

Cost of capital in a wind generated electricity project

An alternative approach of estimating cost of capital

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This Master's Thesis is carried out as a part of the education at the University of Agder and is therefore approved as a part of this education. However, this does not imply that the University answers for the methods that are used or the conclusions that are drawn.

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Acknowledgments

This mandatory master thesis marks the end of the MSc in business administration at the University of Agder, Kristiansand and represents 30 credits.

During the master program and my specialization in finance and through the courses Investment and Corporate Finance, the interest for financial markets increased. Combined with the topic is highly relevant in the current discussion of energy, this thesis has been a very interesting experience, but at times frustrating.

I would like to thank my supervisor Dennis Frestad for useful comments and guidance. A thank to Norwegian Wind Energy Association (NORWEA) for help with defining a subject and help. Last, but not least I would like to thank my family support through these years and friends from the University that made the environment possible for learning and fun.

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Abstract

The main purpose of this thesis is to give both a traditional and a new way of estimating the required return on equity and the cost of capital for a wind generated electricity project. The computations are based on the CAPM and the new three factor model by Long Chen, Lu Zhang and Robert Novy-Marx.

The CAPM model's estimation of cost of equity is 12.5% *after tax*. Further, the estimations extend to estimating the cost of debt of 5.7%. The project financed by 50% equity and 50% debt yields an after tax WACC of 8.25%. The CAPM model's estimations is a result of a Norwegian risk free rate, market return on an international diversified portfolio and beta from looking at historical returns from a broad range of relevant comparable companies. The cost of debt and the WACC is a further extension of the CAPM model which is not considered for the three factor model.

The new three factor model consists of a market factor, an investment factor and a return on assets (ROA) factor and their respective beta values. The computation is done by qualitatively arguing the returns found in the article by Chen, Zhang and Novy-Marx from the US stock market to make a fair estimate for the index for the broad international diversified portfolio. The computations of the beta values are argued looking at the general systematic risk aspect for the wind power project for each of the beta values. The computation yields a cost of equity of 20.46% using the multifactor model.

Comparing the cost of equity found by the three factor model of 20.46% and the *pre-tax* cost of equity of CAPM of 17.4%, there is an apparent difference of results. The reason for this difference will be the increased explanatory power of the new three factor model compared to the CAPM model. According to Chen, Zhang, and Novy-Marx the new factor model captures many of the anomalies that is left to be explained by previous asset pricing model like; financial distress, net stock issues, accruals, earnings surprises and asset growth. The thesis will show that the introduction of the new factors and through these anomalies to an extent are present in our wind power project and are able to capture more of the systemic risk and hence explain the difference of the two models.

In conclusion, the practical implication and validity of the two models are discussed. The new factor model seems to be the best one when it comes to capture more of risk inherent in a wind power project. The CAPM model seems to be the simplest one to use in practice.

Table of contents

- Chapter 1 - Introduction 6
 - 1.1 The price setting process of wind power 8
 - 1.2 Green certificates..... 9
- Chapter - 2 Theory 12
 - 2.1 Efficient portfolios 12
 - 2.2 Weighted average cost of capital..... 14
 - 2.2.1 Types of risk 14
 - 2.2.2 Weighted average cost of capital (WACC) 15
 - 2.2.3 Capital asset pricing model 17
 - 2.2.4 Tax effect..... 18
 - 2.2.5 Cost of equity 18
 - 2.2.6 Cost of debt 19
 - 2.3 CAPM inefficiency..... 19
 - 2.4 An alternative three-factor model..... 21
 - 2.4.1 The basic intuition of the multifactor model 21
 - 2.4.2 Market factor 23
 - 2.4.3 Investment factor 23
 - 2.4.4 ROA factor 25
- Chapter 3 - The input parameters for CAPM 27
 - 3.1 Risk free rate 27
 - 3.2 The tax effect..... 29
 - 3.3 The expected return on the market 30
 - 3.3.1 The market return 30
 - 3.3.2 An alternative way..... 32
 - 3.3.3 Liquidity premium..... 33
 - 3.4 Estimating the beta coefficients..... 34
 - 3.4.1 The debt beta 35
 - 3.4.2 Comparable companies 35
 - 3.4.3 The equity beta 39
- Chapter 4 – Computation of the WACC 42
 - 4.1 Cost of equity 42
 - 4.2 Cost of debt 42

4.3 The WACC.....	43
Chapter 5 – The computation of the three factor model.....	44
5.1 The return on the investment and ROA factor	44
5.2 The beta coefficients	48
5.2.1 The investment beta.....	48
5.2.4 The ROA beta.....	51
5.3 Computation of the factor model.....	57
Chapter 6 - A comparison of the two models.....	58
Chapter 7 - Conclusions	62
7.1 CAPM is CRAP?.....	62
7.2 The three factor model, a better view?	64
7.3 What is best?	65
7.4 Critique and suggestions of further work	66
Chapter 8 - References	67

List of figures

Figure 1 - The price setting process of electricity	8
Figure 2 - A framework of the common green certificate market	9
Figure 3 - The expected development of issued green certificates.....	10
Figure 4 - The risk return relationship for the investor	13
Figure 5 - The reduction of risk due to diversification.....	15
Figure 6 - The negative relation between investment to assets and discount rate	23
Figure 7 – Historical yield last 15 and 10 years	28
Figure 8 - MSCI Barra World index 1970-2010	31
Figure 9 - Historical development of NASDAQ, NYSE and AMEX	45
Figure 10 - 12 month US and Euro interbank offered rate	47
Figure 11 - Historical prices of power and green certificates.....	52
Figure 12 - Predicted power prices.....	53
Figure 13 - Predicted price of green certificates	54
Figure 14 - The distribution of income between green certificates and power	55

List of tables

Table 1 – Average yield last 15 and 10 years.....	28
Table 2 - Regression results, Vestas.....	36
Table 3 - Regression results, Greentech Energy Systems	36
Table 4 - Regression results, Plambeck Neue Energien Wind Systems.....	37
Table 5 - Regression results, Gamesa.....	38
Table 6 - Summary of the asset betas	39
Table 7 - Correlation matrix between MSCI World, NASDAQ, NYSE and AMEX	45
Table 8 - A typical cost structure of initial investments.....	49
Table 9 - Summary of the cost of equity estimates	58

Chapter 1 - Introduction

Development of wind farms in Europe the last decade have increased due to the search for alternative energy sources in order to meet the world's energy demand. The new EU directive for renewable energy from 2008 imposes the European countries to have 20% of total energy supply coming from renewable energy sources by 2020 (www.fornybar.no). The EU-directive have set more focus on renewable energy sources and particular wind power as a substitute for price volatile fossil fuel generated electricity like coal and gas. First and foremost west European countries like Germany and Spain have the largest capacity of wind generating electricity with 24 GW and 17 GW respectively, while Denmark is having the biggest share of total electricity consumption of 20% coming from wind power (ECONA, 2011, p. 58).

In Norway however wind generated electricity only made less than 1% of the total electricity production in 2009 (ECONA, 2011). With the European Union's directive for renewable energy there has been a shift in the general opinion of politicians in Norway about wind generated electricity in Norway. During the last winters and particular during this winter, the spot prices in Norway have been at the all-time high due to electricity production coming from hydro power and the reservoirs being below 20% due to cold and the effects of this cold; heating. The common green certificate system between Norway and Sweden starting from 01.01.2012 will encourage development of renewable energy and wind power in particular. Section 1.1 and 1.2 will provide the basics of the price setting process of wind generated electricity and an introduction of green certificates. According to ENOVA, the investment subsidy for renewable energy from the Norwegian Ministry of Petroleum and Energy managed by ENOVA will lapse due to this common green certificate system (www.enova.no). The new common market of green certificates will be able to finance some of the development still, the certificates won't be able to finance the projects in the same way the subsidy arrangement did. The new wind power projects in Norway must find other ways to finance the projects by finding alternative investors.

In order for investors to make a fair prediction of the risk the investor encounters and how much the investor should earn in compensation for carrying this risk in a wind power project, *the use of cost of capital is required* and the use of this cost of capital to discount the future cash flow to net present value. Thore Johnsen defines cost of capital as; the expected return the general market is offering with the same exposure to risk (Johnsen, 2005). In other words;

a market based opportunity cost for the particular investment. The capital asset pricing model (CAPM) by Sharpe and Lintner is the most used model for obtaining such a cost of capital estimation despite its empirical inefficiencies proved by several researchers. During the recent years several researchers, among them Eugene Fama and Kenneth French have found alternative models that not only takes the market risk into consideration, but also other sources of risk for estimating cost of capital using a *multi factor model*.

This thesis provides estimations of cost of equity by the CAPM model and the new three factor model by Chen, Zhang and Novy-Marx that is under revision to be published in Journal of Finance later this year. Further discussion will be given in order to compare the two models and arrive at a conclusion about the two models validity and practical implications for estimating cost of capital for a wind generated electricity project in Norway. The CAPM estimation is extended to also compute the cost of debt in order to estimate the WACC.

The estimations in this thesis are based on a set of assumptions:

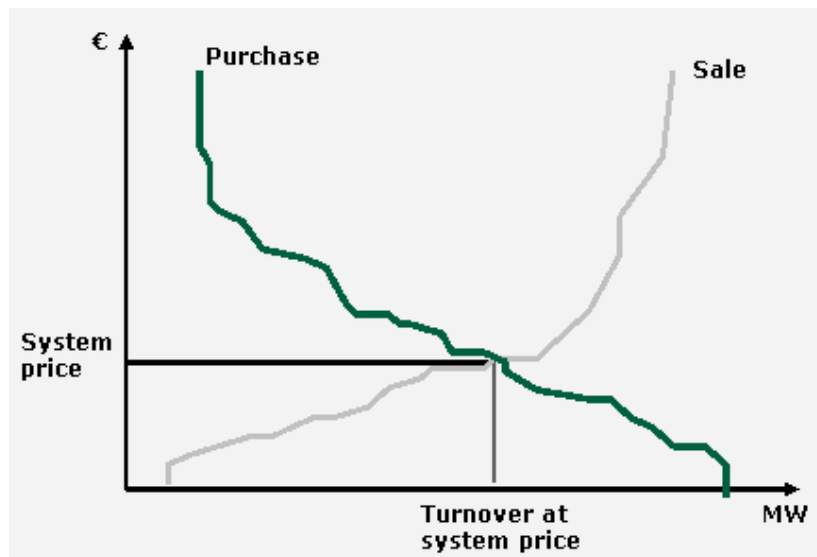
- The estimations are made based on a generalized medium sized Norwegian wind power project
- The common market of green certificates between Norway and Sweden is in place starting from 01.01.2012 and investment subsidies for wind power projects from the Norwegian Ministry of Petroleum and Energy, managed by ENOVA have lapsed as a result of the green certificate market (www.enova.no).
- Trying to attract enough equity to the project there might not be sufficient with only Norwegian investors and projects need to look outside their borders in order to attract capital and the knowledge of wind generating electricity. Therefore the investors are considered to be international diversified investors during this thesis.
- The initial cost of a wind generated electricity project is high and does not pay back until 7-10 years have lapsed during an economic lifetime of 20-25 years of the project (Krohn, Morthorst, & Awerbuch, 2009). Therefore it is natural to assume in this thesis that the investors are defining their investment horizon as long term.

1.1 The price setting process of wind power

Electricity is different from other commodities in the way that electricity cannot be stored; therefore the market requires extensive supervision in order to balance the supply and demand. This applies especially to wind power, because the ability to produce electricity is depended on the wind. In the price setting process for wind generated electricity, each wind farm makes its own predictions of the next days of production based on models and weather forecast. On the spot market like Nord Pool the supply and demand bids are being submitted 12-48 hours in advance and are product of the supply and demand and the spot price for electricity for a 24 hour period. Since the wind power electricity generation can be volatile, the supply bids that are submitted in some cases may not be met. In that case, other producers have to increase their production in order to balance the market and make supply and demand equal (Krohn, et al., 2009).

Figure 1 (www.nordpoolspot.com) gives a typical example of the aggregate demand and supply curve denoted purchase and sale.

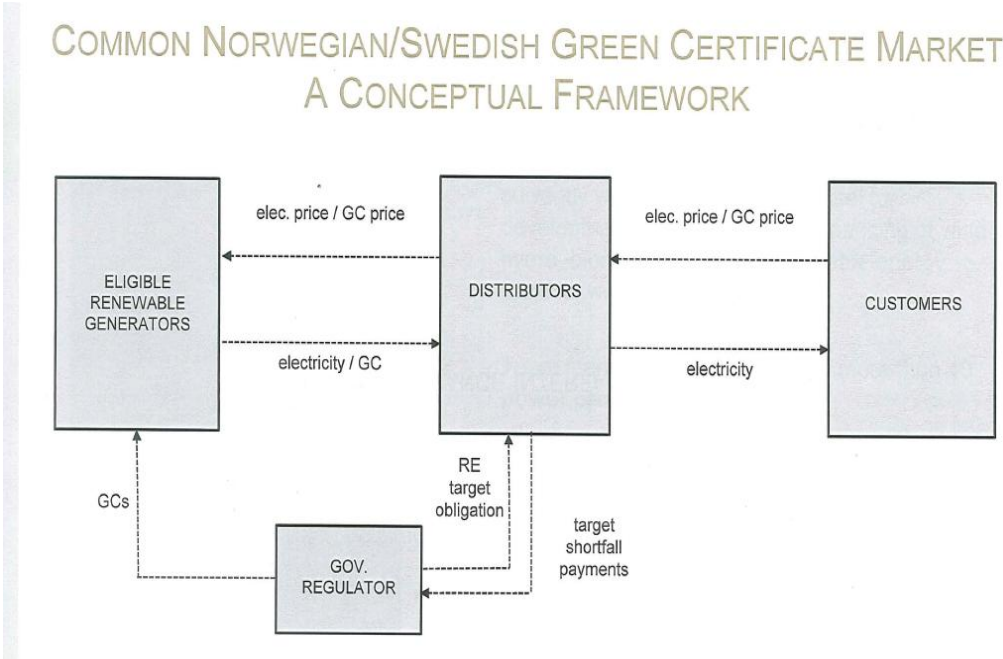
Figure 1 - The price setting process of electricity



1.2 Green certificates

According to press release of 8.12-2010 no. 117/10 Norwegian and Swedish government is agree on a common green certificate market starting from 01.01.2012. The new common market of green certificates between Norway and Sweden will be able to finance and make incentives to develop new renewable energy projects in the two countries. Figure 2 (presentation by Wikborg&Rein 2011) illustrates the conceptual framework of the common market.

Figure 2 - A framework of the common green certificate market

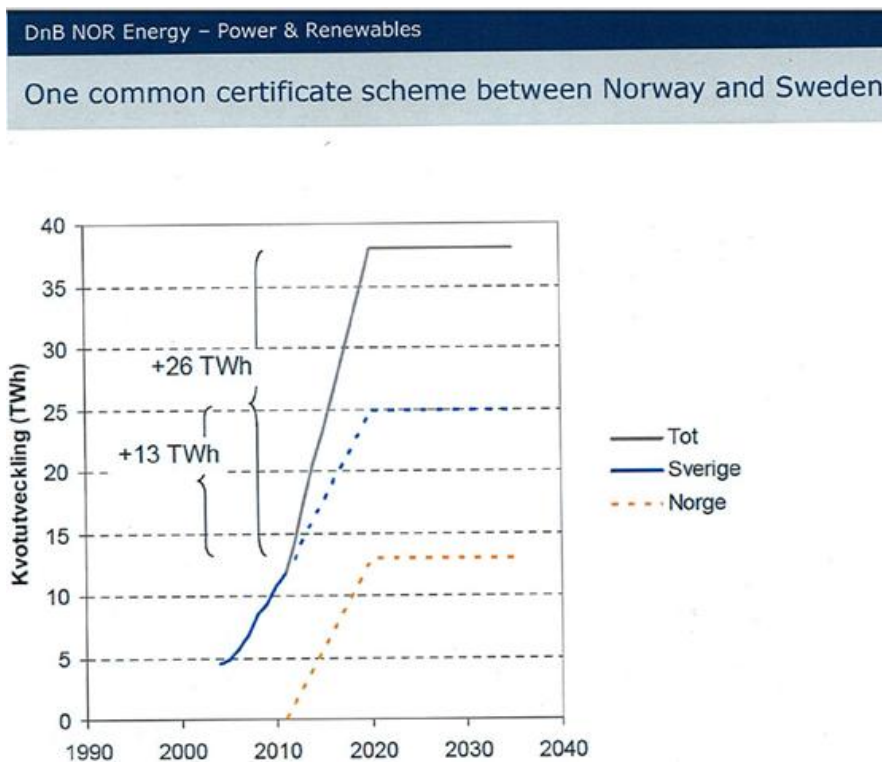


The government regulator in Norway, the Ministry of Petroleum and Energy awards eligible renewable generators green certificates for a corresponding amount of electricity produced. The electricity generator is obligated to also sell the corresponding green certificates with the electricity to the distributors which sell the electricity to the final customer. The process of selling the green certificates will induce a demand for these certificates and a price of these

certificates will be set. The result is that producers of renewable energy will get an extra income from selling the electricity using the green certificates (www.regjeringen.no/oed).

As figure 3 (Dnb Nor Energy, 2011) illustrates, the common market will up to 2035 provide the market with 26 TWh in green certificates, 8.2 TWh will come from wind power.

Figure 3 - The expected development of issued green certificates



This thesis is divided into the following chapters:

Chapter 2 – Theory; this chapter presents the models and the theory behind that is used for estimating cost of capital, the CAPM and the new three factor model.

Chapter 3 – The input parameters CAPM; estimates the different parameters for the CAPM risk free rate, market premium, tax effect and beta coefficients.

Chapter 4 – Computation of the WACC; this chapter estimates the different components cost of equity and cost of debt necessary to compute the WACC.

Chapter 5 – The computation of the three factor model; this chapter estimates the return on the factors and the beta coefficients for the new three factor model.

Chapter 6 – A comparison of the two models; this chapter describes the findings of the two models and what might explain the differences of results in terms of explanatory power of the two models.

Chapter 7 – Conclusions; this chapter discusses the validity and practical implications of the CAPM model and the new three factor model in a wind power setting.

Chapter - 2 Theory

This chapter provides the theory behind the CAPM model and the new three factor model. Part 1 introduces the Markowitz mean efficient portfolio model which lays the foundation of the CAPM model and the weighted average cost of capital in part 2. Part 3 discusses the development from the CAPM model towards newer factor models. Part 4 describes the new three factor model presented in the article of Chen, Zhang and Novy-Marx.

2.1 Efficient portfolios

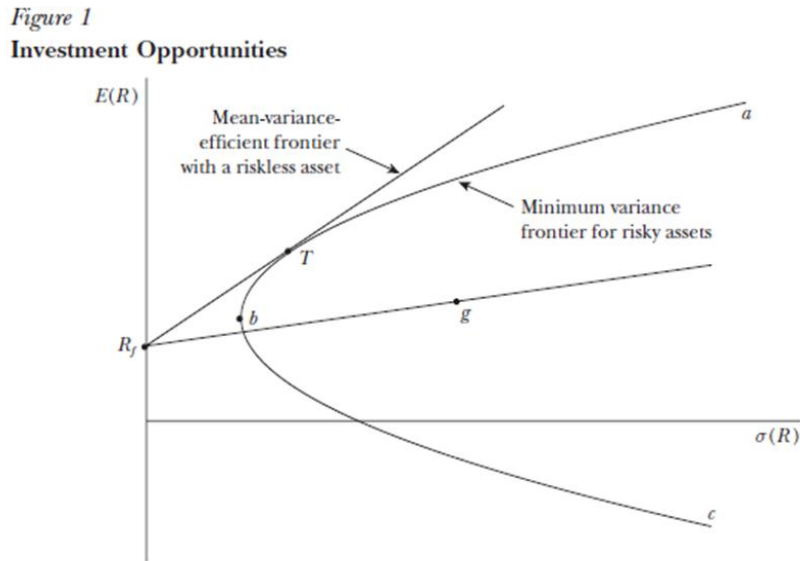
The CAPM model is based on the portfolio choice model developed by Harry Markowitz in 1959. The basic assumptions of the portfolio choice model are (Fama & French, 2004):

- Investors are risk averse, meaning the investor is looking to minimize their exposure to risk.
- Investor only care about mean and variance in their one period investment.

As a result of these assumptions we have the Markowitz's "mean efficient portfolio model"; the investor either maximizes the return given the level of variance or minimizes the variance given a level of return.

Figure 4 on the next page describes the opportunities the investor is faced with and explains the rationale behind the CAPM model. The figure shows the relationship between the expected return and risk measured as standard deviation for the portfolio. The horizontal axis shows the total portfolio variance and the vertical axis shows the expected return on the total portfolio.

Figure 4 - The risk return relationship for the investor



The curve, a-b-c shows the minimum variance frontier for the risky asset. This frontier shows different combinations for risk and return for portfolios with risky assets that minimize the return variance for different levels of expected return. An investor that want a high expected return on the portfolio of risky assets like in point a in the graph, must also accept high volatility of the returns.

If there is no risk free borrowing or lending, only the portfolio above point b on the minimum variance frontier will be mean variance efficient. The portfolios above point b give a higher expected return for the same volatility than directly below point b. So portfolios below point b will not minimize the volatility given the level of return because there are better opportunities lying directly above for the same risk.

Later, Sharpe (1964) and Lintner (1965) added the assumptions to this model that all the investors agree on the distribution of the one period return and introduced risk free borrowing and lending.

The introduction of the risk free asset turns the efficient set into a straight line. Assume an investor is constructing a portfolio and investing the proportion x in the risk free asset and proportion $1-x$ in the portfolio g shown in figure 4; if all funds are borrowed at a risk free rate, the result is the point R_f in the figure and yields a portfolio with zero variance and a risk free rate of return. A combination of the risk free asset and the risky portfolio named g in the

figure makes a portfolio that is plotted on the line between R_f and g in the figure. In order to find the mean variance efficient portfolio consisting of risk free borrowing and lending, one swings a line from R_f up to the left as far as possible to the tangency portfolio T in the figure. All efficient portfolios are a combination of risk free asset and the risky tangency portfolio of stocks.

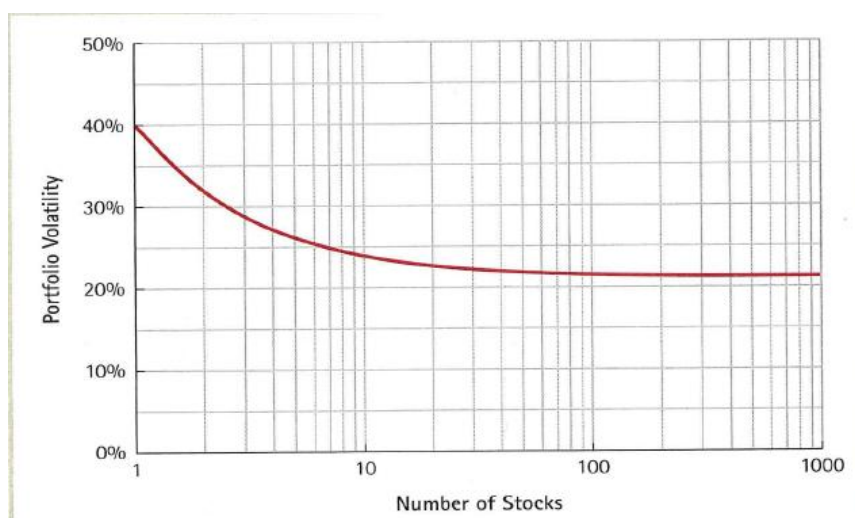
With the assumption that all the investors are looking at the same distribution of returns, all the investors are now looking at the same opportunity set and combine the same risky tangency portfolio T with risk free borrowing or lending. Since all the investors are holding the same portfolio T of risky assets, it must be the value weighted market portfolio of risky assets. This common portfolio among the investors can now be called the market portfolio M . Each of the risky assets weight in the tangency portfolio for market must now be the total market value of all outstanding units of the asset divided by the total market value of all risky assets.

2.2 Weighted average cost of capital

2.2.1 Types of risk

The return of the project will be influenced by different aspects of risk. This risk can be separated in to two parts, systemic and non-systemic risk. Systemic risk is risk that is related to the overall economy like business cycles. Non-systemic risk is related to a single company or industry. When many stocks are combined in one portfolio, the non-systematic risk will be averaged out and diversified away. In a well-diversified portfolio the investor is only facing the systemic risk, the risk that all the stocks in the portfolio are facing (Berk & DeMarzo, 2007). The portfolio does not necessarily have to consist of stocks, but a portfolio of wind power projects for example. Figure 5 shows the power of diversification (Berk & DeMarzo, 2007, p. 333).

Figure 5 - The reduction of risk due to diversification



As depicted in figure 5, the overall portfolio volatility decreases as the number of stocks increases. The curve flattens at about 20% which can be interpreted as the systemic risk.

2.2.2 Weighted average cost of capital (WACC)

According to Berk and DeMarzo (2007), the Law of One Price states that equivalent investments opportunities traded in different markets must trade at the same price in both markets. Miller and Modigliani argued that in absence of tax and transaction costs (perfect capital market conditions) the total value of the total cash flow paid out to all of a firm's security holders is equal to the total cash flow generated by the firm's assets. By the Law of One Price, the firm's securities and its assets must have the same total market value. As long as the firm does not change its choice of securities it does not change the cash flows generated by its assets. This can be illustrated by the equation below:

$$E + D = U = A$$

Where E and D is the market value of equity and debt if the firm is levered, U is the unlevered (no debt) market value of equity and A is the market value of the firm's assets. The total market value of the firm's securities is equal to the market value of its assets, whether the firm is levered or unlevered.

By holding a portfolio of the firm's equity and debt, one can replicate the cash flows from holding unlevered equity. The return of a portfolio is the weighted average of the returns of

the securities in it, therefore the different securities have to be weighted according to the returns on levered equity and debt.

The levered return on equity equals the unlevered return plus an extra effect due to the leverage. This effect pushes the returns of levered equity even higher when the firm performs well, but lowers when it does poorly. The extra effect is measured by the amount of leverage compared to equity.

Different projects or companies have different combinations of equity and debt in their capital structure. In order to find the appropriate discount rate given the risk of the project's free cash flow, the cost of capital should equal the return that is available on other investments with similar risk. If one can identify a comparable firm whose assets have the same risk as the project being evaluated and the firm is unlevered implies that the use of equity cost of capital as the cost of capital for the project. If the comparable firm has debt, the increased risk due to leverage will make its equity cost of capital higher than the cost of capital for the assets and the project. In the case of debt, the use of weighted average cost of capital (WACC) of the firm's equity and debt cost of capital is required. The WACC replicates the return on a portfolio as it was unlevered. The WACC formula is presented formally in equation 2.1 (Berk & DeMarzo, 2007):

$$r_{wacc} = r_e \cdot \frac{E}{E+D} + r_d \cdot (1 - \tau_c) \cdot \frac{D}{E+D} \quad (2.1)$$

The WACC is the weighted average of the required return on equity r_e and debt r_d . Since the cost of debt or interest is tax deductible, we deduct the current corporate tax rate from the cost of debt; $1 - \tau_c$ where τ_c is the current corporate tax rate.

2.2.3 Capital asset pricing model

The CAPM model takes the ideas behind the mean efficient portfolios theory and applies them in order to compute the expected return of a stock. Sharpe and Lintner added more assumptions in order to develop the CAPM model (Bodie, Kane, & Marcus, 2009):

- The investors are holding the asset for one period
- No market imperfections
- Investors are mean variance optimizers
- Homogenous beliefs among investor about the distribution of the return
- All investors are choosing a portfolio that duplicates the assets in market portfolio M.

The CAPM model yields the expected return that is necessary to compensate for the risk investment will contribute to the total portfolio; *the required rate of return*.

The general equation for the CAPM is stated in equation 2.2 (Bodie, et al., 2009):

$$r_i = r_f + \beta_i \cdot [E(r_{mkt}) - r_f] \quad (2.2)$$

The expected return on the stock r_i is explained by a risk free interest rate r_f , the market excess return or market premium denoted as $E(r_{mkt}) - r_f$ and a beta coefficient β_i . According to Berk and DeMarzo (2007) the beta can be interpreted as: “... *the expected percent change in the excess return of the security for a 1% change in the excess return of the market portfolio*”. In other words the beta measures the stock’s sensitivity to a marginal change in the market portfolio.

The beta can be formally defined through equation 2.3 (Bodie, et al., 2009):

$$\beta_i = \frac{Corr(r_i, r_m) \cdot Std(r_i)}{Std(r_m)} \quad (2.3)$$

2.2.4 Tax effect

The following discussion will introduce the tax effect for estimating the cost of equity and debt. The tax effect is the relationship between tax on interest τ_d and tax on equity income τ_e . In order to understand why the tax effect is relevant and what it consists of, we assume that the investor either can choose to hold bonds or stocks. Both options are assumed to be risk free and paid in an after tax amount. The investor is then indifferent between choosing the stock or the bond; this applies to risky projects as well as long as they give the same expected return after tax is deducted. The risk free return before tax is denoted r_{fe} for equity and r_f for debt. In order for the investor to be indifferent between choosing equity or debt it has to satisfy the following equation:

$$r_{fe} \cdot (1 - \tau_e) = r_f \cdot (1 - \tau_d)$$

And solve for r_{fe} yields:

$$r_{fe} = r_f \cdot \frac{(1 - \tau_d)}{(1 - \tau_e)}$$

The tax effect is presented in equation 2.4 (Bøhren & Michalsen, 2010):

$$\tau^* = \frac{1 - \tau_d}{1 - \tau_e} \quad (2.4)$$

This implies that tax on equity income is different from tax on debt income, the return before tax must reflect this difference in order to investor to be indifferent. Now the equation for the *risk free rate for equity* can be rewritten to:

$$r_{fe} = r_f \cdot \tau^*$$

2.2.5 Cost of equity

Equation 2.5 describes the after tax cost of equity r_e for WACC. This equation is an extension of the equation presented in 2.2, introducing the tax effect τ^* (Bøhren & Michalsen, 2010):

$$r_e = r_f \cdot \tau^* + \beta_e \cdot [E(r_m) - r_f \cdot \tau^*] \quad (2.5)$$

The equity beta β_e is a result of the project's financing structure of equity and debt, this will be further investigated in chapter 3.

2.2.6 Cost of debt

Equation 2.6 describes the cost of debt denoted r_d in WACC (Bøhren & Michalsen, 2010):

$$r_d = r_f + \beta_d \cdot [E(r_m) - r_f \cdot \tau^*] \quad (2.6)$$

Contrary to the cost of equity, the cost of debt does not have a tax adjusted risk free rate. This is because this part of the equation shows the expected return of a project that is risk free, in other words a beta of zero. Like previously mentioned the risk free return for debt is denoted r_f while risk free return on equity is denoted $r_f \cdot \tau^*$, hence this component is different from equation 2.5 to 2.6 and only identical if $\tau^* = 1$. In Norway, where the tax for interest is higher than equity income, because of the tax exemption model for equity income, the tax effect is likely to be $\tau^* < 1$. Hence this component is likely to be greater for cost of debt than for cost of equity. The risk premium is deducted for tax in similar way as the cost of equity. The debt beta denoted β_d gives the sensitivity of the project's ability to serve the debt obligation given the market fluctuations.

2.3 CAPM inefficiency

During the 1970's and trough 1980's, several researchers started doubting the theoretical framework and explanatory factors of the CAPM. According to Basu (1977), when common stocks sorted on earnings/price ratio, future returns on high earnings/price are higher than predicted by the CAPM (Basu, 1977). According to Banz (1981), the size effect, when stocks are sorted on market capitalization, average return is higher on small firms than bigger than with CAPM (Banz, 1981). According to Bhandari (1988), high debt to equity ratios are related to returns that are too high relative to their market betas (Bhandari, 1988). According to Statman and Rosenberg, Reid and Lanstein showed that high book to market equity ratios have high average returns that are not captured by their betas (Rosenberg, Barr, Reid, & Lanstein, 1985). In other words; the research are claiming that the ratios are containing information about the expected returns that are missed by CAPM and the market betas.

Instead of focusing only on the market proxy like the CAPM does, it is more useful to focus directly on the ultimate sources of risk and factors driven by the business cycle that might

affect stock returns. This can be useful in risk assessment when measuring ones exposure to particular sources of uncertainty. Factor models are tools that allow us to describe and quantify the different factors that affect the rate of return on a security during any time period like the ratios described above. This theory was first developed by Stephen Ross in 1976 through the arbitrage pricing theory (APT).

Eugene Fama and Kenneth French (1993, 1996) proposed a three factor model for expected returns. They showed that return on stocks of small firms has a higher correlation with each other than returns on bigger firms, the size effect. Also that returns on high book to market stocks have a higher correlation with each other than with returns on low book to market ratios. Even though the size effect and the book to market ratio is not a defined state variable, the higher return on small stocks and high book to market reflect a unidentified state variables that produce systemic risk in returns that are not captured by the market return and are priced separately from market betas. The three factor model can be presented in the following way (Fama & French, 1996):

$$E(r_i) - r_f = \beta_{im}[E(r_m) - r_f] + \beta_{iSMB}[E(r_{SMB})] + \beta_{iHML}[E(r_{HML})]$$

The first part of the equation measures the excess return on the market portfolio, and the beta or the sensitivity to the return known from CAPM. The next term measures the size effect SMB or small minus big, the difference between the returns on diversified portfolios of small and big stocks and its beta factor. The final term measures the book to market effect HML, high minus low. The difference between the returns on diversified portfolios of high and low book to market stocks and its beta factor.

Later research shows that neither CAPM nor the Fama French model can explain many more of the anomalies that are revealed at a later stage like the momentum effect and earnings surprises, but also the negative effects on average return due to financial distress, accruals, net stock issues and asset growth. These types of anomalies can better be captured by the new three factor model by Long Chen, Lu Zhang and Robert Novy-Marx.

2.4 An alternative three-factor model

The new three factor model by Chen, Zhang and Novy-Marx is a contribution to provide a new workhorse model for estimating expected return and obtaining cost of equity estimates for capital budgeting and stock valuation. The model is presented formally in equation 2.7 (Chen, Zhang, & Marx, 2010):

$$E_{(ri)} - r_f = \beta_{iMKT}E_{(rMKT)} + \beta_{iINV}E_{(rINV)} + \beta_{iROA}E_{(rROA)} \quad (2.7)$$

Where the excess return $E_{(ri)} - r_f$ (the expected return on the portfolio minus the risk free rate) is explained by its return to three factors: the market excess return r_{MKT} known from CAPM, the difference between the return of a portfolio of low-investment stocks and the return of a portfolio of high-investments stocks r_{INV} , and the difference between the return of a portfolio of stocks with high returns on assets and the return of a portfolio of stocks with low returns on assets r_{ROA} . β_{iMKT} , β_{iINV} and β_{iROA} are measures firm's sensitivity of r_{MKT} , r_{INV} and r_{ROA} respectively.

This new model is based on the principles of investment-based asset pricing. The investment factor predicts return in the way that given the expected cash flows, high discount rates predicts lower net present value of the new investment while low discount rate predicts higher net present value of the new investment.

The ROA factor predicts return in the way that high expected ROA relative to low investment means high discount rates, this because in order to have low net present value of the project the discount rate have to be high in order to reduce the high expected ROA. Low expected ROA relative to high investment imposes low discount rates, because in order to have a high net present value of the project the discount rate have to be low in order to increase the low expected ROA.

2.4.1 The basic intuition of the multifactor model

In order to understand the basic intuition, Chen, Zhang and Novy- Marx are presenting a two period "toy model". This "toy model" consists of two periods and the firm produces in both periods. The assets in period 0 is denoted A_{i0} and A_{i1} in period 1. The firm's ROA is denoted π_{i0} in period 0 and π_{i1} in period 1. The firm starts with assets A_{i0} in period 0 and at the end

of period 1 the assets have evolved to A_{i1} where $A_{i1} = I_{i0} + (1-\delta) A_{i0}$. The assets from period 0, A_{i0} have been depreciated with δ plus investment from period 0 I_{i0} . With investment entails a quadratic adjustment cost denoted; $\left(\frac{a}{2}\right) \left(\frac{I_{i0}}{A_{i0}}\right)^2$ where $a > 0$ and a constant parameter. Adjustment cost can be defined as the cost due to changes in economic decision parameters in the firm like the cost of training of new workers. The two-period model of the market value of the firm i can be presented in the following way in equation 2.8:

$$\pi_{i0}A_{i0} - [A_{i1} - (1-\delta) A_{i0}] - \frac{a}{2} \left[\frac{A_{i1}}{A_{i0}} - (1-\delta) \right]^2 A_{i0} + \frac{\pi_{i1}A_{i1} + (1-\delta) A_{i1}}{r_i} \quad (2.8)$$

The market value at time 0 of the free cash flow is the operating profits at time 0: $\pi_{i0}A_{i0}$ and subtract the change in asset from time 0 to 1 and subtract again the quadratic adjustment cost, finally the adding of the expected operating profits for time 1 plus the total assets which is discounted at a proper cost of capital r_i yields equation 2.8.

Assuming the firm chooses to maximize market value at the beginning of time 0, we find the first order condition of equation 2.8 with respect to A_{i1} and we get:

Assuming $A_{i1} = I_{i0} + (1-\delta) A_{i0}$

$$\text{FOC: } -1 - a \frac{I_{i0}}{A_{i0}} + \frac{\pi_{i1} + 1 - \delta}{r_i} = 0$$

Solving for r_i and obtains the relation between investment and ROA in equation 2.9:

$$r_i = \frac{\pi_{i1} + 1 - \delta}{1 + a(I_{i0}/A_{i0})} \quad (2.9)$$

The numerator of equation 2.9 denotes the expected ROA π_{i1} or the marginal product of capital plus the marginal liquidation value $1 - \delta$. The denominator denotes the marginal purchasing cost of capital and the marginal adjustment cost: $a(I_{i0} / A_{i0})$. Equation 2.9 can be interpreted as:

$$r_i = \frac{\text{Marginal benefit of investment}}{\text{Marginal cost of investment}}$$

The first order condition states that the ratio of the marginal benefit of investment, what the firm receives from one additional unit produced in date 1 divided by the marginal cost, the opportunity cost of producing one more unit of goods or services should equal required return.

2.4.2 Market factor

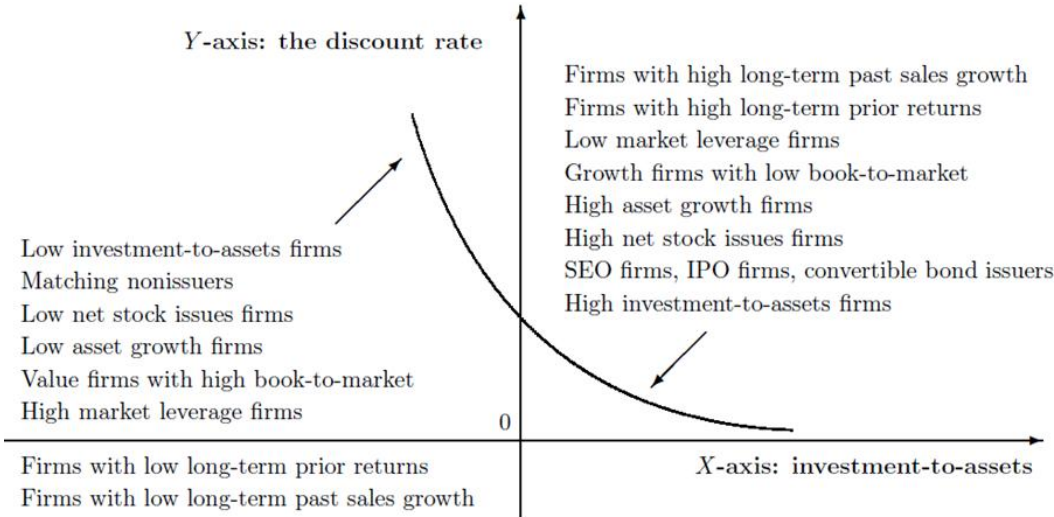
Chen, Zhang and Novy-Marx introduce the market factor from the consumption side of the economy. The market factor will be the same as the one that will be derived in chapter 3 for the CAPM based on the historical return on a broad diversified market portfolio and will not be a part of the following discussion.

2.4.3 Investment factor

Chen, Zhang and Novy-Marx motivate the investment factor by the following hypothesis that states given the expected ROA or π_{i1} , the expected return decreases with investment to assets I_{i0}/A_{i0} and that this relationship drives the negative relations of average returns with net stock issues, asset growth, valuation ratios, long term past sales growth and long term prior returns. Figure 6 illustrates the hypothesis (Chen, et al., 2010).

Figure 6 - The negative relation between investment to assets and discount rate

Figure 1. Investment-to-assets as a first-order determinant of the cross-section of expected stock returns.



As figure 6 illustrates, high investment to assets implies low discount rates. Firms invest more when the net present value of future cash flows is high. Given expected ROA or cash flow,

low discount rate results in high net present value and therefore high investment contrary to high discount rate that results in low investments.

The negative relation between investment and expected return has a long tradition in finance. Irving Fisher (1930) showed that interest rate and investment is negative correlated (Fisher, 1930). Firms invest more when the relation between the using of one additional unit of capital and the net present value of future free cash flow generated from this additional unit of capital, called marginal q is high. In other words; given expected cash flow, high cost of capital would lead to low net present value and low investment. Low cost of capital would lead to high net present value and high investment.

This negative relation between the expected return and investment is conditional on expected ROA, investment is not independent of ROA, and profitable firms tend to invest more than less profitable firms. Using this dependent relation between ROA and investment provides us with a natural portfolio interpretation of the investment hypothesis sorting portfolios on valuation ratios like: net stock issues, assets growth and book to market. These sorts produce wider spreads in investment than in expected ROA. Therefore, we can interpret the average return spreads generated from these sorts using their common implied sort on investment.

Chen, Zhang and Novy-Marx also include the market leverage the ratio of total assets to the market equity in the investment premium, this new model captures the market leverage expected return relation better than Fama French (1992). Because that the market equity is in the denominator, high leverage signals fewer growth opportunities, low investment, and high expected returns, while low leverage signals more growth opportunities, high investment and low expected returns. The general corporate finance theory argues that high leverage means high proportion of asset risk shared by equity holders and this the expected return increases and that the investment policy is fixed and that asset risk does not vary with investment. The investment mechanism in the factor model allows investment and leverage to be jointly determined. This gives rise to the negative relation between market leverage and investment and a positive relation between market leverage and expected returns.

The investment to assets (I/A) is defined as the annual change in gross property, plant and equipment plus the annual change in inventories divided by the lagged book value of assets. The investment factor r_{INV} are constructed and sorted from a two-by-three on size and I/A . Sorting portfolios will according to Ernstberger, Haupt & Vogler (2009) improve the

performance of asset pricing models and explain much more of the anomalies not captured by the CAPM model (Ernstberger, Haupt, & Vogler, 2009).

Chen, Zhang & Novy-Marx are using the *NYSE*, *Amex* and *NASDAQ* stocks and form them into three I/A groups based on breakpoints of the low 30% medium 40% and high 30%. The median *NYSE* market equity is used to split *NYSE*, *Amex* and *NASDAQ* stocks in to two groups. Further, six portfolios are formed based on the intersections of the two size and the three I/A groups. The monthly weighted returns on the six portfolios are calculated from July at time t to June of time $t+1$ and are then rebalanced. The investment factor is the difference between the simple averages of returns of the two low I/A portfolios and the simple average of the returns of the two high I/A portfolios.

2.4.4 ROA factor

The ROA hypothesis given by Chen, Zhang and Novy-Marx states that given the investment to assets measure or I_{i0}/A_{i0} , firms with high expected ROA or π_{i1} should earn higher predicted return than firms with low expected ROA. This follows from the denominator in equation 2.9, the marginal cost of investment equals the marginal q or market to book. In other words, equation 2.9 states that the required return equals the expected ROA divided by the market-to-book ratio of equity equivalently; required return equals the expected cash flow divided by the market equity. This can be applied to the simple, but elegant Gordon growth model (H.Penman, 2010, p. 117):

$$P = \frac{E [CF]}{r-g}$$

The price P equals the expected cashflow divided by the discount rate r subtracted by the growth rate g . High expected cash flows relative to low market equity or price means high discount rate. Low expected cash-flow relative to high market equity or price implies low discount rate.

Equation 2.9 also claims that the required return equals the expected return divided by an increasing function of investment-to-assets. If the expected ROA is high compared to investment, the required return must be high in order to offset the high expected ROA and reduce the net present value and hence the level of investment. If the discount rate is not high enough, the firm will observe high net present value and invest more. If the expected ROA is

low compared to investment, the required return must be low. If the discount rate is not high enough, the firm would observe low net present value and invest less.

According to Chen, Zhang and Novy-Marx the ROA factor is sorted on the current ROA. The ROA factor is defined as income before extraordinary items divided by one quarter lagged total assets. The findings are sorting the *NYSE*, *Amex* and *NASDAQ* stocks into three groups based on the breakpoints of the low 30% medium 40% and high 30% of the ranked values of current quarterly ROA. The *NYSE* median equity is also used to split the *NYSE*, *Amex* and *NASDAQ* stocks into two size-groups. These groups form six portfolios from the intersections of the two size and three ROA groups. The monthly weighted returns for the six portfolios are calculated for the current month and rebalanced each month. The ROA factor is the difference between the simple average of returns of the two high ROA portfolios and the two low ROA portfolios.

Chapter 3 - The input parameters for CAPM

This chapter consists of the parameters necessary to compute the CAPM model. Part 1 will discuss the risk free rate. Part 2 introduces the tax effect. Part 3 will discuss the return on a broad market index that will serve as a market proxy and the market premium. Part 4 will discuss the debt and equity beta for the project. The equity beta is a result of looking at a broad range of comparable companies from Europe.

3.1 Risk free rate

According to Johnsen and Gjølberg (2007) in their report for cost of capital for ENOVA the traditional view of use of risk free rate is one year government issued bond or shorter (Gjølberg & Johnsen, 2007). On the contrary, many practitioners are using the ten year yield on government bonds with the argument that the cost of capital is used to discount cash flows far into the future. The difference of using the long or the short alternatives yields different results first and foremost because the two include different expectations about the future inflation rates, which again determines the expected future cash-flow from the project that is discounted. The long term bond usually includes a risk premium to compensate the investors for surprises in the inflation. This risk premium usually is relevant for a fixed income investor or a bond investor and to a lesser extent for an equity investor where the income in reality is inflation protected. A shorter government bond is much more volatile and using a one year yield to maturity bond would make it hard to point out the risk free rate of a wind-project that has an economic lifetime of 20-25 years (Krohn, et al., 2009).

According to the cost of capital report of Johnsen (2005) for NetCom, the risk free rate can be derived from a historical estimation real rate of interest + expected inflation. Where the real interest rate is described to be the long term growth of a country's GDP. Historically, this growth in the GDP has been about 2.5% over the last 105 years (Johnsen, 2005) . Norges Bank has an inflation target of 2.5% in their fiscal policy making (www.norges-bank.no) which would imply a risk free rate of about 5%.

In contact with investment analyst Terje Iversen in KLP (Kommunal Landspensjonskasse) he has described what their estimation of the risk free rate in the long term is. Iversen claims the use of many different sorts of risk free rates used in practice, the most common use being a

medium term horizon or five year government issued bond. The five year government bond is not as volatile as the one year bond and does not have the premium for inflation like the ten year bond has.

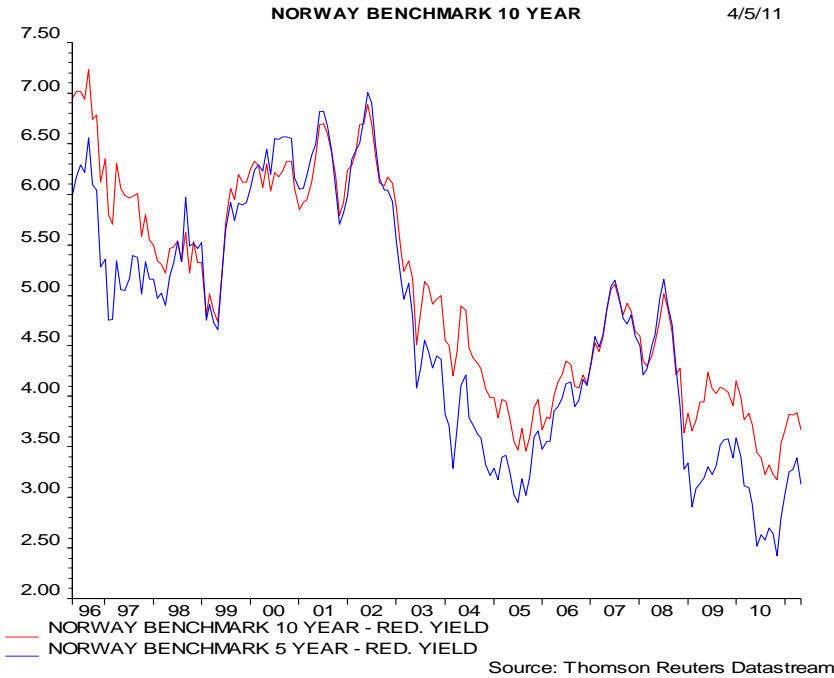
Table 1 (www.norges-bank.no), gives the yearly arithmetic average yield of government issued five and ten year bonds over the last 10 and 15 years.

Table 1 – Average yield last 15 and 10 years

	5 year bond	10 year bond
Yield last 10 years	4,34%	4,66%
Yield last 15 years	4,77%	5,09%

The historical yield on a ten and five year government bond issued by Norges Bank for the last 15 years in figure 7 (Datastream):

Figure 7 – Historical yield last 15 and 10 years



The medium term horizon government bond (five year) is currently yielding 2, 83% while the long term (ten year) bond is yielding 3,52%. According to Iversen, the KLP in-house estimate long term of the ten year yield is 4, 5%-4, 75% which indicates a 4, 15%-4, 4% for a five year yield.

Based on the previous methods of measure the risk free rate and under the assumption that the yield of a five year bonds is the most stable, one can argue a risk free rate in the interval of the highest estimation from KLP and the estimation consisting of the real rate of interest + expected inflation; 4, 4%-5%. **Using a middle value of the interval we arrive to a risk free rate of 4, 7% and I choose this as the risk free rate.**

3.2 The tax effect

Like stated in chapter 2 and equation 2.4, the tax effect consists of the tax on interest and tax on equity income. In Norway today the tax on interest income, τ_d is 28% regardless of the interest receiver is a person or a company. For companies' equity income like dividends or profit from sale of stocks, there are no taxes. Hence there are no opportunities for deducting tax is sold with loss and $\tau_e = 0$ for companies. For private investors, each year investors have the right to deduct a certain amount from the dividends or profit from sale. The deductible amount is computed by multiplying the acquisition cost of the stock times a percentage rate determined by Norwegian tax authorities. Unused deductible amount can be transferred from one year to the next. The amount that exceeds the deductible amount is taxed at a rate of 28%. The tax level of equity income for investors would vary between 0% and 28% (Bøhren & Michalsen, 2010) For simplicity in this thesis, the tax on equity income τ_e is assumed to the rate of 0%.

$$\tau^* = \frac{1-0,28}{1-0} \text{ yields}$$

$$\tau^* = 0, 72$$

3.3 The expected return on the market

3.3.1 The market return

The expected market return and hence the premium is the most important and needed component in the world of financial modeling and have practical and theoretical applications for practitioners and academics alike (Vaihekoski, 2005).

According to Johnsen, 2005 the market premium can be interpreted as expected return on a well-diversified market portfolio in excess of risk free rate (Johnsen, 2005). In order to estimate the expected market return, we can look at the historical return that the market have given and use this as an indicator of future returns. According to Vaihekoski, 2005 the problem that arise is that we are looking at the observed past realized return and not the expected return and long time series are required in order to make precise estimates (Vaihekoski, 2005). According to Damodaran there has been, despite the developed consensus towards the use of realized return for estimating the forward looking premium large differences in the actual premiums observed and used in practice. There are many reasons for this difference, like the time interval of the data, choice of the risk free asset and whether or not choosing an arithmetic or geometric average of the returns (Damodaran). I have based my calculations using arithmetic average when estimating the return on the market portfolio. According to Johnsen (2005), the arithmetic average return should be used no matter the project's length. The arithmetic average gives the growth in expected value of the currency while the geometric average yields the expected growth in the currency (Johnsen, 2005).

The yearly simple return is computed using equation 3.1

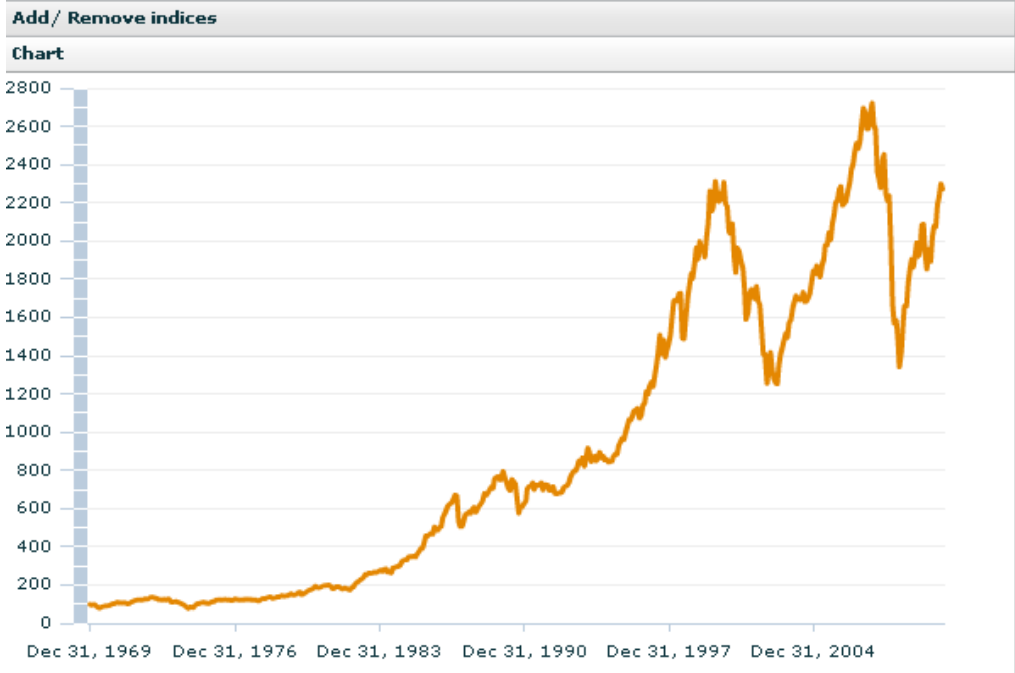
$$\frac{Closingprice_t}{Closingprice_{t-1}} - 1 \quad (3.1)$$

For each year of the sample, the yearly return is computed where t is the last trading day of the year.

When estimating the market return the first important step is to define the broad market portfolio with a long time series of data. The *MSCI Barra World Index* can serve as a proxy for the market portfolio. Another option is to use a proxy for the Norwegian market on Oslo Stock Exchange. In this thesis the *MSCI Barra World Index* will be used in accordance with

the international diversified investors of the project. The *MSCI Barra World Index* is a float-adjusted market capitalization weighted index representing country indexes for 24 countries around the world. Figure 8 illustrates the net (without dividends) *MSCI Barra World Index* the last 40 years (www.msci.com).

Figure 8 - MSCI Barra World index 1970-2010



Beside the fact that the assumption in this thesis is that investors are international diversified investors, the use of a world index can be argued by the fact that more and more investors tend to invest more abroad and the Norwegian market portfolio is to a higher extent depended on the general economic outlook for the world as a whole. Another thing to point out is to use a broader market than the Norwegian market due to Oslo stock exchange’s correlation with the oil price, the world index captures a broader industry that is representative for an international diversified investor.

The historical return for a 40 year period for the world index is in my opinion a bit short, therefore the estimation result from the world index will be subject to discussion using different results found by researchers and alternative methods.

The average return on the market portfolio between 1970-2010 is 9,4% with a risk free rate of 4,7% would this lead to a market premium of 4,7% (9,4%-4,7%)

The findings of the market premium can be verified by the research of Pablo Fernandez and Javier del Campo, 2010. In his survey, Fernandez and del Campo gathered the use of the

required market premium from several analysts and practitioners from all over the world and among them Norway. The mean of the total eight answers from Norway was a use of a market risk premium of 5% that was used in 2010 (Fernandez & Campo, 2010). The survey does not reveal the exact procedure and what the calculations are based on for estimating this market premium from the Norwegian answers, but the results gives a certain picture of the consensus for required market premium.

According to Thore Johnsen from his report on ENOVA and NetCom, the historical market premium from an international index lie in the interval of 3%-5% and using 4% as the market premium in his estimations.

The difference in the market premium found previous from the world index, the average found by Fernandez and Campo and Thore Johnsen's findings can in my perspective be based on the use of different risk free rate and not to a great extent a different return of the overall market portfolio. **With these findings as a background using a market risk premium of 4, 7% would be considered a fair estimate.**

3.3.2 An alternative way

According to Johnsen (2005) and Damodaran, another alternative method is to make more of a forward looking (implied) estimation of expected returns on the market portfolio. Assuming that the price is set according to a certain pricing formula, we use this formula backwards and solve for the implied expected market premium that justifies the current price. For example by using the dividend discount model presented below (Johnsen, 2005).

$$P = \frac{d}{k_e - g}$$

Rearranging with respect to k_e yields

$$k_e = \frac{d}{P} + g$$

Where d is the expected dividend payout in one year, k_e is basically the return on equity which in this case it illustrates the market return. The expected growth rate of the dividends is

denoted g and P is the price now. Assuming the three of the four inputs are obtained externally we can solve for the return k_e and we get an implied expected return on the stocks.

In order to compute the expected dividend for the market portfolio, we compute the returns for the *MSCI World Index* Gross returns including dividends and subtracting the returns for the net index for *MSCI World Index* without the dividends. The average yearly dividend payout between 1970 and 2010 was 1%. Assuming an good growth in the world economy the expected growth rate of 7% per year on the dividends, the market would imply a return of 8% solving for k_e . Subtracting the risk free rate of 4.7% yields an implied risk premium of 3.3%. According to Johnsen, this premium is considered to be a geometric average, in order to arrive at an arithmetic average half of the future variance of the returns needs to be added (Bodie, et al., 2009, p. 128). The standard deviation for the market portfolio based on returns from 1970-2010 is about 17%, computing the added variance yields: $\frac{0.17^2}{2} = 1.445\%$.

This means the adding of another 1.445% to the return and yields an implied market premium of 4.745%. This shows that the findings in section 3.3.1 are in accordance with the implied estimation.

3.3.3 Liquidity premium

According to Johnsen and Gjølberg 2007, the market premium is based on returns from liquid companies traded on the stock exchange. If the market premium is used for a less liquid exchange traded company or maybe a privately owned company or project it is common to increase the return on equity by a liquidity premium (Gjølberg & Johnsen, 2007). This liquidity premium is a compensation the investor takes in order to enter an investment with a higher risk of being “locked in” with no choice of selling or selling at a high discount. Such a premium is usually the situation for financial investors and not so much for institutional investors defining their investment horizon as long term. Since the assumption in this thesis is that the investors are having a long term investment horizon in the project; the return on equity will not be affected by a liquidity premium.

3.4 Estimating the beta coefficients

The estimation of the equity beta β_e from equation 2.5 is a daunting task considering the data available for such estimations for a wind power project in Norway. There are few such projects and even fewer wanting to share their returns or cash flow predictions. One alternative is to look at companies traded on a stock exchange that operate in the same business as the project or company that is the subject of estimation. In the following, a variety of comparable companies on continental Europe has been picked from Thompson Reuters Datastream using their stock returns from the last ten years to make an estimation of beta values using regression. The comparable companies are Vestas, Greentech, Plambeck Neue Energien and Gamesa. The regressions are done using monthly returns for the last ten, five and three years for each of the companies. For each month the excess return is computed both for the company and the overall market portfolio using the risk free return found in section 3.1 and then run a regression using STATA (see appendix for STATA table). All the regressions are done using Euro and a common world index, *MSCI World Index* in order to have a common frame of reference (Johnsen, 2005) both between the different comparable companies from different countries, but also to make a connection between the beta coefficients and the market premium.

The beta coefficients derived in the regression is the comparable companies' respective equity beta. In order to make a useful comparison to our project, the equity and debt beta of the project will be a weighted average of the betas. This will replicate the beta as if the company was unlevered also called asset beta. The equation for asset beta β_a is presented in equation 3.2 (Bøhren & Michalsen, 2010):

$$\beta_a = \beta_e \cdot \frac{E}{E+D} + \beta_d \cdot \frac{D}{E+D} \quad (3.2)$$

Now that the asset beta for the company has been found, one needs to rearrange equation 3.2 with respect to β_e and get the equation for the equity beta for the project in 3.3 (Bøhren & Michalsen, 2010):

$$\beta_e = \beta_a + (\beta_a - \beta_d) \cdot \frac{D}{E} \quad (3.3)$$

3.4.1 The debt beta

Risk free debt is considered to have a beta coefficient of zero. The beta is positive if the company's ability to serve the debt is fluctuating with the general market's cycles (Bøhren & Michalsen, 2010).

The estimation of the debt beta β_d in equation 2.6 could be done by looking at exchange traded debt like company issued bonds. This is a difficult task to gather information about this due to the different loan financing strategies of the comparable companies. According to Bøhren and Michalsen (2010) the lack of data in order to estimate the debt beta is no argument for choosing a beta of zero instead of a beta of for example 0.3. It would also be inconsequent to assume a cost of debt that could be higher than the risk free rate, but at the same time assuming a debt beta of zero (Bøhren & Michalsen, 2010). Bøhren and Michalsen in their book-example is assuming a debt beta of 0.3 in the absence data, **therefore the use of a debt beta of 0.3 will be used in the following calculations.** The debt beta will be the same for both the subsequent asset beta computations for the comparable companies and the computation of the equity and debt beta for the project's cost of equity and debt in chapter 4.

3.4.2 Comparable companies

Vestas

Vestas from Denmark delivers wind turbines to a broad range of clients and considered to be a market leader in its field. Besides manufacturing the wind turbines, Vestas also delivers consulting services when it comes to planning, construction, plant optimization and operation and maintenance (www.vestas.com). Despite the fact that Vestas does not sell the actual electricity, but the product that leads to this electricity generation Vestas faces much of the same risk as an investor in the wind project. The regression results are presented in table 2.

Table 2 - Regression results, Vestas

Regression period	β_e
2001-2011	1.59
2006-2011	1.48
2008-2011	1.65

As we can see from the regression results, the beta values in all of the periods are relatively stable from the longer period 2001-2011 with beta 1.59 to period 2006-2011 with beta 1.48 and 2008-2011 with beta 1.65. Since all the results are within a reasonable proximity, the equity beta for Vestas will be the average of the three results yielding an equity beta of 1.57.

The current debt ratio is 15.5% for Vestas yielding an asset beta of 1.37 using equation 3.2:

$$\beta_a = 1.57 \cdot 0.845 + 0.3 \cdot 0.155 = 1.37$$

Greentech Energy Systems

Greentech Energy Systems are a Danish energy firm with main focus on renewable energy and in particular wind energy, but also solar energy is under development. Greentech are involved in wind farms in Denmark, Germany, Italy, Norway and Poland (www.greentech.dk). Greentech faces to a very high degree the same risks that an investor would do when looking at investing in wind power. The regression results are presented in table 3.

Table 3 - Regression results, Greentech Energy Systems

Regression period	β_e
2001-2011	1.36
2006-2011	1.88
2008-2011	1.96

As we can see from these different regressions, the volatility has increased as the time period has decreased, implying that the latter years have been more volatile for Greentech than in the longer run of ten years. This can be linked to the much greater correction in the financial

markets during this time interval. The period 2001-2011 yields a beta of 1.36, the period 2006-2011 yields a beta of 1.88 and 2008-2011 yields a beta of 1.96. Since we are now focusing on the longer term investment and that the trend looks to be that in the longer term the beta is somewhat closer to 1.36. We choose an equity beta for Greentech of 1.36.

The current debt ratio of Greentech is 6% yielding an asset beta of 1.3 using equation 3.2:

$$\beta_a = 1.36 \cdot 0.94 + 0.3 \cdot 0.06 = 1.3$$

Plambeck Neue Energien Wind Systems

Plambeck Neue Eenergien Wind Systems is a Germany based energy company. Plambeck focuses wind power onshore and offshore and is planning, implementing and financing the wind farms (www.pne.de). As with Greentech, Plambeck is also a highly representative company when it comes to the risk an investor faces when investing in wind projects. The regression results are presented in table 4.

Table 4 - Regression results, Plambeck Neue Energien Wind Systems

Regression period	β_e
2001-2011	0.95
2006-2011	0.49
2008-2011	0.58

As we can see from the different regression results, Plambeck has had a low volatility compared to the general market. The period 2006-2011 and 2008-2011 yields about the same estimate of the equity beta 0.49 and 0.58 respectively. The time period 2010-2011 have a higher beta value of 0.95. Since there is no apparent trend of the betas, we take the average value of the period 2001-2011 and 2006-2011 yielding a equity beta of 0.67.

Debt ratio for Plambeck Wind is currently 59% and yields an asset beta of 0.45 using equation 3.2:

$$\beta_a = 0.67 \cdot 0.41 + 0.3 \cdot 0.59 = 0.45$$

Gamesa

Gamesa is a Spanish wind turbine developer. The company provides a broad range of turbines and consultancy work that regards to the implementation and operation of the plant (www.gamesa.es). Like an investor in a wind project, Gamesa are operating in the renewable energy sector and must face much of the same risk as an investor in these projects. Regression results for Gamesa are presented in table 5.

Table 5 - Regression results, Gamesa

Regression period	β_e
2001-2011	1.56
2006-2011	1.86
2008-2011	2

The equity betas for Gamesa has an distinct direction in that the period 2008-2011 have a beta of 2, while the period 2006-2011 a beta 1.86 and 2001-2011 a beta of 1.56. The table shows that the shorter the period, the higher the beta and since the investment horizon we are looking at is long term, the equity beta for Gamesa is 1.56.

The current debt ratio of Gamesa is 15% yielding an asset beta of 1.2 using equation 3.2:

$$\beta_a = 1.56 \cdot 0.85 + 0.3 \cdot 0.15 = 1.37$$

3.4.3 The equity beta

In order to find the equity beta for the project using equation 3.3 we first need to find an asset beta. The summary of the asset betas for the comparable companies can be found in table 6:

Table 6 - Summary of the asset betas

Company	β_a
Vestas	1.37
Greentech	1.3
Plambeck Neue Energien Wind	0.45
Gamesa	1.37

Greentech and Plambeck is the most relevant comparable companies in question, still the use of all the comparable companies will be used in order to capture much of the risk that exists across the wind power industry. The average of all the asset betas from table 6 gives an asset beta of 1.12.

This asset beta reflects only the specifics for the comparable companies, these betas are a result of the different countries regulatory framework with different subsidy arrangements. A further discussion is required in order to argue an asset beta for the Norwegian project. According to Øyvind Rustad in DnB Nor Energy department the biggest risk factors for a wind power project in Norway is:

- Price risk
- Energy yield assessment
- Access to the electrical grid

The price process of wind is introduced in chapter 1. The price can basically be defined as stochastic; the electricity production of a wind farm is therefore highly sensitive to changes in wind and imposes a risk factor in the price setting process. The price of wind generated electricity is depended on several wind farms in order to balance the demand, if the wind is absent in most of the generating sites, the electricity produced will decline and the price of this electricity will increase. The interaction of other electricity generating sources like hydropower can help to stabilize the market somewhat. Also the introduction of green

certificates is introduces uncertainty because these certificates is supposed to finance a part of the future development of wind projects in Norway. According to Dagens Næringsliv 27/5 2011 many wind projects is at hold until the implementation of green certificates is in place. Chapter 5 will discuss the future development of the price of electricity and green certificates in further depth.

In the development process, the energy yield assessment of the wind opportunities of the project is mapped out. This assessment requires strong and valid wind measurements for a long period of time in order to predict the wind speed the turbines will be exposed to and give an indication of the future potential for the wind power site. Given the predicted wind measurement, the developers can obtain a variance of the wind speed necessary to select and develop the appropriate turbine model (Hassan, 2008).

In order to make incentives to build more renewable energy sources besides hydropower in Norway, the Norwegian authorities and Statnett are required to construct new and better transmissions lines in order to meet the new energy production from wind farms, but also the growing energy demand, not only in Norway. According to a report from ENOVA, the construction of wind power that equals 17-21 TWh towards 2025 is technical possible with the current transmission lines in Norway (Waagaard, Christophersen, & Slungård, 2008). According to Garrad Hassan (2008), the cost of connecting the wind power site to the transmission lines can in some projects be significant (Hassan, 2008). The cost depends on where the project is located with respect to the projects size and topography.

Lastly, a political encouragement in Norway is THE basic factor for creating a stable framework for wind power projects. The future for wind power in Norway looks bright with Minister of Petroleum and Energy, Ola Borten Moe emphasizing on the annual meeting of the Norwegian Wind Energy Association the importance of wind power by increasing the number of licenses for wind power sites and stating the Norwegian government are recognizing wind power as an important part of the future electricity portfolio for Norway.

Still, taken all the previously mentioned discussion points into consideration there are still uncertainty about the future and an asset beta of 1.12 is in my opinion not high enough considering the risk the investor is facing argued by the discussion mentioned above. Hence, the asset beta estimate will be adjusted to 1.5 in order to meet the systemic risk aspects of the market for Norwegian wind power.

According to Øyvind Rustad the most common level of equity ratio of wind power projects in Norway is in the interval of 25%-50% which implies a debt ratio in the interval of 75%-50%. Due to the inherent risk in the market for wind power in Norway, perhaps the bank only will accept debt on the lower bound of the debt ratio interval. Assuming the project is financed by 50% equity and 50% debt, the debt to equity ratio $\frac{D}{E}$ in equation 3.3 is 1.

Using equation 3.3 yields **an equity beta for the project of 2.7.**

$$\beta_e = 1.5 + (1.5 - 0.3) \cdot 1 = 2.7$$

Chapter 4 – Computation of the WACC

In the following chapter the computation of cost of equity and debt will be conducted based on the findings of parameters from chapter 3. The final section will compute the WACC.

The findings from chapter 3 are presented below:

- Risk free rate 4.7%
- Market risk premium 4.7%
- Tax effect 0.72
- Equity beta 2.7
- Debt beta 0.3

4.1 Cost of equity

The after tax cost of equity is found using equation 2.5:

$$r_e = 4.7\% \cdot 0.72 + 2.7 \cdot (4.7\% \cdot 0.72) = 12.5\%$$

In the report from Ecofys, they have computed different after tax required return on equity given the different renewable electricity support scheme available in a country. In Norway there is a transition phase from investment subsidies and to tradable green certificates. Both policy-schemes are argued to have an after tax required return on equity for about 10% (Jager & Rathmann, 2008). This number found in the report from Ecofys are made from a set of assumptions based on the general European wind power setting and meant more as a guideline and 12.5% after tax for our project would be considered a fair estimate for cost of equity considering that the general framework of wind generated electricity projects in Norway is not as developed compared to for example Denmark or Germany.

4.2 Cost of debt

Equation 2.6 computes the pre-tax cost of debt:

$$r_d = 4.7\% + 0.3 \cdot (4.7\% \cdot 0.72) = 5.7\%$$

4.3 The WACC

The computation of the WACC is used by equation 2.1. Like assumed previously the project is financed 50% equity and 50% debt. The WACC is used to discount future cash flow and in this thesis from a long series of cash flows. In the following of the thesis the assumption will be that the project is having a fixed debt and equity ratio for the whole duration of the project.

Cost of equity and debt will be weighted following to the structure of the financing of the project. The cost of equity is an after tax number, the cost of debt or interest payments is tax deductible and will be adjusted with $(1-0.28)$ and obtain the after tax cost of debt.

$$r_{wacc} = 0.5 \cdot 12.5\% + 0.5 \cdot 5.7\% \cdot (1-0.28) \approx 8.25\%$$

The after tax WACC for the project is 8.25%.

According to Johnsen and Gjølberg they claim the use of an after tax WACC of 7.7% for basis when ENOVA was considering applications for the subsidy arrangement. In contact with NOREWA they claim the WACC should lie close to 8% as well.

Chapter 5 – The computation of the three factor model

In the following chapter, the estimation of cost of equity using the three factor model will be conducted. The data for the model has been hard to obtain, and in some cases impossible to obtain in Thompson Reuters Datastream for the world index. Therefore the estimations will be done qualitatively using the findings in the article of Chen, Zhang and Novy-Marx of the US stock market and interpret these findings in order to find reasonable estimates for the factors and its sensitivity to the Norwegian wind power project. All the data from the article is sampled from January 1972- June 2009 and returns are given on a monthly basis.

In the following discussion, the returns and sensitivity for investment and ROA factor will be considered. The market premium and the beta have already been argued for in chapter 3 and require no more discussion.

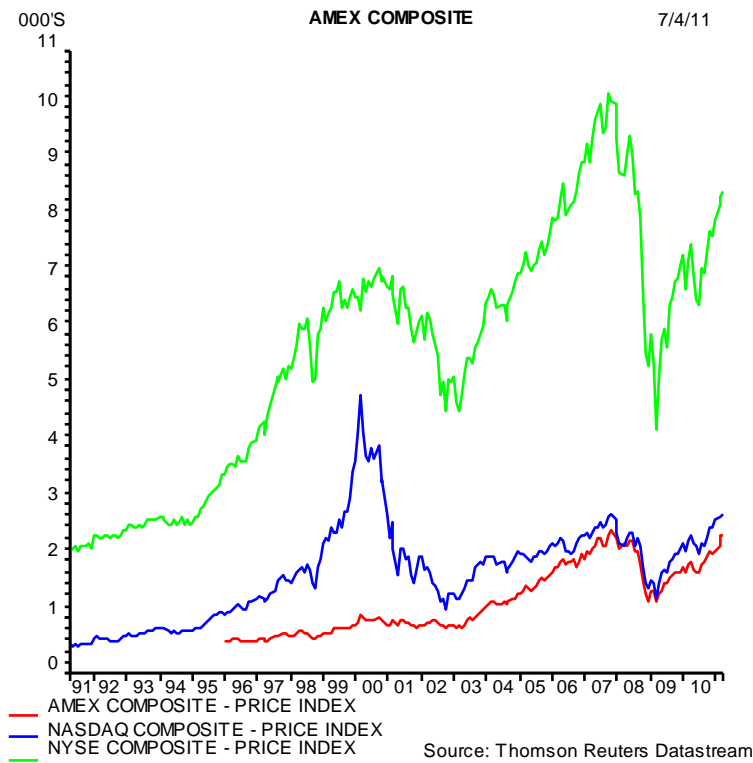
5.1 The return on the investment and ROA factor

The returns from the factor model computed by Chen, Zhang and Novy-Marx are based on stocks from three different US indexes; *Amex*, *NYSE* and *NASDAQ*. The *Amex* index is a market capitalization weighted index and includes about 850 exchange traded companies or less than 5% of the total market value of US stocks. The *NASDAQ* index is a market capitalization weighted index and includes over 3000 stocks. The *NYSE* index is a market capitalization weighted index including 1500 US stocks and about 330 foreign stocks.

The findings of Chen, Zhang and Novy-Marx conclude with a return on the investment factor of 0.28% per month and a return on the ROA factor of 0.76% per month. Chen, Zhang and Novy-Marx define ROA as *income before extraordinary items divided by the one quarter lagged assets*.

In order to find a reasonable estimate for the factors concerning our project it is natural to base our discussion on the *MSCI Barra World* index in accordance with the assumption that the project is invested by internationally diversified investors. The market factor from chapter 3 is also based on this index and to make a useful comparison of the two models later it is required that they have the same reference index. Figure 9 illustrates the historical development of the three US indexes.

Figure 9 - Historical development of NASDAQ, NYSE and AMEX



The graph of the *MSCI Barra World* index can be found in figure 8 in chapter 3.

From Datastream we can compute returns from each of the indexes and compute the correlation between the indexes. In this way one can say something about the way the indexes are moving in the same direction. The monthly returns from each of the four indexes over the last 20 years are used as input in STATA in order to compute the correlation matrix presented in table 7.

Table 7 - Correlation matrix between MSCI World, NASDAQ, NYSE and AMEX

```
. corr MarketMSCI NASDAQ NYSE AMEX
(obs=184)
```

	Market~I	NASDAQ	NYSE	AMEX
MarketMSCI	1.0000			
NASDAQ	0.8517	1.0000		
NYSE	0.9618	0.7812	1.0000	
AMEX	0.7834	0.7276	0.7750	1.0000

As observed from table 7, the *MSCI World Index* denoted MarketMSCI correlates positively with NASDAQ (0.8517), NYSE (0.9618) and AMEX (0.7834). These correlations of returns between the market and the different US indexes implies strongly that the returns to a very high degree are moving in the same direction.

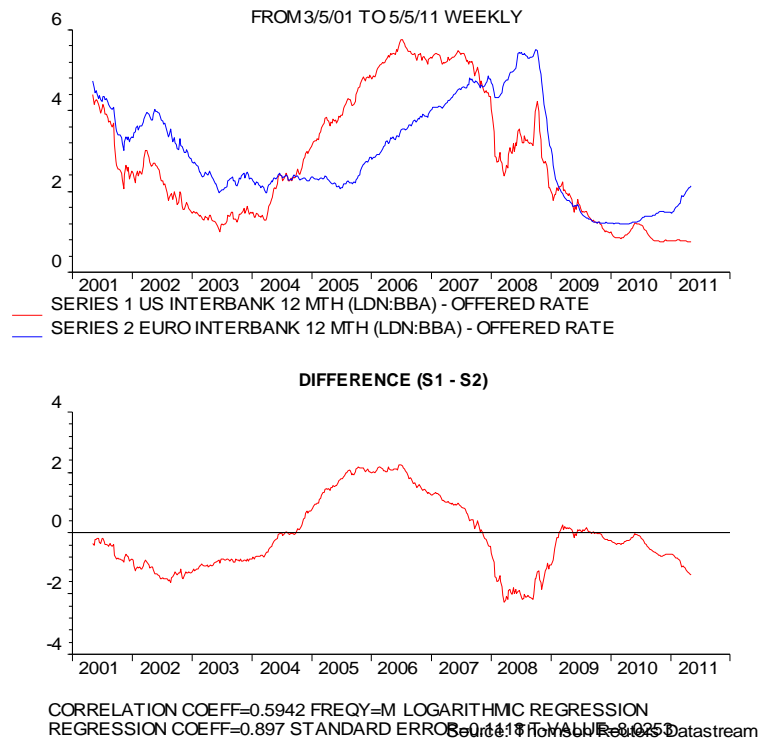
Research shows through the article by Kang, Lee & Min (2010) that investment and ROA factors of Chen, Zhang and Novy-Marx tend to correlate positively with general macroeconomic conditions. The returns on the factors is high in good economic states and low in bad economic states (Kang, Lee, & Min, 2010). The article also shows that the factors have a positive relationship with future economic growth. The article is referring to the previous draft of the new multifactor model under the name "*A better three factor model that explains more anomalies*" written by Long Chen and Lu Zhang. The investment and ROA factor presented in this thesis is the same and constructed in the same manner as the previous draft, only the tests of the factor model is altered in the process of revision and acceptance by Journal of Finance according to an e-mail written by Long Chen.

Based on the findings of Kang, Lee & Min and the fact that there is a strong positive correlation of the returns on the different indexes, the return on the investment and ROA factor for the world index should lie close to the findings for the US.

The *MSCI Barra World Index* is a result of 24 different country indexes from the developed markets of; Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, the United Kingdom, and the United States (www.msci.com). 16 of the 24 countries representing the world index are from Europe and including them Norway. It is a difficult task to state something specific from this broad index as the world index is, therefore the following discussion on the return of the factors will be narrowed in and based on the European part of the world index since this is the most representative part of the index.

It is a dangerous assumption to base the returns solely on the correlation of the indexes and use the similar return from the US market. One factor that influences the investment and ROA factor is the different interest rate regimes. In order to compare the different level of interest rates in European countries and the US the 12 month US and Euro inter-bank offered rate will be used. Figure 10 on next page illustrates the US and Euro offered rate.

Figure 10 - 12 month US and Euro interbank offered rate



As observed from figure 10, the two offered rates are having a correlation of 0.59. The most important thing is the different levels of interest rates and as we can see from the lower part of figure 10; the difference between the rates in the US and Euro is in some periods substantial with a difference of 2%. In the longer run however the effect of this seem to be offsetting despite the limiting data of only eleven years it is difficult to arrive at a final conclusion. Taking the current situation of the US into consideration, the US interest rates are low due to the recession from 2008 and the wake effects of this through unemployment and national deficit is to a higher degree present in the US compared to Western European countries represented in the index. This would imply that the European interest rates will be higher than the US interest rates for some time in the future. This argument is in accordance with the development of the rates in the graph; US rates is in a descending trend while Euro rates is in an increasing trend.

Consequently the investment will increase in the US and decline in Europe argued by the negative interest rate – investment relation by Irving Fisher. The conclusion is that the investment factor with a monthly return of 0.28% from the US **will be adjusted to 0.2% monthly return** for the European market and therefore the world index.

The ROA factor and corporate income can be argued to also be affected by the interest rate; when the interest rates are low, more debt are issued making private persons or firms buying more goods. More money is circulating and opportunities to make money are better due to this high circulation of cash. The opposite is occurring when the interest is high, less money is circulating and the corporate income is reduced. With the same argument as with the investment factor, the ROA and corporate income in Europe should be lower due to higher interest rates in Europe than in the US. The ROA factor from the US indexes with monthly return of 0.76% will be adjusted to **0.53% in monthly return for the European market and the World Index.**

5.2 The beta coefficients

During the following discussion of the beta coefficients for the factors, the general market conditions affecting the different factors will be discussed followed by a discussion based on equation 2.3 in chapter 2 in order to argue a fair beta value. The beta argument will be split into three parts according to equation 2.3; the correlation of the market and the project, the volatility of the project and the market with respect to the different factors.

5.2.1 The investment beta

According to European Wind Energy Association, the significant advantage of wind power is that the fuel is free; this makes the projection of the total investment cost for the project easier to predict. The project costs of wind energy are dominated by the cost of the wind turbine itself. Including upfront costs like foundation of the turbine, electrical equipment and grid connection these costs in table 8 can amount to 75%- 80% of the total cost of a wind power project (Krohn, et al., 2009, p. 31). The remaining project costs are divided by O&M (operation and maintenance) and overhead expenses during the lifetime of the wind power site. Wind power is therefore more capital intensive compared to other forms of electricity generation like fossil fuel technologies (Krohn, et al., 2009).

Table 8 - A typical cost structure of initial investments

TABLE 1.2: Cost structure for a medium-sized wind turbine

	SHARE OF TOTAL COST (%)	TYPICAL SHARE OF OTHER COST (%)
Turbine (ex works)	68-84	-
Grid connection	2-10	35-45
Foundation	1-9	20-25
Electric installation	1-9	10-15
Land	1-5	5-10
Financial costs	1-5	5-10
Road construction	1-5	5-10
Consultancy	1-3	5-10

Note: Based on a selection of data from Germany, Denmark, Spain and the UK adjusted and updated by the author

The greatest cost component and therefore uncertainty factor for the investment factor is what the actual price will be for the wind turbine which depends on not only the institutional setting the wind power plant operates in, but also the general commodity prices. During the recent years, there has been an increase in turbine prices due to an increase of demand for wind power in many countries. Manufacturers like Vestas and Siemens have to design and meet specific requirements of the wind turbines for the different projects due to the different size and wind conditions on site; wind turbines built for rougher climates or cold temperatures is usually more expensive than turbines for more calm locations (Krohn, et al., 2009). The wind turbine also has to be dimensioned and completed with respect to other forms of generating electricity so that these other sources can compensate for changes in the wind power production.

Bottlenecks in the sub-suppliers production line for turbine production due to low capacity and increase of raw material cost have also contributed to increased price of the turbines. According to a survey made of Garrad Hassan in 2008 about the European market for wind power, Garrad Hassan highlights the high demand for wind turbines making it a “seller’s market” and expected to be in the short term (Hassan, 2008, pp. 19-20).

The industry is still to a certain extent in development when it comes to newer and more efficient wind turbines that make the costs of the total production hard to estimate. Still,

recent trends indicates that the market stabilizes the demand on most turbines in the range of 1.5 MW - 3 MW (Krohn, et al., 2009, p. 39).

Like stated earlier, the cost of connecting the wind power site to the transmission lines and the grid can impose high costs depended on the location of the wind power site. These costs are difficult to estimate due to the fact that there is no significant market in Norway yet to base any estimates on, but according to the report of Garrad Hassan the cost can be substantial.

The costs of foundation, electrical installation and road construction are highly depended on commodity prices, with sensitivity to the costs of steel, copper, aluminum, concrete and aggregates. The commodity prices are expected to increase during the nearest future imposing more uncertainty about these costs.

Following the previous discussion, investment in wind power projects are highly capital intensive and requires high investment in the start of the project, and the level of investment is reduced drastically during the years of the actual electricity production. This will further impose that the investment to assets will decrease as the project progresses due to a reduced level of investment and the depreciation of the initial investments. Following the negative relation of discount rate – investment to assets in figure 6 in chapter 2; high investment to assets means low discount rates and vice versa; the investment factor r_{INV} for the project will increase as the project progresses. Since wind power projects are so capital-intensive, the cost structure is to a greater extent also more predictable than other forms of electricity generating sources. Due to the high initial investments and low investments over the years of the project and the depreciation of these assets, makes the uncertainty relatively low for the investment factor for the project.

In order to observe how the general market's investment factor will develop, the natural assumption is to base the argument on figure 8 from chapter 3; the world index. This follows by the argument stated by Kang, Lee & Min (2010); the investment factor is to a high degree moving in the same direction as the market are and therefore a good indication of the movement of the investment factor for the general market. As depicted in figure 8, there has been an increasing trend for the world index over the years. The volatility of the market can also be found looking at the last 20 years of the world index; the market experienced a strong growth with some variations that is significant like the financial crisis. Nevertheless the trend has always been steadily increasing, but the volatility for the investment factor is argued to be larger for the market than for the project.

In conclusion, the correlation of the investment factor between the market and the project is highly and positively present. The volatility of the project's investment factor is lower than the general market's volatility of the investment factor. This would lead to a beta coefficient a bit lower than 1. **The final conclusion is that the beta for the investment factor will be set to 0.8.**

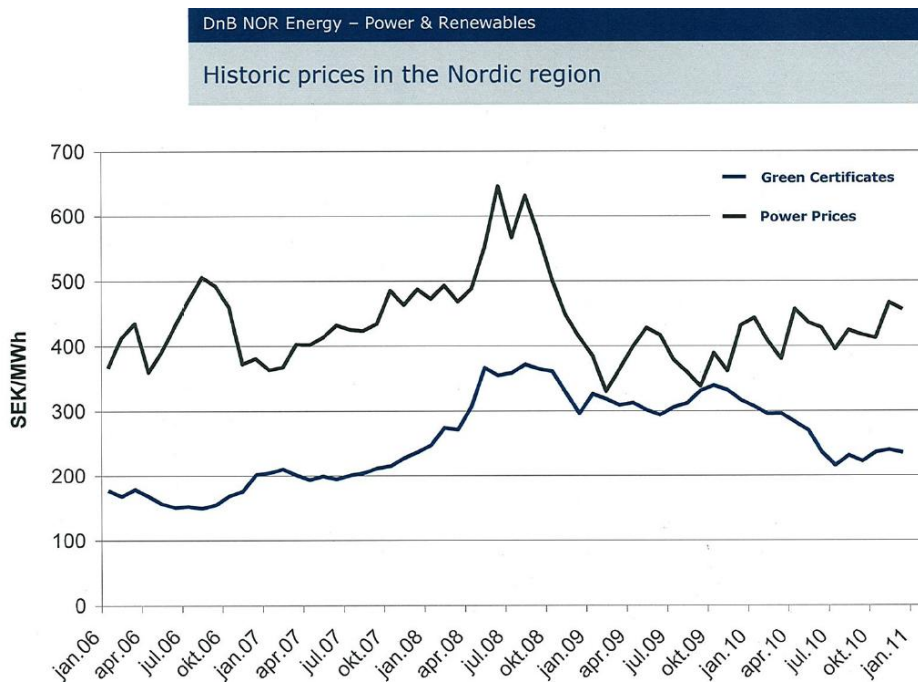
5.2.4 The ROA beta

The ROA factor for the project is driven by the income by selling the electricity, therefore the discussion of the beta will be based on the future development of spot prices and the green certificates since this will be of great importance for the projects future income.

The price of wind generated electricity is determined mainly by the wind and wind speeds at a given site fluctuate. Only on specific hours the turbines are capable of producing grid quality electricity. The price of wind generated electricity also depends very much on the institutional setting the wind is delivered in. One common way to sell the electricity is by a power purchasing agreement (PPA) through a financial intermediary like EGL Nordic. The PPA sets a specific time frame, point and voltage level of delivery. This PPA might be a fixed price, a consumer price index priced contract or access to the spot-market for electricity like Nord Pool (Krohn, et al., 2009).

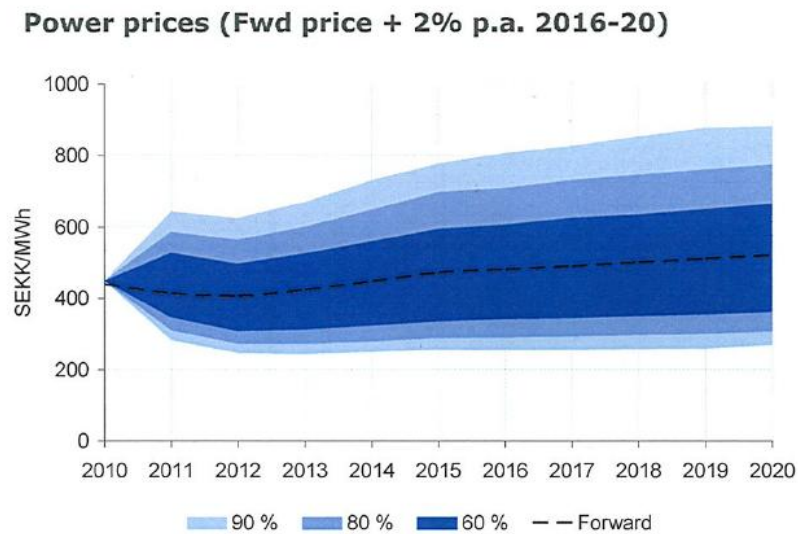
According to Dnb Nor Energy department, the future prices of power and green certificates should be close and having a slight positive correlation. Figure 11 (Dnb Nor Energy, 2011) depicts the historical price of the green certificates (blue line) and power prices (black line) in Sweden and can give an indication of the relationship between the price of power and green certificates for the common market starting 01.01.2012.

Figure 11 - Historical prices of power and green certificates



Since the process of generating wind generated electricity is a volatile process; the question occurring is what effects this will have on the final spot prices in general. One can argue that since the regulative framework of the Nord Pool and the supply and demand bids for the next 24 hours will plan the production of electricity, that other energy generating sources like hydro power can at a low cost easily increase the production and balance the market in a case of low wind. This would lead to a more stable spot price. Another thing to point out is assuming there are several other wind power sites; the wind differences might offset each other making it a more stable market between the different wind sites. According to several arguments from the financial press claiming that new renewable energy like wind power will contribute to stabilize and maybe reduce the spot price in the longer term can be based on the previous argument. Figure 12 from Dnb Nor Energy gives the predicted power prices up to 2020.

Figure 12 - Predicted power prices



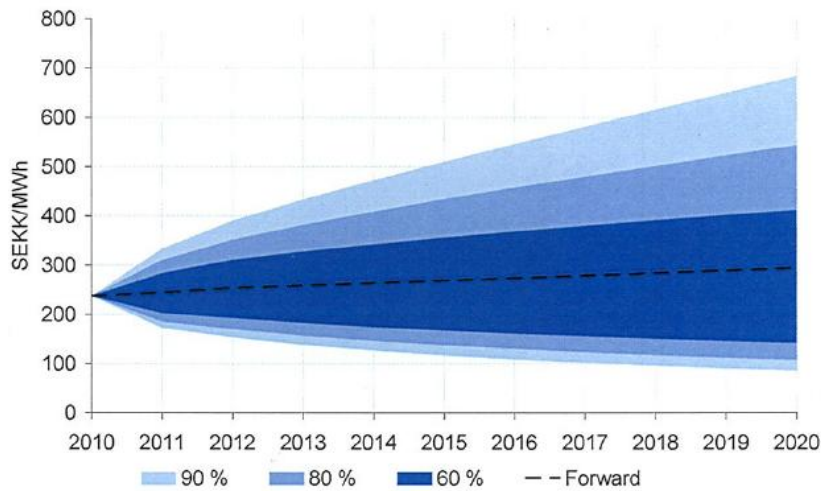
There is a 90% chance the prices will lie between 600 SEK/MWh and about 300 SEK/MWh in 2011 and steadily increase to between 800 SEK/MWh and about 250 SEK/MWh in 2020.

Considering the great span the predicted price range is in can imply that there is a great deal of uncertainty involved. On the other hand, taken into account the previous discussion of the markets ability to plan the production and the interaction of other sources of energy production might lead to a different conclusion. One thing is certain: the price is uncertain, but maybe not as uncertain as figure 12 might predict.

The price of green certificates is depended on the general success and the implementation of the common market. Dnb Nor Energy's estimate of the development of the green certificate price is found in figure 13.

Figure 13 - Predicted price of green certificates

Price of green certificates (Fwd pris + 2% p.a. 2016-20)



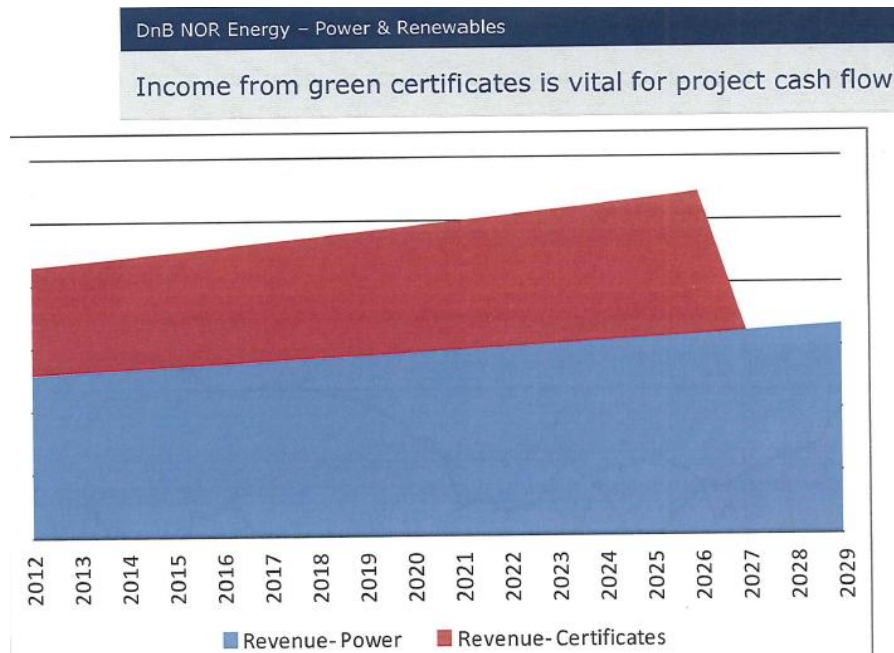
As we can see from figure 13, the price of green certificates are more predictable in the short term, but in the longer run towards 2020 the price range of the predictions are much higher than for the power price.

According to Christian Sjødin director of Nena, a consultancy firm in energy estimates the price of green certificates to be 29 €/MWh in 2012 which yields about 260 Swedish kroner today, and 37 €/MWh in 2012-2035 which yields about 330 Swedish kroner in today's exchange rate.

Despite all these predictions, there is still some uncertainty about the final price setting process of these certificates before the actual market takes place from 01.01.2012. Green certificates can be stored and issued accordingly to the need; this would help to stabilize the price level somewhat. Based on this the estimation of Nena with a price of 330 SEK/MWh in 2012-2035 might be plausible. In Sweden today there are about 6 TWh of certificates "in stock".

The extra income induced by the green certificates for selling wind generated electricity will increase the expected cash flow for the project considerably. Figure 14 illustrates how the income from power and green certificates is distributed. Dnb Nor Energy presumes a 60/40 split in total income from income and green certificates respectively.

Figure 14 - The distribution of income between green certificates and power



Many large power companies have own trading departments to assess the exposure of electricity sold. According to NORWEA it is more common for smaller power companies to sell forward at least part of their electricity production and their green certificates in a PPA at least five years in advance, this in order to minimize risk, something the banks and investors appreciate. The assumption in this thesis is that the wind power site is of a medium size, and it would be natural to assume that some of the project’s production is sold forward at least five years in a PPA.

The ROA factor for the project is expected to increase. Following the ROA hypothesis from chapter 2; low expected ROA implies low discount rates and vice versa. In the beginning of the project there is a relatively high expected income but a high level of assets as a result of the initial investment. As the assets depreciates, the income from selling electricity remains relatively persistent and the ROA factor increases. The reason the income can be argued to be persistent is that electricity is relatively easily sold compared to other types of commodities that fluctuate more with the general business cycle, households and industry need electricity. The volatility of the ROA factor for the project can be based on the previous discussion of the price of green certificates and the power price in general. Assuming a relatively stable price of electricity due to an efficient electricity market that provides the grid with electricity even

when there is no wind, and a relatively mild adjustment period for the prices of the green certificates the uncertainty for the ROA factor is relatively low. Assuming that some of the production of the electricity is sold forward, the risk is also reduced.

The ROA factor for the market can like the investment factor to a great extent be determined by the historical market development. With basis in the findings of Kang, Lee and Min, the ROA factor for the market have experienced a high growth over the last years. The volatility of the ROA factor for the market has been present with some corrections for the last 20 years or so making the volatility significant and perhaps larger than for the project.

The ROA factor for both the market and the project is perceived to steadily increase due to the project's progress. The ROA factor for the project on the other hand is expected to increase more than the general market because the depreciation of the assets is expected to be more aggressive for the project than the general market and therefore appears to be more rapidly increasing. In conclusion, the market and the project ROA factors are to a certain extent positively correlated.

The beta will be 0.9 for the ROA factor, this follows from the risk aspects of the project are a bit lower than the general market and a relatively high positive correlation between the market and the project. The uncertainty of income is to my understanding a bit bigger than the uncertainty of investment in the project with a relatively predictable cost structure in the beginning of the project.

5.3 Computation of the factor model

The investment and ROA factors are a monthly average, in order to make a meaningful comparison between the CAPM and the new factor model we compute the monthly returns to yearly returns. According to Berk & DeMarzo (2007) the conversion of a discount rate can be found using the equation (Berk & DeMarzo, 2007):

$$\text{Equivalent n-Period discount rate} = (1 + r)^n - 1$$

Where n is the number of months, in this case 12 months and r is the return on the investment and ROA factor.

Summary of input parameters for the factor model:

- Market premium 4.7%
- Market beta 2.7
- Investment factor 2.4% (yearly average)
- Investment factor beta 0.8
- ROA factor 6.5% (yearly average)
- ROA factor beta 0.9

Using equation 2.7 yields the required return on equity for the three factor model:

$$E_r - r_f = 2.7 \cdot 4.7\% + 0.8 \cdot 2.4\% + 0.9 \cdot 6.5\% = 20.46\%$$

The required rate of return on equity of 20.46% using the three factor model can be applied to the WACC in the same manner as CAPM. This estimate of the required return on equity is not adjusted for tax effect like the previous computation of the CAPM model. Tax effects with the three factor model will not be taken into consideration here. Further discussion will be based on the explanatory power of the new three factor model compared to the CAPM model.

Chapter 6 - A comparison of the two models

This chapter discusses and compares the different results from chapter 4 and 5. The analysis will in particular be based on the explanatory power of the new three factor model which introduces anomalies that none of the previous asset pricing models have been able to explain. The discussion further will concentrate on how these anomalies materialize in the wind power project.

In order to compare the different results, the findings of the cost of equity will be summarized in table 9.

Table 9 - Summary of the cost of equity estimates

	Cost of equity
CAPM after tax	12.5%
CAPM pre-tax	17.4%
3 factor model	20.46%

The different cost of equity results from the new three factor model and the CAPM model are significant. The after tax cost of equity of 12.5% using the CAPM is found in chapter 4. Using a pre-tax cost of equity using the CAPM model and equation 2.2 yields 17.4% compared to the pre-tax cost of equity for the three factor model of 20.46%. For illustrative purposes and since the new three-factor model is a pre-tax number, the following discussion will be based on the pre-tax result of CAPM as well.

The difference of the results of the two models is considered to be significant taken into account that the cost of equity estimate is used to discount cash flows far into the future. A small change in the cost of equity might affect the final net present value of the project positively or negatively depended on the use of cost of equity.

The estimation of cost of equity using the CAPM model is simple and gives a certain indicator of what risk to expect given the general market conditions reflected through the market premium and the project’s sensitivity to this market premium.

The new three factor model provides through the investment and ROA factor important insights from the production side of the economy. Through the market factor from the

consumption side makes the three factor model a better tool for capture much of the systematic risk in order to obtain cost of equity. Because the new three factor model is capable of capturing more systematic risk, the cost of equity estimate for the project might increase as well due to the increased number of factors compared to the CAPM model of one. This might be an explanatory factor to describe the difference in the results of the two models for our project.

The introduction of the new factors is also according to Chen, Zhang and Novy-Marx better capable of capturing much of the anomalies like earnings surprises, financial distress, accruals, net stock issues and asset growth that are left to be unexplained by previous asset pricing models. The introduction of the new factors and through the anomalies listed below increases the explanatory power of the new three factor model.

- Financial distress - Champbell, Hilscher and Szilagyi (2008), showed the negative relation of average return and financial distress. Using common measures of bankruptcy risk as proxies for financial distress (Campbell, Hilscher, & Szilagyi, 2008).
- Earnings surprises – also called post-earnings announcement drift. According to Ackert & Deaves (2009), this anomaly can be described as the market to a certain extent anticipates negative and positive surprises, however on the day of the earnings announcement, the market reacts positive or negative to the unanticipated surprises (Ackert & Deaves, 2010).
- Total accruals – Sloan (1996) showed that firms with high accruals earn abnormally lower average returns than firms with low total accruals (Sloan, 1996).
- Net stock issues- According to research of Pontiff and Woodgate (2008), can this anomaly be described as the negative association between average returns and net stock issues (Pointiff & Woodgate, 2008).
- Asset growth – According to Cooper, Gulen and Schill (2008) the asset growth anomaly can be described as the negative relation of asset growth and average return. Low asset growth firms earn higher average returns than high asset growth firms (Cooper, Gulen, & Schill, 2008).

According to Berk and DeMarzo, financial distress can be defined as when a firm fails to make the required interest or principal payments on the debt, the debt is in default and the firm is in financial distress. According to findings in the article of Chen, Zhang and Novy-Marx, a big portion of the distress anomaly can be explained by the ROA beta. Less distressed firms are more profitable with a higher expected ROA and earn a higher average return than more distressed firm. Further findings conclude that distressed firms have lower ROA beta than less distressed firms. The ROA beta of 0.9 for the project implies that the project is to a greater extent subject to more financial distress than the general market. Following the report of Krohn, Morthorst & Awerbuch the initial investment in a project does not pay back before 7-10 year have lapsed (Krohn, et al., 2009). In these initial years the risk of financial distress is high; the profitability is low due to low expected ROA and there is risk that the project might default on their interest payments. As the project progresses, expected ROA increases and the project becomes more profitable. After the investment is covered the project is running at a small cost since the resource is free, the longer the project runs after the pay-back time the more profitable the project is. One can conclude that the financial distress anomaly is to a certain extent present in the wind power project.

The post-earnings announcement drift is explained through the ROA factor; firms with positive earnings surprises are likely to experience immediate stock price increases and negative earnings surprises are likely to experience immediate stock price decrease. In the same manner as unexpected earnings surprises for exchange traded stocks might trigger a stock price increase or decrease; the same can be applied to the project. An unexpected increase in spot price might increase the future cash flows and increase the net present value and therefore leads to an increase in the value of the project. However, perhaps the anomaly will not, to any extent, be present in this project due to the investor's long term investment horizon. The project is to a much lesser extent subject to changes in owners because the investors are in the project for the long term. Therefore the wind power project differs from a larger exchange traded stock with higher turnover when it comes to post earnings announcement drift. The post earnings announcement drift is not present in the wind power project.

According to Penman (2010) accruals can be defined as the value of noncash value flows (H.Penman, 2010). According to Chen, Zhang and Novy-Marx, through the multifactor model the investment factor captures to a high degree the accrual anomaly. The most important accruals for the wind power project are the depreciation of the initial investment. The

depreciation represents recognition of the ability to generate future cash has been given up in earnings to date (H.Penman, 2010). Assuming a part of the electricity is sold in advance in PPA's, some of the income received would count as an accrual due to the fact that the receivables is not cash received, but merely a value added in expectation of future cash. The accrual anomaly is an important part for the investment factor in our wind power project.

According to findings in the article of Chen, Zhang and Novy-Marx concludes that firms with high net stock issues earn a lower average return than firms with low net stock issues. There could be two reasons as to why a firm wants to raise money by issue stocks; the need of money to further investments or to pay off debt. This anomaly could therefore be argued to be linked to the financial distress anomaly because firms that issue stocks are likely to be in need of cash in order to meet its future obligations. If the project needs to raise more equity to further investment, or the profitability is low and need more cash to meet its future obligations, the investors can get another investor to the table. The introduction of another investor means lower dividends from the project for the initial investors because more investors need to share the total value. The same happens when an exchange traded company issues stocks. The net stock issue anomaly is present in the project.

According to Chen, Zhang and Novy-Marx the factor model through the investment factor explains the asset growth better than other asset pricing model. The assets for a wind project are high in year 0, but during the course of the project the project is depreciated and the project will have a negative asset growth. Because of the high asset growth in the beginning of the project, the asset growth anomaly is to a certain extent present in the project.

In conclusion one can say that the presence of anomalies like financial distress, accruals, net stock issues and to a certain extent the asset growth anomaly in the new three factor model is able to increase the explanatory power of the model compared to the CAPM model. Due to increased explanatory power through the investment and ROA factors and the ability to capture more systemic risk, the cost of equity might be increased by this.

Chapter 7 - Conclusions

This chapter is divided into three parts, the first two parts discuss the pros and cons of the CAPM model and the new three factor model. The third part contains a conclusion for both models' validity and practical implications and what is assumed to be the best model.

7.1 CAPM is CRAP?

Due to the new empirical work that has put the assumptions and the framework of CAPM in the spotlight, emerges researchers claiming the death of CAPM model as an estimator for cost of capital.

Among the researchers concluding the empirical failures of CAPM model two stories emerge (Fama & French, 2004). The first story is the behavioral finance school that are basing their view on evidence that stocks with high ratios of book to market are typically firms that have fallen in bad times, firms with low book to market ratios is associated with growth. Further they are arguing that sorting on book to market ratios exposes investor to overreact to good times and bad times. According to behavioral analyst James Montier (2007), the CAPM under-predicts returns on low-beta stocks and massively overestimates returns on high-beta stocks. Further, Montier concludes in the following that the CAPM model in reality is *Completely Redundant Asset Pricing* ;CRAP (Montier, 2007). The second story claims that the CAPM model are based on unrealistic assumptions like the investor only cares about the mean and variance of the one period return. They further argue the need of a more complicated model that is able to explain more systemic risk.

Roll (1977) argues that CAPM has never been tested and probably never will, the market portfolio is hard to define and not theoretically clear what should be excluded from the model in form of human capital and data availability substantially limits the assets that are included (Fama & French, 2004). Roll argues that because we use proxies as a form of market portfolio, the true market portfolio will not reveal itself and learn nothing from the CAPM (Roll, 1977).

Another point of critique is the measurement problems of the beta; this is not a problem specific for the CAPM model, but in general to all asset pricing models and their beta. The beta estimate is based on historical data and in many cases may not be representative for the

future. If there is a trend in the data of high volatility, this will be captured in the beta, but there is no certainty that the firm will still continue to experience volatility in the future making the beta estimate uncertain (Bøhren & Michalsen, 2010).

On the other hand; all models in science or in economics are based on simplifications that enable the user to comprehend a complicated reality and perfection could be considered an unreasonable and unusable standard (Bodie, et al., 2009). According to Bøhren & Michalsen (2010), the CAPM model is based on portfolio-theory therefore the model is a logical description of those results that mathematically and economically follows the portfolio-theory's assumptions. The assumptions behind the CAPM model are strict and many of the assumptions would not be relevant in the real world. According to Bøhren & Michalsen, the most important aspect in the application of the CAPM model is not the relevance of the assumptions behind it but whether the CAPM model's ability to estimate expected return in accordance to reality is better than any other alternative models. A model's ability to explain the observed prices of the uncertain future cash flows is more important than the realism of the assumptions behind the model.

In the discussion of CAPM models validity, many argues that the CAPM's problems are spurious, a result of data dredging- publication hungry researchers sourcing the data and unearthing contradictions that occur in specific samples as a result of chance (Fama & French, 2004). A counter argument to this is that several testes are consistent in their findings of CAPM's validity. Several researches have proven the relation between book to market and average returns in several countries. This evidence suggests that the contradictions of the CAPM associated with price are not sample specific. The counter-CAPM empirical work is controversial; if the size effect- the negative relation between return and the market equity is measured in other variables like sales, employee or assets the whole relation between size and return disappears.

7.2 The three factor model, a better view?

In the Fama & French multi factor model more of the variation in average return is being captured for portfolios formed on size, book to market and other price ratios that cause problems for the CAPM. The general multifactor model is now widely used in empirical research that requires a model for expected returns but also as a measure of mutual fund performance.

Over the years the Fama-French three factor model that first tried to explain the empirical inefficiencies of the CAPM has been weakened. The new three factor model provides through the new factors a better understanding of the anomalies that are left to be explained by previous asset pricing models. The new three factor model provides new factors that measures important systemic risk aspects that is highly relevant for the wind power project. Through the factors of investment to assets and ROA, the new three factor model provides important risk aspects from the production side of the economy. This provides the investor with meaningful risk aspects of the project because the investor as a developer is not only facing the general market conditions, but also the risk of the investment and uncertain profitability of the project. This gives the new three factor model a new view of the systematic risk the investor is facing.

Kang, Lee & Min argues that despite the empirical performance, it is not obvious whether expected returns estimated from the new three factor model represent a reward for bearing risk or a result associated with non-risk characteristics. The reason for this is because the portfolio returns are constructed from firm characteristics rather than macro variables themselves. They further argue that one necessary condition for a factor to serve as a measure of risk is that it at some level should be related to macroeconomic risk. The findings of Kang, Lee and Min conclude that the new factors in some way links to the actual macroeconomic conditions.

The problem of empirical approaches such as the new multifactor model that uses proxies for extra-market sources of risk is that none of the factors in the proposed models can be clearly identified as hedging a significant source of uncertainty. When searching for explanatory data, the data may uncover past “patterns” that are due purely to chance.

The main shortcoming of the Fama- French factor model is its empirical motivation; the SMB and HML factors are not constructed as a measure of predictions of the state variables, but

merely as an attempt to capture patterns uncovered by previous work on how average stock returns vary with size and the book to market equity ratio. This can be applied to the new three factor model by Chen, Zhang and Novy-Marx, the investment factor and the ROA factor are constructed the same way as Fama and French constructed their SMB and HML factors.

7.3 What is best?

Like concluded previously in table 9 in chapter 6, the different model's return on equity differs. This difference can be described by the new three factor model's ability to capture more risk compared to CAPM and hence a higher required return on equity for the three factor model.

The CAPM's superiority when it comes to an easy understanding of the framework relating to estimating cost of capital is striking; no other model has up to now been able to estimate the cost of capital easy and quick like the CAPM does. The market portfolio makes a reasonable proxy to serve as the opportunity cost of a similar investment in the market with the same risk.

On the other hand, the new factor model provides important risk aspects that the CAPM model does not cover and describes many of the anomalies the CAPM and other asset pricing models does not. Looking the specific wind generated electricity project, there is little doubt that the new factor model is capable of explaining much more of the risk inherent of a project compared to the CAPM model. The investment and ROA factors is not considered to be risk factors, but more as investment based asset pricing that ties expected returns to firm characteristics. In this way the factor model is different from the market based CAPM that does not include any firm characteristics.

The thing that prevents the use of the new three factor model is the complicated framework and the amount of data required in order to a reasonable extent measure the premiums for the different factors and their following sensitivities. This complexity could question the validity of using such a new model compared to the old CAPM model. It is to the writer's understanding that there have not been conducted any empirical research in order to test the validity of the model like has been with the Fama-French model. Any further in-depth investigation of the new factor model's validity is outside the scope of this thesis. One can still conclude that given the findings of Chen, Zhang and Novy-Marx is correct and

successfully be accepted by the Journal of Finance, the model looks really promising in capture systemic risk for estimating cost of equity.

Based on what we know to this day, the three multi factor model provides us with a much broader estimation of the cost of capital compared to the CAPM model. Admittedly, there are some empirical problems with factor models as well, but the notion of combining the market factor from CAPM and the two new factors captures much of the essence from both the CAPM and the new three factor model making it a more complete and realistic estimation of expected retur. Therefore one could argue that the new factor model is the “best” model. Still the CAPM remains the most common used measure for estimating expected returns and is expected to be for a quite a while due to the simplicity of the model.

7.4 Critique and suggestions of further work

The computation of the new three factor model is based on a risk free rate based on the US market, while the CAPM computations are based on a Norwegian risk free rate. The use of different risk free rates will also have consequences for the frame of reference later in the thesis during the comparison of the two models.

The computations of the equity beta for the CAPM can in retrospect be viewed as a bit high, the intension was that the market for wind generated electricity projects in Norway is subject to much uncertainty. It is my personal opinion that the wind power industry in Norway is no place to be for a risk averse investor due to this uncertainty.

The three factor model is subject to a qualitative analysis and not based on returns, this will make the predictions of the model for the project uncertain. One idea is to a greater extent gather the returns necessary to find the cost of equity for the Norwegian market in a wind power setting. The cost of equity can be used in order to compute the project’s WACC and problematize tax effects inherent in the new three factor model.

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Appendix

1. Regression results from STATA used in chapter 3.

Vestas:

2001-2011

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. reg Vestas Market
```

Source	SS	df	MS			
Model	.595469553	1	.595469553	Number of obs =	119	
Residual	2.40588474	117	.020563117	F(1, 117) =	28.96	
Total	3.00135429	118	.025435206	Prob > F =	0.0000	
				R-squared =	0.1984	
				Adj R-squared =	0.1915	
				Root MSE =	.1434	

Vestas	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Market	1.591358	.2957212	5.38	0.000	1.005697	2.177018
_cons	.0351573	.0189583	1.85	0.066	-.0023885	.0727032

2006-2011

```
. reg Vestas Market
```

Source	SS	df	MS			
Model	.251610254	1	.251610254	Number of obs =	60	
Residual	.958198961	58	.016520672	F(1, 58) =	15.23	
Total	1.20980922	59	.020505241	Prob > F =	0.0003	
				R-squared =	0.2080	
				Adj R-squared =	0.1943	
				Root MSE =	.12853	

Vestas	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Market	1.484257	.3803285	3.90	0.000	.7229471	2.245568
_cons	.0381447	.0241804	1.58	0.120	-.0102575	.086547

2008-2011

```
. reg Vestas Market
```

Source	SS	df	MS			
Model	.25013206	1	.25013206	Number of obs =	36	
Residual	.668659063	34	.019666443	F(1, 34) =	12.72	
Total	.918791124	35	.026251175	Prob > F =	0.0011	
				R-squared =	0.2722	
				Adj R-squared =	0.2508	
				Root MSE =	.14024	

Vestas	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Market	1.655389	.4641714	3.57	0.001	.7120795	2.598699
_cons	.010937	.0308236	0.35	0.725	-.0517041	.073578

Greentech:

2001-2011

. reg Greentech Market

Source	SS	df	MS			
Model	.43786897	1	.43786897	Number of obs =	119	
Residual	3.73888469	117	.031956279	F(1, 117) =	13.70	
Total	4.17675366	118	.035396217	Prob > F =	0.0003	
				R-squared =	0.1048	
				Adj R-squared =	0.0972	
				Root MSE =	.17876	

Greentech	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Market	1.364615	.3686516	3.70	0.000	.6345197	2.09471
_cons	.039132	.0236337	1.66	0.100	-.0076734	.0859374

2006-2011

reg Greentech Market

Source	SS	df	MS			
Model	.407094651	1	.407094651	Number of obs =	60	
Residual	2.11351656	58	.036439941	F(1, 58) =	11.17	
Total	2.52061121	59	.042722224	Prob > F =	0.0015	
				R-squared =	0.1615	
				Adj R-squared =	0.1470	
				Root MSE =	.19089	

Greentech	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Market	1.88796	.5648509	3.34	0.001	.7572877	3.018632
_cons	.0376497	.0359118	1.05	0.299	-.0342357	.1095351

2008-2011

. reg Greentech Market

Source	SS	df	MS			
Model	.35170614	1	.35170614	Number of obs =	36	
Residual	1.89019297	34	.055593911	F(1, 34) =	6.33	
Total	2.24189911	35	.06405426	Prob > F =	0.0168	
				R-squared =	0.1569	
				Adj R-squared =	0.1321	
				Root MSE =	.23578	

Greentech	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Market	1.962933	.7804212	2.52	0.017	.3769261	3.548939
_cons	.0268766	.0518244	0.52	0.607	-.0784431	.1321964

Plambeck Neue Energien

2001-2011

. reg Plambeck Market

Source	SS	df	MS			
Model	.21127794	1	.21127794	Number of obs =	119	
Residual	2.99773855	117	.025621697	F(1, 117) =	8.25	
Total	3.20901649	118	.027195055	Prob > F =	0.0048	
				R-squared =	0.0658	
				Adj R-squared =	0.0579	
				Root MSE =	.16007	

Plambeck	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Market	.9479056	.3300973	2.87	0.005	.2941653	1.601646
_cons	-.0127532	.0211621	-0.60	0.548	-.0546636	.0291572

2006-2011

. reg Plambeck Market

Source	SS	df	MS			
Model	.027895407	1	.027895407	Number of obs =	60	
Residual	1.73532665	58	.029919425	F(1, 58) =	0.93	
Total	1.76322206	59	.02988512	Prob > F =	0.3383	
				R-squared =	0.0158	
				Adj R-squared =	-0.0011	
				Root MSE =	.17297	

Plambeck	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Market	.4942098	.5118252	0.97	0.338	-.5303196	1.518739
_cons	-.0070569	.0325406	-0.22	0.829	-.072194	.0580802

2008-2011

. reg Plambeck Market

Source	SS	df	MS			
Model	.030679083	1	.030679083	Number of obs =	36	
Residual	.931311719	34	.027391521	F(1, 34) =	1.12	
Total	.961990802	35	.027485451	Prob > F =	0.2974	
				R-squared =	0.0319	
				Adj R-squared =	0.0034	
				Root MSE =	.1655	

Plambeck	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Market	.5797445	.5478019	1.06	0.297	-.5335229	1.693012
_cons	-.0182477	.0363771	-0.50	0.619	-.0921749	.0556796

Gamesa:

2001-2011

. reg Gamesa Market

Source	SS	df	MS			
Model	.576971553	1	.576971553	Number of obs =	119	
Residual	1.01470033	117	.008672652	F(1, 117) =	66.53	
Total	1.59167189	118	.013488745	Prob > F =	0.0000	
				R-squared =	0.3625	
				Adj R-squared =	0.3570	
				Root MSE =	.09313	

Gamesa	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Market	1.566445	.1920499	8.16	0.000	1.186101	1.94679
_cons	.0300893	.012312	2.44	0.016	.0057059	.0544727

2006-2011

reg Gamesa Market

Source	SS	df	MS			
Model	.395895059	1	.395895059	Number of obs =	60	
Residual	.679676702	58	.011718564	F(1, 58) =	33.78	
Total	1.07557176	59	.01823003	Prob > F =	0.0000	
				R-squared =	0.3681	
				Adj R-squared =	0.3572	
				Root MSE =	.10825	

Gamesa	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Market	1.861809	.3203186	5.81	0.000	1.220621	2.502996
_cons	.0352668	.0203651	1.73	0.089	-.0054983	.0760319

2008-2011

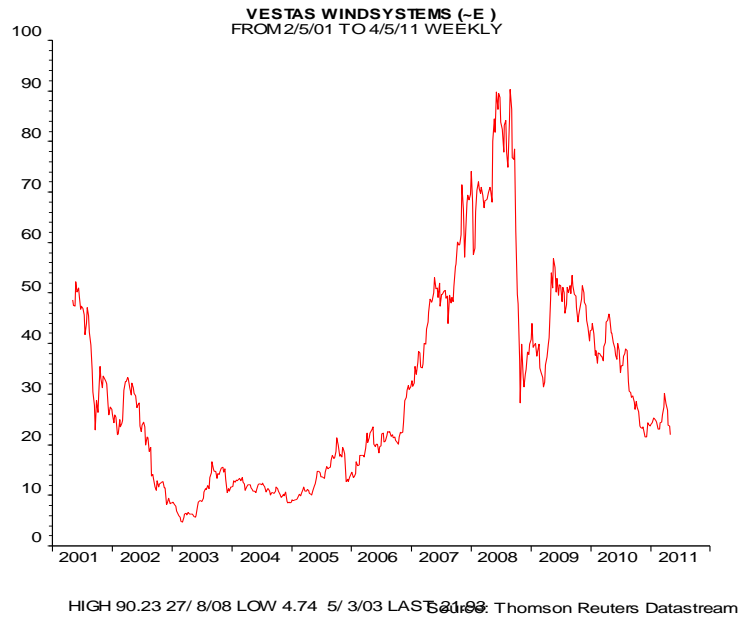
. reg Gamesa Market

Source	SS	df	MS			
Model	.380637753	1	.380637753	Number of obs =	36	
Residual	.43605374	34	.01282511	F(1, 34) =	29.68	
Total	.816691493	35	.023334043	Prob > F =	0.0000	
				R-squared =	0.4661	
				Adj R-squared =	0.4504	
				Root MSE =	.11325	

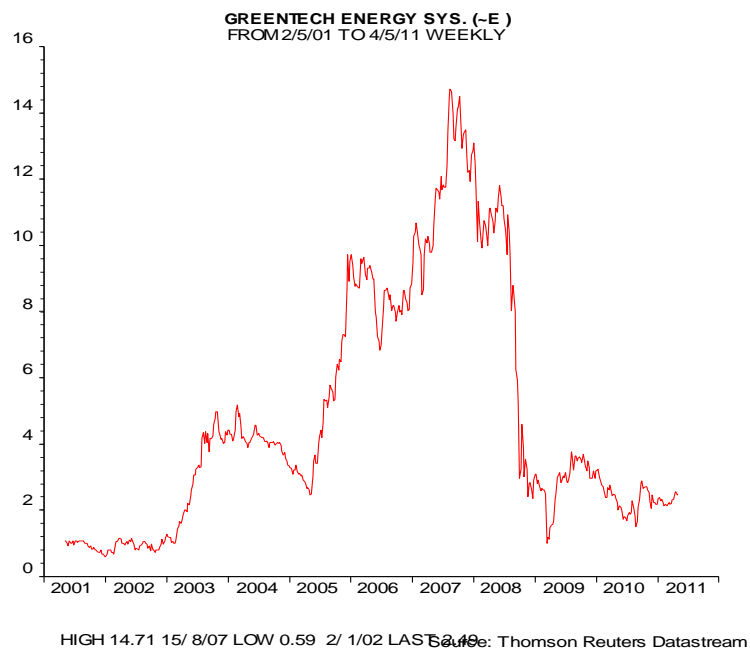
Gamesa	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Market	2.042074	.3748401	5.45	0.000	1.280307	2.80384
_cons	.0145381	.0248915	0.58	0.563	-.0360475	.0651237

2. Historical development of the comparables during the regression period:

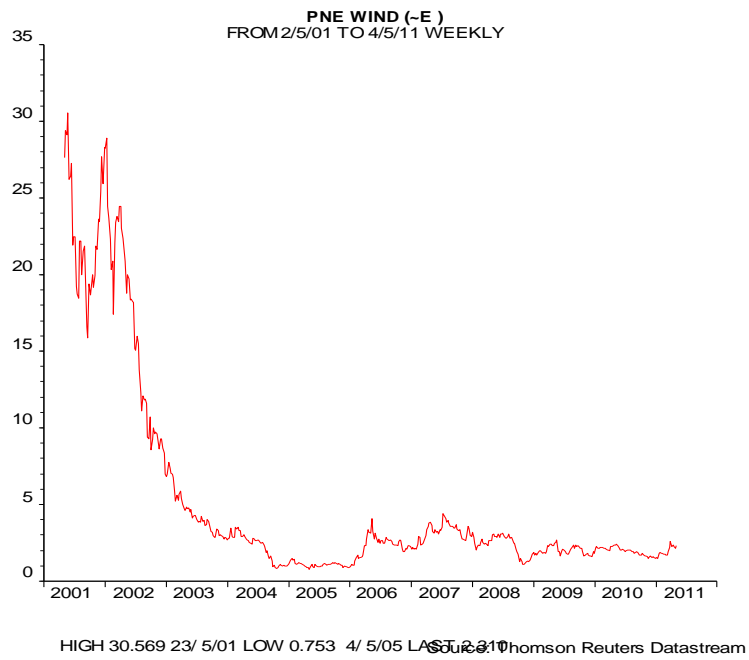
Vestas:



Greentech:



Plambeck Neue Energien:



Gamesa:

