possibly pointing out flaws in the efficient market hypothesis.

The Value Effect or The Value Premium first discovered by (Basu, 1977) is an anomaly that states that in the long run, high book-to-market (value) stocks have higher average returns than low book-to-market (growth) stocks. Essentially this are stocks that have low prices in relation to their net worth, which is measured by accounting book value (Ang, 2014). Growth stocks on the other hand, are stocks that are priced high by the market due to their expected growth. The value premium is the gap between the returns of value companies and growth companies. This effect has been widely researched and in the '90s a debate between several researchers emerged about the origin of this value premium (Chan & Lakonishok, 2004). (Fama & French, 1992) chose the side of the efficient market hypothesis and used higher risk to explain the higher average returns. (Lakonishok, Shleifer, & Vishny, 1994) used behavioural reasons and agency costs of investment management to explain the higher returns.

In a paper by (Zhang, 2005) the value premium is explained by costly reversibility and the countercyclical price of risk. This research finds that since value stocks are more risky in economic bad times, they should underperform relative to growth stocks in times of crises. According to (Zhang, 2005) this is due to the inflexibility of the installed assets whereas growth stocks hinge upon their growth options that are more valuable in good times and less costly in bad times. This finding is in contrast with the dotcom bubble, where internet stocks which had no substantial book value, but very high market values would have been considered less risky than value stocks like traditional utilities (Chan & Lakonishok, 2004).

In the area of renewable energy, there are a lot of differences in the likeliness of upcoming cash flows representing the difference between value and growth stocks. Proven technologies with less technological or capacity growth potential are regarded as safer investments than uncertain newer technologies (Masini & Menichetti, 2013). In general, growth stocks that have seen high past growth rates. According to the behavioural explanation, investors tend to overestimate the growth potential into the future, leading to an increased demand for these stocks, bidding up the market price. When this expected higher growth does not materialize, stock prices fall, leading to lower returns relative to value firms (Lakonishok, Shleifer, & Vishny, 1994). The uncertainty about the materialization of the future growth makes the stocks more risky. The rational explanation for the value premium comes from the increased riskiness of value stocks due to their inflexible asset base (Zhang, 2005).

Data

To investigate the hypotheses regarding (over)valuation of renewable energy and to research the main research question, the stocks that are in the EFI Renewable Energy Database are used.

EFI Renewable Energy Database

In 2015, the Energy Finance Institute at the Erasmus University Rotterdam extracted a database according to fundamental requirements that determined whether a company's stock should be regarded as a renewable energy stock or not. Among these was the requirement that a company should be active in one of the stated sub-sectors. The different technology sub-sectors are Geothermal, Biomass, Hydropower, Wind, Solar and Wave & Ocean. Solar will be divided in photovoltaics and concentrated solar, this is due to their different technology maturity and risk profile (Awerbuch, 2000) (Masini & Menichetti, 2013). The database consists of companies with dummies that are "1" if a firm is active in the sub sector and "0" if the company is not active in the sub sector. After correcting for missing data, companies that are bankrupt during our entire timeframe and companies that were founded in 2014, a total of 253 Renewable Energy companies is used.

A description of the renewable energy technologies will be given, as well as the assumed riskiness and growth opportunities of the technology according to (Ellabban, Abu-Rub, & Blaadjerg, 2014). The renewable energy companies in the database are active along the entire value chain, ranging from R&D activities at the beginning of the value chain to the physical delivery of electricity to the end user at the end of the value chain. To translate the technological progress en prospects into a model that we can compare to the valuations of the companies active in the renewable energy technologies, above information will be complemented by data on the maturity, expected growth and riskiness of the technologies found in the literature.

Biomass

Energy from biomass (Bio-energy) represents all the energy generated from organic material originating from plants, trees and crops. This can be done by converting the energy into heat, electricity or biofuels. The biomass can either come directly from the land or from waste streams from the processing of crops for food. A big advantage of biofuels on top of the ability to directly convert the biomass into energy is their storability. This is believed to be one reason for biomass to become a major contender in the future's energy mix because of the presence of discontinuous energy sources such as wind and solar. Because biomass energy is storable it can mitigate the supply volatility of wind and solar. Biogas for example, can be refined into green gas, which has the same physical properties as natural gas and can be fed into the gas grid (Vertogas, 2015). Also these green gasses can be further processed into liquefied natural gas or compact natural gas, that are already widely diffused in the transportation sector.

The downside to biomass is the low energy density and costly collection of the raw materials. Also the production of biomass is intensive in the use of land, water and fossil energy, which all have an opportunity cost (Negro, Alkemade, & Hekkert, 2012). And even though biomass is part of the carbon cycle and reduces carbon dioxide emissions with 90% compared to fossil fuels, it does raise questions about air pollution (Menegaki, 2007). Globally the annual average (past 5 year) growth rate of biomass is around 5% and total biomass energy production capacity is estimated to grow from 62GW in 2010 to 270GW in 2030 (Ellabban, Abu-Rub, & Blaadjerg, 2014).

Geothermal

Geothermal Energy resources consist of thermal energy (heat) from the earth, stored in rock, trapped steam or liquid water. It is considered a cost effective, reliable and environmentally friendly energy source (Hammonds, 2003). Geothermal reservoirs are found in different geological environments in which the temperatures and depths of the thermic reservoirs vary. High temperature geothermal systems (above 180˚C) originate from volcanic systems and moderate to low temperature systems are also found in continental environments (IPCC, 2012). The different temperature geothermal sources can be used for both electricity generation in an often larger geothermal power plant, as the direct use of heat by (smaller) domicile heat pump installations. In 2012, global geothermal energy generating capacity was 11.4 GW and is expected to grow to 140GW in 2050 (IPCC, 2012).

Hydropower

Hydropower is referred to as the electricity that is generated from the energy of moving water with the use of turbines. The most common way in which the water is directed through the turbines is with the use of dams. Hydropower stems from the hydrological cycle that is driven by the heat of the sun. Water travels from higher ground to lower ground forced by gravity and the movement of this water is used to generate electricity. Hydropower plants range from very small plants with the capacity of a few watts to the current largest ‘Three-Gorges-Dam’ in China with a capacity of 22.4GW. Hydropower plants are always site specific and exist in 3 forms. Run-of-River (RoR) plants only use the natural flow of the water to generate electricity. Storage hydro power plants are able to store water in order to consume the energy for power generation some later period. Pumped storage hydro power plants are not energy sources but they operate as storage devices. They have the ability to pump up water during off-peak hours into some higher located reservoir and generate electricity (on-peak) by letting the water flow down again. As with biomass, storage is an effective mitigation of the availability differences of natural energy sources, but these pumped storage hydro plants are net-users of energy.

Hydropower is a well advanced and proven technology that exists for more than a century and has the highest electricity conversion efficiency (>90%) of all renewable energy sources. And although hydro power has lower direct costs, it's a mature technology with less opportunity for significant technological advances (Popp, Hascic, & Medhi, 2010). Another restriction to hydropower capacity growth is the saturation of the plant locations and thus the ability to drastically increase capacity in the future. In Switzerland for example, 88% of the hydro potential was already developed in 2010 (IEA, 2010).

Wind

Generating energy from wind is done through the conversion of the winds kinetic energy into electricity. Wind technology stems from a long time ago, when on-shore wind was mainly used for the creation of mechanical power, for example used to pump water. Wind technology efficiency has already seen a lot of advancements, but still only 40-50% of the winds energy is converted into power. In the future the technology yet awaits more cost reductions (IRENA, 2012). Wind power is generated by power plants that consist of several windmills, also referred to as a windfarms. The downside of these on-shore windfarms are their visibility, noise of wind turbines and land use.

Offshore wind technology is less mature than on-shore technology and demands higher investments. Since 2008, onshore wind has seen cost reductions of 30%, whereas offshore wind still costs 3 times more than onshore wind per installed KW of capacity. Also the maintenance costs for offshore wind are twice as high as for onshore wind (IEA, 2016). In 2012, global wind capacity attributed 2.6% of the total global energy production. Wind power capacity increased with 25% annually over the period 2008-2012 and is believed to grow from its 2012 level of 2.6% of global energy output to 18% by 2050 (IEA, 2013).

Concentrated Solar

The heat produced by concentrating solar light can be used to heat a liquid, gas or solid where after that heat can be converted into electricity. Large plants use reflection devices (mirrors) or lenses to direct the sunlight towards one point in order to bundle many solar beams onto the targeted spot. As a result of the positive experiences and successful projects in concentrated solar, global capacity grew on average by 40% per year to around 2,5GW globally in 2012 (Ellabban, Abu-Rub, & Blaadjerg, 2014). The majority of the companies active in concentrated solar projects are located in Spain and in the south west of the United States.

Photovoltaics (PV)

Another technology which uses the energy of the sun to generate electricity is the photovoltaic system. The technology essentially consists of a PV solar cell that directly converts sunlight into electricity. Many solar cells together form a solar panel and solar panels can be linked together as a modular electricity plant. PV technology has made huge progress in the last years but still a lot of research is done to keep on developing more efficient solar cells (Ellabban, Abu-Rub, & Blaadjerg, 2014). An advantage when compared to concentrated solar is that PV systems generate electricity even when it is not sunny. The majority of installed systems makes use of silicon based solar cells, but the newer panels work with thin film modules. Even though thin film is less efficient, the price per unit of generating capacity is lower. Despite that photovoltaic power does not generate air pollution, there are a lot of environmental concerns regarding the manufacturing, installation and disposal of the solar panels (Menegaki, 2007). Other more advanced technologies like concentrating PV and organic PV cells are still in research phase. Between 2008 and 2015 the average cost of solar PV decreased by almost 80% (IEA, 2016).

Wave & Ocean

The renewable energy sources that are described as Wave & Ocean are generated from 6 sources: waves, tidal range, tidal currents, ocean currents, ocean thermal energy conversion and salinity gradients (Pelc & Fujita, 2002). Various technologies try to capture the energy from waves, water currents, heat differences and even water salt level differences. All ocean energy technologies are currently undergoing intensive research & development, the theoretical potential of ocean energy technologies exceeds current and future human energy demands but still less than 25 MW of capacity is installed each year (Ellabban, Abu-Rub, & Blaadjerg, 2014). The costs of ocean energy are among the highest of all renewable energies per installed MW of capacity. It is estimated that it will take another ten years at least to make the technology cost competitive with other energy sources (IRENA, 2014). Wave & ocean energy does have the potential to generate over 330GW of energy by the year 2050 (EY Global Cleantech Center, 2013). In the database, the company 'Rushydro' was qualified as both a hydro company and a wave & ocean technology company, but the company description states their activities mainly involve generating energy from hydro and thus the wave & ocean dummy was set to 0.

Financial Data

Monthly data like stock prices, total return index, number of shares outstanding, book value per share as well as yearly data like turnover and R&D expenditures are collected from Datastream. As a benchmark, the combination of the S&P Utility index and the STOXX 600 Utilities are used. These indexes constitute out of 50 companies that are mostly conventional electricity generating companies. The MSCI World index will be used as the market portfolio and the one month treasury bill rate will be used as the risk free rate as the data is retrieved from Kenneth French's website.

For the comparison of valuations, the book-to-market and the earnings to price ratio will be used. These are calculated:

$$Book\ to\ Market\ ratio = \frac{(Book\ value\ per\ share)}{(Stock\ Price)} \tag{1}$$

The book to market is thus an indicator of the valuation of the book equity by the market. The higher the stock price (market price) for one unit of book equity, the lower the book-to-market ratio will be. Overvaluation of current book value occurs when the book-to-market ratio is low and people pay relatively more for the equity of the company than when the book-to-market ratio is high. The book value of equity is a yearly metric, and thus this monthly ratio is only affected by a change in the stock price.

$$Price\ earnings\ ratio = \frac{(Stock\ Price)}{(Earnings\ per\ share)} \tag{2}$$

The price earnings ratio is an indicator of the yield of a stock. Is measures the valuation of a company by the market. It is the price paid for a unit of return and thus, the lower the ratio, the more profitable the stock.

To correct for firm size differences, the research and development expenditures must be corrected some way. A proper way to do so is by dividing the yearly research and development expenditures by the company sales (Chan, Lakonishok, & Sougiannis, 2001). This way, the variable displays the relative amount of expenses due to R&D.

For the performance analysis, returns are calculated using the total return index of the stocks. The total return index adjusts for dividend pay-outs and thus reflects the total return from owning a stock. The returns used are calculated with continuous compounding:

$$R_{i,t} = \ln(\frac{P_{i,t}}{P_{i,t-1}}) \tag{3}$$

The time period covered is from January 2005 to December 2014. Monthly data is measured at the end of the month and yearly data is calculated every year at end of December.

Methodology

The research will be executed along the same order as the hypotheses are stated. By testing the hypotheses a thorough understanding will be gained about the companies in the database, their technologies and the matching riskiness. By answering the research question, the earlier findings can be used to understand why performing a value strategy should or should not lead to above market returns.

The first hypothesis will be tested by comparing the book-to-market ratios of conventional energy companies to the book-to-market ratios of the companies in the EFI database. Renewable energy technology is on the rise and is expected to become an important future source of energy. Therefore should all the stocks in the database be regarded as growth stocks by the market and a lower book-to-market ratio should be found than for the average conventional energy company. Also, if there is a trade-off between financial and non-financial performance, the renewable energy stocks should be valued higher by the market because of their social responsibility.

The book-to-market ratios over the period 2005-2014 are compared and tested for significant differences. First a Levene's test is performed to see whether variances are equal or not. If variances are to be assumed equal, an independent samples T-test is performed. If variances are not equal, a Welch's T-test is performed to see the differences among the renewable energy sub categories.

The second hypothesis will be investigated by comparing 'book-to-market' ratios of different subsectors with each other and with the results of the qualitative assessments of the technologies found in the literature. Since the companies are ranked by categorical variables or dummy variables, the only data we use is whether a company is active in a sub-sector and the related book-to-market ratio. If a relation between qualitative (literature) and quantitative (book-to-market ratios) results is found, we get a view on what kind of companies are bought in a value strategy.

The third hypothesis tries to link the underlying characteristics of growth companies to their operational business. If growth companies enclose more growth opportunities, this must be visible in a company metric that possibly predicts growth. To search for a relation between a company's book to market ratios and their R&D expenditures the following OLS regression is performed in Eviews.

$$(\frac{B}{M})_t = \alpha + \beta * \left(\frac{R\&D}{Sales}\right)_t + \varepsilon \qquad (4)$$

In addition to this, a link is made between a company's position in the value chain and a company's growth perspectives. (Chan, Lakonishok, & Sougiannis, 2001) Find that R&D intensity is positively associated with return volatility, and they point out that earnings of companies that have more R&D activity are less certain. This is tested by investigating whether companies that are active in the research and development stage of the value chain have different book-to-market ratios than companies that are for example active in the manufacturing of power plants or in the generation of energy.

The fourth hypothesis, with regard to the possible explanations of the value premium, looks into the increased risk that value companies are ought to have compared to growth companies. If value stocks earn a premium over growth stocks in the long run, this should be due to increased risk. Value companies are seen as inflexible, asset-heavy companies that perform better in economic good times and worse in economic bad times (Zhang, 2005). If this is valid and if the state of the world is indicated by the returns on the MSCI World index (the market portfolio), then the market betas are expected to be higher for value stocks.

To test the fourth hypothesis and to answer the research question, the returns and premiums of the value portfolio must be calculated. The stocks in the EFI database are sorted on book-to-market ratio at every point in time and split up into 3 portfolios according to (Fama & French, Common risk factors in the returns on stocks and bonds, 1992). The stocks with the 30% highest book-to-market ratios are selected for the 'Value' portfolio. Stocks with the 30% lowest book-to-market ratios are added to the 'Growth' portfolio and the stocks with the remaining middle 40% book-to-market ratios is added to the neutral portfolio. The portfolios are rebalanced every month over the period from January 2005 to December 2014. If a value premium is found for the top 30% book-to-market ratio stocks, there is a strong effect. If nothing is found, portfolios can be made by dividing the database into quintiles or deciles to see whether an effect is to be found with bigger differences between the value and the growth portfolio.

Results

Hypothesis 1

An underlying objective of the value strategy is for investors to avoid buying overvalued stocks. When looking at the valuation of a company's equity by the market, high book-to-market ratios hint towards an undervaluation of the equity. When a company's book-to-market ratio is low, this means the market is paying more for the company's equity than its accounting value.

Global warming and climate change are perceived as the most significant threats facing the global economy (SIF, 2007). Because of investor's green preferences and the internalization of company's externalities, it is possible that renewable energy companies are regarded as socially responsible by the market.

Because of a higher demand for responsible stocks, investors are willing to pay more for responsible stocks than for their non-responsible equivalents. It is found by (Dam, 2008) that even when the risk levels for responsible and irresponsible companies are equal, socially responsible firms will have both lower returns and lower book-to-market ratios than their irresponsible industry peers. A result of the increasing popularity of SRI stocks is that they mostly generate negative abnormal returns (Nofsinger & Varma). (Hong & Kacperczyk, 2009) Find that companies have a higher book-to-market ratio resulting from negative ethical issues. These so-called sin stocks are under-priced and have higher excess returns. With the current status quo being against carbon emissions and polluting conventional power technologies, the renewable energy index might be overvalued relative to conventional energy sources.

To see whether there is a trade-off between financial and non-financial performance and to find out whether investors are willing to pay a premium for renewable energy stocks, the hypothesis is tested:

Renewable energy stocks are overvalued relative to conventional energy stocks

The average book-to-market ratios of the EFI companies over time are compared to the average book-to-market ratios of a benchmark index. The benchmark index is created by combining the companies that are in the S&P 500 Utilities and the STOXX 600 Utility indexes. These indexes consist of mostly conventional energy companies that are located in the US and in Europe.

The results of the Welch's t test can be found in table A. From this table it can be seen that the average book-to-market ratio of the utilities benchmark is 0.12 lower than the average book-to-market ratio of the stocks in the EFI database. The renewable energy companies seem not to be overvalued compared to their conventional counterparts. According to (Berry & Junkus, 2012) this might be caused by the lack of a social responsible certification of the EFI stocks. Institutional investors determine their investments based on ESG certificates and a company's carbon footprint rather than the simple requirement that a company is active in the renewable energy sector (Berry & Junkus, 2012).

Table A	B/M			P/E		
	Mean	Std.Dev	Difference	Mean	Std.Dev	Difference
Conventional Energy	0.61	0.38	*-.12	24.15	32.93	***-16.32
EFI Renewable Energy	0.73	0.59		40.49	61.82	

The significant difference between the book-to-market ratios of the conventional and the renewable energy stocks might partially be explained by a more stable earnings yield of the conventional energy companies. The P/E multiple for the conventional energy companies is 16.32 lower than the P/E multiple of the renewable energy stocks. Higher earnings should be discounted in the stock price of a company, correcting for this effect. But the standard deviation of the P/E ratios is almost twice as high for the renewable energy stocks, this indicates higher risk. So a lower P/E multiple explains the lower book-to-market ratio of the conventional energy companies partially because of investors' risk aversion and preferences for more certain earnings.

Since the renewable energy sector is not overvalued as a whole, but there still is a lot of uncertainty regarding the relative valuation of the stocks, it is interesting to analyse the differences and explanations of the book-to-market ratio within the EFI database.

Hypothesis 2

If a value strategy in renewables is performed, the stocks of companies with a high book-to-market ratio are bought because they are believed to have better and more guaranteed returns than the growth stocks that have a low book-to-market ratio. To gain a fundamental understanding of the differences in book-to-market ratios between different technologies, their book to market ratios are analysed. The hypothesis is tested:

Stocks of mature and proven technology companies are value stocks and stocks of newer technology companies are growth stocks.

To start the assessment of each technology's risk and outlook, the literature on the different renewable technologies is analysed. In general, value stocks are stocks from companies that are safer to invest in because their business model is proven and less risky. On the other hand the growth potential of these companies is relatively low. Growth stocks are companies that have much more uncertainty due to their newer business model and technologies. Meanwhile, growth stocks are expected by the market to grow more in the future.

When translating this to renewable energy technology, there are a lot of differences in the factors that determine whether a stock is a growth or a value stock. A summary of recent studies and the findings in this thesis' data section about the technology maturity, the past 5 year capacity growth rate and expected future potential is given in table B. The low past 5 year growth rate and 2030 potential for wave & ocean is a result of the technology's novelty and the related uncertainty (Negro, Alkemade, & Hekkert, 2012).

Technology	Maturity	Past 5 year capacity growth	2030 potential	Average Book-to-Market^{2014}	Average Pure Play Book-to-Market^{2014}
Hydro	proven	3.50%	0.3-0.8x	0.89	1
Geothermal	proven	3.60%	4-15x	0.95	0.97
Biomass	proven	8%	3-5x	0.78	1.17
Wind	moderate	25%	4-12x	0.83	0.86
Concentrated Solar	moderate	40%	20-350x	0.63	0.69
Photovoltaics (PV)	new	60%	7-25x	0.64	0.65
Wave & Ocean	new	5%	x	0.5	0.61

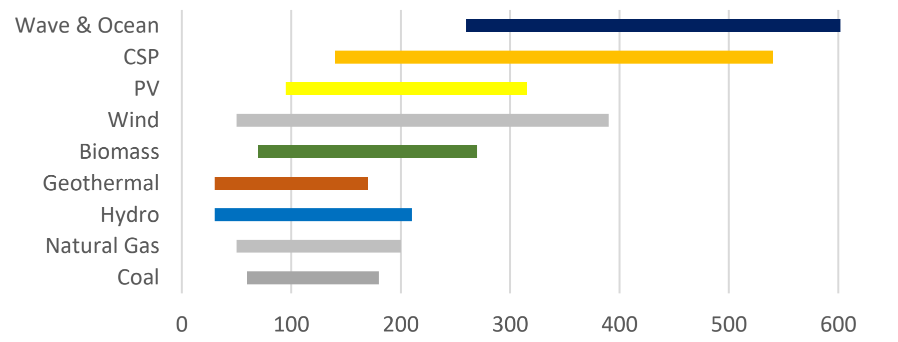
Table B. Source: (GWEC, 2015), (REN21, 2015), (Ellabban, Abu-Rub, & Blaadjerg, 2014), (Evans, Strezov, & Evans, 2008), (Parida, Iniyan, & Goic, 2011)

When we compare the findings about renewable energy technology maturity, risk and growth potential, we indeed see that Biomass, Geothermal and Hydro are expected to be safer investments. Concentrated solar and Photovoltaics have experienced higher growth rates and their 2030 potential is high, but there is more uncertainty regarding the probability of successful materialization of the technologies' growth.

This is also confirmed by comparing the levellized cost of energy of the different energy sources. To be representative for the used data period, the cost levels of 2012 are used. The benchmark is the energy price when generated with coal and natural gas in the bottom of graph 1. Energy sources like Hydro, Geothermal, Biomass and Wind can compete with these conventional energy sources, but as the price spread becomes wider for the newer technologies this characterizes the technology uncertainty. For Hydro the spread is large because prices are given for both large-scale and small-scale energy generation. The wide spread for Wind displays the cost of the cheaper onshore wind energy generation as well as its more expensive offshore counterpart.

PV, CSP and Wave & Ocean energy generation is still too costly to compete with conventional energy sources and the commercialization of these energy sources is still largely dependent on governmental subsidies. In order to become cost competitive, research and development is required, hence are these technologies expected to have a low book-to-market ratio.

Graph 1: Cost of energy[2] ($/MWh)



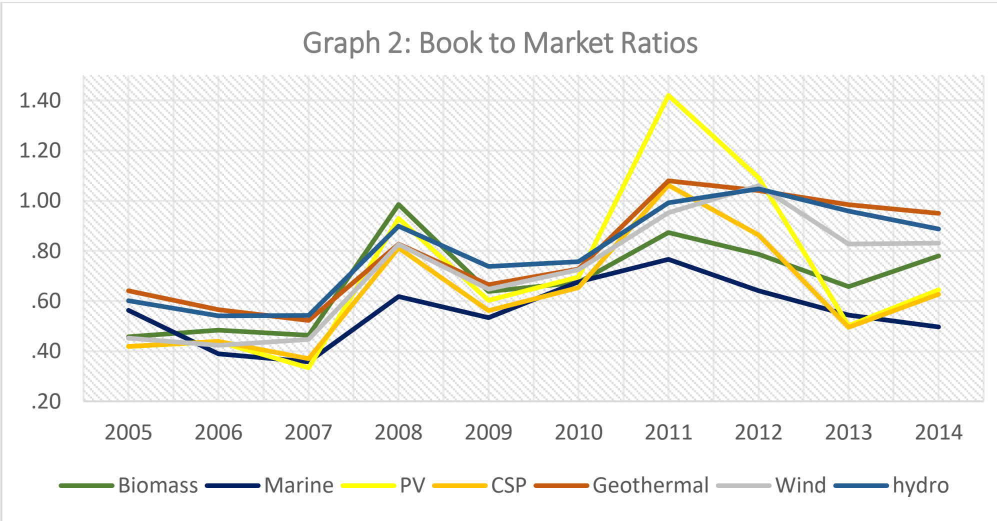
When the book-to-market ratios of the different technologies are analysed over time (table C) overlap is found with the findings about the technologies' characteristics in the literature.

[2] Source: (Nature, 2012), (Bloomberg New Energy Finance, 2013)

Table C: Mean Differences

2005-2014	Biomass	Wave & Ocean	PV	CSP	Geo	Wind
Wave & Ocean	0.170	x				
PV	-0.022	-0.195	x			
CSP	0.063	-0.109	0.085	x		
Geo	-0.120	**-0.293	-0.099	*-0.184	x	
Wind	-0.045	-0.218	-0.023	-0.108	0.075	x
Hydro	-0.167	***-0.328	-0.133	***-0.219	-0.035	-0.110

Starting with the wave & ocean technology companies, the market relatively overvalues these companies the most, as wave & ocean companies have lower book-to-market ratios than any other technology. PV has no significant differences in book-to-market ratios, but as is illustrated in graph 2, this is due to a temporary outflow of capital from PV companies in 2011 and 2012, causing the book-to-market ratios to rise. The capital outflow from solar stocks in 2011 and 2012 was caused by the sectors' market dependence on the Eurozone and worries about the development of the demand for solar panels because of the Euro crisis (Schultz, 2011).



Hydro and geothermal technologies have the highest book-to-market ratios. Both technologies are characterized by their high initial investment and long lifespan. Because of their independence from subsidies, Hydro and geothermal plants can offer stable and predictable cash flows (when revenues are backed by long-term contracts with investment grade counterparties) (Kaminker & Stewart, 2012). Hydro and Geothermal technology are amongst the more mature technologies and have seen the lowest growth rates of all renewable energy technologies in the past years.

In executing the investment strategies, the terms 'value stocks' and 'growth stocks' are determined by a relative measure. The 30% stocks with the highest book-to-market ratio are identified as value and the lowest 30% as growth. When performing these sorts every month to form the value, neutral and growth portfolios, the high book-to-market ratios of the hydro and geothermal companies cause these companies' stocks to be relatively more selected for the value portfolio than the stocks of newer technologies like wave & ocean and concentrated solar. On average 31% of all hydro, 30% of geothermal, 24% of biomass and 24% of wind companies are in the value portfolio. While on average only 6% of the wave & ocean, 19% of photovoltaic and 17% of all concentrated solar power companies are selected for value portfolio over time. So on average mature and proven technologies are more often selected for the value portfolio and newer technologies are more often in the growth portfolio due to their corresponding book-to-market ratios.

Hypothesis 3

The expectations made by investors about the future of a company define how the company is valued on the market. If investors believe that a company's growth options are valuable because they will be commercialized in the form of increased sales, this is anticipated in the stock price. One source of growth options is research and development. Investments made in R&D by a company are expected to generate cash flows in the future. Therefore there should be a relation between R&D expenditures by a company and their growth options (Sadorsky, 2010). The hypothesis is tested:

Growth companies undertake more R&D activities than value companies.

Since high book-to-market companies are defined as value companies and low book-to-market companies as growth companies, a negative relation is predicted to be found between growth options and book-to-market ratios.

The R&D expenditures are normalized for sales and regressed against the book-to-market values of the companies in the EFI database. Resulting from this regression, no significant relation is found between these variables. No conclusions may be drawn however, because this might be due to the limited availability of data. As it is not obligatory to distinctly report R&D expenditures, this might explain why this metric is only available for 68 out of 253 companies in the sample.

Other influential data on the book-to-market ratio of a company may be its position in the value chain. If R&D is among a company's core activities, this might lead to more growth options, which in turn leads to a lower book-to-market ratio. The companies in the database are sorted based on their presence in the value chain. Table D gives an overview of the differences in book-to-market ratios between the value chain positions.

2005-2014	R&D	Manufacturing	Re-Assembly	Services	Energy Generation
Manufacturing	-0.05	x			
Re-Assembly	-0.09	-0.04	x		
Services	-0.07	-0.01	0.02	x	
Energy Generation	***-0.28	***-.227	**-.187	**-.208	x
Transport	**-0.19	*-.138	-0.098	-0.119	0.088

Table D

From this table it can be borrowed that companies active in R&D have lower book-to-market ratios compared to an energy generating company. Energy generating companies have a book to market ratio that is on average 0.28 higher than the ratios of companies active in R&D. The higher book-to-market ratio of generation companies is an indicator of fewer growth options. These results are similar to the results found by testing the second hypothesis in the sense that risks and uncertainties are priced by financial markets. The market values the companies with earnings growth potential by commercializing R&D higher than low growth firms.

There is a relation between the activities of a renewable energy company and its book-to-market ratio. It is not certain however that growth stocks are more active in R&D than value stocks. The only significant outcome of the research is that companies that are active more downstream (closer to the end user) have higher book-to-market ratios.

Hypothesis 4

Historically, value stocks have earned higher average returns than growth stocks. To explain this value premium two features are introduced by (Zhang, 2005). Costly reversibility and the countercyclical price of risk are used to explain the value premium. Costly reversibility means that cutting capital is more costly than expanding capital. Countercyclical price of risk is an effect that causes discount rates to be higher during bad times. This leads to the underestimation of the firms continuation value causing the company to over reduce its assets.

Costly reversibility and the countercyclical price of risk both occur during economically bad times. The value premium that is earned on the stocks of the value companies is therefore explained as a compensation for the higher systematic risk or a higher exposure to the market factor. When the market portfolio is performing badly, the world is considered to be in recession and value stocks should have worse returns. Hence the fourth hypothesis is tested:

Value stocks have more systematic risk than growth stocks.

According to (Zhang, 2005), companies that have an inflexible asset base, such as a large plant, find it harder and more costly to reduce their unproductive capital in economically bad times. Growth firms however have more flexible assets and experience less problems with reducing their capital stocks. In contrast, in economically good times, value firms can use their previously unproductive capital whereas growth firms have to invest more. This effect can be verified by the covariance of the returns of the value and growth portfolio's with returns of the market. The regression and its output is as follows:

$$R_{pt} - R_f = \alpha + \beta(R_m - R_f) + \varepsilon$$

Table E 2005-2014

Portfolio	Value	Neutral	Growth
Alpha	0.002	***-0.01	***-0.02
Market	***1.23	***1.27	***1.29
R^2	0.55	0.59	0.63

As can be derived from table E, the market beta for the value portfolio is lower than the market beta of the growth portfolio. This means the value portfolio has lower exposure to the market factor than the growth portfolio and thus has less systematic risk. (Zhang, 2005) however argues that mostly during times of crises the market beta's of value stocks are higher. To find whether a break in the data can result in a more accurate estimation of the coefficients a Chow-break test has to be performed. This will be done for the period that is recognized as the global credit crisis period. A Chow-break test is performed for the period from September 2008 to March 2009. The test indicates that by handling this period as distinct from the sample, the coefficients can be estimated more accurately. Therefore, a dummy variable that has the value 1 for the crisis period is added to the model. Resulting in the output in table F.

$$R_{pt} - R_f = \alpha + \beta(R_m - R_f) * crisis + \varepsilon$$

Table F Credit crisis

Portfolio	Value	Neutral	Growth
Alpha	*0.06	0	-0.03
Market	***1.94	***1.67	***1.41
R^2	0.88	0.81	0.77

This effectively only regresses the data in the crisis period. The market beta of the value portfolio turns out to be 1.94, and the market beta of the growth portfolio is 1.41. This indicates that in the crisis period, when the entire market had negative returns, the value portfolio performed even worse. According to Zhang, this is due to inflexible assets that are hard to reduce and due to the higher discount rate for future earnings that make the companies want to over-divest their assets.

Since the market beta of the value portfolio over the entire sample is lower than the market beta of the growth portfolio, systematic risk over the entire period is lower. And if the larger losses for the value portfolio only occur during short periods of economic downturn, the strategy might still be profitable.

Conclusion

Renewable energy is a relatively new field with many uncertainties surrounding the technologies, keeping investors from investing the required amount of capital. Private investment is required in order to achieve global emission reduction targets and to develop a feasible alternative for non-renewable fossil fuels. The uncertainties about future growth and cost development of renewable energy discourages investors. When book-to-market ratios of the stocks in EFI Database are compared to conventional energy stocks, it is found that on average, investors are willing to pay more for conventional energy stocks. And that renewable energy firms on average are relatively undervalued. It therefore makes sense to investigate profitable investment strategies in renewable energy stocks.

The value strategy essentially entails buying relatively safe renewable energy stocks. As this thesis has shown, the stocks selected in a value strategy are mostly proven technologies, with low past and low expected future growth rates. Despite the high growth rates and high potential of newer technologies, investing in newer technologies is regarded as more risky. And even though growth stocks are valued much higher than the book value of their equity, these investments on average don't pay off in the long run.

Research question

This thesis' research question is:

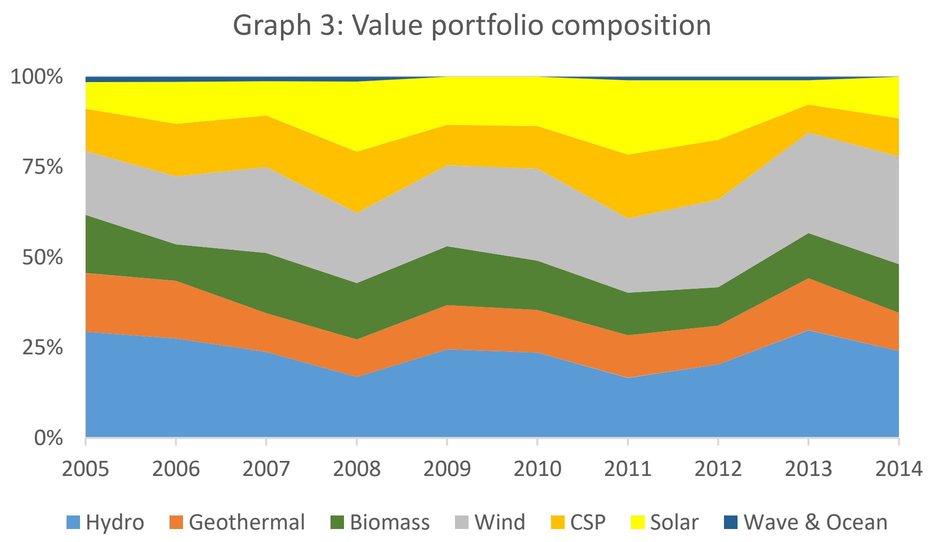
Can a value investing strategy in renewable energy stocks outperform the market?

To provide an answer to this research question, the returns and statistics of the value, neutral and growth strategy are summarized for comparison with the MSCI world index in table G.

2005-2014	Monthly return	Std.Dev.	Sharpe	Beta
MSCI	0.75%	0.044	0.60	1
Value	1.09%	0.073	0.46	1.23
Neutral	-0.15%	0.071	-0.13	1.27
Growth	-1.46%	0.073	-0.74	1.29
EFI	-0.17%	0.070	-0.14	1.27

Table G

The value index has a monthly return of 1.09% compared to the 0.75% return on the MSCI world index. Over the ten year period, the value strategy had a return of 130% and the MSCI World had a return of 90%. At first sight, the value strategy has a higher return than the market. Especially when compared to the neutral and growth portfolio that have negative returns. The entire EFI database had a monthly return of -0.17% and the growth portfolio had a return of -174% over the ten year period. A growth strategy in renewables did not pay off over this period. (Chan & Lakonishok, 2004) found similar results, their value portfolio had a 1.30 percent monthly higher return than the growth portfolio, even though the market betas were very similar.

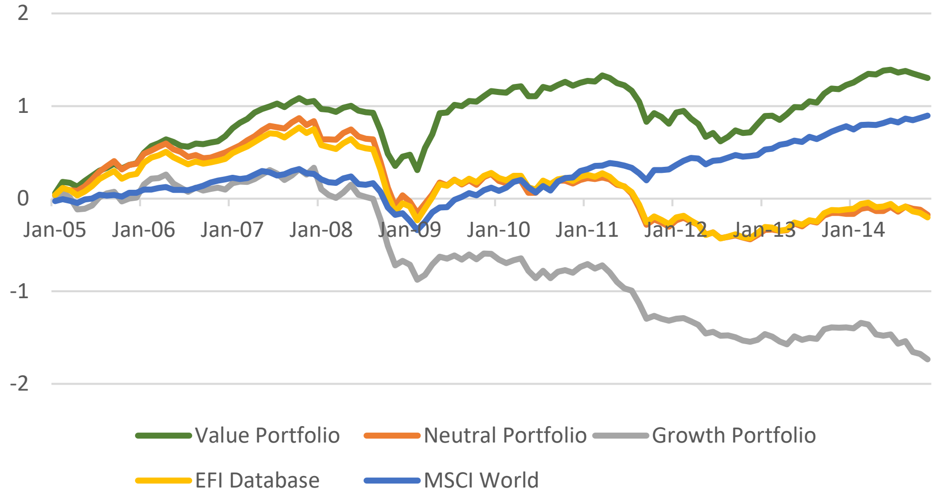


Graph 3 shows the composition of the value portfolio over time. Hydro and Wind are the largest contributors to the strategy. As a result of the Euro crisis in 2011, the share of solar stocks is larger in 2011 and 2012. Remarkable is also, that the share of wind technology companies grows over the period, indicating maturation of the technology. Wave & Ocean technologies attribute virtually nothing to the value index, as their largest contribution stalls at 1%.

To outperform the market, not only the return needs to be above the market return as performance also measures risk. So besides return percentages, the return that is adjusted for risk matters. The sharpe ratio measures the excess return of a portfolio corrected for risk. When the sharpe ratio of the value portfolio is compared with the sharpe ratio of the MSCI world index, it shows that the value strategy has a lower risk adjusted return. Even though a value strategy aimed to select the least risky stocks in the EFI Renewable energy database, the strategy is still more risky than the world index. (Laurikka, 2008) argues that diversification across various renewable technologies could present the best trade-off between risk and return through diversifying plant-specific risk.

When the graph of the value, neutral and growth strategies is examined, it is clear that the three strategies are very correlated. The strategies perform fairly well up until the credit crisis in the late months of 2008. And even though the value portfolio has more systematic risk during crisis periods, in the long run it generates a superior return than the growth and neutral portfolios.

Graph 4: Cumulative returns



Adjusted for risk, a value strategy does not outperform the market as a benchmark. However, more institutional and private investors are altering their preferences towards sustainable investing. If investors believe in a trade-off between financial and non-financial performance, investing in renewable energy could lead to a higher utility for the investor. Given that an investor wants to invest in the more risky universe of renewable energy, a value strategy involving committing to proven and mature renewable energy technology companies that operate closer to the end user could lead to attractive returns.

As renewable energy is a trending topic among investors, further research can be done into the relation between a company's carbon footprint and the attitude of investors towards the company. As manufacturing companies in the renewable energy technology sector are working towards a renewable future, but have large carbon footprints, the stocks of these companies are often not seen as sustainable investments. Also, as this industry is driven by the need for carbon reduction, it could be interesting to research the effect of a technology's carbon pay-back period. This is the amount of years needed in saved carbon emissions to make up for the carbon needed for the construction of the system.

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