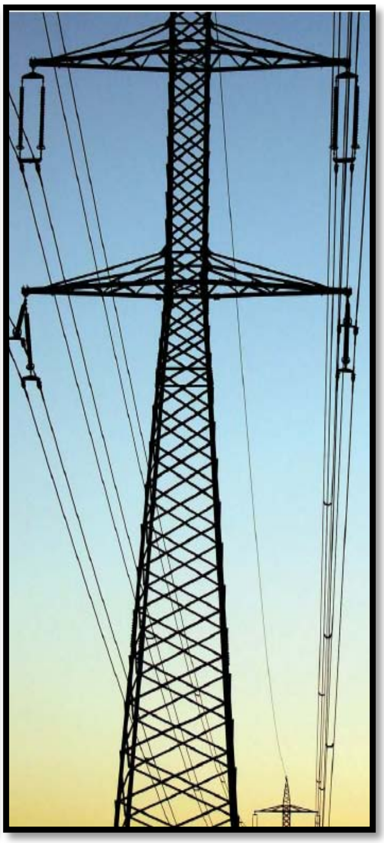
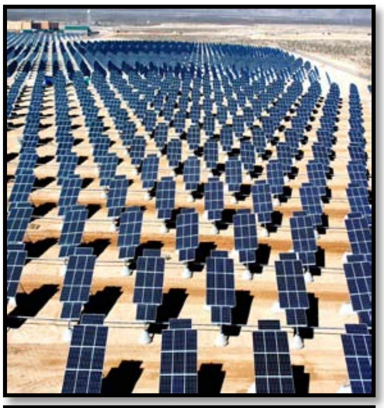
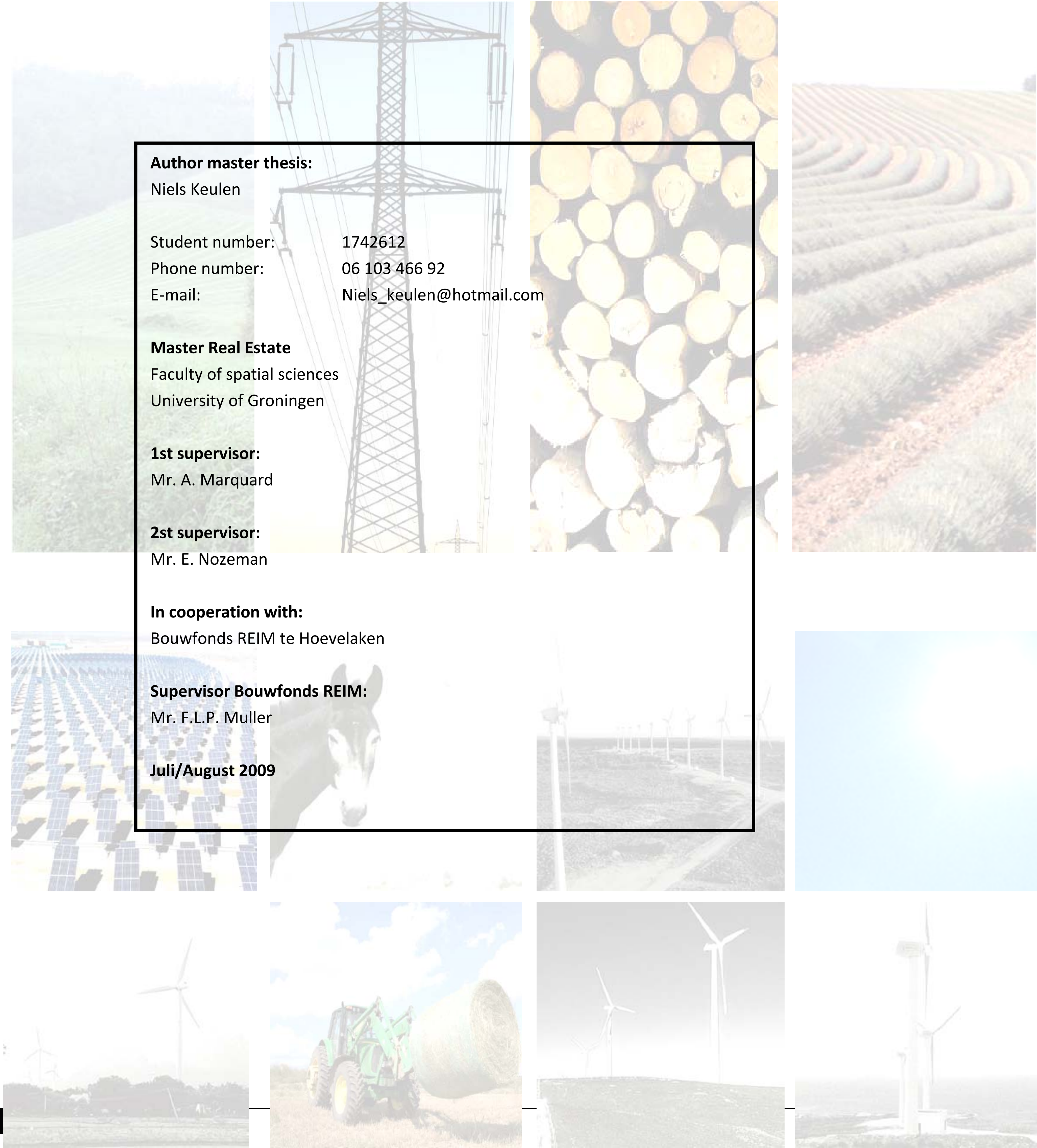
CLEAN TECH - A NEW ASSET CLASS





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VOORWOORD

Voor u ligt mijn scriptie ter afsluiting van de master Vastgoedkunde, aan de Rijksuniversiteit Groningen. Deze scriptie is het eindresultaat wat geheel in het teken staat van beleggen in windmolens, zonnepanelen en biomassa.

Het onderzoek is uitgevoerd bij Bouwfonds REIM te Hoevelaken. Via deze weg wil ik Bouwfonds REIM bedanken voor de gegeven mogelijkheid, om in een aangename werksfeer, bij hen te kunnen afstuderen. Hierdoor heb ik met veel plezier in de keuken kunnen kijken bij een professionele vastgoedorganisatie. In het bijzonder wil ik hier de heer Léon Muller bedanken voor de begeleiding vanuit Bouwfonds REIM. Hierbij heeft de heer Léon Muller een goede balans weten te vinden tussen het zelfstandig laten opereren en het (bij) sturen van het afstudeerproces.

Daarnaast gaat mijn dank uit naar mijn begeleider van de Rijksuniversiteit Groningen, te weten de heer Arthur Marquard, voor de begeleiding en adviserende rol die hij heeft vervuld tijdens mijn afstudeerscriptie. Tot slot wil ik iedereen bedanken, die een bijdrage heeft geleverd aan het afstudeerproces, in de vorm van het geven van interviews en/of verstrekken van adviezen en informatiegegevens.

Vragen naar aanleiding van mijn scriptie zijn van harte welkom.

Niels Keulen

Hoevelaken, juli 2009

FOREWORD

This master thesis forms the completion of my master Real Estate at the University of Groningen. This master thesis is the result of the research about investing in windmills, solar panels and biomass.

The research is conducted at Bouwfonds REIM in Hoevelaken. I would like to thank Bouwfonds REIM for the given opportunity, working in a pleasant atmosphere, to graduate. By this opportunity I gained some experience at a professional real estate organisation. In particular, my gratitude goes to Mr. Leon Muller. Mr. Leon Muller provided me with good comments and interesting advises about the master thesis and research process.

In addition, I would like to thank Mr. Arthur Marquard, supervisor of the University of Groningen, for his guidance and advisory role during my master thesis. Finally, I would like to thank everyone, who contributed to this master thesis, in the form of giving interviews and/or provide advice and information data.

Questions following my master thesis are welcome.

EXECUTIVE SUMMARY

The purpose of this study is to identify the attractiveness of Clean Tech as an alternative investment category compared to other asset classes such as shares, bonds and real estate. The study is the first step to investing in clean tech. This research answered questions such as why invest in clean tech, which categories of clean tech are real estate, what is the status of the technological developments, in which countries to invest, and what are the risks and returns of investing in clean tech?

Continued dominance of fossil fuels, but the urgency of renewable energy increases.
Due the continued growth of the world's population combined with emerging economies of China and India and an increasing level of prosperity, the energy consumption increases more than a half in 2030 compared to 2005. Fossil fuels remain their dominant role in the energy mix till 2030. But the demand for renewable energy will increase. First, fossil fuels are finite. According the forecasts the world has natural oil for 41.6 years, natural coal for 60.3 years and coal for 133 years. Another aspect of uncertainties regarding the production of fossil fuels is the sharp rise in prices. The record price of oil, $ 147, - per barrel, was paid in July 2008. Through the financial crisis the oil price hits his lowest level of $ 32, - per barrel. At the time writing this master thesis the oil price is $ 71 per barrel. The expectation is that the oil price will increase in the coming years. Second, the use of renewable energy is stimulated by the government. The EU agreed on a set of ambitious climate and energy objectives: 20-20-20 ambitions. Objectives are 20% reduction of greenhouse gasses and a 20% share of renewable energy by 2020, including a 10% share of biofuels in transport. This objective is also important to reduce the growing dependence on fossil fuels of the European countries. The production and reserves of oil and gas are increasingly concentrated in a limited number of countries such as Russia and the Middle East. Renewable energy is an important weapon against this dependency. Finally a larger share of alternative energy sources is important regarded to climate change. The emissions of CO_2 are limited by making a greater use of renewable energy.

Clean tech is real estate.
This study sought to answer the question which categories of clean tech fit within the definition of real estate. Several characteristics of real estate such as: financeable, wealth creating, physical, multiple users, stable cash flow is compared with the characteristics of clean tech categories. From this equation follows the conclusion that windmills, solar panels, and biomass fits within the definition of real estate.

Status of the clean tech possibilities.
Onshore wind energy is a mature technology and is currently the most cost-competitive renewable energy form. The first offshore windmills are currently in use and this is also the weakness of offshore wind energy. This technology is still in development and the risks must be identified for the coming years, because windmills at sea have other requirements than windmills on land. Photovoltaic solar energy is a mature technology, and will benefit from the developments in energy-efficiency and reducing production costs in the coming years. Concentrated solar power is a relatively new technology with an interesting future ahead. The technology of biomass is more difficult than wind energy and solar energy. First there are more processes needed to produce energy compared to wind energy and solar energy. Second, the first generation has to deal with the food-for-fuel debate. Third, biomass becomes only profitable with large quantities of biomass crops and is a lot of farmland is needed.

Where to invest in clean tech?
Two factors play an important role for investing in clean tech in a specific country: site factors and subsidy regime. In Europe, the windiest regions are the coastal regions and the highest annual solar irradiance can be

found in southern Europe. But the best countries to invest in onshore wind energy, on a basis of site factors and subsidy-regime, are: Germany, France, Ireland, Spain and the U.K. And for offshore energy: U.K., Ireland and France. The best countries to invest in solar energy, on a basis of solar irradiation and subsidy regime are: Spain, Italy and Germany. The most interesting countries for biomass, on a basis of suitable arable lands, are: northern and western France, Ireland, Germany, Eastern Hungary, and the Po Valley, along the Danube in Bulgaria and Romania, and parts of the Baltic States.

What are the biggest risks of investing in clean tech?

First risk is the stability of subsidy regimes. Without subsidies no clean tech category would be profitable. Second risk is raising finance, because there is limited capital available caused by the financial crisis. Third, low oil prices, because with high oil prices clean tech is a good alternative. Finally, technological developments. Clean tech need technological developments to get more cost-competitive compared to fossil fuels, and only then clean tech will play a meaningful role.

The performance analysis of clean tech.

Figure: performance analysis: 2000:Q1 – 2009:Q1 (source: authors edit)

Asset class	Average annual return	Annual risk	Risk/return ratio	Sharpe ratio
Global transmission & distribution	3,01%	16,84%	5,59	-0,07
European transmission & distribution	2,99%	18,35%	6,14	-0,07
Global generation	-0,59%	41,82%	-70,42	-0,12
European generation	6,89%	27,90%	4,05	0,05
Global Utilities	2,22%	18,06%	8,15	-0,11
European utilities	3,25%	18,31%	5,63	-0,05
Global infrastructure	2,90%	16,34%	5,63	-0,08
European infrastructure	4,13%	16,00%	3,88	-0,01
Listed property	2,09%	22,86%	10,96	-0,09
Stocks	-1,76%	19,44%	-11,07	-0,31
Real Estate UK	2,90%	8,24%	2,85	-0,16
Real Estate NL	9,84%	9,22%	0,94	0,61
Bonds	2,73%	3,90%	1,43	-0,38

Figure: performance analysis clean tech categories (source: authors edit based on data of Green Investing, 2009)

Clean tech categorie	LCOE (levelized cost of energy)	Project returns
Wind - onshore	US$ 89 - 126/MWh	10%-20% depending on market and resources
Wind - offshore	US$ 158 - 205/MWh	Marginal
Solar - photovoltaic	US$ 341 - 549/MWh	Heavily dependent on incentive regime
Solar - Concentrated solar power	US$ 241 - 299/MWh	n/a
Biomass - First generation	Brazilian sugar based ethanol is cost-competitive at US$ 40/barrel	n/a
Biomass - Next generation	5-7 years away from commercial production	n/a
CO^2 - storage	The viability of CCS is entirely dependent on the existence of the carbon markets and CO^2 price	n/a

The interviewed specialists are positive about the expectations of investing in clean tech. First, because fossil fuels are finite. There technological improvements possible according production costs and energy efficiency. The specialists expect the most of solar energy, given the potential of this technology. But the expectations are only positive if the subsidies on clean tech are extended. Because the specialists don't think that clean tech becomes profitable without subsidies for the coming years.

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1. INTRODUCTION

"Solving problems, exploit opportunities"

The energy markets are at turbulent times. Causes for this turbulence are the financial crisis, the downfall of oil and gas prices after the financial crisis, the geopolitical risks associated with gas supplies, the increased attention for climate change, the ongoing discussions about the price and allocation mechanisms of CO_2 permits, the increase in global coal prices, and the implementation of governmental financial incentives for renewable options to realise renewable energy targets.

Since the summer of 2007 the world has witnessed a severe global financial crisis. The consequences are enormous. There are significant challenges arise for the global economy and capital markets. A global recession should not be excluded. The World Economic Forum writes in his report 'Green Investing' that it is crucial that the environmental challenges are not left aside when focusing on stabilizing the global financial system and reviving global economic growth. Waiting for economic recovery, rather than taking decisive action now, will make the future climate and energy challenge far greater (Green investing, 2009).

One of these environmental challenges is the demand for energy. The world is facing an energy problem. There has to be a solution to respond the increasing demand for energy. The stock of fossil fuels for the use of energy such as oil and natural gas are decreasing, while the demand is increasing. The world economy is too dependent on these fossil fuels at this moment.

The main sustainable alternatives for the extraction of energy are wind energy and solar energy (DuurzaamMkb, 2008). That is also the idea of the Dutch government. The Dutch government has agreed to build 6.000 megawatt of wind turbines in the North Sea for 2020. The EU has also ambitions for renewable energy. In March 2007, the European council agreed on a set of ambitious climate and energy objectives to enhance the security of energy supply, to curb the projected rise in energy prices and to reduce greenhouse gas emissions. And one of these objectives is a 20% share of renewable energy by 2020, including a 10% share of biofuels in transport in Europe.

Recent attention has been giving to "real estate-related" assets to provide potential enhanced returns and diversification benefits in an investment portfolio. As such, for example infrastructure has taken on increased interested among investors. Parts of investments in infrastructure are wind- and solar energy and biomass, also known as clean tech. Investing in clean tech is a respond on the future demand of energy. The problem, the increasing demand for energy, could be converted into a solution and an *opportunity* for real estate investors. That's why it is interesting to investigate of these opportunities, investing in clean tech, also lead to a good result and performance compared to other asset classes such as shares, bonds and real estate. Bouwfonds REIM is interested to gain more insight into investment opportunities in clean tech. So I, student of the Master Real Estate at the University of Groningen, was engaged to analyse the potential of clean tech as an alternative real estate investment opportunity. This master thesis is the result.

1.1. Research background

Studies showed that it is interesting for investors to include real estate in the portfolio, because real estate has opportunities for better spread and more risk reduction for the whole portfolio (Van Gool, 2001). But the studies only discuss the most common types of real estate: residential, retail, industrial and offices. Investments in alternative real estate are hardly addressed in the scientific literature. Reasons for the lack of alternative real estate investments in the portfolio are that it would be too risky, because of a lack of historical data. This is also covered by the investigated literature. There is enough information about the previously described most common types in real estate. But alternative real estate has little attention in the literature. A reason may be that alternative real estate amounts only a small percentage of the portfolio. And the composition of alternative real estate changed much over time. A limited number of studies relating to investing in alternative real estate are those of Hardin & Cheng (2005) and Newell & Eves (2007). These studies were about the role of agricultural land in real estate portfolios. Tiemstra (2006) examined if it is interesting to invest in real estate in addition to invest in land investments, project development and construction. And Lont & Hari (2007) examined the investment in infrastructure.

Investors need to spend more attention on alternative real estate investments. The PROVADA International real estate investor's debate of July 2008 was about alternative real estate investments. Conclusions of this debate were that alternative real estate sometimes escaped from the current financial crisis. Some alternative real estate can be seen as 'safe heaven'. The pioneers benefit. The 'early adapters' have the most advantages from this alternative investments. The direct returns decline as an alternative investment becomes common and increases the value.

In this master thesis I will examine whether it is interesting to invest in clean tech. In the literature there is little information available about investing in clean tech. This research can therefore be regarded as pioneering. The following sections provide an exposition of the investigation.

1.2. Research objective and central question

The research objective of this master thesis is as follows:

The purpose of the study is to identify the attractiveness of Clean Tech as an alternative investment category compared to other asset classes such as shares, bonds and real estate.

The central question of this master thesis is as follows:

What makes an investment in Clean Tech an interesting alternative investment category for investors?

The central question has the following sub-questions:

1. **What are the developments on the energy market?**
   - What is the demand for energy?
   - What is the supply of energy?
   - How does the energy market develop in the future?

2. **What to invest in?**
   - What are the different segments of Clean Tech?
   - Which segments of Clean Tech is real estate?

3. **What is the status of the clean tech sub-categories?**
    - What are the reasons for investing in Clean Tech?
    - What are the technology gaps?
    - What are the potential bottlenecks?
    - What are the characteristics of Clean Tech?

4. **Where to Invest?**
    - Which regions ensure the best results?

5. **How to Invest in Clean Tech?**
    - What are the risks?
    - What is the return?

6. **What are the expectations of the clean tech specialists on investments in clean tech?**

1.3. Methodology

The research consists of theoretical research and empirical research. The theoretical research consists of a combination of different sources; among other literature, published articles and interviews, aimed to collect information about investing in clean tech. And if it is possible there will be an attempt to sketch figures on investments in clean tech.

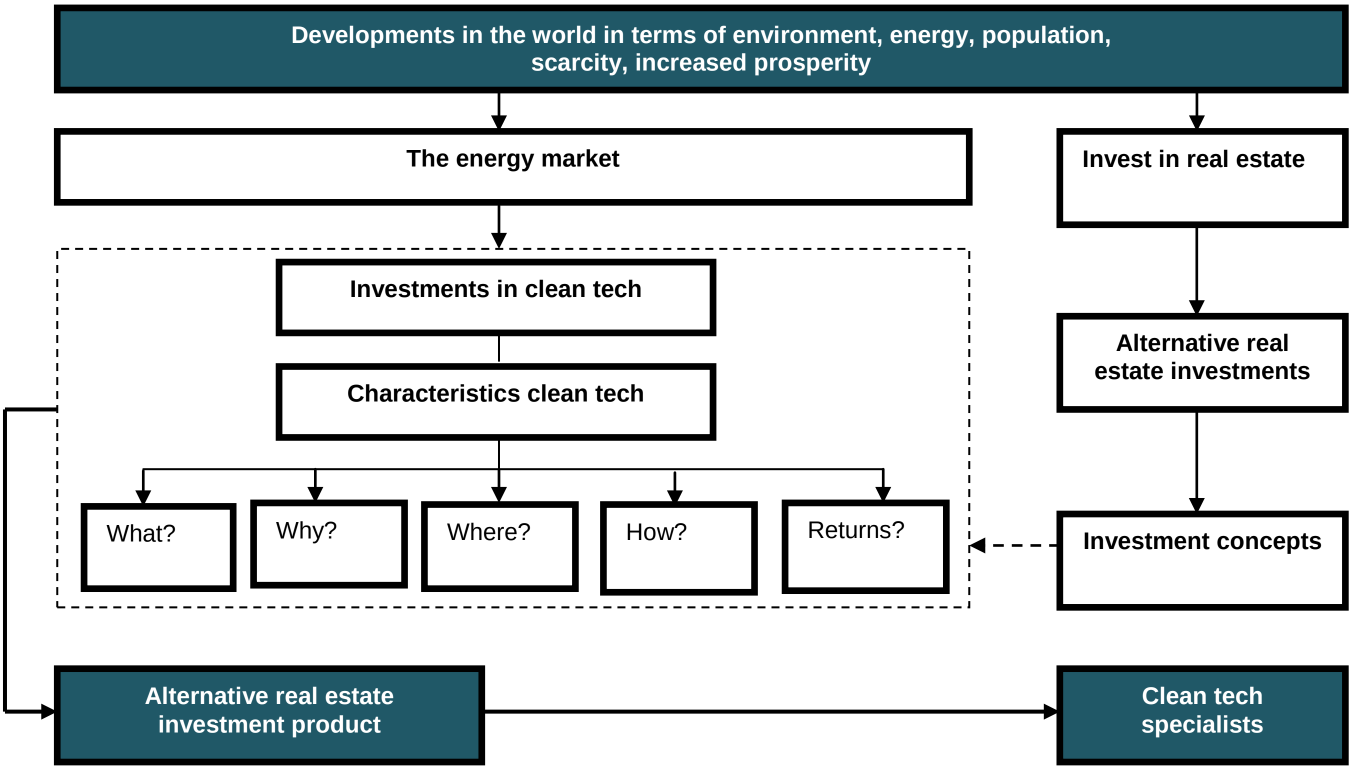
The empirical research exists of interviews with different real estate investors. These interviews should identify the expectations on investments in clean tech.

This research can be considered as an *explorative research* into sustainable energy as a real estate investment category. For example, this research attempts to answer the 'open' question: *Is renewable energy real estate?*

1.4. Conceptual model

The figure below shows the conceptual model.

Figure 1: conceptual model



Source: author edit

1.5. Research model

In the following research model is shown which stages can be found in this research. The entire research can be divided into five different phases;

1. Description
2. Possibilities
3. Empirical research; possibilities and variants
4. Testing and calculation
5. Conclusions

Within these phases is indicated what aspects are treated in the various chapters. Stage 1 and 2 will be discussed in chapter 2 to chapter 4. These two stages together form the theoretical framework of this research. Stage 3 treats the various segments of clean tech. Stage 4 will consist of calculating returns and risks of investing in clean tech. Also at this stage investors will be interviewed about clean tech as an investment opportunity. Stage 3 and stage 4 will be elaborated in chapters 5 to 8. These two stages together form the empirical part of the research. Stage 5, chapter 9, the last stage of the research, describes the conclusions and recommendations of the research.

In the preface of each chapter the research model will be presented. The research model of in each chapter shows the position in the research process. For the reader this makes it easy to identify the different phases of the research with the chapters.

The following example shows that the master thesis is in phase 3 and this chapter is about solar energy, wind energy, and biomass.

Figure: example position in research process

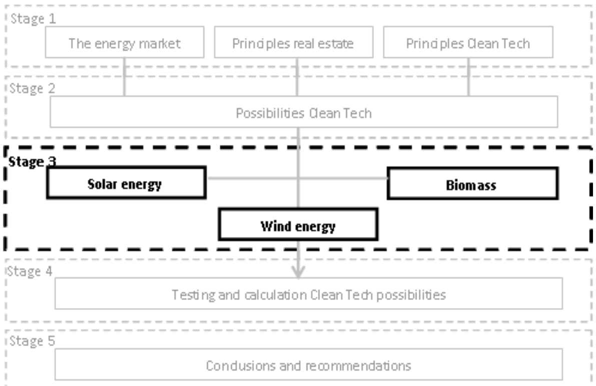
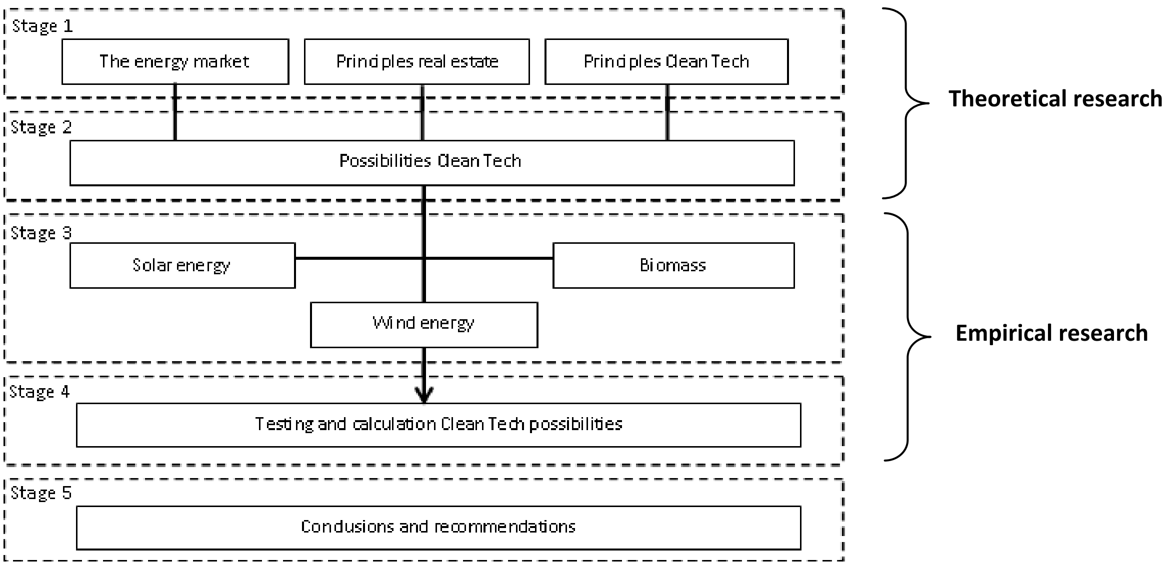


Figure 2: research model



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1.6. Outline of the study

Chapter 1: Introduction

The introduction describes the theme of the master thesis. The problem is defined and the objective of the research is formulated. This leads to six research questions with ten sub questions. And finally, the conceptual model and research model are explained

Chapter 2: The real estate market

This chapter is about the real estate market. Addressed are the investment characteristics of real estate. The advantages and disadvantages are described. And finally the alternative real estate market is clarified.

Chapter 3: The energy market

This chapter describes the energy market. What is the demand and supply for energy? What is the stock of fossil fuels? What are the future challenges of the energy market? Does the financial crisis affect the energy market? At last, a brief overview of the current news on energy.

Chapter 4: What is clean tech?

This chapter describes the different types of clean tech that are related to real estate. By type, the production and market are defined.

Chapter 5 Status of the clean tech categories

This chapter is about the status and the clean tech possibilities. Including the technological gaps and potential bottlenecks. In addition, the investment characteristics of clean tech are described.

Chapter 6 Where to invest

This chapter describes where to invest in clean tech. On the basis of different maps are the different site-factors of Europe described, per sub-sector. Followed by a description of the policies of the European countries on clean tech.

Chapter 7 How invest?

This chapter is about how to invest in clean tech. This chapter focuses on the 'investment- and portfolio risk management'. A part of this chapter is the calculation of the returns and risks of clean tech.

Chapter 8 Clean tech specialists

In this chapter the interviews are addressed. A number of specialists of clean tech investments were interviewed for this master thesis. The answers of the interview questions are fully described.

Chapter 9 Conclusions & recommendations

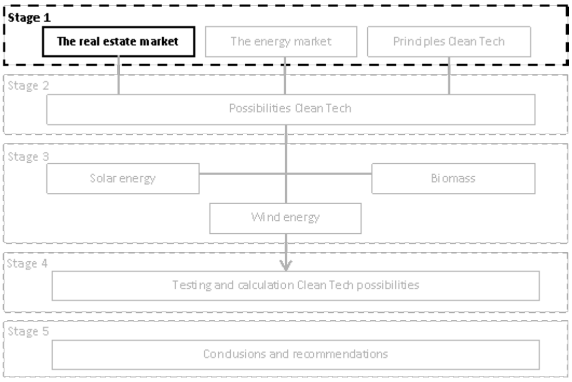
This chapter describes the conclusions and recommendations of this master thesis.

2. THE REAL ESTATE MARKET

2.1. Preface

This section will discuss the real estate market. The emphasis in this chapter will be on real estate as an asset class. The paragraphs are about the characteristics of real estate, the advantages and disadvantages of real estate, the allocation of real estate, and finally, we will discuss the alternative real estate investments.

Figure: position in the research process



2.2. Terminology

First, it is important to describe the definition '*real estate'* that is used in this master thesis. This definition is often come back in this master thesis (for example in chapter 4). I have used this definition to examine which categories of clean tech can be seen as real estate. In paragraph 4.2 the characteristics of real estate are linked to the different segments of real estate.

Real estate is defined as follows:

"Real estate is a financeable, wealth creating, physical asset, suitable for multiple users and generating a stable and over time inflation related cash flow (Rabobank International: Industry Analysis - Commercial real estate, 2009)."

<u>Financeable</u>

An investment characteristic of real estate is a stable and predictable stream of cash flows. Because the cash flows are stable and predictable real estate is more financeable then other types of transactions. Real estate is also highly financeable because it is tangible. Therefore real estate serves excellent as collateral, and lenders provide relatively higher debt levels, at longer periods, and lower cost of capital (Kuzmicki et al, 2008).

<u>Wealth creating</u>

Through value-add management, the net-operating income can increase. For example by improving rental- and energy management. The net-operating income and the value of real estate can also be enhanced by maintenance, renovation and redevelopment. This is not possible with shares and bonds.

<u>Physical asset</u>

Physical assets are not divisible: you cannot buy some fraction of a house or office. The opposite is financial asset. For example you can buy some shares of TomTom or Randstad. Because real estate is not divisible this results in high prices for real estate objects in comparison with shares and bonds.

<u>Suitable for multiple users</u>
Real estate can be used for commercial, private, and public purposes. Among commercial real estate includes offices, retail, and industrial. Private real estate includes first- and second homes. Public real estate includes government buildings, schools, hospitals etc (Van Gool, 2007).

<u>Generating stable and over time inflation related cash flow</u>
Real estate has a long technical life. This allows the investor to create cash flows for decades. The probability of stable rental income is especially great when there is a long-term lease, if interim changes are regulated to inflation and if the tenant is solvent (Kuzmicky et al, 2008).

2.3. Real estate as an asset class

Real estate is a different investment such as shares and bonds because real estate is a real asset, which takes place in local markets (each location is unique) and the real estate markets are dynamic through processes of aging and upgrading (value change through redevelopment and conversion) (Bol, 2003). Real estate as an asset class can be described as a series of net rental income with a residual value. The residual value is the future value and the property value.

Several studies showed that real estate has an added value in the investment portfolio. Examples of such studies are those of Eicholtz (1997) en Van der Geer & Berkhout (2005). The research of Eicholtz has an international perspective and the research of Van der Geer & Berkhout shows it from a national perspective. Both of these studies demonstrate the diversification potential of real estate in a (inter)national portfolio of stocks and bonds.

One of the most main important reasons for investors to invest in real estate is the diversification potential of real estate in the portfolio with other asset classes. The return of direct real estate is limited and sometimes negatively correlated with that of other asset classes, such as stocks and bonds. By adding real estate at the portfolio, given the returns, there will be a risk reduction and, given the risk, the returns increase (Van Gool, 2007).

2.4. Characteristics of real estate

Real estate has specific characteristics. These characteristics of real estate determine for a large extent the advantages and disadvantages of investing in real estate. The advantages and disadvantages are discussed in the next section. The characteristics differ mainly in relation to shares and bonds.
The main characteristics of real estate that are described in the books of Van Gool (2007) in 'Onroerend goed als belegging' and Ten Have (2003) in 'Taxatieleer vastgoed' are described below:

- Not transparent
- Not relocatable
- Illiquid
- Long durability
- Intensive management

The characteristics will be explained below.

<u>Not transparent</u>
The market is not transparent when information about the market is not of hardly known by parties. This is in contrast to a transparent market, where much information is available by parties, whereto they can also act. Data about transactions in the real estate market are often kept secret. The transactions are not publicly available or incomplete, and so the real estate market is not transparent. So there is no continuous pricing. In addition, real estate is heterogeneous. Hereby is real estate difficult to compare. Each building is unique because of its geographical location, the nature of the building, the state of the maintenance, the tenants etc. (Van Gool 2007). This makes the real estate market more opaque.

Not relocatable

Location of property is important because real estate is not moveable. Therefore environmental factors play an important role in real estate and it makes real estate also vulnerable. For example, changes in economic and physical environment, such as retail, a change of the population and purchasing power can play an important role. As the owner you can hardly influence the environment.

Illiquid

Real estate is relatively difficult transferable. The purchases and sales require a lot of time. This is due to the heterogeneity of real estate, the relatively high prices of real estate, the high transaction costs, the complexity of the investment form, and the opacity of the market.

Long durability

Real estate has a long durability, and the durability of land is even infinite. Land is rarely lost and building stay for many years. Hereby real estate delivers returns and services for many years. Real estate is a long term investment (Van Gool, 2007; Ten Have, 2003).

Intensive management

Investing in direct real estate is management intensive. This has everything to do with a strong business character of the asset real estate. Unlike bonds and shares, the investor can influence the direct (rental) income. When there must be achieved good returns on real estate, tasks must be accomplished as; rental, rent collection, energy management, maintenance, renovation and redevelopment (Van Gool, 2007).

2.5. Advantages of real estate investments

The above characteristics of real estate result in a number of advantages of real estate investments. The advantages are frequently analyzed and they often come back in many studies, articles, theses and other literature.

The advantages are discussed below:

- Stable cash flow of direct income
- Attractive returns with limited risk
- Additional portfolio diversification
- Reasonable protection against inflation
- More return on investment through intensive management
- Benefit of specific opportunities in real estate markets
- Profit by tax advantages

2.6. Disadvantages of real estate investments

The characteristics listed in Section 1.2.1 also result in a number of disadvantages to investing in real estate. The disadvantages are frequently analyzed and they often come back in many studies, articles, theses and other literature. The disadvantages are discussed below:

- Highly specific knowledge and intensive form of investment
- High unit prices
- Illiquid compared to stocks and bonds
- Performance measurement and benchmarking is difficult
- Not transparent

2.7. Allocation of real estate

Most of the institutional investors invest in the traditional main categories such as stocks, fixed-income, and real estate. Several studies have examined how much of the portfolio should be invested in real estate. Studies of Van der Geer & Berkhout (2008) and Eicholtz (1997) demonstrate the added value of real estate within the investment portfolio. The study by Van der Geer & Berkhout focused on the Dutch market and the study of Eicholtz on the international market. The study of Eicholtz shows the diversification potential of international (direct and indirect) real estate in the international investment portfolio consisting of equity and fixed income securities.

The allocation to real estate within the investment portfolio is low. In 2009, institutional investors invest about 10% of their capital in real estate. This is on the low side, since the yield of real estate over a longer period of years is higher than that of other investment categories (FGH vastgoedbericht, 2009). An area of tension arises, however, because the results on shares in particular have fallen so sharply that real estate in the investment portfolio is becoming predominant. In ALM models (Asset Liability Management) this results in a relatively high share of real estate and investors are being forced to dispose of property because the proportions would no longer be correct. This is actually an undesirable mechanism because, due to the relatively stable yield of real estate, an increase in the share of real estate in the asset mix is justified (FGH vastgoedbericht, 2009).

The figure below represents the full coverage of the IPD Dutch database at the end of December 2008. The figure shows the allocation to different categories of real estate in the investment portfolio. Most capital is invested in residential real estate, and 2.1% is invested in alternative real estate. The next section will focus on a number of different types of alternative real estate.

Figure 3: The Netherlands real estate index

ROZ / IPD Nederlandse Vastgoedindex Samenstelling Database	Kapitaalswaarde Capital value	
	€m	%
Alle Objecten / All Property	43,812	100.0
Winkels / Retail	13,006	29.7
Kantoren / Office	8,859	20.2
Bedrijfsruimten / Industrial	1,042	2.4
Woningen / Residential	19,982	45.6
Overig / Other	922	2.1

Source: ROZ/IPD

2.8. Alternative real estate investments

There are several types of direct real estate. There are traditional forms of investment, such as residential, retail, offices, parking garage, industrial and logistic spaces. And there are different types of real estate that can be seen as alternative real estate, such as prisons, hotels, land, toll roads, childcare facilities, power plants, and windmills. And there are also several types of indirect real estate such as real estate derivatives, loans, CMBS, RMBS, and mezzanine.

The following sections describe some of this direct and indirect alternative real estate as discussed above. This paragraph closes with a description of the alternative real estate investment class infrastructure. This, because in the theory (RREEF, 2005; and Peng & Newell, 2008) clean tech is seen as part of the asset class infrastructure.

2.8.1. Land investments

Agricultural land for farmers is traditionally an important source of income. Having rural land is important for real estate developers and investors to generate work for the future or for speculative reasons. Important issue of land investment is that the overall yield of land investments consists of indirect return. The indirect return is created by the increase in the value of the land. Obviously there can also be direct return. This is often applied to agricultural land where there is a lease income reduced with the operating costs (Schrama, 2008).

Meanwhile, there are several studies done into the role of farmland in the investment portfolio including by Schrama (2008), Newell & Eves (2007) en Hardin & Peng (2005). The study of Newell & Eves show that, over the period 1984-2006, farmland under-performed the other major asset classes, had higher risk levels than real estate, but did provide significant portfolio diversification benefits in a mixed-asset portfolio. However, the optimal mixed-asset portfolio analysis highlighted the added-value of farmland in a portfolio with no other real estate options; more so than in a fully mixed-asset portfolio context with real estate included, and farmland then being seen as an alternative real estate sector. This conclusion corresponds with the study of Hardin en Cheng. Schrama has done research on the value of land investments for institutional investors in the Netherlands. According Schrama land investments contribute in a positive way to improving the return and risk ratio of a portfolio of an institutional investor. According Schrama the return on the land investments is low, but it has a better risk profile. The function of land investments in the portfolio is to reduce the risk of the portfolio.

2.8.2. Real estate derivative

A derivative is a financial product whose value depends on an underlying product (Langens, 2008 & Hull, 2008). Examples of derivatives in the financial world are exchange-traded futures and options. Until a few years ago the real estate market was the only major asset class without a developed derivatives market. Attempts to set up a derivatives market for real estate failed by a lack of mass and volume in the United Kingdom.

This changed by adjusting the unfavourable tax legislation for real estate derivatives in 2005. Since then swaps, based on the Investment Property Index, are traded in Great Britain. The market in the UK is growing rapidly, with a trade of £ 1 billion in 2005, £ 7 billion in 2006 and about £ 10 billion in 2007 (Langens, 2008). In 2005 it were the big insurers and real estate companies such as Quintain, British Land and Prudential that did most transactions, from 2006 were that in particular the hedge funds.

The future expectation is that the trading of real estate derivatives will grow at the same speed as other derivatives with underlying values such as credit derivatives and freight derivatives which both, after a start-up period of several years, are traded as a standalone product and become part of the core activities of companies that act in the underlying markets. If this occurs the trade in real estate derivatives can become bigger than the volume in the underlying market (Langens, 2008).

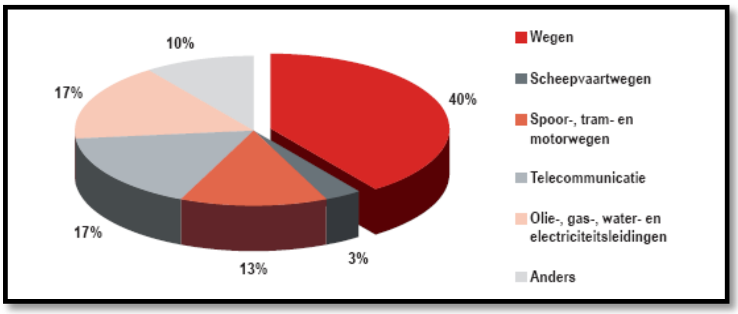
By using real estate derivatives there is an exchange of risk and return between two parties for a certain period; there is not a real exchange of the real estate. The risk that is exchanged is the systematic risk, the so-called beta ("β") risk, the risk that is not eliminated trough diversification (Geltner & Miller). Investors can 'sell' (some of) its systematic risk trough real estate derivatives, which only the specific risk of the portfolio remains. In addition, an investor can buy systematic risk without exposing themselves to specific risks. In other words, an investor does not need object-specific knowledge, 'only' a vision of the market as a whole (Buijs, 2006). Beside the non-eliminated systematic risk there is a counterpart risk.

2.8.3. Infrastructure/Clean tech

Infrastructure can be classified into economic infrastructure (eg: utilities, toll roads, airports, pipelines, energy power stations and wind farms) and social infrastructure (eg: healthcare facilities, education facilities and correctional facilities) (RREEF, 2005; and Peng & Newell, 2008). Figure 4 gives a complete overview of the various asset classes of infrastructure. For this research, the categories of regulated investments and contracted investments are important.

Infrastructure investment provides a number of important investment characteristics (RREEF, 2005; UBS, 2006; Hopkins, 2007; Lont & Hari, 2007; and Newell & Peng, 2008), including: high entry barriers; monopoly characteristics; long duration re: operating concessions (e.g., up to 99- year leases); large investment scale; inelastic demand; stable, tax effective, and predictable cash flows via government regulation and long-term contracts; low volatility of cash-flows; low correlation with major asset classes; low operating cost; attractive returns via long-term income streams and capital growth; high degree of regulatory control; track record of public private partnership performance; hybrid performance regarding income and capital returns; supporting the community, with these infrastructure characteristics effectively matching the long-term liabilities of pension funds based upon nominal values (Rakowski, 2003; RREEF, 2005; Lont & Hari, 2007; and Newell & Peng, 2008). Investing in infrastructure is not without risk. First there is the interest rate risk. Investments in infrastructure are largely financed with debt. In addition, there is an exchange rate risk in investments in different countries. This also means the country risk. The country risk can be separated in a sovereign risk, transfer risk, and a generic risk. For example a change in regulation or regime can have an adversely affect. And there are operational risks. Efficient management of such a project is essential to control the operational costs. The report 'Vastgoedbeleggingsbeleid 2008' of Jones Lang LaSalle, describes the developments in the real estate investment strategy. That report shows that investing in infrastructure is seen as a promising alternative investment asset for the coming years. The figure 'promising investment infrastructure' shows which forms of infrastructure are seen as the most likely by the institutional investors. Research of Newell & Peng (2008) showed that investment in U.S. & Australia infrastructure leads to an improved efficient investment portfolio. Infrastructure is negatively correlated with other asset classes and provides diversification benefits.

Figure 5: Promising investment infrastructure



Source: Jones Lang Lasalle, 2008

Figure 4: subcategories infrastructure, also known as clean tech

Social Infrastructure	Regulated investments	Investments on connections	Contracted investments
> Hospitals	> Electricity distribution	> Roads	> District energy
> Old people's home	> Electricity transmission	> Tunnels	> Energy generation
> School complex	> Gas distribution	> Bridges	> Communication / transmission masts
> Courthouses	> Water distribution	> Airports	
> Prison		> Railroads	

Source: Lont et al, 2007

The above figure shows the various subsectors in infrastructure. As the figure shows clean tech is a part of the alternative investment category infrastructure. See the red circles in the above figure. The red circled segments will return in paragraph 4.2. Here, as previously mentioned in paragraph 2.2, the characteristics of real estate are linked with the various segments of clean tech. The investment category infrastructure plays also an important role in chapter 7. Chapter 7 presents the results of calculating the returns and risks. But more about that later in this master thesis. First I will give an explanation about how the returns and risks are calculated.

2.9. Methodology for calculating return and risk

The previous paragraphs of the chapter were designed to give you more insight into the asset class real estate. This paragraph will describe the calculation of risks and returns of real estate, also called the Modern Portfolio Theory. The choice for the Modern Portfolio Theory was because this method is a widely used method of calculation in real estate sector. In chapter 7 of this master thesis, these formulas are used to calculate the risks and returns of clean tech and other asset classes.

The following concepts and formulas are described:

- Average portfolio return
- Risk (variance)
- Standard deviation
- Co-variance
- Correlation
- Sharpe ratio

Average portfolio return:

$\overline{R}$ is the average return, ***t*** the regarding period, ***g*** the weighted observation, ***G*** the total divisor and ***rt*** the return in period ***t***. The returns that are used in this study are returns on quarterly basis. The average portfolio return is the basis for further calculations.

The formula for the average portfolio return, used in this master thesis, is:

$$\overline{r}_t = \sum_{t=1}^{t} \left[\frac{g_t}{G} \right] rt$$

In the investment World, a distinction is made between the arithmetic and geometric returns. In 'Vastgoedbeleggingen' (Hendriks, 2003) the difference is explained through an example. Suppose I invest € 100 in a project. The first year I have a positive return of 100% and € 100 has grown to € 200. The second year I have a negative return of -50%. € 200 has dropped to € 100. Arithmetic my return is: 100%-50% = 50% or 25% on average per year. Geometric my return is: € 100 grows to € 200, dropped to € 100 = 0% profit per year.

Risk (variance)

Once the average portfolio return is known, the risk or the volatility can be calculated of the portfolio. The volatility of the portfolio is measured by the standard deviation. But before the standard deviation can be measured, the variance of the portfolio must be calculated. The variance is the weighted average of the squared differences between each possible outcome and the expected outcome. For the calculation of the variance the following formula is used. ***N*** is the number of number of observations

$$\sigma^2 = \sum_{i=1}^{n} \frac{(X_i - X_m)^2}{n}$$

Standard deviation

The square root of the variance, called standard deviation, provides a much more usable measure of dispersion, particularly when it is used to compare alternative investment opportunities with significantly different expected values (Greer, 2009). The standard deviation is actually the range of expected returns.

The formula for the standard deviation is:

$$\sigma = \sqrt{\sigma^2}$$

Co-variance

The modern portfolio theory assumes that a portfolio becomes more efficient as a result of diversification. Diversification is mainly achieved as asset classes are not fully correlated with each other. To understand the diversification effect it is necessary to measure the degree of coherence between the different variables. The co-variance measures this degree of coherence between the different variables. For calculation of the co-variance the following formula is used:

$$\operatorname{cov}(A,B)=\sum_{i=1}^{n}\frac{(X_{A,i}-X_{A,m})(X_{B,i}-X_{B,m})}{n}$$

Correlation coefficient

By using the co-variance the correlation coefficient can be measured. The correlation coefficient indicates the extent to which there is a relationship between two or more different asset classes. The result of the correlation coefficient is always between -1 and 1. Is the result -1, this means that there is a perfect negative correlation, or the investments react exactly opposite to each other. Is the result 1, investments respond exactly the same. Diversification is achieved if an investment has a correlation of less than 1 with another asset class. The formula for the correlation coefficient is:

$$\rho(A,B)=\frac{\operatorname{cov}(A,B)}{\sigma_A\sigma_B}$$

Sharpe ratio

After calculating the above parameters the Sharpe ratio can be calculated. Or which portfolio composition has the highest reward to variability. The Sharpe ratio establishes a link between the return on investment and the risk-free return.

The formula for the Sharpe ratio is:

$$Sharpe=\frac{R_p-R_f}{S_p}$$

The sources for the above figures are the power point presentations from the course Real Estate Investment, Master Real Estate Studies, University of Groningen, author A. Marquard. The explanation of the formulas are based on the book: Guide to data analysis (2006)

2.10. Conclusions

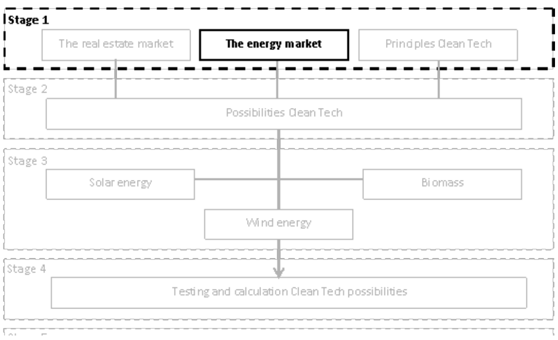
This chapter gave a description of the real estate market. It started with real estate as an asset class. Then the added value of real estate in the investment portfolio is demonstrated, on the basis of a number of national and international studies. Also the characteristics of real estate and accruing advantages and disadvantages of real estate from these characteristics are treated. Then, the allocation of real estate in the investment portfolio is presented. Following, a description of alternative real estate and a few categories of alternative real estate are delineated. And finally the Modern Portfolio Theory was presented. The Modern Portfolio Theory is applied in chapter 7. The next chapter is about the energy market. This chapter will address the demand and supply of energy, fossil fuels and future challenges.

3. THE ENERGY MARKET

3.1. Preface

The combination of an increase in the world population and an increasing global prosperity leads to a substantial increase in the demand for energy for the coming decades. In this chapter the prospects of the demand and supply of energy are defined. The data are from reputable organizations with a focus on energy markets, such as; International Energy Agency (IEA), part of the OECD, which deals with the implementation of an international energy program, and the Energy Information Administration, the statistical agency for energy of the American government. In addition, I have used several independent studies in the field of energy consumption and production such as the European Environment Agency, World Energy Council and BP statistical review. After the prospects of demand and supply of energy the impact of the financial crisis on the energy market is described. Next there is an enumeration of current news about energy. And the chapter is closed with a conclusion.

Figure: position in the research process



3.2 World energy demand

The IEA writes in his report 'World Energy Outlook 2008' that in the reference scenario[1] the world primary energy demand grows by 1.6% per year on average in 2006-2030, from 11.730 Mtoe (million tonnes of oil equivalent) to just over 17.010 Mtoe – an increase of 45%. Fossil fuels account for 80% of the world primary energy mix in 2030 – down slightly on today. The next decades India and China have continuing strong economic growth, thereby these countries account for just over half of the increase in world primary energy demand between 2006 and 2030. Middle East countries strengthen their position as an important demand centre, contributing a further 11% to incremental world demand. Collectively, non-OECD countries account for 87% of the increase. As a result, their share of the world primary energy demand rises from 51% to 62%. Global primary demand for oil (excluding bio fuels) rises by 1% per year on average, from 85 million barrels per day in 2007 to 106 millions of barrels per day in 2030. However its share of world energy drops from 34% to 30% (World Energy Outlook 2008).

Figure 6: Incremental primary energy demand

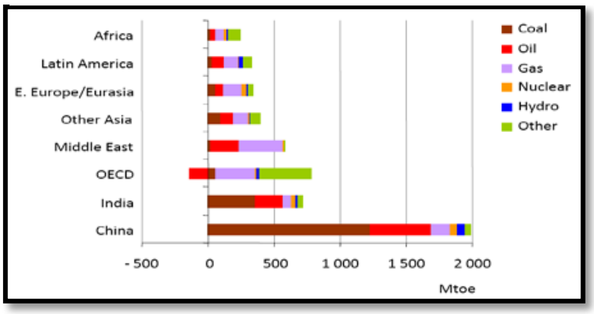
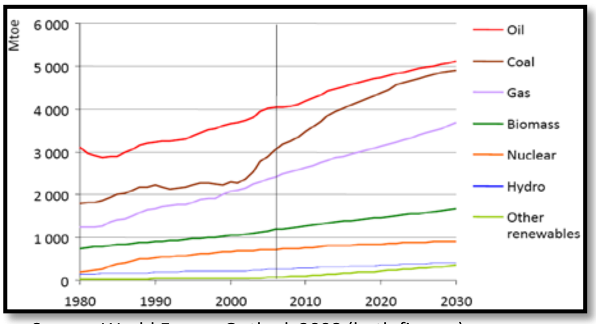


Figure 7: World primary energy demand



Source: World Energy Outlook 2008 (both figures)

The EIA predicts in his 'International Energy Outlook 2008' that the total world consumption of marketed energy is projected to increase by 50% from 2005 to 2030. The largest projected increase in energy demand is for the non-OECD economies. Although high prices for oil and natural gas, which are expected to continue throughout the period, are likely to slow the growth of energy demand in the long term, world energy consumption is projected to continue increasing strongly, as a result of robust economic growth and expanding populations in the world's developing countries. OECD member countries are, for the most part, more advanced energy consumers. Energy demand in the OECD economies is expected to grow slowly over the projection period, at an average annual rate of 0.7%, whereas energy consumption in the emerging economies of non-OECD countries is expected to expand by an average of 2.5% per year (International Energy Outlook 2008).

According the EIA, China and India — the fastest growing non-OECD economies — will be key contributors to world energy consumption in the future. The last decades, their energy consumption as a share of total world energy use has increased significantly. In 1980, China and India together accounted for less than 8% of the world's total energy consumption; in 2005 their share had grown to 18% (International Energy Outlook 2008). In the *IEO2008* reference case is even a stronger growth is projected over the next 25 years, with their combined energy use more than doubling and their share increasing to one-quarter of world energy consumption in 2030. In contrast, the U.S. share of total world energy consumption is projected to reduce. The U.S. has a share of 22% in 2005 and 17% in 2030.

In the 'World Energy Outlook 2008' is written that the consumption in other non-OECD regions also is expected to grow strongly from 2005 to 2030, with increases of around 60 percent projected for the Middle East, Africa, and Central and South America. A smaller increase is expected for non-OECD, Europe and Eurasia (including Russia and the other former Soviet Republics). An increase of around 36%.

Till 2030, the use of all energy sources increases in the time frame of the *IEO2008* reference case (Figure 8 & 9). Given these expectations the world oil prices will remain relatively high throughout the projection, liquid fuels are the world's slowest growing source of energy; liquids consumption increases at an average annual rate of 1.2% from 2005 to 2030 (International Energy Outlook 2008). Renewable energy and coal are the fastest growing energy sources, with consumption increasing by 2.1% and 2.0%, respectively. The prospects for renewable energy are growing. Mainly by the prices for oil and natural gas, and the rising concerns about the environmental impacts of fossil fuel use. Costs of coal are comparatively low to the costs of liquids and natural gas, and coal is abundant in large energy-consuming countries (including China, India, and the United States). The choice for coal would be an economical choice.

Figure 8: World marketed energy consumption

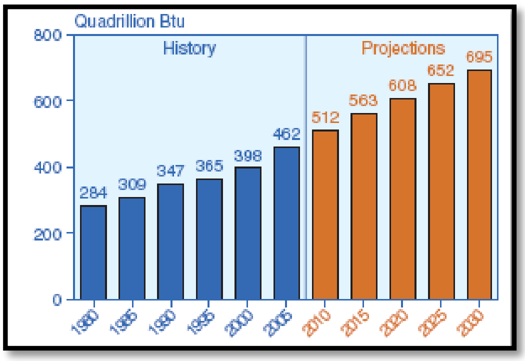
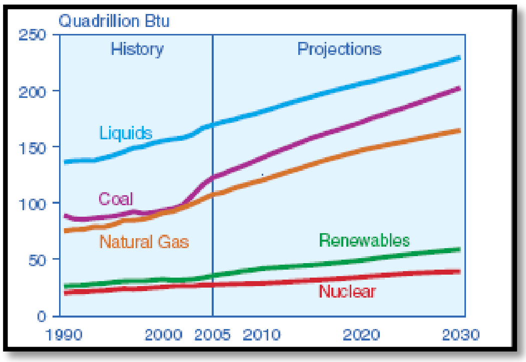


Figure 9: World marketed energy use by fuel



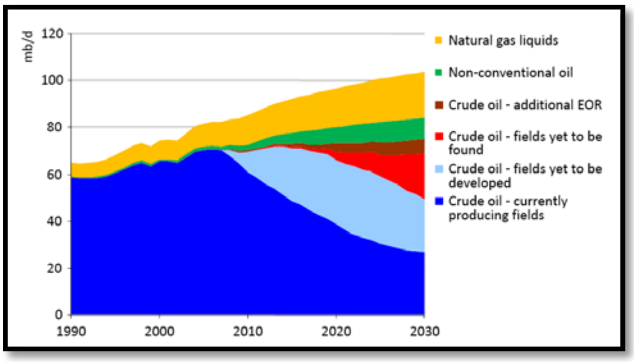
Source: International energy outlook 2009 (both figures)

3.3. World energy supply

The IEA projects that the world's total stock of oil is large enough to support the projected rise in production beyond 2030 in the reference scenario. In the 'Reference scenario' the world's oil supply is projected to rise 84 million barrels per day in 2007 to 106 million barrels per day in 2030. Conventional crude oil production alone increases only modestly over 2007-2030 – by 5 million barrels per day – as almost all the additional capacity from new oilfields is offset by declines in output of existing fields. The bulk of the net increase in total oil production comes from natural gas liquids (driven by the relatively rapid expansion in gas supply) and from non-conventional recourses and technologies, including Canadian tar sands (World Energy Outlook 2008). Paragraph 3.4 will discuss the production and supply of the different types of fossil fuels.

According the IEA, modern renewable technologies grow most rapidly, overtaking gas to become the second largest source of electricity, behind coal soon after 2010. Higher fossil fuel prices are assumed. This, with a strong policy support is an opportunity for the renewable energy industry to bring emerging technologies to the mainstream. And maybe eliminate its reliance on subsidies. Wind, solar, tide and wave energy are the fast growing energy source worldwide. These energy sources grow with an average of 7.2% per year. Till 2030, the share of non-hydro renewables grows from 1% in 2006 to 4% in 2030. Hydropower output increase, though its share of electricity drops two percentage points to 14%. In the OECD, the increase in renewable-based power generation exceeds that in fossil-based and nuclear power generation (World Energy Outlook 2008).
The EIA projects that fossil fuels (liquid fuels and other petroleum, natural gas, and coal) are expected to continue supplying much of the energy used worldwide. Liquid supply has the largest share of world energy consumption over the projection period, but their share falls from 37% in 2005 to 33% in 2030 (International Energy Outlook 2008).

Figure 10: World oil production



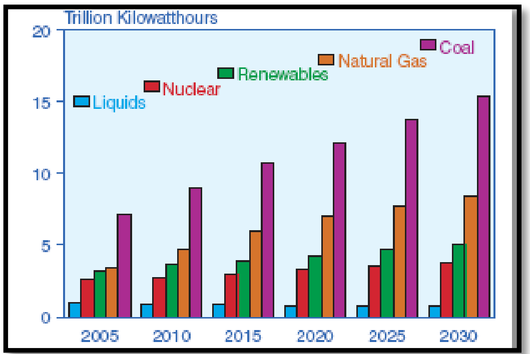
Source: World Energy Outlook 2008

The demand for liquid fuels grows with 28.2 million barrel per day in comparison with the level of 2005, 84.3 million barrels per day. The reference case of the EIA predicts that unconventional oil becomes increasingly competitive. Unconventional oil is tar sands, extra heavy oil, bio fuels, coal-to-liquids, and gas-to-liquids (Energy revolution, 2007). World production of unconventional resources, which totalled only 2.5 million barrels per day in 2005, increases to 9.7 million barrels per day in 2030, accounting for 9% of total world liquids supply in 2030 on oil equivalent basis (International Energy Outlook 2008). Biofuels, including ethanol and biodiesel will be an increasingly important source of unconventional liquids supply, largely because of the growth in U.S. biofuels production (International Energy Outlook 2008).

In the International Energy Outlook 2008 the worldwide natural gas consumption increases from 104 trillion cubic feet in 2005 to 158 trillion cubic feet in 2030. This increase has to do with the expectation that natural gas will replace oil whenever possible. Moreover, because natural gas combustion produces less carbon dioxide than coal or petroleum products, governments may encourage its use to displace the other fossil fuels as national or regional plans to reduce greenhouse gas emissions begin to be implemented (International Energy Outlook 2008).

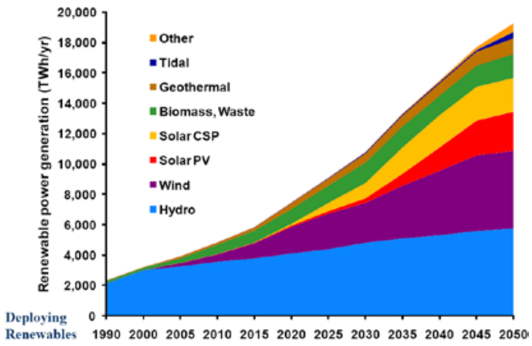
The expectation is that prices for oil and natural gas will rise again and maybe to record heights. This is the change to expand the use of renewable energy. Renewable energy sources are attractive for several reasons. The first reason is energy security and the second reason is the environmental impact. The use of renewable energy will reduce greenhouse gas emissions. Government policies and incentives to increase the use of renewable energy sources for electricity generation are expected to encourage the development of renewable energy even when it cannot compete economically with fossil fuels (Green Investing, 2009). In the *IEO2008* reference case, the worldwide consumption of hydroelectricity and other renewable energy sources increases by 2.1% per year, from 35 quadrillion British thermal unit[2] in 2005 to 59 quadrillion British thermal unit in 2030. In the non-OECD countries, much of the growth in renewable energy is expected from Asia and Central and South America. Several countries have hydroelectric facilities planned or under construction. Also in the OECD countries there are a few plans to build major hydroelectric power plants in the future. But the OECD counties have more the focus on nonhydroelectric renewables, especially wind and biomass. Many individual OECD countries have incentives in place to increase the penetration of nonhydroelectric renewable electricity sources, both to reduce greenhouse gas emissions and to promote energy security, and in the IEO2008 projections OECD renewable generation grows by 1.6% per year from 2005 to 2030, faster than all the other sources of electricity of generation except natural gas (International Energy Outlook 2008).

Figure 12: World Electricity generation by fuel



Source: International Energy Outlook 2008

Figure 11: Supply of renewable energy



Source: World energy outlook 2008

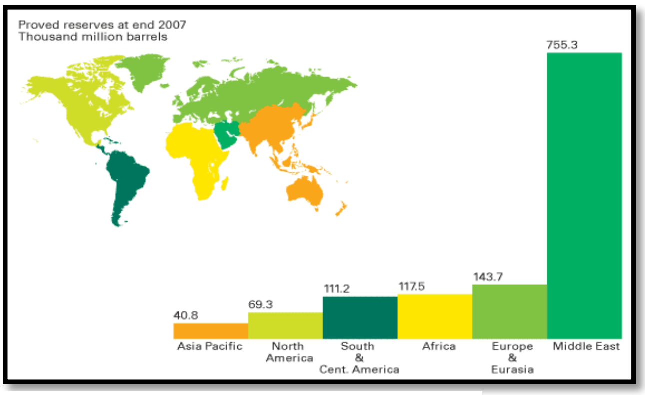
3.4. Fossil fuels

Fossil fuels are hydro carbon compounds that are formed from remnants of plant and animal life in the geological past of the earth, especially in the Carboniferous[3] but also in other eras. These include oil, natural gas, and coal. But when is the world without these fossil fuels? This section provides an answer to this.

3.4.1 Natural oil

The total proven findable natural oil exists of 1237.9 billion barrels of oil according BP (see attachments) at the end of 2007. From this stock is 61% in the Middle East, 11.6% in Europe / Eurasia, 9.5% in Africa, 9% in South & Central America, 5.6% in North America and 3.3% in Asia Pacific (see figure). According to EIA there is a stock of 1331.7 billion barrels of oil. 56% of the World's proved oil reserves are located in the Middle East. Among the top 20 reserve holders in 2008, 11 are OPEC member countries, together they account for 69% of the world's total reserves.

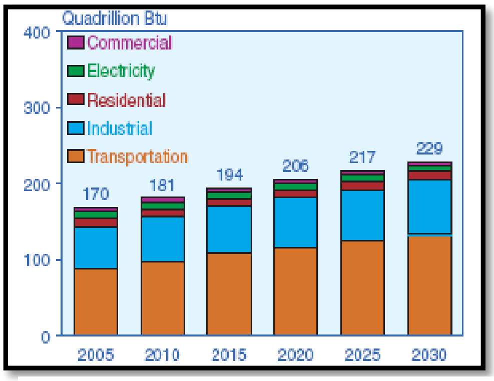
Figure 13: Proved reserves natural oil



Source: BP statistical review

PeakOil Netherlands writes in his report 'Olieschaarstebeleid' that there is enough oil in the ground to meet the consumptions need till the end of the 21st century and maybe longer. Approximately half of the oil under the ground consists of conventional oil sources, which exists of 97% of the oil production in 2007. The other half consists of unconventional oil, including tar sands of Canada. In practice, the total quantity of oil under the ground is not representative for calculations on the oil market because the winning of oil is limited through the physical environment in which the oil is trapped. PeakOil Netherlands assumes that conventional oil production will reached its peak in the coming decade. The extraction of unconventional oil is difficult and by far not enough to replace the conventional oil production. The next 10 years this is not possible because there are not enough quality personnel, material and energy present in the catchments areas to achieve this at such a scale. From an environmental point of view it is also undesirable to launch such an increase in unconventional oil production. Because, measured over the entire cycle, from extraction to consumption, CO_2 emissions of synthetic crude oil from tar sands are 40% higher than the production of conventional oil (Brandt and Farrel 2007). PeakOil Netherlands, International Energy Agency, and institute Clingendael assume a global shortage of oil from 2010, which will last at least a decade. Europe will feel this worldwide deficit not in a physical but in an economic way. Europeans can continue to pay the oil, but demand for oil will decline because of the high price (PeakOil Nederland).

Figure 14: World liquids consumption by sector



Source: International Energy Outlook 2008

World-wide, the reserves-to-production ratio[4] is estimated at **41.6 years** (BP statistical review). By region the highest ratios are about 82.2 years for the Middle East, 45.9 years for South & Central America, 31.2 years for Africa, 22.1 years for Europe/Eurasia, 14.2 years for the Asia Pacific, and 13.9 for North America (International Energy Outlook 2008).

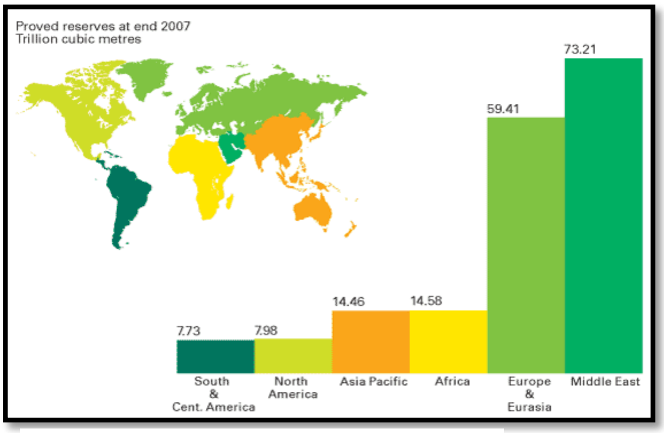
3.4.2 Natural gas

The total proven findable natural gas exists of 6,263 trillion cubic feet according BP (see attachments) at the end of 2007. From this stock is 41.3% in the Middle East, 33.5% in Europe / Eurasia, 8.2% in Africa, 8.2% in Asia Pacific, 4.5% in North America and 4.4% South & Central America (see figure). According to the EIA, the stock of natural gas is 6,186 trillion cubic feet.

Almost three-quarters of the world's natural gas reserves are located in the Middle East and Eurasia. Russia, Iran, and Qatar together accounted for about 57% of the world's natural gas reserves on January 1, 2008.

The EIA and BP pronounce, despite high rates of increase in natural gas consumption, particularly over the past decade, most regional reserves-to-production ratios are substantial. World-wide, the reserves-to-production ratio is estimated at **60.3 years**. By region the highest ratios are about 48 years for Central and South America, 78 years for Russia, 79 years for Africa, and more than 100 years for the Middle East (International Energy Outlook 2008).

Figure 15: Proved reserves natural gas



Source: BP statistical review

3.4.3 Coal

Coal is mined by two methods:

- Surface mining
- Underground mining

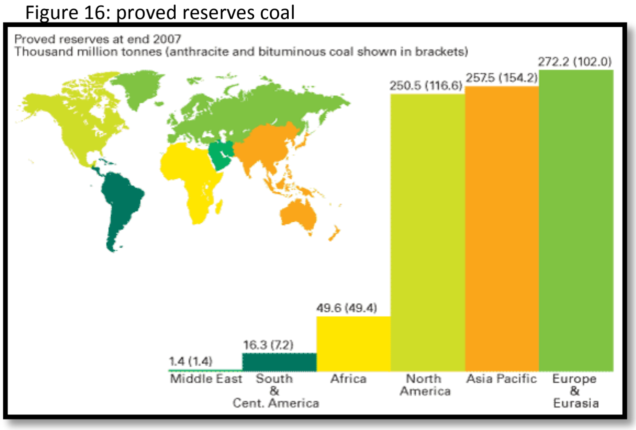
According to the website www.worldcoal.org: 'the choice of mining method is largely determined by the geology of the coal deposit'. Underground mining currently accounts for about 60% of world coal production; although in several important coal producing countries surface mining is more common. Surface mining accounts for around 80% of production in Australia, while in the USA it is used for about 67% of production'.

For more information about mining methods you can consult the website www.wordcoal.org.

The total proven coal stock according to the BP is 847 billion tonnes at the end of 2007. From this stock is 32.1% in Europe/Eurasia, 30.4% in the Asia Pacific, 29.6% in North America, 6% in the Middle East and Africa and 1.9% in total South and Central America (see figure). According to the EIA, the total recoverable reserves of coal are estimated at 930 billion tons around the world. Historically, estimates of world recoverable coal reserves, although relatively stable, have declined gradually from 1,174 billion tons in 1990 to 1,083 billion tons in 2000 and 930 billion tons in 2006(International Energy Outlook 2008). Although coal deposits are widely distributed, 76 percent of the world's recoverable reserves are located in five countries: the United States (28%), Russia (19%), China (14%), Australia (9%) and India (7%) (International Energy Outlook 2008).

World-wide, the reserves-to-production ratio is estimated at **133 years** (BP statistical review). By region the highest ratios are about 224 years for Europe/Eurasia and North America, 188 years for South & Central America, 186 years for Middle East & Africa, and 70 years for the Asia Pacific.

Figure 16: proved reserves coal



Source: BP statistical review

3.5. Nuclear power

Nuclear power is seen as a possible replacement for fossil fuels. How does nuclear power develop for the coming decades and for how many years will there be enough uranium to supply the power reactors? According the EIA the electricity generation from nuclear power will increase from 2.6 trillion kilowatt-hours in 2005 to 3.8 trillion kilowatt-hours in 2030. The development of nuclear energy generation is improved by several factors, such as energy security, high fossil fuel prices and greenhouse gas emissions. And high fossil fuel prices make nuclear energy economically competitive. Despite the fact that nuclear energy has high capital and maintenance costs. Issues that could slow the expansion of nuclear power in the future include plant safety, radioactive waste disposal, and concerns that weapons-grade uranium may be produced from centrifuges installed to enrich uranium for civilian nuclear power programs (EIA, 2008).

According the EIA the uranium supplies are sufficient to power reactors worldwide through 2030. According to results from the OECD Nuclear Energy Agency, annual uranium requirements are expected to grow from 68,000 metric tons per year in 2005 to 96,000 tons per year in 2030. The cumulative demand for uranium to meet the projected increase in nuclear electricity generation from 2005 to 2030 would be 2.1 million metric tons. According the Nuclear Energy Agency there will be enough uranium to fuel the world's fleet of nuclear reactors at current consumption rates for **100 years.**

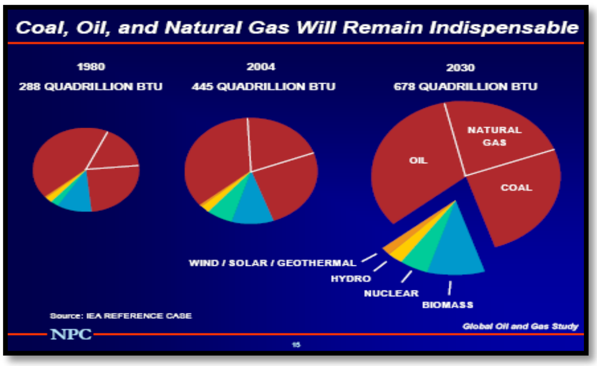
There are theories that assume that the actual amount of irrecoverable uranium is about two to six times higher than the aforementioned numbers. It has everything to do with the price, if uranium is scarce, people are more willing to pay and therefore it is attractive to find harder and dig deeper. Also, the extraction technology of uranium is continuously improving.

3.6. Challenges future energy productions

We have seen significant growth in non-fossil fuel energy sources and more is projected. Although the share of non-fossil fuels is growing rapidly, fossil fuels will continue to play a significant role through 2030. This is the hard truth about the demand that fossil fuels are indispensable to satisfy demand as global prosperity and incomes increase. Also the IEA and the EIA assume that the number of fossil fuels needed to meet rising energy demand for the coming years, in theory, can be realized. Only there are great challenges to expanding the production of fossil fuels. There are billions of amounts needed for the expansion of production capacity (unconventional oil) and there should be heavily invested in technologies that extract more oil from existing and new fields. There is also a serious shortage of equipment and qualified personnel and the cost of production continues to rise.
There are also uncertainties in the energy production as a result of growing nationalism and protectionism regarding to the energy sources. And the possibilities to increase the oil and gas production are limited to the Middle East, Russia and some OPEC countries. In addition, climate change will play an important role in the energy debate in the future.

To mitigate these risks, expansion of all economic energy sources will be required, including coal, nuclear, biomass, other renewables, and unconventional oil and natural gas. Each of these sources faces significant challenges including safety, environmental, political, or economic hurdles, and imposes infrastructure requirements for development and delivery (NPC, 2007).

Figure 17: Fossil fuels in the energy mix



Source: NPC, 2007

Figure 18: Growth of renewable electricity

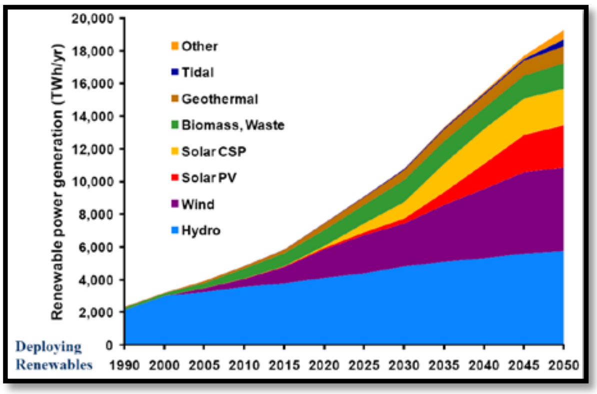
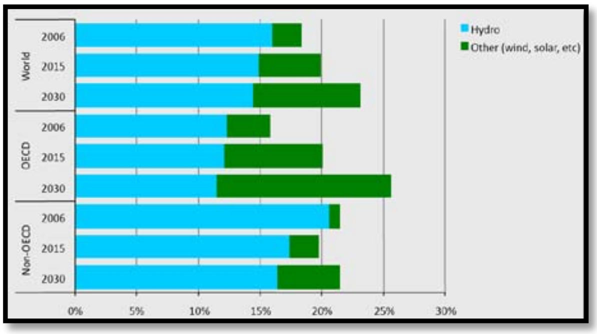


Figure 19: Share of renewables in energy

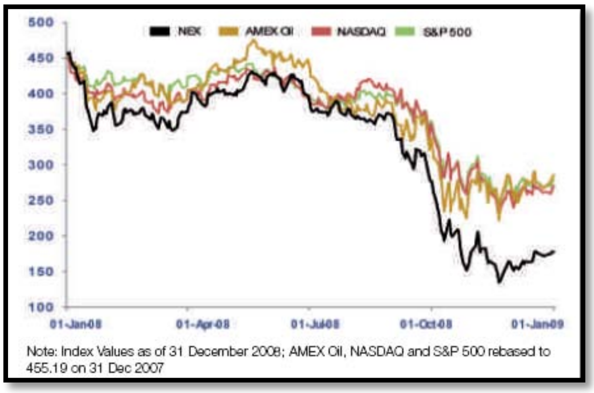


Source: World energy outlook 2008 (both figures)

3.7. Financial crisis: opportunity and a threat

The global financial crisis of 2008, and the following, are a serious threat to the clean energy sector. Clean tech becomes less competitive, because prices have fallen of energy and oil. Further, it is much harder to get finance for clean tech projects. But on the other hand the crisis may, however, also represent something of opportunity: as policy-makers take decisive action to refuel their economies, they are at least talking about ensuring the resulting fiscal and monetary stimuli benefit the clean energy sector (Green Investing, 2009). Clean energy investment held up well during the early phase of the financial crisis, as did the valuations of publicly-quoted clean energy companies, but there was a very hard hit during the closing months of 2008 (Green Investing, 2009).

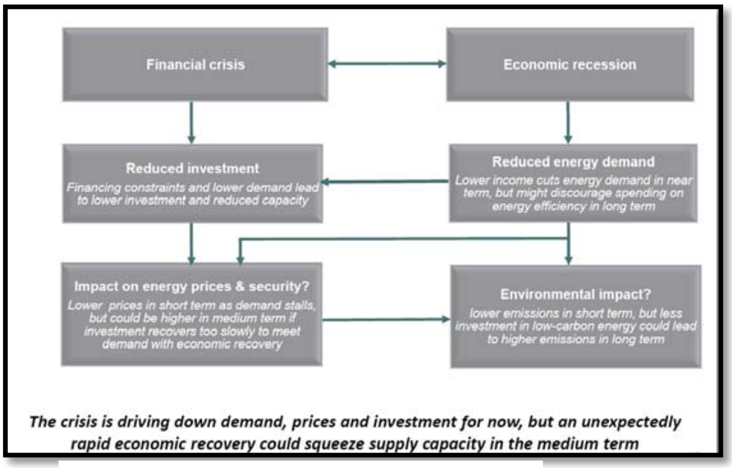
Figure 20: Performance of NEX vs. major indices



Source: Green investing, 2009

According the report, Green Investing, there are three reasons why the sector was hit so hard. First, energy prices collapsed by 70%. Through the financial crises, the oil price hits his lowest level of $ 32, - per barrel in December 2008. While the record price of $ 147, - per barrel was paid in July 2008. At the time of writing this master thesis the oil price was at $ 71 per barrel (June, 2009). The oil price is rising again. Maybe these are signs that the economy is recovering. Second, investors were getting rid of stocks with any sort of technology or execution risk, in favour of longer established businesses. Third, in an era of sharply constrained credit, investor's penalized companies with high capital requirements – even the more established, asset-based clean energy companies, which bear no technology risk, being high-growth are capital-hungry. There is no question that the short-term priority for the world's policy makers is to do whatever is necessary to prevent the effects of the financial crisis turning form a recession to a depression. The good news for clean energy investors is that supporting the sector is seen by the leaders of many world's major economies as consistent with achieving this goal. For example: Barack Obama and the United States, which after eight years of George W. Bush, their police on renewable energy drastically changed. Now, renewable energy is one the main themes of the policy of the United States (Green Investing, 2009).

Figure 21: Financial crisis



Source: World energy outlook, 2009

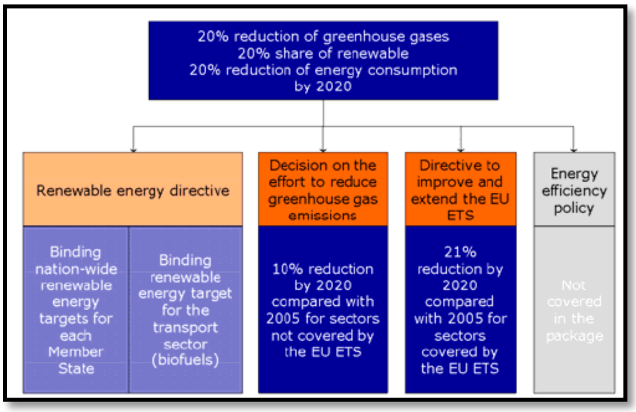
3.8. EU ambitions

In March 2007, the European council agreed on a set of ambitious climate and energy objectives to enhance the security of energy supply, to curb the projected rise in energy prices and to reduce greenhouse gas emissions. The EU-wide objectives are:

- 20% reduction of greenhouse gas emissions by 2020 compared to 1990 levels (even 30% when other countries set also substantial targets).
- 20% share of renewable energy by 2020, including a 10% share of befouls in transport.

- 20% reduction of energy consumption compared to projected consumption for 2020.

Figure 22: EU ambitions



Source: Rabobank International

3.9. Current actuality

A lot is written about the energy market in the newspapers. Energy is a hot item. Therefore it is interesting to see what is written about energy in the Newspapers. Below there is an enumeration about a view headlines from several newspapers. The headlines from the Dutch newspapers are translated into English. And to show that renewable energy is not only a hot item in the Netherlands but also in the rest of the world, there are headlines added of the Financial Times.

Het Financiële Dagblad

- The Dutch main weapon against short-term CO_2 – underground storage – is likely to be a fiasco *(date: March 30 2009).*
- Shell does not invest in wind parks anymore *(date: March 17 2009).*
- Eneco strengthens their positions in wind parks *(date: March 4 2009)*.

De Volkskrant

- Shell: ‘We do not stop with all the renewable energy’ *(date: March 20 2009).*
- Car of the future is made from biomass *(date: March 1 2009).*
- From crisis to green revolution *(date: December 9 2008).*

De Pers

- The future of the electric car. Volvo makes the car *(date: June 3 2009).*
- Renewable energy consumption increased slightly *(date: April 27 2009).*
- More and more sustainable energy *(date: February 23 2009).*
- Electric cars still far away *(date: February 23 2009).*

Financial Times

- Renewable energy: Sunny days ahead *(date: June 9 2009).*
- Obama remarks energy *(date: May 27 2009).*
- Switch to renewable energy? If only it were that simple *(date: May 15 2009).*

3.10. Conclusion

Chapter 3 gives an answer to the first sub-question: what are the developments on the energy market?

Fossil fuels will continue to play a significant role in the energy production till 2030, but the proportion of non-fossil fuel will increase in the energy mix. According to forecasts the world has natural oil for approximately 41.6 years, 60.3 years of natural gas, and 133 years of coal. A possible replacement for fossil fuels is nuclear energy. Uranium for nuclear energy is necessary, and according the predictions the world has uranium for approximately 100 years.

According PeakOil Netherlands, IEA and Clingendael there will be a shortage of oil in the next decade. This is because the production of conventional oil is declining and this cannot be replaced by the production of unconventional oil. This is because the production of unconventional oil has a shortage of good personnel and equipment. In the short term this deficit led to a rising price of oil and demand will decrease.

To meet the future demand for energy a lot of money must be put in the production of energy. In addition, factors such as nationalism and protectionism will play a major role in the energy production, because the oil and gas reserves are limited to a number of countries.

To avoid these risks, countries should seek other opportunities for the energy production. A solution is clean tech. See also the policy of the EU. In March 2007, the European council agreed on a set of ambitious climate and energy objectives to enhance the security of energy supply, to curb the projected rise in energy prices and to reduce greenhouse gas emissions. And one of these objectives is a 20% share of renewable energy by 2020, including a 10% share of bio fuels in transport in Europe. Renewable energy makes countries less dependent on those counties with a lot of oil and gas reserves. The following chapters will deal with the various forms of clean tech, which also includes renewable energy and real estate.

[1] The reference scenario of the IEA and EIA are derived from current policies of governments worldwide regarding to the energy mix.

[2] British thermal unit is a unit of energy used in the power, steam generation, heating and air conditioning industries. In scientific contexts the BTU has largely been replaced by the SI unit of energy, the joule (J), though it may be used as a measure of agricultural energy production (BTU/kg).

[3] The **Carboniferous** is a geologic period and system that extends from the end of the Devonian period, about 359.2 ± 2.5 Ma (million years ago), to the beginning of the Permian period, about 299.0 ± 0.8 Ma.

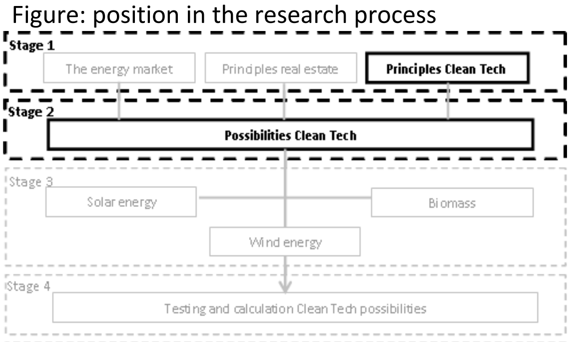
[4] reserves-to-production ratio - If the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that rate.

4. WHAT IS CLEAN TECH - *DEFINING POSSIBILITIES*

4.1 Preface

This chapter will discuss the different segments of clean tech that also fits within the definition of real estate. The chapters 2 & 3 of this master thesis focused on the real estate market and the energy market. These chapters come together in this chapter about clean tech. First, this chapter will focus on the definitions real estate and clean tech. Subsequently, this chapter will go on about the different segments of clean tech that also fits within the definition of real estate. These segments are wind energy, solar energy, biomass, and co_2 storage. Of each segment there is a briefly explanation about the production of energy and the market. Co_2 storage is a separate form of clean tech, and will be explained in the relevant paragraph.

Figure: position in the research process



4.2 Terminology

In paragraph 2.2, the definition of real estate is explained and the various characteristics of real estate were interpreted. The definition of real estate will, for convenience, again be described in this section. Following, the definition clean tech is explained and this paragraph closes with the segments of clean tech that are real estate.

"Real estate is a financeable, wealth creating, physical asset, suitable for multiple users and generating a stable and over time inflation related cash flow (Rabobank International: Industry Analysis - Commercial real estate, 2009)."

The definition of clean tech is:

"Clean tech is a product, service or process that provides superior performance at lower costs greatly reduces or eliminates negative ecological impacts and improves the productive and responsible use of natural resources (Clean tech Network, 2007)."

The following table shows the different segments clean tech, and which segments of clean tech answer the characteristics of real estate. As the table reflects 'energy generation' and 'energy transmission & distribution' answer the aspects of

Figure 23: subcategories of clean tech

Segment	Financiable	Wealth creating	Physical	Multiple users	Stable cash flow	Examples
Agriculture	-	-	-	x	-	
Air & Environment	-	-	-	-	-	
Energy generation	x	x	x	x	x	Wind, solar, biomassa
Energy transmission & distribution	x	x	x	x	x	Networks
Energy storage	-	-	-	-	-	
Energy efficiency	-	x	x	-	-	
Manufacturing	-	-	x	x	-	
Materials	-	-	-	-	-	
Recycling & waste	-	-	x	-	x	
Transportation	-	-	x	x	-	
Water & wastewater	-	-	x	x	x	

real estate. Energy generation includes windmills- and solar parks and biomass. Energy transmission & distribution are networks for energy transport. This research will focus on windmills- and solar parks and biomass and this chapter gives an explanation about these forms of clean tech/real estate.

4.3 Wind energy

This paragraph will discuss the production of wind energy and the wind energy market.

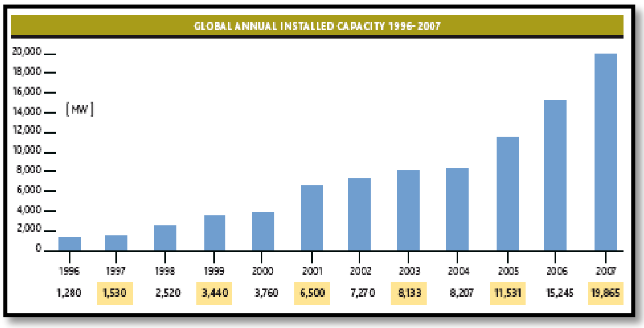
4.3.1 The production of wind energy

The further increase of wind turbines has evolved the wind power production from a standalone production to a larger, on-grid application. In 1980, the average diameter of a rotating turbine of 50 kW (1 kilowatt = 10^3 watt) was 15 meters, and in 2003 turbines had a capacity of 50 MW with a rotating turbine of 124 meter. Modern turbines produce 180 times more energy than the turbines in 1980, while the costs per kW/h are halved since 1980.

4.3.2 Wind energy market

Wind power currently contributes about 1% of global electricity production. Figure 24 shows the annual growth of wind capacity. In 2007, the wind capacity increases with 19.865 MW. The rising demand has ensured that the price of wind turbines has increased by 20-30% in recent years (Iris, 2008). Europe remains the leading market for wind energy; new European installations represented just 43% of the global total, down from nearly 75% in 2004. For the first time in decades, more than a half of the annual wind market was outside of Europe. This trend is like to continue (Global wind energy outlook, 2008). The Global Wind Energy Council has made different growth scenarios for wind energy in the global electricity supply, based on the forecasts of the IEA. In the reference scenario of the IEA, the share of wind power in the global electricity supply in 2030 is 4.2%. In the advanced scenario the share of wind energy meet 19.7% in 2030. Wind offers a good alternative to fossil fuels. The costs, especially for onshore wind energy are competitive with the costs generated by fossil fuels (Iris, 2008).

Figure 24: Global annual installed capacity



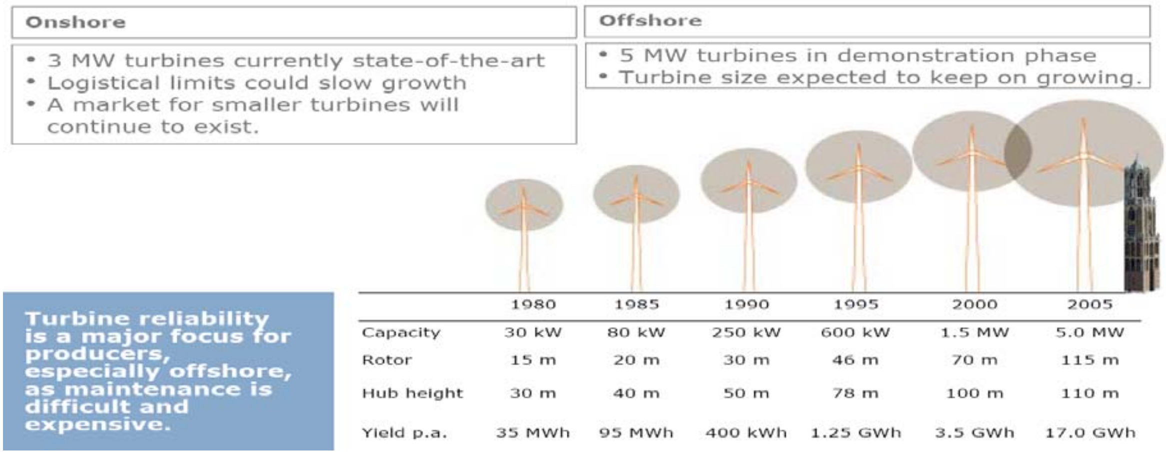
Source: Global wind energy outlook 2008

4.4 Solar energy

This paragraph will discuss the production of solar energy and the solar energy market.

4.4.1 The production of solar energy

Solar energy is the most abundant permanent energy resource on earth and it is available for use in direct (solar radiation) and indirect (wind, biomass, hydro, ocean etc.) forms (World energy council, 2008).



Solar radiation is the world’s prime energy resource, and this paragraph focuses on the direct use of solar radiation.

According to the World Energy Council the sun emits energy at a rate of 3.8x1023 kW. Of this total, only a tiny fraction, approximately 1.8x1014 kW is intercepted by the earth. About 60% of this amount reaches the surface of the earth. The rest is absorbed by the atmosphere or reflected back into space. Even if only 0.1% of this energy could be converted at an efficiency of only 10% it would be four times the world's total generating capacity of about 3 000 GW (World energy council, 2008). Looking at another way, the total world energy consumption is about 450 EJ. If this is compared with the number of solar radiation that is falling on the earth, solar radiation is 7500 times of the world's total annual primary energy consumption.

The annual solar radiation reaching the earth's surface, approximately 3 400 000 EJ (exajoule), is an order of magnitude greater than all the estimated (discovered and undiscovered) non-renewable energy resources, including fossil fuels and nuclear energy (World energy council, 2008).

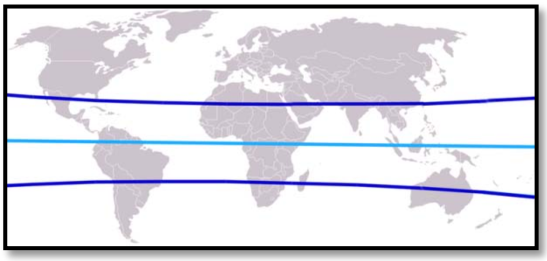
Figure 25: Energy produced by the sun

Source: energy convention, University of Groningen

There are various forms of technology of solar energy. These can be divided into concentrating solar power and photovoltaic conversion. Both technologies are explained below.

- **Concentrating solar collectors** can achieve temperatures in the range of 3.000 Celsius to 10.000 Celsius or even higher, which is ideal for generating electricity via thermodynamic power cycles (world energy council, 2008). The current power plant, for fossil fuels and nuclear energy, work at the same way. This provides advantages, because the current knowledge base can be used to generate electricity from the sun. The intermittency of sunlight, the uncontrollably variable energy source, can easily overcome by the use of fossil fuels such as natural gas as a back-up fuel or to store high temperature heat. The promising areas for concentrating solar collectors are between the longitude and the latitude (see figure 26). These are countries such as Africa, the Middle East, south Asia, southern Europe, China, Australia, south-western United States, Central and South America, and, certain countries of the Former Soviet Union.

Figure 26: Longitude & latitude



Source: www.risoe.dk

- **Photovoltaic conversion** is the direct conversion of sunlight into electricity with no intervening heat engine. As indicated above, photovoltaic devices are rugged and simple in design and require very little maintenance (World Energy Council, 2008). The biggest advantage of Photovoltaic conversion is that it can be used as a stand-alone system (off-grid) and it can be connected to an electrical network (on-grid). This technology is also used as power sources for example calculators, watches, vehicles, and satellites. Because this technology is widely deployed, the demand for Photovoltaic conversion is increasing every year. In 2005, over 1 700 MW of photovoltaic panels were sold for terrestrial uses and the market is growing at a phenomenal rate: about 35% per year worldwide (World Energy Council, 2008).

Solar cell consists of two layers of silicon. The increasing demand for solar cells, leads to an increased demand for silicon. And silicon is relatively expensive. A new generation of Photovoltaic conversion, thin-film solar cells, have been developed to reduce the dependence on silicon. Thin-film uses little or no silicon. In general, the conversion efficiency is lower than the solar cells with silicon. But the thin-film solar cells are more flexible and so more applicable to more locations.

4.4.2 Solar energy market

The sun delivers 10,000 times more energy than what is consumed worldwide per year. However, the share of generated electricity through the sun in total is almost nothing. The Economist has calculated that the production costs of solar panels decrease by approximately 5% annually. However, this is not enough to be cost competitive with electricity from fossil fuels. In the U.S., solar energy is two to three times expensive as the regular retail price of electricity (source: Iris, 2008). Predictions about when solar energy could be cost competitive with conventional energy differ from 2020 to after 2030. According the IEA solar energy may be cost competitive after 2020 and Iris indicates in its report 'The Future of Energy' that solar energy can be cost competitive before 2020.

4.5 Biomass

This paragraph will discuss the production of biomass energy and the biomass energy market.

4.5.1 The production of biomass energy

Biomass is the biodegradable fraction of products, waste, and residues from agriculture (including vegetable and animal substances), forestry, and related industries, and the biodegradable fraction of industrial and household waste (source: Richtlijn 2001/77/EG).

Biomass exists of three different generations. The generations are explained below:

- First generation: these are biomass that is based on sugars, vegetable oil, starch, and animal fats; the biomass of the first generation is directly derived from the crop. These are usually food that is transformed into biomass.
- Second generation: plants that are not related to food. These are plants that only grow for biomass (energy crops) or this is from inedible parts of food crops. Biomass for the second generation include: willow, Indian birch (pongamia pinnnata), purghera, (jatropha curcas), wood chips, straw and waste
- Third generation: this is biomass wherefore special prepared organisms are produced. Such as Algae, that exists of 30% of oil. The use of algae is limited, but emerging.

The first and second generation biomass use only for about 0.5%, of the sunlight and the third generation, and Algae convert 205 of sunlight into biomass.

Biofuels is a collective name for different types of fuels made from biomass.

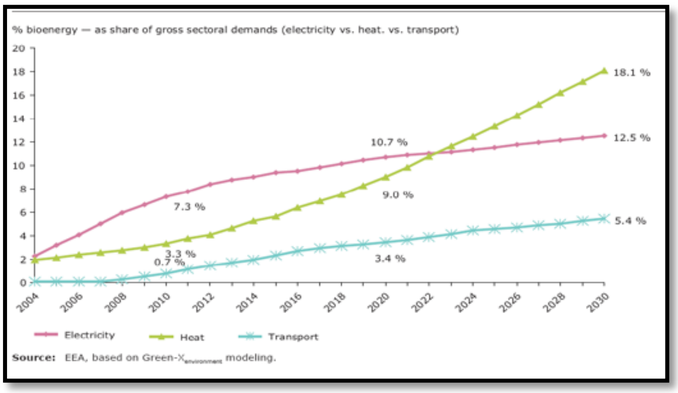
4.5.2 The biomass energy market

High gasoline prices, the reducing of independence on fossil fuels, and the reduction of greenhouse gas emissions to prevent further climate change, have led governments of more than 40 countries to establish targets for the use of biofuels. In Europe, the aim is that 5.75% in 2010, and 10% in 2020 of the transport-related energy use exists of biofuels. The U.S. wants a 20% part of Ethanol of the gasoline consumption in 2022. China has the objective that 9% of the gasoline consumption exists of biofuels (IRIS, 2008). Compared to fossil fuels, biomass prices are highly variable, ranging from no or low costs for residues or traditional biomass in Africa or Asia to comparatively high costs for biofuels from cultivated energy crops (Energy Revolution, 2007). For other regions prices were assumed to be lower, considering the large amount of traditional biomass use in developing countries and the high potential of yet unused residues in North America and the Transition Economies (Energy Revolution, 2007).

Figure 27: biomass price development

$2000/GJ						
BIOMASS	2003	2010	2020	2030	2040	**2050**
Biomass In $2000/GJ						
- Europe	4.8	5.8	6.4	7.0	7.3	**7.6**
- other Regions	1.4	1.8	2.3	2.7	3.0	**3.2**

Figure 28: bioenergy deployment as a share of gross sectoral demands



Source: Maximizing the environmental benefits of Europe's bioenergy potential, 2008 & Energy Revolution, 2007 (both figures)

4.6 CO_2 storage

As you can read in paragraph 3.4 of this master thesis, there is still enough coal for the next 133 years. Coal is a relatively cheap fossil fuel, but has the major disadvantage of CO_2 emissions. A solution for the emission of CO_2 is Carbon Capture and Storage (CCS). CCS is the capture and storage of CO_2 from the combustion of (fossil) fuels. With CO_2 storage it is in potential possible to continue use fossil fuels without any substantial contribution to the greenhouse effect. This option for power generation is also known as 'clean fossil'. The use of 'clean fossil' can provide extra time for further development of the techniques of renewable energy. To save CO_2, it has to be separated during the combustion of fossil fuels from the other exhaust gases. There are different technologies with whereby CO_2 in various stages of the combustion process for 85% to 95% can be separated. The separated CO_2 can be stored in empty gas field and aquifers.

4.6.1 The production of CO_2 storage

There are three types of CO_2 capture systems: post-combustion, pre-combustion and oxyfuel combustion. The concentration of CO_2 in the gas stream, the pressure of the gas stream and the fuel type (solid or gas) are important factors in selecting the capture system (IPCC, 2005).

In the report '*Carbon dioxide capture and storage'* written by the Intergovernmental Panel on Climate Change the different types are described as follows:

- Post-combustion capture of CO_2 in power plants is economically feasible under specific conditions. It is used to capture CO_2 from part of the flue gases from a number of existing power plants. Separation of CO_2 in the natural gas processing industry, which uses similar technology, operates in a mature market (IPCC, 2005).
- The technology required for pre-combustion capture is widely applied in fertilizer manufacturing and in hydrogen production. Although the initial fuel conversion steps of pre-combustion are more elaborate and costly, the higher concentrations of CO_2 in the gas stream and the higher pressure make the separation easier (IPCC, 2005)
- Oxyfuel combustion is in the demonstration phase and uses high purity oxygen. This results in high CO_2 concentrations in the gas stream and, hence, in easier separation of CO_2 and in increased energy requirements in the separation of oxygen from air (IPCC, 2005).

For the separation 10-40% extra fuel is needed for the same production.

4.6.2 The CO_2-storage market

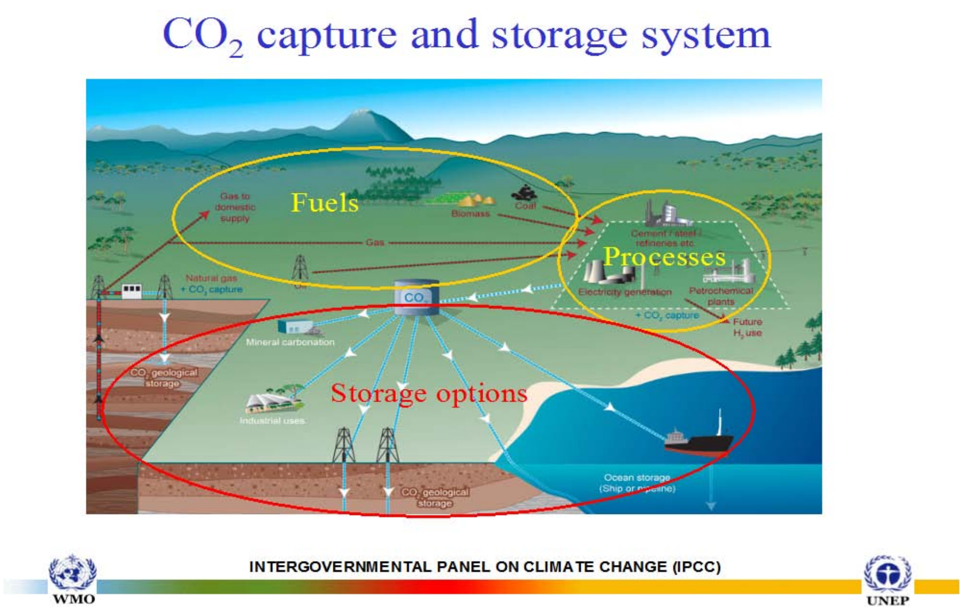
For the development of CCS it is important to identify what the long term effects are on the environment. The costs of CCS are currently high. IPPC estimates that these costs in the coming decades could be reduced by 20-30%. The advantage of CCS is the empty oil- and gas fields, which can serve as repository for CO_2. Shell is working on a pilot project for CCS in an empty gas field in Barendrecht (The Netherlands). But this encountered much resistance from the local population. Norway is currently precursor in CO_2-storage. Since 1992 Norway stored CO_2 in the ground. Algeria and Canada are also working on pilot projects for the storage of CO_2.

4.7 Conclusion

This chapter 4 gives an answer to the second sub-question: what to invest in?

The main part of this chapter was which segments of clean tech fits within the definition of real estate. These are windmills, solar panels, biomass, and CO_2 storage. These segments are further explained, with emphasis on the production of energy and associated energy market. The next chapter will elaborate on these segments of clean tech. Per segment the technology gaps and potential bottlenecks are discussed.

Figure 29: schematic diagram of possible CCS systems showing the sources for which CCS might be relevant, transport of CO_2, and storage options



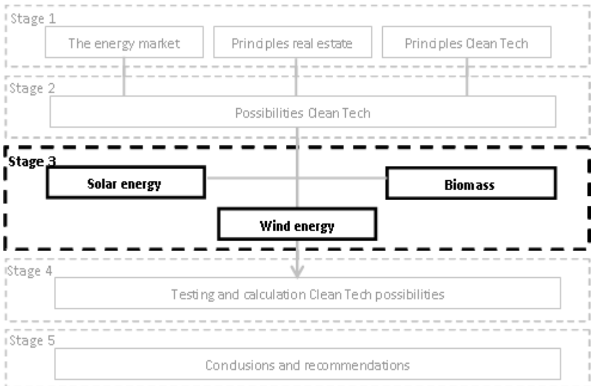
Source: Carbon dioxide capture and storage (both figures)

5. STATUS OF THE CLEAN TECH CATEGORIES

5.1. Preface

This chapter is about, as the title indicates; the status of the clean tech categories (see categories in figure 23, page 35). First, this chapter will briefly address the shortage of fossil fuels and the EU-policy about renewable energy. Then, the status of the various clean tech categories are discussed. This result in an overview of technological gaps and potential bottlenecks. Following, the investment characteristics of clean tech are discussed. And the chapter closes with a conclusion.

Figure: position in the research process



5.2. Shortage of fossil fuels and EU policy

Chapter 3 of this master thesis is about the energy market. One of the conclusions is that fossil fuels continue play a significant role in the energy production till 2030, but the proportion of non-fossil fuels will increase in the energy mix. According the forecasts the world has:

- Natural oil for 41.6 years
- Natural gas for 60.3 years
- Coal for 133 years

There is going to be a time that the stocks of fossil fuels become exhausted. The best replacement of fossil fuels is renewable energy. This is also according the EU. The EU agreed on a set of ambitious climate and energy objectives to enhance the security of the energy supply. One of these objectives is 20% share of renewable energy by 2020, including a 10% share of biofuels in transport. So, the shortage of fossil fuels in the future and EU policy could be a reason for invest in clean tech.

5.3. Status clean tech possibilities

5.3.1. Wind energy – onshore

Technology gaps

The first windmill was connected to the energy grid in 1976. In the subsequent years, the technology of onshore wind has continuously developed. The further increase of the wind turbines has led wind energy develop from a standalone production to bigger on-grid applications. Onshore wind energy is a mature technology. Now, the profit in technology can be achieved in the turbine size (see page 28). The wind-turbines consist mainly of 3-bladed turbines. There are also improvements possible in the energy infrastructure; this infrastructure must be extended (Iris, 2008). Only a lot of capital is required to realize this extension, rather than technology. There are also improvements needed in the production of windmills. For example, using less volatile commodities in the production process such as steel and copper (Green Investing, 2009).

Potential Bottlenecks

Wind energy could be cost-competitive with an oil price of US$ 50/barrel. The prices that are calculated for wind energy are between US$ 52 – 90 per MWh. A price at the bottom of this range is cost-competitive with electricity from coal and gas. All renewable energy projects will experience that raising finance is the toughest challenge (Green Investing, 2008). This is partly due the limited capital that is available, caused by current financial crisis. In the long term, the production of wind turbines can have problems with shortage appropriate commodities that are used for production. Also the planning permission could cause problems and delays (Krohn et al, 2009). In densely populated areas this an important issue, for example in the Netherlands.

5.3.2. Wind energy – offshore

Technology gaps

The technology of offshore wind energy is more complicated than onshore wind (Krohn et al, 2009). First, the environmental conditions are more difficult. Secondly, the salted see air can damage the mechanism of the wind turbine. Now, most of the problems are solved by the manufactures of these wind turbines. These innovations lead to more energy-efficiency and a growing demand for offshore wind by governments.

Potential Bottlenecks

The margin of profit of offshore wind energy is lower than that of onshore wind (Krohn et al, 2009). And if the market for onshore wind energy continuously develops, manufactures will on focus on onshore turbines (Green Investing, 2008). This could result in a problem for the offshore wind energy market.

5.3.3. Solar energy - photovoltaic

Technology Gaps

The biggest challenges are reducing the production costs for crystalline silicon modules (Green Investing, 2008). This is important because solar energy should be more cost competitive with other clean tech possibilities, and it will become less dependent on subsidies.

Potential Bottlenecks

Solar energy is currently two to three times as expensive as the regular retail price of electricity in the US. In the coming years, there seems to be an oversupply arises of photovoltaic modules. Given the oversupply, prices will decline, possibly to the marginal cost of production. Other challenges that may hinder growth are; the shortage of capital (nearly all the costs are upfront), permitting and power transmission (Green Investing, 2009).

5.3.4. Solar energy - Concentrated Solar Power

Technology Gaps

Concentrated solar power plants are similar to power plants based on fossil fuels. So there is a possibility to switch to fossil fuels when the sun is not shining. Concentrated solar power energy is a mature technology, but at some points needs to be improved, for example the energy-efficiency which must be increased. According to the World Economic Forum has Concentrated Solar Power the potential to improve the economics of photovoltaic when the technology is proven.

Potential Bottlenecks

The biggest challenges are permitting, transmission and raising capital (Green Investing, 2009). Spain is an example for other countries, where several solar projects have been established.

5.3.5. Biomass – First Generation (Sugar based ethanol)

Technology Gaps

Sugar based ethanol is produced from the fermentation of sugars. In sufficiently form it can be used as fuel for engines. All sugar cane residues can be used for the ethanol production. In addition, sugar based ethanol is easy to mix with gasoline. The disadvantage of sugar based ethanol is its hydrophilic and corrosive nature. Hereby it is not possible to transport sugar based ethanol through the existing infrastructure for gasoline.

Potential Bottlenecks

Currently ethanol is only produced by sugars (Brazil) and corn (US). Potential bottleneck is the food-for-fuel debate. Socially, there is much resistance by the fact that food is used for the biofuel industry. Food becomes scarce by the relative rapid increase in the level of prosperity. The extra competition for food by the biofuel sector will result in rising food prices. In addition there will be a pressure on agricultural land. And more agricultural land leads to additional demand for water. An example of the food-for-fuel debate is the tortilla-riots in Mexico in 2007. The Mexican people were in revolt after the price of tortillas was exploded. The limited reduction of the greenhouse gases is also a potential bottleneck. Research of the journal Science showed that much biofuels even contributes to the green house effect if the use of available land is included (Iris, 2008). Another challenge for sugar based ethanol is the decrease of the oil price (see paragraph 3.7). Sugar based ethanol becomes cost-competitive with an oil price above US$ 40/barrel (Green Investing, 2009). The price of the sugar based ethanol cannot compete with a low oil price. Also import tariffs and local subsidies are a problem for sugar based ethanol. These should be removed to create a more international level playing field. Market mechanisms such as hedging instruments help the market to contribute to become a transparent global market for ethanol. Finally the energy output plays an important role. The energy output is in no comparison with the next generation biomass.

5.3.6. Biomass – Cellulosic and next generation bio fuels

Technology Gaps

The main challenges lies in lowering production costs and finding the right crops, so it can compete with conventional energy and also with the first generation of biomass, particularly sugar based ethanol (Green Investing, 2008). The next generation biofuels fits in the current production capacity and does not need high investments and haves the best chance of success.

Potential Bottlenecks

Again, the biggest threat is the decrease of the oil price. And logistic could be a problem. The crops are large in size and therefore too expensive to transport over long distances. So, it is important that conversion plants are situated near where the feedstock is grown and close to harbours (see paragraph 6.2.3.)

5.4. Investment characteristics

Clean tech energy gives stable returns on a basis of long-term contracts.

By closing long term contracts with energy companies for the takeover of energy and the long lifetime of the clean tech categories gives the investor the possibility to generate (stable) income for many years. It is important to choose the right location, regarding the site factors and subsidy policy, which can vary by country (see chapter: Where to invest?). In addition, the quality of the energy companies (especially solvability), and the agreement of mid-term adaptation, is important. For example, to adjust the long term contracts for inflation.

Inflation hedge

The indexation of the price of energy take over in the contracts with the energy companies, and the continuously increase of the land value would be a reasonable protection against inflation.

Diversification

An important investment characteristic is the diversifying character of the investment in clean tech in relation to other asset classes. This ability is based on the low and sometimes negative correlation with that of other asset classes, such as stocks and bonds. By adding clean tech to the investment portfolio, could therefore, by a given return result in a risk reduction, and by a given risk the result in a return increase. An explanation could be that the energy returns have no direct relationship with the securities market, where shares and bonds are traded.

A conservative risk profile where the main risks in course of time diminish

The risks of investing in clean tech will diminish in the coming years. First, the demand for renewable energy will increase in the future. The decrease in supply of fossil fuels will lead to an increased use in renewable energy in the future. Secondly, countries will reduce the dependence on other countries in the field of energy. Partly due to the decline of stocks of fossil fuels this issue will play an increasing role. Countries solve this problem by investing in renewable energy. Thirdly, countries become more environmentally conscious. The emissions of CO_2 receive more attention. And the solution for reducing the CO_2 emissions is clean tech. Finally, the techniques for clean tech are getting more sophisticated. The productions costs of clean tech will go down. And clean tech will show a better performance in the future.

5.5 Conclusion

Chapter 5 gives answer to the third sub-question: what is the status of the clean tech sub-categories?

In general, for all categories technological profit can be achieved in energy-efficiency and reducing production costs. Potential bottlenecks for all categories are: raising capital, shortage of appropriate commodities and a decrease of the oil price.

Investment characteristics of the clean tech categories are: stable return on a basis of long term contracts, inflation hedge, diversification, and a conservative risk profile.

6. WHERE TO INVEST – *WEATHER CONDITIONS & SUBSIDY REGIMES*

6.1 Preface

In the previous chapter is described which sub-categories of clean tech also fit within the definition of real estate. This includes wind energy, solar energy, and biomass. In paragraph 4.6, CO_2 storage is added. This is because the world has enough coal for 133 years (see paragraph 3.4). CO_2 storage is the clean solution for the use of coal. This chapter tries to answer the question: what are the best locations for these various types of alternative real estate? Location is one of the most influential factors in real estate. The best sites are not just dependent on the right site factors. Another important factor is subsidy policy. At this moment, renewable energy is subsidy-driven. Without subsidy, many renewable energy projects would not exist. So, not only the **site factors** play an important role, but also the degree of **subsidy**, available by country, plays an important role in **site selection**. Through different maps, the site factors for the various types of alternative real estate will be identified. Followed by the subsidy policy of European countries. And this chapter is closed with a conclusion.

6.2 Site factors

6.2.1 Wind characteristics

Some of the windiest regions are to be found in the coastal regions of Europe. Other windy areas in the world are the coastal regions of the Americas, Asia and Australia. Most mountain regions are also windy, while the interiors of large land masses are generally less so. The higher wind speeds do not usually compensate for the higher construction costs, but the chief attractions of offshore are that it is a large resource with a low environmental impact (World energy council, 2008). The next two maps show the wind characteristics of Europe.

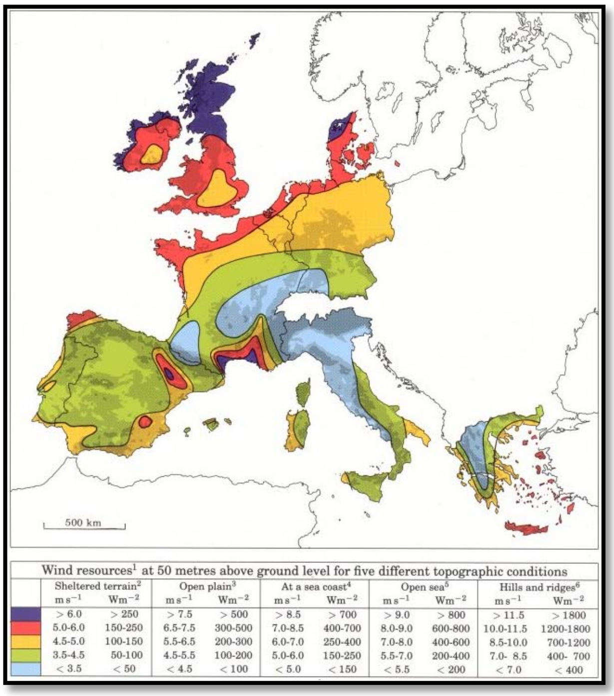
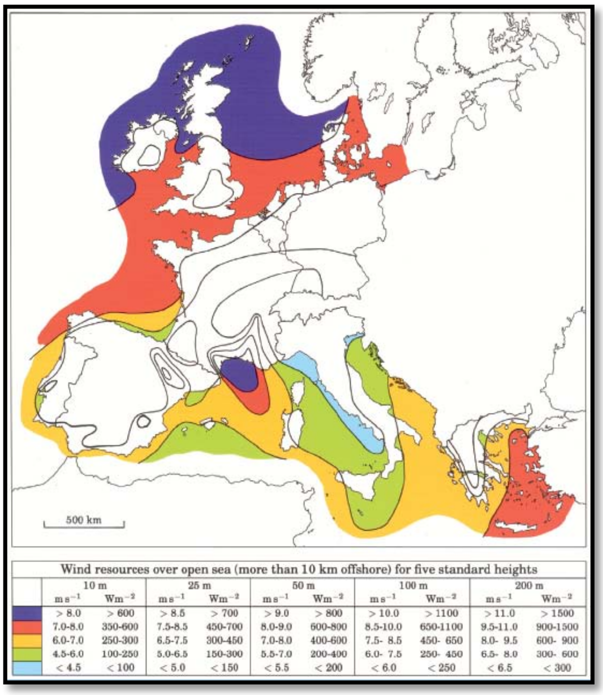


Figure 30: Onshore & offshore wind characteristics



Source: www.risoe.dk (both figures)

Onshore

It is clear that the Atlantic coastline of the European continent, Scandinavia, the UK and Ireland have the most wind-potential. However, with government support and the careful selection of turbines, wind farms can be economically viable almost everywhere (Rabobank International).

Offshore:

In Europe, many offshore wind projects have been announced over the past years and are now in various stages of development, with more projects still being announced. To put this in perspective: no offshore wind farms currently exist anywhere else in the world, apart from a few single test turbines. Site selections factors: available sites and procedural issues, wind (see figure), water depth, distance to shore and harbor.

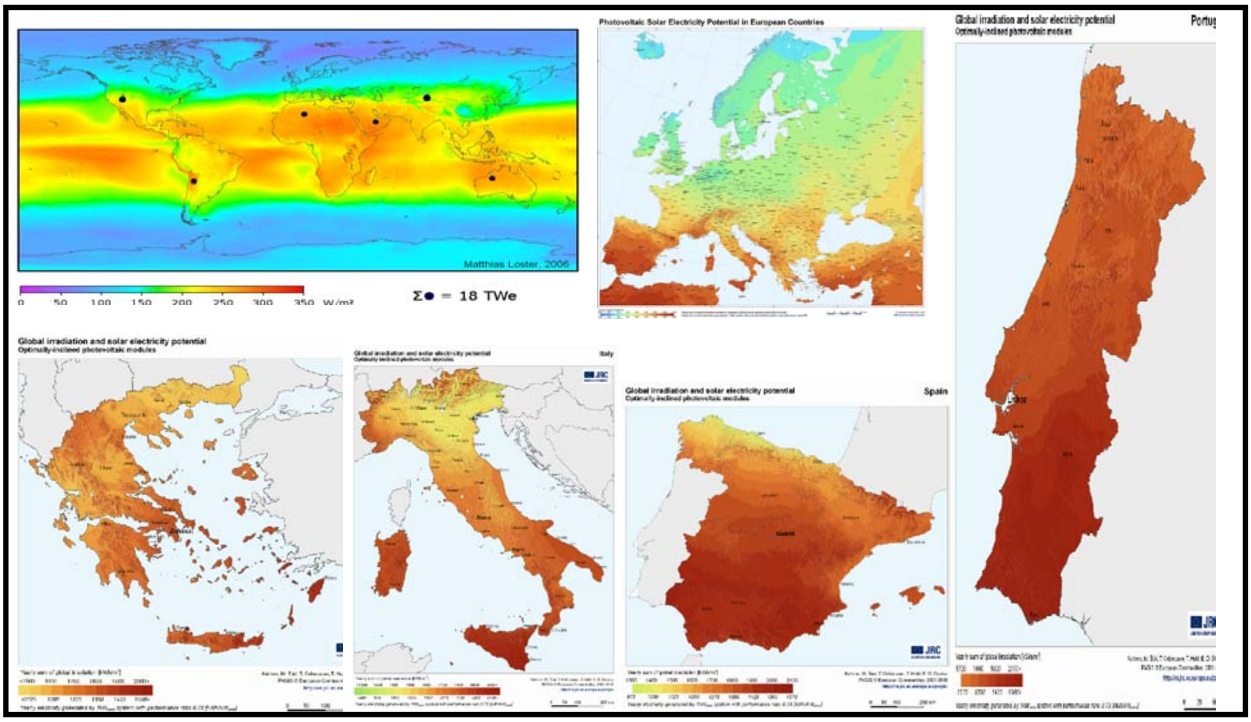
6.2.2 Solar characteristics

According to the World Energy Council the annual average horizontal surface irradiance is approximately 170 W/m^2 (watt per square meter).

The highest annual mean irradiance of 300 W/m^2 can be found at the red sea area, and typical values are about 200 W/m^2 in Australia, 185 W/m^2 in the United States and 105 W/m^2 in the United Kingdom (source: world energy council).

The different maps show the irradiation of sunlight on Earth, Europe and some European countries. The first figure shows clearly that most sunlight falls within the longitude and latitude of the Earth. Several European countries are within these longitude and latitude; such as Spain, Portugal, Italy, and Greece. The dark red colours in the maps are areas with the most sunlight.

Figure 31: solar irradiance: Earth, Europe, Spain, Italy, Greece, and Portugal



Source: http://re.jrc.ec.europa.eu/pvgis/

6.2.3 Biomass characteristics

The future expansion of biomass supplies will be from two very distinct streams:

1. The residues associated with current agricultural land commodity production and processing
2. The planting of energy crops on available land.

Option 2 is not available for small highly-populated countries such as the U.K. and the Netherlands. But for countries such as Argentina, Brazil, Canada, the USA and Russia as well as some eastern part of Europe, increased land utilisation must be feasible (World energy council).

The several maps above show which locations are most suitable for the first and second generation biomass (see explanation paragraph 4.5) in Europe. Big, ideal production sites can be found in northern and western France, Ireland, Germany, Eastern Hungary, and the Po Valley, along the Danube in Bulgaria and Romania, and parts of the Baltic States. Figure 32 shows the areas currently used as arable land, and how suitable they are for the production of first generation biomass. The crops for the second generation biomass are more robust and make less demand on soil and climate. Figure 33 shows which areas are suitable for the cultivation of these crops; areas with very good suitability for cultivation are excluded.

Figure 32: arable land suitability for the first generation biomass

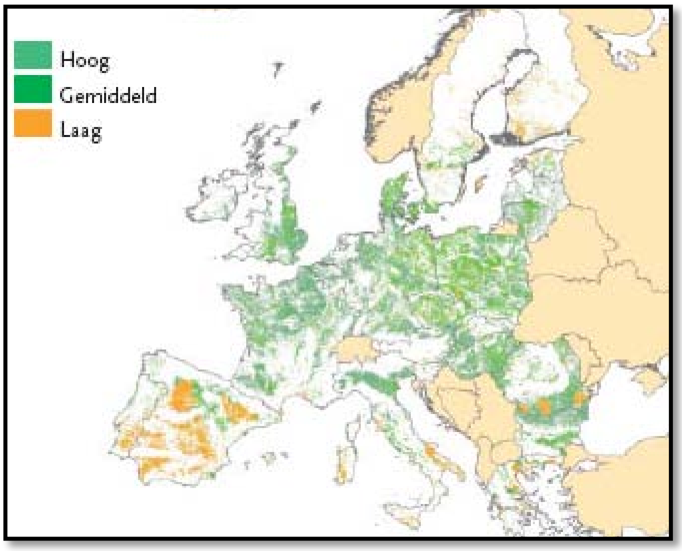


Figure 34: arable land suitability for the 2nd generation biomass

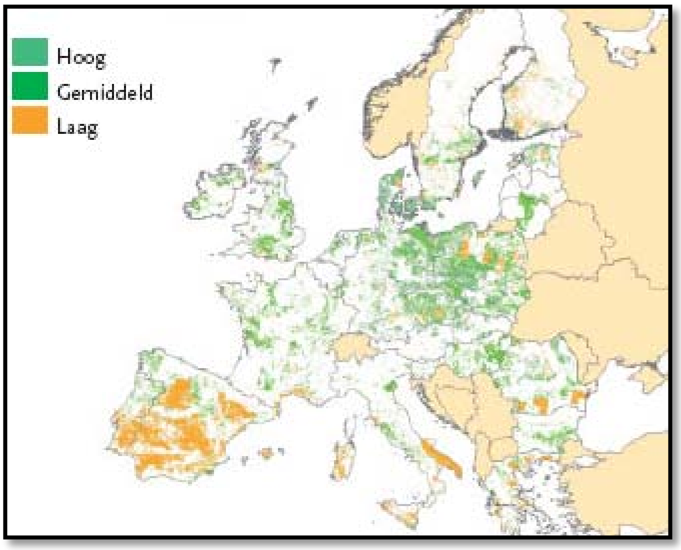


Figure 33: potential first generation biomass based on soil, climate, logistics and urban pressure

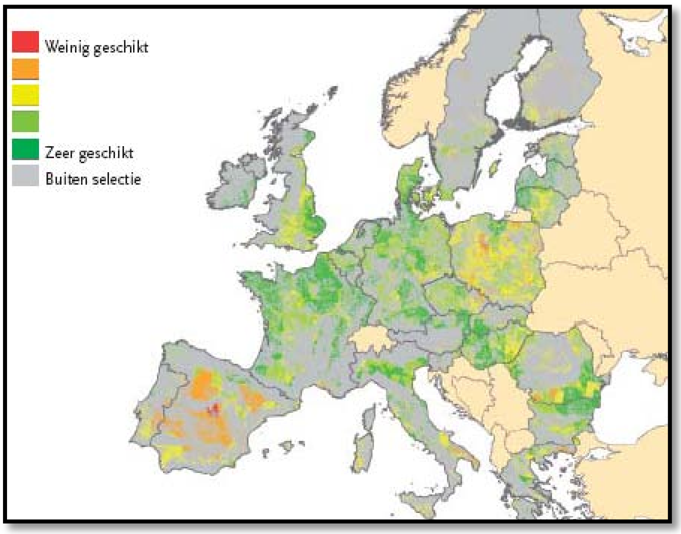
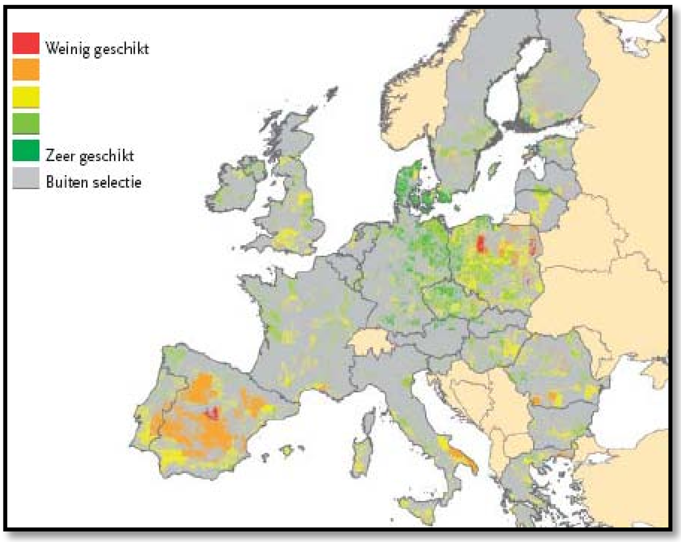
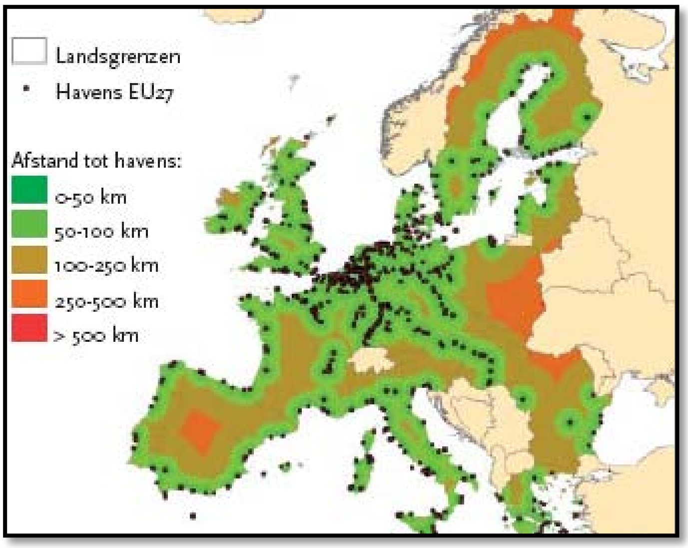


Figure 35: potential 2nd generation biomass based on soil, climate, logistics and urban pressure.



Farmers and landowners will not easily convert their best arable land into the cultivation of perennial crops with an uncertain return. Transport is an important site factor. The location nearby harbours are advantageous because cheap bulk transportation. On these sites conversion plants are to be expected and that reflects an impulse to the cultivation in the hinterland. The map with the harbours indicates the maximum distance to sites that are accessible for bulk transport by sea or inland waters. Maps 34 & 35 show the combined suitability of the first and second generation, based on information about soil, climate, logistics, and urban pressure.

Figure 36: distances from the hinterland to harbours and inland harbours that are accessible for bulk transport



Source: Ruimte voor biomassa, 2009 (all figures of biomass)

6.2.4 CO_2-storage characteristics

Prospective areas for CO_2-storage are empty oil- and gas fields and sedimentary basins. A sedimentary basin is often a first indication to search for occurrences of oil and gas. Large emissions of CO_2 are concentrated in proximity to major industrial and urban areas. Empty oil and gas fields within 300 kilometres are in potentially suitable. Intergovernmental Panel on Climate Change indicate that the number of large point sources is projected to increase in the future, and that, by 2050, given expected technical limitations, around 20-40% of global fossil fuel CO_2 emissions could be technically suitable for capture, including 30–60% of the CO_2 emissions from electricity generation and 30–40% of those from industry (IPCC, 2005).

Figure 37: Global distribution of large stationary sources of CO_2 (Based on a compilation of publicly available information on global emission sources, IEA GHG 2002)

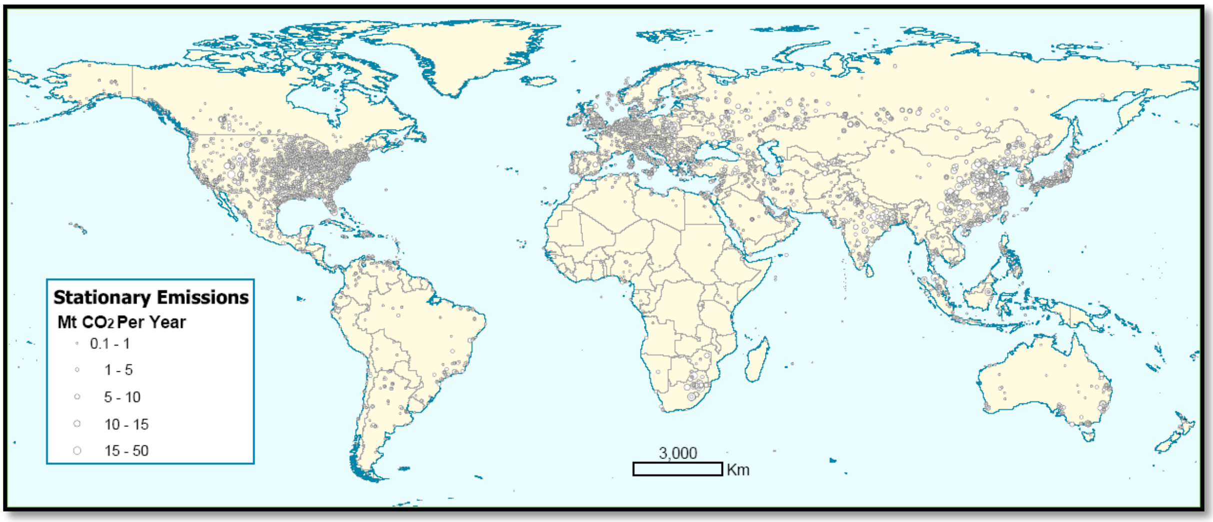
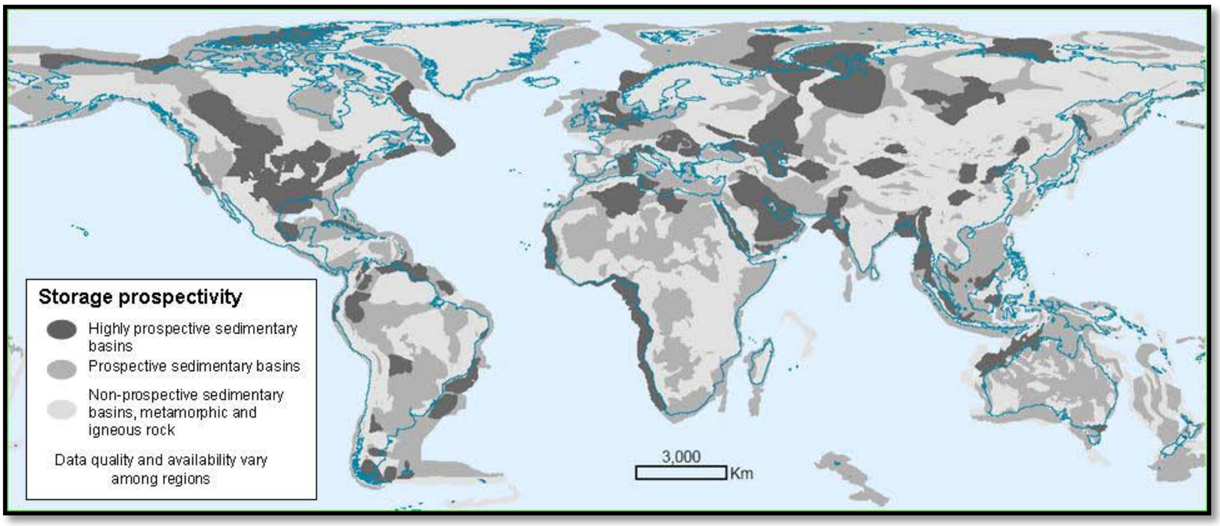


Figure 38: storage prospects



Source: carbon dioxide capture and storage (both figures)

6.3 Subsidy-policy

Subsidy-policy of a country is an important component for choosing the right location. In the annexes of this master thesis the subsidy-policy is described of a defined number of European countries. This description includes the support system, total revenue in 2008, level of support, and duration of support. The policy of CO_2-storage is not described because, CO_2-storage is a relatively new concept, and so countries have little or no policy formed on CO_2-storage. The subsidy-policy is included in the conclusions that can be read the next paragraph.

6.4 Conclusions

Chapter 6 gives an answer to the fourth sub-question: where to invest in?

Onshore wind
Belgium and Italy give the highest level of subsidy on onshore wind energy of all European countries. Belgium has a level of support of €100/MWh and Italy €100-120/MWh. The duration of this subsidy is the longest in Germany, Ireland and Spain, with a duration time of 15 to 20 years. Looking at the onshore wind factors, the best locations are Ireland and the UK. Rabobank International has even compiled a top 5 of best countries for onshore wind.

1. Ireland
2. Spain, France, UK
3. Germany, Italy, the Netherlands
4. Belgium
5. Poland, Turkey

Offshore wind energy
Germany, Ireland, Italy and France give the highest level of support on offshore wind energy of all European countries. The duration of this subsidy is the longest in Belgium, Spain, France, and Germany, with a duration time around 20 years. Looking at the offshore wind factors, the best locations are the coastlines of Ireland and the UK, followed by the coastlines of the Netherlands, Belgium, and France.

Solar energy
The Southern European countries have the most irradiance of Europe. These countries are Spain, Portugal, Italy, and Greece. In addition, Germany, Spain, and Portugal have the highest subsidy level for solar energy.

Biomass energy
For biomass, it is important that there is enough suitable land available on which biomass crops can grow. For example, countries such as the Netherlands and UK are not suitable for biomass production by a shortage of available land. Big, ideal production sites can be found in northern and western France, Ireland, Germany, Eastern Hungary, and the Po Valley, along the Danube in Bulgaria and Romania, and parts of the Baltic States.

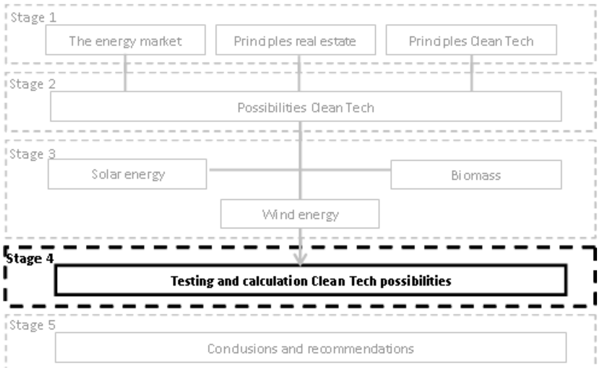
CO_2*-storage*
Large emissions of CO_2 are concentrated in proximity to major industrial and urban areas. Empty oil- and gas fields, within 300 km, are suitable for CO_2 storage. Parts of countries that are suitable for CO_2 -storage are The Netherlands, Belgium, Northern Italy, and Ukraine. Offshore CO_2-storage is also possible in the North Sea, Norwegian Sea, and the Mediterranean Sea.

7 HOW INVEST – *RISKS & DIVERSIFICATION POTENTIAL*

7.1 Preface

Clean tech is a relatively new asset class for institutional and private investors. For new asset classes investment and portfolio risk management is very important. That is what this chapter is about. This chapter begins with an overview of the general risks of investing in clean tech. The next step in investment and portfolio risk management is the collection of different performance series to create performance analysis of various asset classes. On the basis of these results the asset classes are compared, followed by a sub-period performance analysis of the asset classes. In addition, the performance analyses are presented per sub-category: wind, solar, biomass, and CO_2-storage. And this chapter closes with a conclusion.

Figure: position in the research process



7.2 Risks

The risks of clean tech are analyzed in five categories. In the figure below the general risks are discussed. The subcategories of clean tech have also their own specific risks. These specific risks are reflected in the annexes of this master thesis.

Figure 39: general risks clean tech

Regulatory risk	Changes in laws and regulations (price, period, form).	Within a subsector (for example onshore wind) the revenues and risks vary greatly from country)	Tariff system + stability			
Construction risk	Licenses (no projects, delay, product adaptation)	Construction risk (costs, delay, mistakes, and default)	Stock of equipment, for example silicon	Quality developer	Energy storage	Need for development
Production risk	Operational (costs, fines, lower production, additional replacement	Take off energy (no purchase at agreed price)	Input costs	Grid connexion	Climate conditions	Land quality and price
Long term O&M risk	More management related including corporate governance	Local knowledge	The availability of good managers and partners	Administrative matters	Labour	
Market risk	Ease of developing operational scale	Low oil price	Trade dependency	Ownership rights	Infrastructure	Monetary risk
	Majeure situations (for example earthquakes)	Interest rate (risk is not hedged)	Competition	Liquidity		

Source: Author edit

7.3 Structure of the performance analysis

In the next paragraphs the performance analysis are calculated of the clean tech sector and categories. This master thesis is characterized by using the top-down approach. For example, in chapter 2 & 3, the real estate market and the energy market are described. The following chapter, chapter 4, describes the definition of clean tech, and which sub-categories of clean tech fit within the definition of real estate. Chapter 3 to 6 focuses on detail on the clean tech categories. This top-down approach is also applied for the clean tech performance analysis. First, a performance analysis will be calculated for the clean tech sector in general and then the results are presented of the clean tech categories. For the calculation of the clean tech performance analysis the formulas are used of chapter 2. To clarify the selected indices the following figure is presented that is also used in chapter 4.

Energy generation and Energy transmission & distribution are used for the calculation of the clean tech in general (see figure 40 & the green field on the next page). Of these categories a performance analysis will be calculated. These performance analyses will be compared with the major asset classes: stocks, bonds, listed real estate, and direct property of the Netherlands and Great Britain. On the basis of this comparison can be seen how the clean tech sector in general perform compare to these major asset classes.

In chapters 3 to 6 the subcategories, wind, solar, biomass, and CO_2-storage are described in detail. This design comes back in the presentation of the performance analysis. First, a performance analysis is calculated of the clean tech sector, followed by a performance analysis by sub-category: wind, solar, biomass, and CO_2-storage.

7.4 Description of infrastructure and utilities sub-sectors

The following paragraphs are about the data that is used to calculate the return and risk of clean tech. In the literature clean tech is seen as part of the asset class Infrastructure (see paragraph 2.7.3).

UBS, a global financial service manager, has an index composed that forms a stable and objective basis for evaluating the performance analysis of the growing global listed Infrastructure and Utilities Market: *The UBS Global Infrastructure & Utilities Index series.* This index is chosen because it has a reasonable size (see paragraph 7.5) and gives a good indication of how clean tech sector perform. Because clean tech is a part of Infrastructure, the index components energy generation and energy transmission & distribution can be selected from the *UBS Global Infrastructure & Utilities Index series* (see figure 40 & green field next page). And thus, a performance analysis can be calculated of these categories.

Figure 40: sub-categories of clean tech

Segment	Financiable	Wealth creating	Physical	Multiple users	Stable cash flow	Examples
Agriculture	-	-	-	x	-	
Air & Environment	-	-	-	-	-	
Energy generation	x	x	x	x	x	Wind, solar, biomassa
Energy transmission & distribution	x	x	x	x	x	Networks
Energy storage	-	-	-	-	-	
Energy efficiency	-	x	x	-	-	
Manufacturing	-	-	x	x	-	
Materials	-	-	-	-	-	
Recycling & waste	-	-	x	-	x	
Transportation	-	-	x	x	-	
Water & watewater	-	-	x	x	x	

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On the basis of the UBS Global Infrastructure and Utilities index a return/risk analysis has been set and compared with other major asset classes; stocks, bonds, and real estate. The figure below presents a profile of the various UBS Global Infrastructure and Utilities indices. A performance analysis of the categories, **Generation and Transmission & Distribution**, results in a well-formed picture of the returns and risks of clean tech sector.

Infrastructure

Concessions, lease or freehold for:

•**Toll roads**: revenue from collection tolls.
•**Airports**: revenue from collection of aircraft landing fees, terminal fees and revenue from airport retail, property and parking.
•**Ports**: involves sea ports; revenue from port usage, cargo handling and property fees.
•**Rail**: revenue from rail usage fees; does not including rolling stock
•**Communications**: revenue from communication usage fees (e.g., broadcast/mobile towers, satellites, fiber optics).
•**Diversified**: combination of above sub-sectors.

Utilities

•**Integrated utilities**: vertically integrated utility business that is more exposed to competitive markets than regulated markets (e.g., electricity, gas, generally own generation, production, and energy retailing.
•**Integrated Regulated**: vertically integrated utility business that is more exposed to regulated markets than competitive markets.
•**Transmission & distribution**: utility business exposed to transmission and distribution assets (e.g., electricity transmission towers, pipelines, distribution networks.
•**Generation**: involved of generation of electricity: includes renewable energy generation.
•**Diversified**: combination of above sub-sectors: not related or integrated.

Source: UBS, 2006

7.5 Data for comparative analysis

Infrastructure series

The following infrastructure performance series is used: UBS Total return indices for the infrastructure and utilities sector over 2000:Q1 to 2009:Q1, representing the Global and European listed infrastructure sector. The UBS global infrastructure and utilities series comprised 242 companies/funds with a total market capitalization of $ 1,321 billion (UBS, 2006).

The following categories of the UBS Total return indices for the infrastructure and utilities sector were used in this study:

- Global Infrastructure: 39 funds/companies @ $ 88 billion
- Global Utilities: 203 funds/companies @ $ 1,233 billion
    - Transmission & distribution: 50 funds/companies @ $ 130 billion
    - Generation: 21 funds/companies @ $ 58 billion
- European Infrastructure: 23 funds/companies @ $ 55 billion
- European Utilities: 56 funds/companies @ $ 480 billion
    - **Transmission & distribution: 12 funds/companies @ $ 45 billion**
    - **Generation: 8 funds/companies @ $ 27 billion**

(last two items: **Clean tech**)

Other investment performance series

For comparative analysis the following data is used:

- Real estate:
    - United Kingdom: IPD
    - The Netherlands: ROZ-IPD
- Stocks: MSCI
- Listed property: EPRA
- Bonds: Bloomberg EFSAS

Risk free rate

- European central bank: ECB government bond yield 10 year period average.

7.6 Clean tech performance analysis

Return-/risk analysis

The figure below presents the return-/risk performance analysis for the global and European infrastructure and other major asset classes over the period 2000 – 2009:Q1.

Figure 41: performance analysis: 2000 – 2009:Q1

Asset class	Average annual return	Annual risk	Risk/return ratio	Sharpe ratio
Global transmission & distribution	3,01%	16,84%	5,59	-0,07
European transmission & distribution	2,99%	18,35%	6,14	-0,07
Global generation	-0,59%	41,82%	-70,42	-0,12
European generation	6,89%	27,90%	4,05	0,05
Global Utilities	2,22%	18,06%	8,15	-0,11
European utilities	3,25%	18,31%	5,63	-0,05
Global infrastructure	2,90%	16,34%	5,63	-0,08
European infrastructure	4,13%	16,00%	3,88	-0,01
Listed property	2,09%	22,86%	10,96	-0,09
Stocks	-1,76%	19,44%	-11,07	-0,31
Real Estate UK	2,90%	8,24%	2,85	-0,16
Real Estate NL	9,84%	9,22%	0,94	0,61
Bonds	2,73%	3,90%	1,43	-0,38

Source: author edit

- Annual risk is the annualised standard deviation of the perspective quarterly returns
- Real estate volatility has not been adjusted for valuation - smoothing.
- 2000 – 2009:Q1 – from the year 2000 till the first quarter of 2009

Real Estate NL and Generation Europe have the best average annual return of all asset classes, with an average annual return of 9.84% and 6.89%. The asset classes Stocks and Global Generation are the only asset classes with a negative average annual return, with an average annual return of -1.76% and -0.59%. It is remarkable that Global Generation returns significantly under-performed their equivalent European Generation.

Global Generation and European Generation have the highest annual risk rate, with a risk rate of 41.82% and 27.90%. Global Utilities and European Utilities show a significantly lower risk rate, with annual risk rates of 18.31% and 18.06%.

The risk rates of Global Generation and European Generation are also significantly higher than the risk rates of the major European asset classes. Bonds show the lowest annual risk rates. It is striking that the vast majority of the asset classes show negative Sharpe ratios, except Generation Europe and Real Estate NL. The Sharpe ratio is used to show how the extra returns compensate the extra risk. A higher ratio means a relatively higher compensation for the investment. A negative Sharpe ratio means that the returns of the asset class are lower than the risk-free returns. For the calculation of the Sharpe ratio a risk-free rate is used of 4.37%, based on an ECB government bond yield 10 year period average.

<u>Portfolio diversification</u>

To assess the portfolio diversification benefits of European infrastructure, the figure below presents the inter-asset correlation matrix over 2000 – 2009:Q1. Diversification is achieved if investments have a correlation coefficient of less than 1. By adding European Generation or European transmission and distribution to the investment portfolio leads to a more efficient diversified portfolio. Global Generation and European Generation are even negatively correlated with Real Estate NL and bonds. A negative correlation means that, for example, higher returns for European Generation should result in lower returns for Real Estate NL and Bonds.

Figure 41: inter-asset correlation matrix: 2000 – 2009:Q1

Asset class	Global transmission & distribution	European transmission & distribution	Global generation	European generation	Global Utilities	European Utilities
Global transmission & distrubution	1,00					
European transmission & distrubution	0,63	1,00				
Global generation	0,70	0,44	1,00			
European generation	0,63	0,41	0,80	1,00		
Global Utilities	0,88	0,63	0,87	0,78	1,00	
European Utilities	0,65	0,73	0,68	0,76	0,82	1,00
Global Infrastructure	0,64	0,64	0,64	0,74	0,76	0,80
European Infrastructure	0,60	0,53	0,56	0,73	0,69	0,72
Listed property	0,58	0,54	0,49	0,65	0,59	0,66
Stocks	0,62	0,63	0,71	0,79	0,76	0,87
Real estate UK	0,31	0,44	0,29	0,42	0,38	0,55
Real estate NL	0,11	0,12	-0,04	-0,05	0,03	0,16
Bonds	-0,19	-0,07	-0,38	-0,56	-0,32	-0,41

Asset class	Global Infrastructure	European Infrastructure	Listed property	Stocks	Real estate UK	Real estate NL	Bonds
Global transmission & distribution							
European transmission & distribution							
Global generation							
European generation							
Global Utilities							
European Utilities							
Global Infrastructure	1,00						
European Infrastructure	0,93	1,00					
Listed property	0,74	0,79	1,00				
Stocks	0,84	0,76	0,71	1,00			
Real estate UK	0,59	0,61	0,74	0,53	1,00		
Real estate NL	0,07	0,08	0,07	0,21	-0,03	1,00	
Bonds	-0,31	-0,35	-0,22	-0,51	-0,29	0,01	1,00

Source: author edit

7.7 Sub-period performance analysis

Figure 42: performance analysis 2000 - 2002

Asset class 2000-2002	Average annual return	Annual risk	Risk/return ratio	Sharpe ratio
Global transmission & distribution	4,07%	20,97%	5,16	-0,04
European transmission & distribution	-0,32%	20,17%	-62,48	-0,25
Global generation	-15,77%	60,22%	-3,82	-0,34
European generation	-1,01%	32,23%	-32,00	-0,18
Global utilities	-0,97%	23,89%	-24,60	-0,24
European utilities	-1,87%	14,98%	-8,01	-0,45
Global infrastructure	-0,03%	17,73%	-646,27	-0,27
European infrastructure	4,05%	16,98%	4,19	-0,04
Listed property	3,59%	14,97%	4,17	-0,08
Stocks	-7,81%	21,38%	-2,74	-0,59
Real Estate UK	4,51%	1,05%	0,23	-0,29
Real Estate NL	9,07%	3,69%	0,41	1,16
Bonds	3,70%	3,16%	0,86	-0,35

Figure 43: performance analysis 2003 – 2005

Asset class 2003-2005	Average annual return	Annual risk	Risk/return ratio	Sharpe ratio
Global transmission & distribution	6,24%	14,17%	2,27	0,17
European transmission & distrubution	4,53%	15,44%	3,41	0,05
Global generation	18,26%	26,74%	1,46	0,54
European generation	20,88%	18,44%	0,88	0,93
Global utilities	9,54%	11,49%	1,21	0,50
European utilities	12,12%	14,98%	1,24	0,55
Global infrastructure	12,00%	10,46%	0,87	0,78
European infrastructure	10,38%	14,17%	1,37	0,46
Listed property	13,63%	14,18%	1,04	0,69
Stocks	8,99%	13,92%	1,55	0,37
Real Estate UK	7,69%	2,41%	0,31	1,60
Real Estate NL	8,38%	3,28%	0,39	1,39
Bonds	2,78%	3,16%	1,14	-0,33

Figure 44: performance analysis 2006-2009:Q1

Asset class 2006 - 2009:Q1	Average annual return	Annual risk	Risk/return ratio	Sharpe ratio
Global transmission & distrubution	-0,93%	15,32%	-16,39	-0,33
European transmission & distribution	0,06%	19,32%	336,36	-0,21
Global generation	-4,00%	25,87%	-6,47	-0,31
Europees generation	-0,13%	27,91%	-221,76	-0,15
Global utilities	-4,00%	15,96%	-3,99	-0,50
European utilities	1,80%	22,60%	12,57	-0,10
Global infrastructure	-2,79%	16,92%	-6,06	-0,40
European infrastructure	-1,57%	15,32%	-9,74	-0,37
Listed property	-9,96%	29,75%	-2,99	-0,47
Stocks	-6,08%	19,10%	-3,14	-0,53
Real Estate UK	-3,02%	11,57%	-3,83	-0,61
Real Estate NL	7,30%	2,55%	0,35	1,27
Bonds	1,79%	5,11%	2,85	-0,44

Source: author edit

To assess the potential changing investment dynamics, the full period of 2000 – 2009:Q1 was broken in three sub-periods of 2000 – 2002, 2003 – 2005 and 2006 – 2009:Q1. The above figures present the different results. What immediately strikes, the period 2003 – 2005 is the only period in which all asset classes show positive returns. All asset classes show higher returns in this period, in comparison with the periods 2000 – 2002 and 2006 – 2009:Q1, except for bonds. Bonds gain the highest return in the period 2000 – 2002. Remarkably, in the period 2003 – 2005 the risk rates of all asset classes are lower than the other two periods. 2003 – 2005 is a period of higher returns and lower risks compared with the periods 2000 – 2002 and 2006 – 2009:Q1. This also results in better risk/return ratios and positive Sharpe ratios for the relevant period.

Now the focus on the asset class generation. European Generation shows better returns than Global Generation in all periods. But the returns are only positive in the period 2003 – 2005. In this period, European Generation and Global Generation are even the best performing asset class, with an average annual return of 20.88% and 18.26%. Real Estate UK (1.60) and Real Estate NL (1.39) show the best Sharpe ratio in this period.

7.8 Performance analysis of wind, solar, biomass (levelized cost of energy)

World Economic forum has calculated levelized cost of energy of the clean tech categories. In the report 'Green Investing' (2009) the levelized of cost of energy (LCOE) is described as follows:

"Levelized cost of energy allows different energy technologies to be compared, taking into account their cost of production and generation efficiency. Levelized costs of energy exclude any subsidies".

A levelized cost of energy model has the following input:

- Investment costs
- Depreciation period
- Real interest rate
- Cost of maintenance
- Annual return (kWh)

For the calculation of the LCOE the following assumptions are made:

- Internal hurdle/return rate: 10% (which is used to derive generation costs)
- Interest rate: 2.5%
- Fuel price: Coal=US$ 115.29/tonne; Natural Gas = US$ 11.49/MMBtu; Carbon price (2009) = US$ 28.11/tonne.

In the report 'Green Investing' the following results are presented:

Wind energy – onshore

Potential Scale	Greater than 1,000GW, of which only 100GW has been exploited.
Market Readiness	LCOE = US$ 89- 126/MWh
Project Returns	10-20% depending on market and resources

Wind energy – offshore

Potential Scale	100GWs
Market Readiness	LCOE = US$ 158-205/MWhProject
Returns	Marginal

Solar energy – photovoltaic

Potential Scale	13.3GW currently installed Potential capacity limited only by economics
Market Readiness	LCOE = US$ 341-549/MWh Currently extremely uneconomical but with potential to halve in next 2 years
Project Returns	Heavily dependent on incentive regime

Solar energy – Concentrated solar power

Potential Scale	438MW currently Scale limited only by space and grid connection has been exploited.
Market Readiness	LCOE = US$ 241-299/MWh Uneconomic
Project Returns	n/a

Biomass – First generation

Potential Scale	70 billion Lpa commissioned production capacity Global production estimated to reach 255 billion Lpa by 2030
Market Readiness	Brazilian sugar ethanol is market-ready i.e. competitive in its own right with oil at US$ 40/barrel
Project Returns	n/a

Biomass – Next generation

Potential Scale	10 mLpa commissioned production capacity currently
Market Readiness	5-7 years away from commercial production
Project Returns	n/a

CO_2-storage

Potential Scale	18 $MtCO_2e$ injected in 2008, equivalent to CO_2 capture from 1.4GW generation
Market Readiness	The viability of CCS is entirely dependent on the existence of the carbon markets and CO_2 price
Project Returns	n/a

Glossary abbreviations:

- GW: Giga-Watt (10^9 watts)
- MWh: Megawatt hours
- US$: United States Dollars
- N/a: not available
- LPA: Litres per annum
- mLpa: Million litres per annum
- $MtCO_2e$: Metric tons of carbon dioxide equivalent
- MMBTU: one million British Thermal Units per hour
- CCS: carbon capture storage

LCOE is a cost of generating energy (usually electricity) for a particular clean tech category. Of the clean tech categories onshore wind energy has the lowest costs to produce energy, with an LCOE of US$ 89-126/MWh. Solar energy - photovoltaic has the highest costs for producing energy, with an LCOE of US$ 341 – 549/MWh, and is currently very uneconomical without subsidies, but has the potential to halve in the next two years. The project returns of onshore wind energy are 10-20%, depending on market and resources. The project returns of offshore wind energy are marginal and the project returns of solar energy – photovoltaic are heavily dependent on incentive regime in the countries. First generation biomass - sugar based ethanol - is cost-competitive with an oil price at US$ 40/barrel. The next generations of biomass are 5-7 years away from commercial production. The viability of CO_2-storage is dependent on CO_2-price and carbon markets.

7.9 Conclusion

Chapter 7 gives an answer to the fifth sub-question: how to invest in clean tech?

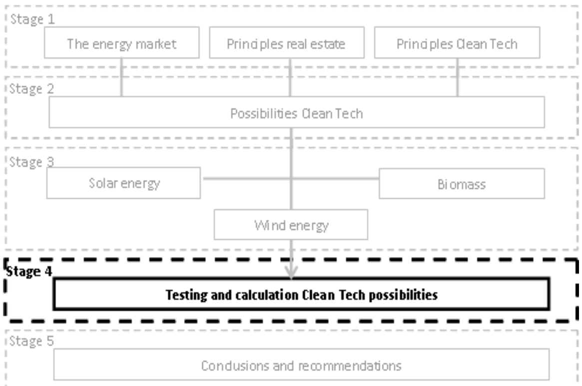
There are great differences between the sub-periods. Period 2003 – 2005 is a period with a lot of positive returns. The periods 2000 – 2002 and 2006 – 2009:Q1 show the opposite picture, periods with many negative returns. Possible explanation for the negative returns of the period 2000 – 2002 could be the 'dot.com bubble'. The dot.com bubble was a boom that lasted from 1997 until the spring of 2001. During this boom the value of stock raised rapidly due the growth of the internet sector. The bubble refurbished in the spring of 2001, and caused a mild global recession but this recession lasted unexpectedly long for most western countries. A possible explanation for the negative returns for the period 2006 – 2009Q1 is the financial crisis. The financial crisis has already been addressed in this master thesis (see paragraph 3.6). The financial crisis arose around the summer of 2007 and led to a global recession which is ongoing at the time writing this thesis. The results per sub-category: wind energy has with US$ 89-126/MWh the lowest LCOE and solar energy-photovoltaic has with US$ 341 – 549/MWh the highest LCOE. First generation biomass-sugar based ethanol is cost-competitive with an oil price of US$ 40/barrel. The next generation biomass is 5-7 years away from commercial production. The viability of CO_2-storage is entirely dependent on the existence of the carbon markets and CO_2-price. The project returns of onshore wind energy are between 10-20%, depending on market and resources. The project returns of offshore wind energy are marginal. And the project returns for solar energy-photovoltaic are heavily dependent on subsidy regimes. The project returns of the other categories are not available.

8 CLEAN TECH SPECIALISTS

8.1 Preface

This chapter focuses on the clean tech specialists. A number of specialists, from the field, were interviewed. The persons that are chosen for the interviews are directly or indirectly involved in investing in clean tech. Besides real estate investors, also a specialist in DBFM-contracts and PPP-contracts and an analyst of clean tech from Rabobank were interviewed. I chose for this mix of specialists to get a clear view of clean tech as an alternative investment category. This chapter will give an overview of the results arising from these interviews. This chapter gives an answer to the last research question: what are the expectations of the clean tech specialists on clean tech investments?

Figure: position in the research process



8.2 Methodology

First, I will explain what methodology I have used during the interviews with these specialists. I have chosen a wide range of companies from the real estate sector, such as institutional investors, private investors, banks and consultancies, because clean tech is a new investment category. And to interview a wide range of companies, a clear view is formed about how the real estate sector thinks about investments in clean tech. Before the interview, the specialists received a questionnaire. The interviews were interactive and the questionnaire was used as a checklist. The questionnaire contained a number of questions with subjects, which also have been treated earlier in this master thesis. The theory material that was found was presented before the interview started. There are five specialists interviewed: Mr. Henk Huizing of PGGM, Mr. Menno Witteveen of DIF, Mr. Robbert Coomans of APG Asset Management, Mr. Rienk de Jong of Rebel Group Advisory and Mr. Harold Meinders of the Rabobank Group.

8.3 Related companies

PGGM

From PGGM I have spoken with Mr. Huizing, Head of Infrastructure Investments. PGGM invest 74.4 billion euro’s for its client Pensioenfonds Zorg en Welzijn. The total value of the real estate portfolio (including infrastructure) is 13.605 billion euro’s at end 2008 (Vastgoedmarkt, 2008). Of the real estate portfolio is about 55% invested in listed real estate funds and 45% invested unlisted real estate funds. PGGM also invest in infrastructure; include some categories of clean tech. The infrastructure assets consist of long-term contracts, sometimes with government counterparts. The cash flows are stable, possible related to inflation and relatively insensible for fluctuations in the economic cycle. PGGM invest in infrastructure through funds, or direct.

DIF

From DIF I have spoken with Mr. Witteveen, Managing Partner. DIF is an independent investment fund manager offering investor's access to infrastructure portfolio's by investing risk bearing capital in the underlying projects (DIF, 2009). In 2005, DIF launched their first investment funds with the focus on investments in Public Private Partnerships. In 2007, DIF launched their second investment funds with the focus on renewable energy. In 2008, their third investment fund Infrastructure II was launched. DIF is one of the few fund managers that give investors the opportunity to invest in clean tech, such as onshore wind energy and photovoltaic projects.

APG

From APG Asset Management I have spoken with Mr. Coomans, advisor to the board. APG is one of the world's largest pension administration organisation. APG has asset under management of approximately € 173 billion. The total value of the real estate portfolio is 15 billion euro's at end 2008 (Vastgoedmarkt, 2008). APG Asset Management invests globally in a large number of funds that invests in infrastructure. In many cases is APG Asset Management one of the larger participants in these funds, so that they can exert serious influence on the investments. APG Asset Management is, within the sector, increasingly searching for innovative projects, such as wind energy or biomass plants.

Rebel Group Advisory

From Rebel Group Advisory I have spoken with Mr. De Jong, Analyst at Rebel Group Advisory. Rebel Group has been working with a strong financial-strategic orientation at the interface between public and private sectors. Rebel Group has an international order portfolio in sectors such as infrastructure, regional development, real estate, health care, energy and water. One of Rebel Group Advisory specializes are PPS- and DBFM contracts. This type of contacts can play an important role for investing in clean tech. Therefore Rebel Group Advisory was an interesting conversation partner.

Rabobank Group

From the Rabobank Group I have spoken with Mr. Meinders, Industry Analyst at the Industry Knowledge Team. Internationally, Rabobank focuses on the food, beverage, and agribusiness sectors offering specialized products and services in more than 50 countries. Sustainability is important at the Rabobank Group. Rabobank Project Equity invests equity capital in the development and construction of clean tech in Europe. Examples include wind farms, biomass/biofuel plants and solar projects. Mr. Meinders is a specialist in within the Rabobank Group, who is engaged with the analysis of the clean tech market.

8.4 Interviews

Does your company currently invest in clean tech? If so, in which categories of clean tech is invested?

In theory, investments in clean tech are a part of the asset class infrastructure. This is also reflected in the interviews with the specialists. PGGM and APG Asset Management include investments in clean tech in the category infrastructure. Of the interviewed organisations PGGM, APG Asset Management and DIF are the organisations that actually invest in clean tech. DIF invests in onshore wind energy and photovoltaic projects. PGGM & APG Asset Management invests in clean tech mainly trough investment funds and joint ventures. For example, through investment funds Ampere. Ampere is cooperation between PGGM and APG Asset Management, which invests in onshore and offshore wind energy and biomass power stations in Western European Countries. Invest in biomass is more difficult than investing in wind- and solar energy. To get biomass profitable you need large quantities in comparison with wind and solar energy. In addition, biomass is socially difficult, because the food-for-fuel debate. Therefore APG Asset Management focuses on the second generation biomass crops, non-edible crops, and waste incineration. APG Asset Management also invests in technological developments in renewable energy. These developments will contribute to new methods of generating renewable energy. Rabobank Group invests equity capital in wind energy, biomass/biofuel plants and solar projects. This corresponds with the policy of Rabobank group: the development of sustainable energy and technology throughout the world. Rebel Group Advisory does not invest in clean tech, but has done many advisory on PPS- and DBFM-contracts for infrastructure and clean tech projects.

What are the main risks of investing in clean tech?

According Mr. Huizing the greatest risk of investing in clean tech is the technological development, mainly for solar energy and biomass. For the clean tech industry it is important that these technologies develop. A lot of technological progress can be achieved in energy-efficiency and production costs. The energy-efficiency must be improved, to get clean tech more cost-competitive with fossil fuels. Another risk is the duration time of the projects, and especially to obtain a permit. The duration time to get a permit is long in some countries and this leads to additional costs. Subsidy is in some extent also a risk. Clean tech projects are dependent on subsidy and are no longer viable once clean tech subsidy is abolished. Finally, according to Mr. Huizing, the oil price is a risk because low oil prices are not favourable for investing in clean tech.

Mr. De Jong said that the clean tech investment market is relatively immature and that leads to uncertainties. The clean tech market is in the development phase. There are still coming new technologies on the market that could be, according the developers, the solution for the energy problem. It is not clear which category of clean tech will be the leading form in the future. Wind energy is less risky than biomass, because wind energy has developed through the years. Compared to biomass, biomass is still in the development phase and for biomass some technological developments expected in the coming years. There is also a political risk. For example, new policy about clean tech trough elections may have adverse affects.

Mr. Coomans said that the biggest risks for clean tech are the subsidies. Not one clean tech category is profitable without subsidies. This means when there are no subsidies no one will develop any clean tech projects. This doesn't count for existing projects, but for developers is the existence of these subsidies very important. Another risk is the technological development. For example, offshore wind energy, the first wind farms on sea are recently put into use, so the risks are not even identified.

Mr. Witteveen said that investments in clean tech, in the way DIF invest, has few risks. The investments in clean tech are very conservative. DIF only invests in clean tech projects when all permits are granted and all contracts are signed. For example contracts of energy take-over are signed before DIF invests in a clean tech project. And so, DIF is insured of a stable stream of cash flows. If DIF invests in a clean tech project, they try to get a majority interest, to get control over the clean tech project. DIF only invest in the clean tech categories; wind energy and photovoltaic. The other categories, such as offshore wind energy and biomass are too risky.

What do you expect of the development of return of investing in clean tech?

The projected return of clean tech is in general positive. There are technological developments to expect for the energy-efficiency, and there are improvements to expect regarding to the production costs of clean tech. Looking forward, the interviewees think that the demand for renewable energy will increase, but much depends on subsidies. Without subsidies clean tech is not profitable for the coming years.

Is investing in clean tech associated with much government interference? If so, what is your opinion about this?

There is consensus about that government interference, for clean tech investments, has advantages and disadvantages. The advantages are the energy take-over contracts with public authorities. The payments of public authorities are safe. So there is no debtor risk. Another important advantage is the subsidies. Without subsidies clean tech projects could not exist. Therefore governments play an important role in clean tech projects. Disadvantages of government influence can be granting permits. The duration time can be long for granting permits and this result in planning difficulties. Another disadvantage is if a government decides to change the policy about clean tech. For example, the abolition of the MEP-regeling initiated by Minister Wijn of the Netherlands in 2006. The MEP-regeling was designed to support the production of sustainable energy. The MEP-regeling had become too expensive and was suddenly abolished. The trust disappeared among developers of clean tech projects; perhaps this is the reason why the renewable energy ambition of the Netherlands is far behind schedule.

Is investing in clean tech management intensive? If so, what is your opinion about this?
Mr. Witteveen, Mr. Huizing, and Mr. Coomans indicate that the management intensity of investments in onshore wind energy and photovoltaic is not as intensive is it seems. Once a project is realized and all contracts are completed, it is not management intensive. In contrary to biomass, investing in biomass is management intensive, because there are many more processes needed to produce energy. This leads to additional costs and risks, and making investments in this type of clean tech less attractive.
Mr. De Jong and Mr. Meinders indicate that the management intensity is related to the phase at which an investor steps in a project. Participate in the initial phase of a project will be much more management intensive than participate in a project that is already completed. And when an investor participates in an early phase of the project he needs to hire qualified personnel to support these projects.

Research has shown that some countries offer benefits for investing in clean tech. Is this reflected in your investment strategy?
Mr. Huizing said that the subsidy regimes of the countries are ultimately decisive. Precursors with subsidy regimes for clean tech are Spain and Germany. Investments in clean tech are therefore preferred in these countries. The Netherlands are behind in subsidy-regime compared to other European countries, partly due the abolition of the MEP-regeling.
Also Mr. Witteveen and Mr. Meinders said that the subsidies are the most important factor for selecting a country. Countries such as Germany, Spain and France are preferred.
Mr. Coomans said that attractive countries for biomass are Germany, France and The Netherlands. Preferred counties for solar energy are Spain and Italy.

How does the market of clean tech develop in the coming years?
There is consensus that the market of clean tech will continue develop. Clean tech has the future. The objectives of the EU play also an important role. Many countries are fully engaged to achieve the 20-20-20 goal of the EU. The development of the oil price is also an important factor. Clean tech will benefit from a high oil price. There are also expectations about reducing the production costs and improving the energy-efficiency, mainly for solar energy. Mr. De Jong said that the returns over the years, maybe fall back. Especially when there are many parties / competitors in the market, the returns could be reduced.

8.5 Conclusions

Chapter 8 gives an answer to the final sub-question: what are the expectations of the clean tech specialists on investments in clean tech?

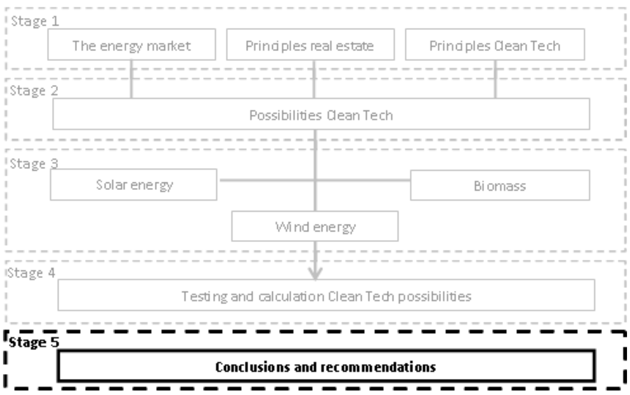
The interviewed specialists are positive about the expectations of investing in clean tech. This because fossil fuels are finite. There are technological improvements possible according production costs and energy efficiency. The specialists expect the most of solar energy, given the potential of this technology. But the expectations are only positive if the subsidies on clean tech are extended. Because the specialists don’t think that clean tech becomes profitable without subsidies for the coming years.

9 CONCLUSIONS & RECCOMENDATIONS

9.1 Preface

The research objective of this master thesis was to identify the attractiveness of clean tech as an alternative investment category compared to other asset classes such as shares, bonds and real estate. The intention was to write a guide for Bouwfonds REIM, so that they may set up an investment fund with clean tech in the future.

Figure: position in research process



The central question of this master thesis is as follows:

"What makes an investment in clean tech an interesting alternative investment category for investors?"

The central question was divided into six sub-questions:

- What are the developments on the energy market?
- What to invest in?
- What is the status of the clean tech sub-categories?
- Where to invest in?
- How to invest in clean tech?
- What are the expectations of the clean tech specialist on investments in clean tech?

The answers to these questions will lead to a conclusion that is presented in paragraph 9.2. And after the conclusions the recommendations are described in paragraph 9.3. The master thesis consists of a literature study and interviews with specialists in clean tech investments. And there is a risk-/return performance analysis calculated of the clean tech sector and compared with the major asset classes: stocks, bonds, and real estate. The UBS Global Infrastructure & Utilities index series was used to calculate the risk-/return performance analysis of the clean tech sector. In addition, the performance analyses were presented per subcategory: wind, solar, biomass, and CO_2-storage.

9.2 Conclusions

It is expected that the share of renewable energy in the energy mix will increase in the coming decades. The fossil fuels are finite and harmful to the environment. Alternative forms of energy are needed and renewable energy is one of the solutions. The world is currently very dependent on fossil fuels and is facing an energy problem. The demand for fossil fuels is increasing while the supply is increasing. This is partly due the economic growth of countries such as China and India, which the demand for fossil fuels increased enormously. With help of the financial crisis, the demand for fossil fuels decreased slightly (see the oil price) but it is likely that the consumption of fossil fuels will restore in the coming years. So the demands of fossil fuels increases and supply decreases, but what are the predictions about fossil fuels and how many years can the world use these fossil fuels. The predictions are:

- Natural Oil: **41,6 years**
- Natural Gas: **60,3 years**
- Coal: **133 years**

As can be read the end of natural oil and natural gas is within a few decades. There is still enough coal for the next 133 years, but coal has one big disadvantage: the use of coal is very bad for the environment. With the combustion of coal a lot of CO_2 releases. A possible substitution for fossil fuels is nuclear energy. But nuclear energy has also one big disadvantage and that is nuclear waste. There are problems with the storage of nuclear waste and nuclear waste can be radioactive for thousands of years. So a solution for the energy problem is renewable energy also called as clean tech.

But what to invest in? Which categories of clean tech is also real estate. Several characteristics of real estate such as: financeable, wealth creating, physical, multiple users, stable cash flows are compared with the characteristics of clean tech categories. From this equation follows the conclusion that **windmills**, **solar panels**, and **biomass** fits within the definition of real estate.

Technological developments are important for the clean tech sector. So what is the status of the clean tech categories?

Onshore wind energy: onshore wind energy is currently the most cost competitive renewable energy form with the costs of electricity from the network. Onshore wind energy is a mature technology with established markets.

Offshore wind energy: the first offshore windmills are currently in use and that is immediately the weakness of offshore wind energy. This technology is still in development and the risks must be identified for the coming years. Windmills at sea have other requirements than onshore windmills and there is no clarity the durability of windmills on the sea. The maintenance of offshore wind energy is much harder than on land and the grid connection is much more expensive.

Solar energy: such as onshore wind energy photovoltaic solar can be seen as a mature technology with established markets. In the coming years, photovoltaic will benefit from the increasing energy-efficiency and the reducing production costs party through the use of other materials. Thin-film and Concentrated Solar Power are relatively new technologies with an interesting future. Solar energy is seen as the technology, if the development continues, could be cost-competitive with fossil fuels in the future.

Biomass: this technology is more difficult than wind energy and solar energy. First, biomass becomes profitable with large quantities of biomass crops. And therefore you also need a lot of farmland. Second problem is the food-for-fuel debate. Only that doesn't count for 2^{nd} and 3^{rd} generation biomass. Third, there are many more processes needed to produce energy compared to wind and solar energy. Finally, this technology is still in development and new biomass technologies will be developed the coming years.

Climate factors and subsidy regime are the main factors for choosing a location for clean tech. So where to invest in clean tech? In conclusion: the best countries to invest in onshore wind energy, on a basis of wind characteristics and subsidy regimes, are: **Germany**, **France**, **Ireland**, **Spain** and the **U.K.** And for offshore energy: **U.K., Ireland** and **France**. The best countries to invest in solar energy, on a basis of solar irradiation and subsidy regime are: **Spain, Italy** and **Germany**. The most interesting countries for biomass, on a basis of suitable arable lands are: **northern and western France**, **Ireland**, **Germany**, **Eastern Hungary**, and the **Po Valley**, along the **Danube** in **Bulgaria** and **Romania,** and parts of the **Baltic States**.

To answer the question how to invest in clean tech the risks of clean tech need to be identified. What are the conclusions about the biggest risks for investing in clean tech? The biggest risk of clean tech is the **stability of the subsidy regimes**. Clean tech is not profitable without subsidies. So if subsidies are abolished, there will be no clean tech projects be developed in the future. Abolition will not happen retroactively, so this doesn't count for the current projects. Second risk, raising **finance** for the clean tech projects is one of the toughest challenges. This is partly due the limited capital that is available, caused by the current financial crisis. Third risk, **low oil prices**. Clean tech will benefit from high oil prices, because with high oil prices clean tech is a good alternative. For example, the prices that are calculated for wind energy are usually between ranges of $52 - $90 per MWh. So wind energy could be cost-competitive with oil prices of $ 52,-. Last risk, **technological development**. Clean tech need technological development to get more cost-competitive with fossil fuels, and only then clean tech will play a meaningful role in the future.

There is a difference in risks between investments in projects that are under development or a realised project that's already in use. For a realised project permits are granted and long term energy take-over contracts are completed and so the cash-flows are known for a long period. In this case there is little risk, and it can be regarded is a conservative investment. This does not apply to invest in a project still under development. These risks are much greater because, for example, permits must be requested and granted, energy take-over contracts must be completed and changes may occur in subsidy regimes. With regard to the risks, the difference between a project under development and a realised project is very important.

What are the conclusions about the return-/risk performance analysis of the clean tech sector calculated over the period 2000-2009:Q1? European Generation has a return of **6.89%** and Global Generation has a return of **-0.59%**. European Transmission & Distribution has a return of **2.99%** and Global Transmission & Distribution has a return of **3.01%**. In addition the correlations are calculated. European Generation is positive correlated with listed property (0.65), Stocks (0.79), and Real Estate UK (0.42). And European Generation is negative correlated with Real estate NL (-0.05) and Bonds (-0.56). European Transmission and Distribution is positive correlated with listed property (0.54), Stocks (0.63), Real Estate UK (0.44) and Real Estate NL (0.12). And European Transmission and Distribution is negative correlated with Bonds (-0.19).

The project returns per subcategory are: wind energy between 10-20%, depending on market and resources. The project returns of offshore wind energy are marginal. And the project returns for solar energy-photovoltaic are heavily dependent on subsidy regimes. First generation biomass-sugar based ethanol is cost-competitive with an oil price of US$ 40/barrel. The next generation biomass is 5-7 years away from commercial production. The viability of CO_2-storage is entirely dependent on the existence of the carbon markets and CO_2-price.

The interviewed specialists are positive about the expectations of investing in clean tech. First, the stocks of fossil fuels are finite and clean tech is a replacement for fossil fuels. And there are technological improvements possible and with these technological improvements becomes clean tech more cost-competitive with fossil fuels. The specialists expect the most of solar energy, given the potential of this technology. But much of these expectations depend on subsidies. Because the specialists don't expect that clean tech is profitable without subsidies for the coming years.

In conclusion, this master thesis gives a clear view for investing in clean tech. Clean tech is a new alternative investment category. This master thesis can be used as a guide for investing in clean tech. This master thesis has answered the questions why invest in clean tech, which categories of clean tech are real estate, what is the status of the technological developments, in which countries invest in clean tech, and what are the risks and return of investing in clean tech. Finally, answers to these questions leads to the following clean tech investment categories:

- Clean tech energy gives stable returns on a basis of long-term contracts.
- Inflation hedge.
- Diversification.
- A conservative risk profile where the main risks in course of time diminish.

9.3 Recommendations

My first recommendation is choose to establish an investment funds for the following investment categories: onshore wind energy, photovoltaic solar energy, and concentrating solar power. I give this recommendation because, onshore wind energy and photovoltaic solar energy, are mature technologies with established markets. These technologies have been tested and developed for several years, and therefore the risks are well identified. And if concentrating solar power gets its technological developments, such as lowering production costs and improving energy-efficiency, it becomes cost-competitive with fossil fuels within 10-15 years. With these technologies, in the countries with the best subsidy-regimes, good returns can be achieved.

Other technologies such as offshore wind energy and biomass are still in development. The first offshore wind farm has recently put in use. The weather conditions at sea cannot be compared with the weather conditions on land. So the question is what the duration time of the offshore wind turbines is. For example, it is not attractive for an investment if you have to replace the wind turbines within 1.5 year, as 10 years were intended. Another example: the prolapsed offshore windmills off the coast of Egmond aan Zee. The long-term consequences are unclear and recovery options seem impossible at the moment (Telegraaf, 2009). There is not a clear view about these risks. And maintenance is a problem. Maintenance at sea is much more difficult than on land. In addition, the energy must be replaced from the sea to the mainland. Biomass is also a difficult business. This technology is still in development. You need large quantities to get biomass profitable. And there many uncertainties about which biomass crops you can best use. In addition, there are many more processes needed to produce energy compared to wind and solar energy.

My second recommendation is that the market should become more transparent. It is difficult to get returns from the several clean tech categories. Possibly, this also reflects the fact that it is a new asset class and this means that there are low return series available. Investment funds that invest in clean tech can possibly play a role to get the market more transparent. A possible solution could be that the Investment Property Bank IPD, performances of infrastructure investments stores in its database and also treat infrastructure investments as a separate asset class. So it is easier to measure the performance of the clean tech categories and also to benchmark it against other asset classes.

9.4 Self-reflection

Finally, this paragraph is not a part of the scientific framework of the master thesis, but is my opinion about the master thesis. What went well in this research and what could better next time.

I am satisfied with the *research process*. From the start I was able to get the research in the right direction, because I had a good research plan. I've had no setbacks and I was able to keep myself to the predetermined research planning. So I had no delays. I am pleased with the *structure of the master thesis*. The structure is an important part of the master thesis, and the structure ensures that the master thesis is easily readable. I think this master thesis has *interesting information* for real estate professionals. Clean tech is a relative new asset class for real estate investors. This research can be seen as a first step to invest in clean tech. This master thesis has much new information for real estate investors, for example the energy market, explanation of the various clean tech categories and performance analysis of the clean tech categories. The new information combined with the current actuality makes it to an interesting master thesis.

If I can do the research again, what will I do different with the current research? First, I would like to calculate the returns of the clean tech categories by myself. But at this moment the returns of the clean tech categories are not fully available. So at this moment it is not possible to calculate these returns. In addition, if I can do it again I would like to do more interviews with specialists from the real estate sector. But due the limited time of the research I had to keep the current number of interviews.

Finally, I get often the question: do you think clean tech is real estate? A first indication that clean tech is real estate is that I have conducted my research at a real estate investor: Bouwfonds REIM. Bouwfonds REIM is a specialist in the field of real estate investments for the business – and private market. A second indication is the various definitions of real estate. Clean tech fits within the definition that I have used in this master thesis (p. 14). If we look at another definition, used by Van Gool in 'Onroerend goed als belegging' and course material for the module 'Real estate investing': *real estate is everything that is non-movable: land and everything build thereon.* Clean tech categories such as windmills and solar parks are permanently linked with the land and are non-movable. Biomass is agricultural land. So according the definitions this is real estate. Solar cells on roofs of houses of offices are not real estate within my opinion, but a part of real estate.

Of course there are differences with the traditional real estate categories, residential, retail, offices and industrial. Clean tech categories have no tenants; there are differences in management activities, different customers and other risk profile. But that also applies to bridges, tunnels, airports and hotels, and that is also real estate. There are also similarities between clean tech and the traditional real estate categories, such as stable cash flows, both are not quickly realizable, it is a long term investment, long production time, much government regulation and provides protection against inflation.

My opinion as writer of this master thesis is: clean tech is real estate, an alternative form of real estate.

Niels Keulen - July 2009
Student Master Real Estate at the University of Groningen

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ANNEXES

1. **Oil reserves**
2. **Natural gas reserves**
3. **Coal reserves**
4. **Renewable energy policy**
5. **Risk subsectors clean tech**
6. **Questionnaire interviews**

1. OIL RESERVES

Oil

Proved reserves	At end 1987 Thousand million barrels	At end 1997 Thousand million barrels	At end 2006 Thousand million barrels	At end 2007 Thousand million tonnes	At end 2007 Thousand million barrels	At end 2007 Share of total	At end 2007 R/P ratio
US	35.4	30.5	29.4	3.6	29.4	2.4%	11.7
Canada	11.7	10.7	27.7	4.2	27.7	2.2%	22.9
Mexico	54.1	47.8	12.8	1.7	12.2	1.0%	9.6
Total North America	**101.2**	**89.0**	**70.0**	**9.5**	**69.3**	**5.6%**	**13.9**
Argentina	2.2	2.6	2.6	0.4	2.6	0.2%	10.2
Brazil	2.6	7.1	12.2	1.7	12.6	1.0%	18.9
Colombia	1.9	2.6	1.5	0.2	1.5	0.1%	7.4
Ecuador	1.6	3.7	4.5	0.6	4.3	0.3%	22.5
Peru	0.5	0.8	1.1	0.1	1.1	0.1%	26.4
Trinidad & Tobago	0.6	0.7	0.8	0.1	0.8	0.1%	14.1
Venezuela	58.1	74.9	87.0	12.5	87.0	7.0%	91.3
Other S. & Cent. America	0.6	1.1	1.3	0.2	1.3	0.1%	25.2
Total S. & Cent. America	**68.1**	**93.4**	**111.0**	**15.9**	**111.2**	**9.0%**	**45.9**
Azerbaijan	n/a	n/a	7.0	1.0	7.0	0.6%	22.1
Denmark	0.4	0.9	1.2	0.1	1.1	0.1%	9.8
Italy	0.7	0.8	0.8	0.1	0.8	0.1%	17.6
Kazakhstan	n/a	n/a	39.8	5.3	39.8	3.2%	73.2
Norway	6.6	12.0	8.5	1.0	8.2	0.7%	8.8
Romania	1.3	0.9	0.5	0.1	0.5	*	12.4
Russian Federation	n/a	n/a	79.3	10.9	79.4	6.4%	21.8
Turkmenistan	n/a	n/a	0.6	0.1	0.6	*	8.3
United Kingdom	5.2	5.2	3.6	0.5	3.6	0.3%	6.0
Uzbekistan	n/a	n/a	0.6	0.1	0.6	*	14.3
Other Europe & Eurasia	61.7	68.0	2.2	0.3	2.1	0.2%	12.8
Total Europe & Eurasia	**75.8**	**88.0**	**144.1**	**19.4**	**143.7**	**11.6%**	**22.1**
Iran	92.9	92.6	138.4	19.0	138.4	11.2%	86.2
Iraq	100.0	112.5	115.0	15.5	115.0	9.3%	*
Kuwait	94.5	96.5	101.5	14.0	101.5	8.2%	*
Oman	4.1	5.4	5.6	0.8	5.6	0.5%	21.3
Qatar	4.5	12.5	27.9	3.6	27.4	2.2%	62.8
Saudi Arabia	169.6	261.5	264.3	36.3	264.2	21.3%	69.5
Syria	1.7	2.3	3.0	0.3	2.5	0.2%	17.4
United Arab Emirates	98.1	97.8	97.8	13.0	97.8	7.9%	91.9
Yemen	1.1	1.8	2.8	0.4	2.8	0.2%	22.7
Other Middle East	0.1	0.2	0.1	†	0.1	*	10.9
Total Middle East	**566.6**	**693.2**	**756.3**	**102.9**	**755.3**	**61.0%**	**82.2**
Algeria	8.6	11.2	12.3	1.5	12.3	1.0%	16.8
Angola	2.0	3.9	9.0	1.2	9.0	0.7%	14.4
Chad	–	–	0.9	0.1	0.9	0.1%	17.2
Republic of Congo (Brazzaville)	0.7	1.6	1.9	0.3	1.9	0.2%	23.9
Egypt	4.7	3.7	3.7	0.5	4.1	0.3%	15.7
Equatorial Guinea	–	0.6	1.8	0.2	1.8	0.1%	13.2
Gabon	1.0	2.7	2.0	0.3	2.0	0.2%	23.8
Libya	22.8	29.5	41.5	5.4	41.5	3.3%	61.5
Nigeria	16.0	20.8	36.2	4.9	36.2	2.9%	42.1
Sudan	0.3	0.3	6.6	0.9	6.6	0.5%	39.7
Tunisia	1.7	0.3	0.6	0.1	0.6	*	16.7
Other Africa	1.0	0.7	0.6	0.1	0.6	0.1%	10.2
Total Africa	**58.7**	**75.3**	**117.1**	**15.6**	**117.5**	**9.5%**	**31.2**
Australia	3.2	4.0	4.2	0.4	4.2	0.3%	20.3
Brunei	1.6	1.1	1.2	0.2	1.2	0.1%	16.9
China	17.4	17.0	15.6	2.1	15.5	1.3%	11.3
India	4.4	5.6	5.7	0.7	5.5	0.4%	18.7
Indonesia	9.0	4.9	4.4	0.6	4.4	0.4%	12.4
Malaysia	3.3	5.0	5.4	0.7	5.4	0.4%	19.4
Thailand	0.1	0.3	0.5	0.1	0.5	*	4.1
Vietnam	†	1.2	3.3	0.5	3.4	0.3%	27.5
Other Asia Pacific	0.9	1.2	0.9	0.1	0.9	0.1%	11.0
Total Asia Pacific	**39.8**	**40.4**	**41.0**	**5.4**	**40.8**	**3.3%**	**14.2**
TOTAL WORLD	**910.2**	**1069.3**	**1239.5**	**168.6**	**1237.9**	**100.0%**	**41.6**
of which: European Union	9.0	8.8	6.9	0.9	6.8	0.5%	7.8
OECD	119.1	113.4	89.5	11.9	88.3	7.1%	12.6
OPEC	676.0	818.7	935.3	127.6	934.7	75.5%	72.7
Non-OPEC‡	174.7	184.1	176.2	23.6	175.0	14.1%	14.3
Former Soviet Union	59.5	66.5	128.0	17.4	128.1	10.4%	27.4
Canadian oil sands*	n/a	n/a	152.2	24.7	152.2		
Proved reserves and oil sands	n/a	n/a	1391.7	193.4	1390.1		

* More than 100 years.
† Less than 0.05.
* Less than 0.05%.
* 'Remaining established reserves', less reserves 'under active development'.
‡ Excludes Former Soviet Union.
n/a not available.

Notes: Proved reserves of oil – Generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions.

Reserves-to-production (R/P) ratio – If the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that rate.

Source of data – The estimates in this table have been compiled using a combination of primary official sources, third-party data from the OPEC Secretariat, *World Oil*, *Oil & Gas Journal* and an independent estimate of Russian reserves based on information in the public domain. Canadian proved reserves include an official estimate of 21.0 billion barrels for oil sands 'under active development'. Reserves include gas condensate and NGLs as well as crude oil.

Annual changes and shares of total are calculated using thousand million barrels figures.

Source: BP (2007). Oil reserves table. Website: http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/downloads/pdf/oil_table_proved_oil_reserves_2008.pdf, consult at March 24, 2009.

2. NATURAL GAS RESERVES

Natural gas

Proved reserves	At end 1987 Trillion cubic metres	At end 1997 Trillion cubic metres	At end 2006 Trillion cubic metres	At end 2007 Trillion cubic feet	At end 2007 Trillion cubic metres	Share of total	R/P ratio
US	5.30	4.74	5.98	211.08	5.98	3.4%	10.9
Canada	2.69	1.81	1.62	57.55	1.63	0.9%	8.9
Mexico	2.12	1.80	0.39	13.01	0.37	0.2%	8.0
Total North America	**10.11**	**8.34**	**7.99**	**281.65**	**7.98**	**4.5%**	**10.3**
Argentina	0.69	0.68	0.45	15.54	0.44	0.2%	9.8
Bolivia	0.14	0.12	0.74	26.13	0.74	0.4%	54.7
Brazil	0.11	0.23	0.35	12.89	0.36	0.2%	32.3
Colombia	0.10	0.20	0.12	4.41	0.13	0.1%	16.2
Peru	0.34	0.20	0.33	12.54	0.36	0.2%	*
Trinidad & Tobago	0.30	0.52	0.48	16.95	0.48	0.3%	12.3
Venezuela	2.84	4.12	5.10	181.87	5.15	2.9%	*
Other S. & Cent. America	0.15	0.15	0.07	2.51	0.07	*	21.0
Total S. & Cent. America	**4.67**	**6.21**	**7.64**	**272.84**	**7.73**	**4.4%**	**51.2**
Azerbaijan	n/a	0.84	1.26	45.13	1.28	0.7%	*
Denmark	0.07	0.11	0.12	4.10	0.12	0.1%	12.6
Germany	0.38	0.26	0.16	4.84	0.14	0.1%	9.6
Italy	0.30	0.27	0.09	3.14	0.09	0.1%	10.0
Kazakhstan	n/a	1.87	1.90	67.20	1.90	1.1%	69.8
Netherlands	1.77	1.79	1.32	44.07	1.25	0.7%	19.4
Norway	2.29	3.65	2.99	104.57	2.96	1.7%	33.0
Poland	0.16	0.16	0.11	3.99	0.11	0.1%	26.4
Romania	0.20	0.37	0.63	22.18	0.63	0.4%	54.4
Russian Federation	n/a	45.17	44.60	1576.75	44.65	25.2%	73.5
Turkmenistan	n/a	2.71	2.67	94.22	2.67	1.5%	39.6
Ukraine	n/a	0.98	1.03	36.24	1.03	0.6%	54.0
United Kingdom	0.64	0.77	0.41	14.55	0.41	0.2%	5.7
Uzbekistan	n/a	1.63	1.74	61.60	1.74	1.0%	29.8
Other Europe & Eurasia	39.25	0.45	0.44	15.31	0.43	0.2%	39.4
Total Europe & Eurasia	**45.06**	**61.02**	**59.37**	**2097.89**	**59.41**	**33.5%**	**55.2**
Bahrain	0.20	0.14	0.09	3.00	0.09	*	7.4
Iran	13.92	23.00	27.58	981.75	27.80	15.7%	*
Iraq	1.00	3.19	3.17	111.95	3.17	1.8%	*
Kuwait	1.21	1.49	1.78	63.00	1.78	1.0%	*
Oman	0.27	0.54	0.69	24.37	0.69	0.4%	28.6
Qatar	4.44	8.50	25.64	904.06	25.60	14.4%	*
Saudi Arabia	4.19	5.88	7.07	253.03	7.17	4.0%	94.4
Syria	0.13	0.24	0.29	10.17	0.29	0.2%	54.7
United Arab Emirates	5.68	6.06	6.11	215.07	6.09	3.4%	*
Yemen	0.11	0.48	0.49	17.23	0.49	0.3%	*
Other Middle East	†	†	0.05	1.73	0.05	*	18.5
Total Middle East	**31.18**	**49.53**	**72.95**	**2585.35**	**73.21**	**41.3%**	*
Algeria	3.16	4.08	4.50	159.45	4.52	2.5%	54.4
Egypt	0.31	0.93	2.05	72.85	2.06	1.2%	44.3
Libya	0.73	1.31	1.49	52.80	1.50	0.8%	98.4
Nigeria	2.41	3.48	5.22	186.99	5.30	3.0%	*
Other Africa	0.79	0.82	1.20	42.84	1.21	0.7%	*
Total Africa	**7.39**	**10.62**	**14.46**	**514.92**	**14.58**	**8.2%**	**76.6**
Australia	1.07	1.48	2.49	88.64	2.51	1.4%	62.8
Bangladesh	0.35	0.30	0.39	13.77	0.39	0.2%	24.0
Brunei	0.33	0.39	0.33	12.11	0.34	0.2%	28.0
China	0.89	1.16	1.68	66.54	1.88	1.1%	27.2
India	0.55	0.69	1.08	37.26	1.06	0.6%	35.0
Indonesia	2.37	2.15	2.63	105.94	3.00	1.7%	45.0
Malaysia	1.49	2.46	2.48	87.40	2.48	1.4%	40.9
Myanmar	0.27	0.28	0.54	21.19	0.60	0.3%	40.8
Pakistan	0.63	0.60	0.85	30.02	0.85	0.5%	27.6
Papua New Guinea	0.09	0.43	0.44	15.36	0.44	0.2%	*
Thailand	0.18	0.21	0.33	11.65	0.33	0.2%	12.7
Vietnam	†	0.17	0.22	7.77	0.22	0.1%	28.5
Other Asia Pacific	0.23	0.41	0.37	13.02	0.37	0.2%	21.9
Total Asia Pacific	**8.45**	**10.73**	**13.82**	**510.69**	**14.46**	**8.2%**	**36.9**
TOTAL WORLD	**106.86**	**146.46**	**176.22**	**6263.34**	**177.36**	**100.0%**	**60.3**
of which: European Union	3.75	3.85	2.94	100.26	2.84	1.6%	14.8
OECD	17.19	17.05	15.79	556.89	15.77	8.9%	14.4
Former Soviet Union	38.90	53.44	53.46	1890.24	53.53	30.2%	67.7

*More than 100 years.
† Less than 0.05.
*Less than 0.05%.
n/a not available.
Notes: Proved reserves of natural gas – Generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions.
Reserves-to-production (R/P) ratio – If the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that rate.
Source of data – The estimates in this table have been compiled using a combination of primary official sources and third-party data from Cedigaz.

Source: BP (2007). Natural gas reserves table. Website: http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/downloads/pdf/gas_table_of_proved_natural_gas_reserves_2008.pdf, consult at March 24, 2009.

3. COAL RESERVES

Coal

Proved reserves at end 2007 Million tonnes	Anthracite and bituminous	Sub-bituminous and lignite	Total	Share of total	R/P ratio
US	112261	130460	**242721**	28.6%	234
Canada	3471	3107	**6578**	0.8%	95
Mexico	860	351	**1211**	0.1%	99
Total North America	**116592**	**133918**	**250510**	**29.6%**	**224**
Brazil	–	7068	**7068**	0.8%	*
Colombia	6578	381	**6959**	0.8%	97
Venezuela	479	–	**479**	0.1%	60
Other S. & Cent. America	172	1598	**1770**	0.2%	*
Total S. & Cent. America	**7229**	**9047**	**16276**	**1.9%**	**188**
Bulgaria	5	1991	**1996**	0.2%	66
Czech Republic	1673	2828	**4501**	0.5%	72
Germany	152	6556	**6708**	0.8%	33
Greece	–	3900	**3900**	0.5%	62
Hungary	199	3103	**3302**	0.4%	336
Kazakhstan	28170	3130	**31300**	3.7%	332
Poland	6012	1490	**7502**	0.9%	51
Romania	12	410	**422**	*	12
Russian Federation	49088	107922	**157010**	18.5%	500
Spain	200	330	**530**	0.1%	29
Turkey	–	1814	**1814**	0.2%	24
Ukraine	15351	18522	**33873**	4.0%	444
United Kingdom	155	–	**155**	*	9
Other Europe & Eurasia	1025	18208	**19233**	2.3%	278
Total Europe & Eurasia	**102042**	**170204**	**272246**	**32.1%**	**224**
South Africa	48000	–	**48000**	5.7%	178
Zimbabwe	502	–	**502**	0.1%	237
Other Africa	929	174	**1103**	0.1%	*
Middle East	1386	–	**1386**	0.2%	*
Total Middle East & Africa	**50817**	**174**	**50991**	**6.0%**	**186**
Australia	37100	39500	**76600**	9.0%	194
China	62200	52300	**114500**	13.5%	45
India	52240	4258	**56498**	6.7%	118
Indonesia	1721	2607	**4328**	0.5%	25
Japan	355	–	**355**	*	249
New Zealand	33	538	**571**	0.1%	124
North Korea	300	300	**600**	0.1%	20
Pakistan	1	1981	**1982**	0.2%	*
South Korea	–	135	**135**	*	47
Thailand	–	1354	**1354**	0.2%	74
Vietnam	150	–	**150**	*	4
Other Asia Pacific	115	276	**391**	*	29
Total Asia Pacific	**154216**	**103249**	**257465**	**30.4%**	**70**
TOTAL WORLD	**430896**	**416592**	**847488**	**100.0%**	**133**
of which: European Union	8427	21143	**29570**	3.5%	50
OECD	162490	194420	**356910**	42.1%	168
Former Soviet Union	93609	132386	**225995**	26.7%	463
Other EMEs	174797	89786	**264583**	31.2%	70

*More than 500 years.
*Less than 0.05%.

Source of reserves data: *Survey of Energy Resources 2007*, World Energy Council.

Notes: Proved reserves of coal – Generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known deposits under existing economic and operating conditions.
Reserves-to-production (R/P) ratio – If the reserves remaining at the end of the year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that rate.

Source: BP (2007). Coal reserves table.
http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/downloads/pdf/coal_table_of_proved_coal_reserves_2008.pdf, consult at March 24, 2009.

4. RENEWABLE ENERGY POLICY

▪ Explanation definitions

Feed-in-tariff: The price per unit of electricity that a utility or supplier has to pay for renewable electricity from private generators. The government regulates the tariff rate. The regional of national electricity utilities are obligated to buy renewable electricity at above market rates set by the government (European environment agency).

Green certificates: an official record proving that a specified amount of green electricity has been generated. Green certificates represent the environmental value of renewable energy production. The certificates can be traded separately from the energy produced (European environment agency).

kWh: kilowatt hour. The kilowatt-hour (symbolized kWh) is a unit of energy equivalent to one kilowatt (1 kW) of power expended for one hour (1 h) of time. The kilowatt-hour is not a standard unit in any formal system, but it is commonly used in electrical applications (serachCIO-midmarket.com)

kWp; kilowatt-peak is the nominal electrical power provide by a solar module under standard test conditions (abc-solar)

▪ Subsidy regime - onshore wind energy

	Support system	Total revenue in 2008 (EUR/MWh)	Level of support in 2008 (EUR/MWh)	Duration of support (years)	Market electricity price estimate (EUR/MWh)	Subsidy decrease an inflation correction
Belgium	Hybrig green certificates	140-170 (variable)	100 (variable)	20 years [1]	60-70	Not relevant
France	Feed-in-tariff	82	82	10+5 [2]	Not relevant	Decrease by 2% per year, partly inflation corrected
Germany	Feed-in-tariff	80.20	80.20	5+15 [2]	Not relevant	Decrease by 2% per year, partly inflation corrected
Ireland	Feed-in-tariff	57	57	15	Not relevant	Fixed level, fully inflation corrected
Italy	Green certificates	160-200 (variable)	100-120 (variable)	15	60-80	Not relevant
Netherlands	Premium payment	110	30-50 (variable)	15 [3]	60-80	Fixed level, not inflation corrected
Poland	Green certificates	95 (variable)	65 (variable)	?	30	Not relevant
Portugal	Feed-in-tariff	74	74	15 [3]	Not relevant	Fixed level, not inflation corrected
Spain	Feed-in-tariff or Premium payment	73.22 OR 71.27 - 84.94	73.22 OR 29.29	20	50-60	Fixed level, partly inflation corrected
Turkey	Feed-in-tariff or Bilateral contracts	50-55 OR 60-90 (variable)	50-55 OR 60-90 (variable)	10	60-90	Level adjusted annually not inflation corrected
UK	Green certificates	90-110 GBP (variable)	50 GBP (variable)	Asset lifetime	40-60 GBP	Not relevant

1. Belgium government guarantees minimum GC price at 80 EUR/MWh for first 10 years.
2. France and Germany have a subsidy system where the producers receive a high FiT for the first ten years (10 in France and 5 in Germany), and after that a lower tariff, depending site wind level.
3. In the Netherlands and Portugal, the subsidy capped at a yearly maximum number of full load hours (1760 for the Netherlands, 2000 for Portugal)

Source: Rabobank International

- **Subsidy regime - offshore wind energy**

	Support system	Total revenue in 2008 (EUR/MWh)	Level of support in 2008 (EUR/MWh)	Duration of support (years)	Market electricity price estimate (EUR/MWh)	Grid connection paid by
Belgium	Hybrig green certificates	170 (variable)	107	20	60-70	Both
Denmark	Tender + premium payment	125 (varies per tender)	85 (varies per tender)	14 [1](varies per tender)	30-50	Government
France	Feed-in-tariff	130	130	10 + 10 [2]	Not relevant	[3]
Germany	Feed-in-tariff	1503	150	12 + 8 [2]	Not relevant	Government
Ireland	Feed-in-tariff	140	140	15	Not relevant	Developer
Italy	Green certificates	180-220 (variable)	140 (variable)	15	60-80	[3]
Netherlands	Likely: tender plus premium payment	Unknown	Unknown	Unknown, likely 15	60-80	Developer
Spain	Premium payment	140 (variable)	84,30	20	50-60	[3]
UK	Green certificates	160 (variable)	65 (variable)	Asset lifetime	50-75	Developer

1. The Danish tender system works with a number of full load hours for which the premium payment is received. In the most recent tender, this is 50,000 full load hours, likely equal to approximately 14 years of production.
2. France and Germany have a subsidy system where the producers receive a high FiT for the first ten years (10 in France and 12 in Germany), ant after that a lower tariff, depending on project circumstances (in Germany, water depth amd distance to shore, and France wind level)
3. Currently, no offshore wind farms exist in these countries, and yet it is as yet unclear how the cost of the grid connection will be divided

Source: Rabobank International

- **Subsidy regime – solar energy**

Country	Subsidy policy
Belgium	Green Certifacates (with guaranteed minimum price): 0.15; Flanders from 1 january 2006: 0.45 EUR/kWh for 20 years. The support schemes used are investment subsidies, eco premiums, tax reductions, and interest reduced mortgages.
Cyprus	Feed-in-tariff: 0.196 CYP£/kWh (0.342 EUR/kWh) for enterprises. If an investment grant is taken, the tariff is reduced to 0,012 CYP£/kWh. For enterprises, the grant is 40% of eligible costs and the maxmum amount of the grant is 12.000 EUR
France	Feed-in-tariff: 0.30 EUR/kWh for 20 years. For building-intergrated PV installations there is a supplement of 0.25 EUR/kWh. 50% of the investments costs are tax deductible. Lower VAT of 5.5% on system costs (without labour). Accelerated depreciation of PV systems for enterprises.
Germany	Feed-in-tariff for 20 years with built-in annual decrease of 5% from 2005 onward. For plants, neither on buildings nor sound barriers, the annual decrease is 6.5% from 2006 onward. Feed-in-tariff: - free standing systems: 0.3796 EUR/kWh - systems on buildings and sound barriers: 0.4921 EUR/kWh < 30 kWp 0.4682 EUR/kWh > 30 kWp and 0.4630 EUR/kWh > 100 kWp
Greece	Feed-in-tariff: 0.45 EUR/kWh (0.50 EUR/kWh on islands) for systems < 100 kWp and 0.40 EUR/kWh (0.45 EUR/kWh on islands) for systems > 100 kWp guaranteed for 20 years. Commercial installations are eligible to grants (30 to 55% of total systmen costs), while domestic systems are eligible for a 20% tax deduction capped at EUR 700 per system
Italy	Feed-in-tariff: guaranteed for 20 years. **Nominal power / not intergrated / partly intergrated / building intergrated** 1 - 3 kWp / 0.40 EUR/kWh / 0.44 EUR/kWh / 0.49 EUR/kWh 3 - 20 kWp / 0.38 EUR/kWh / 0.42 EUR/kWh / 0.46 EUR/kWh >20 kWp / 0.36 EUR/kWh / 0.40 EUR/kWh / 0.44 EUR/kWh
Netherlands	Feed-in-tariff: 0.097 EUR/kWh for 10 years
Portugal	Feed-in-tariff: guaranteed for the first 15 years. - 0.45 EUR/kWh < 5 kWp - 0.28 EUR/kWh > 5 kWp
Spain	Feed-in-tariff: - 0.44 EUR/kWh < 100 kWp for 25 years then 0.3523 EUR/kWh - > 100 kWp < 10 MWp: 0.4145 EUR/kWh for 25 years then 0.332 EUR/kWh. - 0.23 kWh > 10 MWp for 25 years

Source: Rabobank International

- **Subsidy regime - biomass energy**

EU biofuel legislation	
Scope	Land (road & rail) transport 2010-2020. Note: rail not yet properly investigated
Blending target	A minimum 10 percent share of renewable energy by 2020, mandatory, of which: - first generation biofuels count 1x - next generation biofuels count 2x - Cars using electricity count 2.5x - Note: the methology to monitor the use of green electricity is to be decided 2012 the latest.
Excise duties Greenhouse gas (GHG) emissions savings	No provisions yet - 2009: 35% for post 2008 plants - 2013: 35% for all plants - 2017: 50% for all pre-2017 plants and 60% for all new plants
Sustainability requirements feedstocks	"Sustainable" feedstock to be required - EU wide standard to overule national initiatives - 2010: EC methodology proposal - 2012: EP & council decision - Bi-annual reviews form the EC
Fuel quality and GHG emissions	- 2020: fuel suppliers are required to realise a minimum of 6% less GHG emissions in fossil fuels by 2020 compared to 2010. On top of this there is an additional voluntary target of 4% emissions savings by 2020. These savings could be realised via many routes including the use of biofuels. - 2012: review of suggestion to add voluntary 4% GHG emissions reduction target on top of the 6% mandatory reduction.
Role of the EC	Providing bi-annual reporting on a wide range of sustainability issues Suggestions for methodologies to measure sustainability of biomass feedstock; default values for GHG savings; and the use of green electricity cars.

Source: Rabobank International

Figure: final assumed mix of energy crops by member state in 2030 (1)

	Traditional arable crops						Whole crops					
MS	Rape seeds	Sunflower seeds	Sugar beets	Maize corn	Wheat corn	Barley/ triticale corn	Maize whole plant	Rriticale whole plant	Wheat whole plant	Double cropping optimal	Double cropping reduced	Sweet sorghum
AT	10 %	10 %	0 %	30 %	25 %	25 %	0 %	0 %	0 %	0 %	0 %	0 %
BE	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
DE	10 %	0 %	0 %	10 %	20 %	15 %	0 %	0 %	0 %	20 %	10 %	0 %
DK	0 %	0 %	0 %	10 %	30 %	25 %	0 %	0 %	0 %	20 %	10 %	0 %
ES	0 %	10 %	0 %	10 %	30 %	20 %	0 %	0 %	0 %	0 %	0 %	15 %
FI	0 %	0 %	0 %	0 %	45 %	20 %	0 %	0 %	0 %	10 %	5 %	0 %
FR	0 %	5 %	0 %	15 %	40 %	10 %	0 %	0 %	0 %	10 %	5 %	0 %
GR	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
IE	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
IT	0 %	5 %	0 %	15 %	20 %	15 %	0 %	0 %	0 %	0 %	10 %	10 %
NL	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
PT	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
SE	0 %	0 %	0 %	0 %	30 %	25 %	0 %	0 %	0 %	10 %	5 %	0 %
UK	0 %	0 %	0 %	15 %	40 %	20 %	0 %	0 %	0 %	10 %	5 %	0 %
CZ	15 %	0 %	0 %	10 %	20 %	20 %	0 %	0 %	0 %	0 %	5 %	0 %
EE	0 %	0 %	0 %	0 %	35 %	40 %	0 %	0 %	0 %	0 %	5 %	0 %
HU	10 %	5 %	0 %	5 %	20 %	15 %	0 %	0 %	0 %	10 %	5 %	0 %
LT	0 %	0 %	0 %	0 %	30 %	30 %	0 %	0 %	0 %	10 %	5 %	0 %
LV	0 %	0 %	0 %	0 %	30 %	30 %	0 %	0 %	0 %	10 %	5 %	0 %
PL	15 %	0 %	0 %	10 %	15 %	15 %	0 %	0 %	0 %	15 %	5 %	0 %
SI	10 %	5 %	0 %	5 %	20 %	15 %	0 %	0 %	0 %	0 %	10 %	0 %

Source: estimating the environmentally compatible bio energy crops potential from agriculture.

Figure: final assumed mix of energy crops by member state in 2030 (2)

	Perennials					
MS	SRC poplar	SRC willow	Miscanthus	Reed canary grass	Giant reed	Switchgrass
AT	0 %	0 %	0 %	0 %	0 %	0 %
BE	0 %	0 %	0 %	0 %	0 %	0 %
DE	0 %	5 %	5 %	0 %	5 %	0 %
DK	0 %	0 %	0 %	5 %	0 %	0 %
ES	0 %	0 %	0 %	0 %	15 %	0 %
FI	0 %	0 %	0 %	10 %	0 %	10 %
FR	5 %	0 %	5 %	10 %	0 %	0 %
GR	0 %	0 %	0 %	0 %	0 %	0 %
IE	0 %	0 %	0 %	0 %	0 %	0 %
IT	0 %	0 %	5 %	0 %	10 %	10 %
NL	0 %	0 %	0 %	0 %	0 %	0 %
PT	0 %	0 %	0 %	0 %	0 %	0 %
SE	5 %	5 %	0 %	10 %	0 %	10 %
UK	0 %	0 %	0 %	5 %	0 %	5 %
CZ	0 %	5 %	10 %	0 %	0 %	15 %
EE	5 %	5 %	5 %	5 %	0 %	0 %
HU	0 %	5 %	10 %	0 %	0 %	15 %
LT	5 %	5 %	5 %	10 %	0 %	0 %
LV	5 %	5 %	5 %	10 %	0 %	0 %
PL	5 %	5 %	0 %	0 %	0 %	15 %
SI	0 %	5 %	10 %	5 %	0 %	15 %

Source: estimating the environmentally compatible bio energy crops potential from agriculture.

- **CO_2-storage**

There is no information available about subsidy regimes of CO_2-storage of European countries. The Dutch government now subsidizes small demonstration projects for CO_2 capture (E.ON) and CO_2-storage (Shell and GTI). The EU's made €250 million available for large-scale demonstration projects in the Netherlands and suggest a further 300 million allowances in prospect for 12-15 projects in Europe.

5. RISKS SUB-SECTORS CLEAN TECH

Onshore wind energy	Opposition from local action groups.	Radar and aviation interference issues.	Quality of wind measurement data.	Turbine availability, selection and quality.	Grid limitations.		
Offshore wind energy	Lack of turbines, installation vessels, and available capital.	Operational risks are complex compared to onshore market.	More complex problems when project failures occur.	Turbine reliability is in many cases unproven.	Permitting and regulatory challenges.	Quality of wind measurement data.	Grid limitations.
Risks solar	Shortage of commodities. As a result more expensive commodities.	Surplus of solar panels			Quality of wind measurement data.		
Risks biomass	Surplus of bio fuels.	Food for fuel debate – increasing food prices.	Limited availability of land and/or high land prices	Potential threats to biodiversity and water resources.	Soil erosion.		
Risks CO_2-storage	Storage is forever and everlasting.	Opposition from local action groups	CO_2 pipelines: similar to or lower than those posed by hydrocarbon pipelines.	Geological storage: Comparable to risks of current activities (natural gas storage, EOR, disposal of acid gas).	Ocean storage: mortality of ocean organisms, ecosystem consequences, chronic effects unknown.	Operations	

Source: author edit

6. QUESTIONNAIRE INTERVIEWS

Vragenformulier, interview master scriptie:
Is clean tech een aantrekkelijke alternatieve vastgoedbelegging?

Introductie

Functie en organisatie:

1. Welke functie bekleedt u binnen de organisatie en wat houdt dat in?
2. Hoe lang bent u werkzaam bij deze organisatie en hoe lang bent u werkzaam binnen dit vakgebied?
3. Welke visie en werkwijze heeft de organisatie?
4. Hoeveel werknemers heeft de organisatie?

Interviewvragen

Beleggen in vastgoed.

5. In welke typen vastgoed belegd uw organisatie?
6. Hoeveel bedraagt het belegde vermogen in vastgoed?

Is Clean Tech vastgoed?

7. Organisaties spelen steeds meer in op het thema clean tech. Op welke manier is uw organisatie betrokken bij clean tech?
8. Hoe typeert u de term clean tech?

Beleggen in clean tech.

9. Past beleggen in clean tech binnen jullie beleggingstrategie?
10. Beleggen jullie op dit moment in clean tech?

Risico/Rendement

11. Waar liggen volgens u de grootste risico's van beleggen in clean tech?
12. Wat vindt u van de getoonde rendementen?
13. Passen deze rendementen binnen jullie beleggingsstrategie?

Beleggingskarakteristieken

14. Beleggen in clean tech gaat gepaard met veel overheidsinvloed. Hoe kijkt uw organisatie aan tegen beleggingen met veel overheidsinvloed?
15. Beleggen in Clean Tech is managementintensief. Hoe kijkt uw organisatie tegen management intensieve beleggingen aan?
16. Uit onderzoek blijkt dat bepaalde landen de beste resultaten laten zien. Passen deze landen binnen jullie beleggingsstrategie? (Windmolens: Spanje & Duitsland. Solar: Spanje, Portugal. Biomassa: Frankrijk en Oost-Europa).
17. Wat verwacht u van de marktontwikkeling van beleggen in clean tech

Afsluiting

18. Gaat uw organisatie in de toekomst ook beleggen in clean tech?