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2007 **Zuzana Tóthová**

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DIPLOMOVÁ PRÁCE

Investing in Environmental Markets

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Prohlášení

Prohlašuji, že jsem diplomovou práci vypracovala samostatně a použila pouze uvedené prameny a literaturu.

V Praze, 20. května 2007:

podpis studenta

ABSTRAKT

Environmentální trhy jsou tématem, které je opomíjeno akademickým sektorem nejen v České republice, ale i v zahraničí. Téma představuje novou oblast pro vědecké zkoumání, což má za následek obecné nedostatky v terminologii. Pro účely této práce jsme si environmentální trhy definovali jako sektor společností obchodovaných na veřejných trzích, které dodávají ekologicky „čistší" a efektivnější produkty a služby v sektoru energetiky, vodohospodářství a zpracování odpadů. Každý z těchto segmentů je zvlášť zkoumán, s důrazem na jeho *business model* a faktory, které ovlivňují jeho úspěšnost.

Zkoumali jsme investiční nástroje, které investorům umožňují využít růstového potenciálu tohoto sektoru, přičemž jsme se zaměřili zejména na evropské environmentální podílové fondy. Zajímali jsme se o jejich profil výnosu a rizika a empiricky jsme testovali, zda tyto fondy překonaly během posledních pěti let výkonnost akciových trhů. Nakonec jsme analyzovali potenciální rizika spojená s investováním na environmentálních trzích.

ABSTRACT

The topic of Environmental Markets remains unexplored by academics not only in the Czech Republic but internationally. It presents a new field of research without a clear terminology. For the purpose of this study we have defined Environmental Markets as a universe of quoted companies which deliver cleaner and more efficient products and services in the energy, water and waste sectors. We have then proceeded with the study of each of the three sub-sectors, their business models and factors that influence their growth.

We reviewed the investment vehicles that can enable investors to take advantage of the sectors' growth potential, with a concentration on European environmental mutual funds. We studied their main risk-return characteristics and empirically tested whether they outperformed the general stock market over the last five years. Finally, the potential risks connected to Environmental Markets' investments were addressed.

Acknowledgements

I would like to express my gratitude to Prof. Ing. Michal Mejstřík CSc., my supervisor, for his insightful comments and suggestions, as well as for substantial encouragement when supervising my thesis.

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Special thanks belong to my family for their support and devotion during all the years of my studies. Lukas, for his patience and support.

Masters' thesis project

Subject: Are green stocks the blue chips of tomorrow? Growth potential of environmental technology companies
Author: Zuzana Tóthová
Director of the thesis: Prof. Ing. Michal Mejstřík CSc.
Academic year: 2006/2007

Masters' thesis project :

Today's economy produces a high volume of negative externalities and it is often discussed that economic activity needs to be altered in order to be sustainable in the future. This is based on many alert signals given by scientists considering the pollution generated by human activity and its (un)known consequences. Such consequences include global warming, depletion of non-renewable resources, accumulation of non bio-degradable waste and pollution of renewable resources such as water, leading to potential global unrest.

A central question raised by alarms from ecologists and scientists concerns the steps that ought to be done to change this direction. Some warn that not changing the ways our economies function will have dramatic and irreversible consequences. Recommendations as to what should be done are varied. Several point towards a slowdown of economic activity and a focus on different targets other than global competition. Even if one agrees with this statement, most people will not believe this shift can happen; further on, few seem ready to abandon their lifestyle in favor of future generations. Another option could be to change today's economic activity to one that is sustainable. This has been interpreted in several ways, however, it mainly involves relying on renewable resources and engaging in correcting current damages made to the environment.

Along these ideas, one can expect environmental technology companies engaged in the shift to **sustainable development**[1] to gain momentum in the coming years towards becoming an

[1] **Sustainable development**: There are numerous definitions of Sustainable Development. I have chosen one by Richard Douthwaite. According to him , "in a sustainable world, all the processes by which things are produced, once established would be capable of being carried

important sector in the economy. This is the main hypothesis that will be explored throughout the thesis.

Hypothesis:

The term "Green stocks" will be used to describe listed companies involved in the field of environmental technologies in the broad sense. The purpose of green companies is to correct environmental damage that is caused by traditional industries or to replace traditional industrial activities that pollute with non-polluting and renewable solutions. For instance, in the field of energy, a green company will be one involved in producing energy with as limited pollution as possible, and from renewable resources. In order to limit the scope of areas examined, the thesis will focus on three sub-sectors; renewable energy, waste management & recycling and water management.

These stocks will have an increasing role in the economy and potentially represent an important sector in the future for the following reasons:

1. **Political:** Governments are pushing for sustainable economic activity and environmental improvement[2]. Legislation will drive economies to be cleaner and more sustainable.
2. **Economic:** Companies that are environmentally performing will be more performing financially on the long term. This idea suggests that those players involved in improving environmental performance (green stocks) will see a strong growth in activity.
3. **Social[3]:** Our society is aware of the need for a "greener" economy. Steps are slow but the environmental economy is achievable as it is recognised as a need by the people. Awareness is increasing due to non-governmental organisations, interest groups and

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out or unchanged for an indefinite period without causing a progressive deterioration in any factor, human or environmental that they affected or on which they relied."

2 Currently, rising oil prices are major factor pushing governments to react as those economies that rely heavily on imported oil will suffer more and more as prices keep on rising. Similar issues concerning water and waste are acting as catalysts for governments to encourage research on water and waste management.

[3] "World is starting to think differently about environmental realities, and that different thinking is creating new markets." Green Investment analyst, Terry Foeke quoted in Altucher, J. (2005) When lean and green are worthwhile – Financial times August 10 2005

education. However environmental progress still has to be driven by political and economic factors (Paul Hawken's hypothesis[4]).

4. **Technological:** Environmental technology is improving significantly. Current improvements suggest that environmentally friendly solutions for the economy are feasible and can be profitable business. Technological innovation has usually been a key to business revolutions.

Expected table of contents:

4 Hawken, P. (1994) The ecology of commerce

9.0 GLOSSARY OF TERMS

The goal of the paper is to explore current developments which lead to believe that we are going towards cleaner and sustainable economic activity and then further quantify the growth potential of environmental technology companies involved in sustainable development. It will consist of five main parts.

The first part of the paper will give an overview of three sub-sectors dedicated to the environment and their current investor base as well as other supporting agents. These sub-sectors are renewable energy, waste management & recycling and water management. It then aims to examine the growth potential of these activities. This potential is based on assumptions which are explored in economic theory.

The literature review, which will constitute **the second part** of the paper, will expose the debate between limited growth and new growth theory. The latter argues against Keynes' proposition that growth is limited by natural constraints, and is used as the basis to prove that our economy can be sustainable if it manages to reinvent itself. It further shows that ideas should shift towards technological progress in favour of environmentally sound activities in order to experience long term economic growth that is sustainable in the future due to its inherent respect of nature and the non-depletion of natural resources. This path could lead to the creation of an important economic sector in charge of environmental technologies.

The third part of the paper will then discuss the main factors that will influence future growth of green stocks. Such factors will be explored via a political, economic, social and technological analysis.

Upon these assumptions, in **the fourth part** of the paper, which will represent the core of the paper, growth factors will be identified and assigned a coefficient that will be used towards estimating the growth potential of green stocks.

Finally (in **the fifth part** of the paper), limits will be addressed regarding the growth potential of green stocks. The envisioned economy will not be an environmentalist one. It will essentially remain a capitalist model with a strong environmental component.

Overall, the paper shall contribute to the theme of sustainable development by suggesting a model which allies western countries' present capitalist economy and environmental responsibility.

It should interest investors by recommending business models and sectors of future growth and should interest academics by suggesting a modern economic theory of infinite growth according to Solow's model with an additional environmental factor[5].

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[5] A paper by William A. Brock and Scott Taylor suggests that "a key finding in environmental economics -The Environmental Kuznets Curve - and the core model of modern macroeconomics - the Solow model - are intimately related." The team designed an amended model of Solow's theory incorporating the Kuznets curve. The model defined as the "Green Solow" generates an EKC (Environmental Kuznet's Curve) relationship. The EKC suggests that pollution increases as a result of increased economic development, however levels of pollution start to diminish as development progresses. This is the result of increased technological progress aimed at perfecting efficiency of the utilised machinery and limiting emissions.

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In Prague, 12.june 2006

Signature of the Director of the thesis:

1. Introduction

Today's economy produces a high volume of negative externalities and it is often discussed that economic activity needs to be altered in order to be sustainable in the future. This is based on many alert signals given by scientists considering the pollution generated by human activity and its (un)known consequences. Such consequences include global warming, depletion of non-renewable resources, accumulation of non bio-degradable waste and pollution of renewable resources, leading to potential global unrest.

A central question raised by alarms from ecologists and scientists concerns the steps that ought to be done to change this direction. Some warn that not changing the ways our economies function will have dramatic and irreversible consequences. Recommendations as to what should be done are varied. Several point towards a slowdown of economic activity and a focus on different targets other than global competition. Even if one agrees with this statement, most people will not believe this shift can happen; further on, few seem ready to abandon their lifestyle in favor of future generations. Another option could be to change today's economic activity to one that is sustainable. This has been interpreted in several ways, however, it mainly involves relying on renewable resources and engaging in correcting current damages made to the environment.

Along these ideas, one can expect Environmental Markets' companies engaged in the shift to sustainable development[6] to gain momentum in the coming years towards becoming an important sector in the economy. This idea will be explored throughout the thesis.

Despite the utilization of the notion of Environmental Markets not only in the investment community, we will see that the meaning of this term is very ambiguous and there is almost no literature covering this topic. Therefore, a number of information presented in the thesis stems from personal interviews with the Environmental Markets' participants and current institutional and private investors and is therefore subject to fluctuations.

The goal of the thesis is to explore the yet unexplored Environmental Markets while looking for answers to questions of the Markets' definition, structure, business models, factors that influence the development of Environmental Markets, investment vehicles which enable

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[6] **Sustainable development**: There are numerous definitions of Sustainable Development. According to Richard Douthwaite, "in a sustainable world, all the processes by which things are produced, once established would be capable of being carried out or unchanged for an indefinite period without causing a progressive deterioration in any factor, human or environmental that they affected or on which they relied." (Douthwaite, 1999)

gaining exposure to them and risks connected with these investments. It is structured as follows:

The first part of the diploma thesis (section 2) will be devoted to the definition of the Environmental Markets' universe with the next three sections (sections 3, 4, 5) dedicated to the overview of the three Environmental Markets' sectors. Section 6 will describe the features of the business models that are particular to the sectors.

The next part (section 7) will discuss the main factors that influence future growth of the three sectors. Such factors are explored via a political, economic, social and technological analysis.

In section 8 we will review the investment vehicles that can enable individual investors to take advantage of the growth potential of environmental markets with the following section (section 9) particularly concentrating on the European environmental mutual funds. These funds' portfolios comply with our definition of Environmental Markets and therefore consist only of companies active in at least of the three sectors. We will study their main risk-return characteristics and compare them to the stock market in general. Our aim will be to verify empirically whether the environmental mutual funds outperformed the general stock market (as represented by MSCI World Index) over the defined study period. Therefore, the following hypothesis will be tested:

Hypothesis 1: Environmental mutual funds outperformed the general stock market represented by MSCI World Index over the defined study period.

Finally (section 10), the potential risks connected to the investment into Environmental Markets will be addressed.

2. Environmental Markets

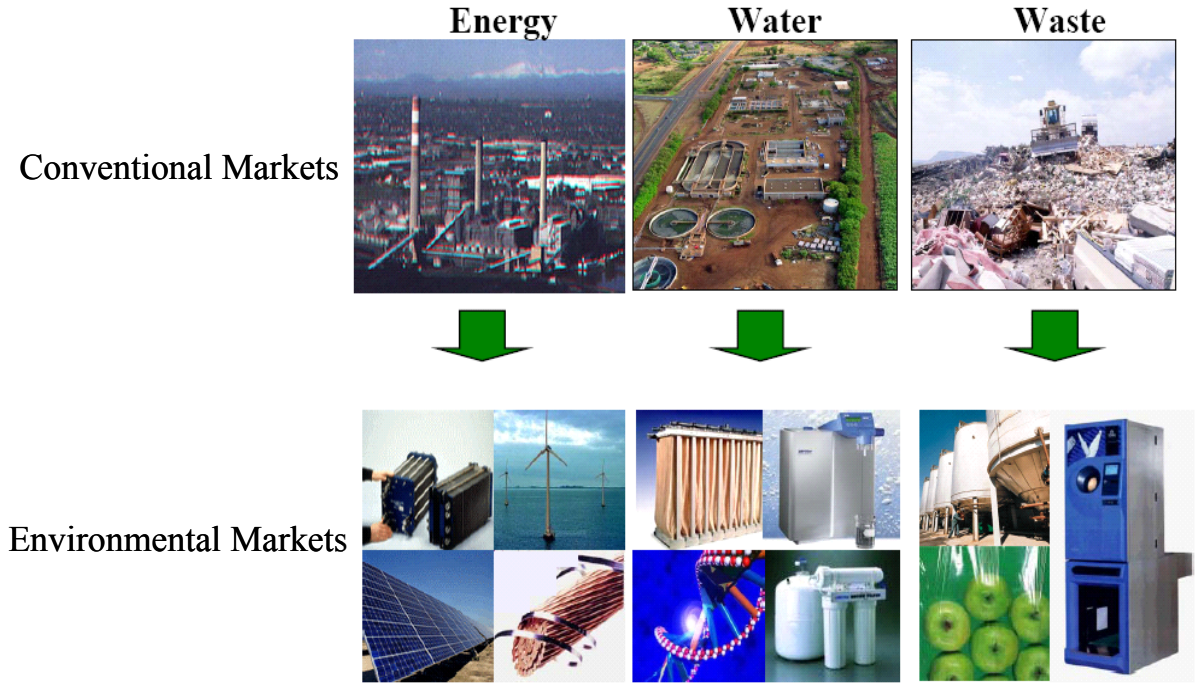
As already mentioned in the Introduction, there is no universal definition of Environmental Markets. Different people understand this term very differently and the answer to the question of what constitutes Environmental Markets varied greatly among people interviewed and sources consulted. For some, Environmental Markets represent the carbon market, thus emission allowances trading. Others were convinced that biotechnologies are the constituents of Environmental Markets or that the production of bio-products explains the expression.

One cannot argue that any of the above mentioned definitions is incorrect as the expression "Environmental Markets" is not a *terminus technicus* deeply enrooted in our minds. However, for the purpose of this study we will define Environmental Markets the following way:

Definition of Environmental Markets: Environmental Markets consist of companies which develop and promote new technologies to address environmental problems. More specifically, quoted companies active in the markets for cleaner and more efficient delivery of products and services of energy, water and waste.

Today, major transition is taking place in the energy, water and waste sectors, particularly a shift towards more efficient, cleaner and decentralized products and services as depicted in Figure 1. This trend creates attractive business opportunities and Environmental Markets' Companies are here to take advantage of them by providing, utilizing, implementing or advising upon systems, products or services in the energy, water and waste sectors.

Figure 1: Changing structure of products and services



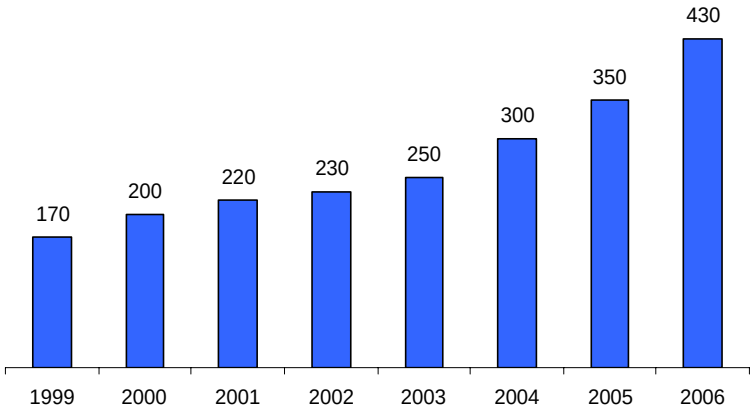
Environmental Markets have developed as a result of four principal factors:

- Governmental policies to liberalize basic service industries
- Legislation designed to reduce or reverse environmental damage
- Falling costs of technology
- Increasing costs of substitutes

These four factors have created demand from global utilities, multinationals, government agencies and individuals for new technologies and new infrastructure solutions.

Environmental Markets are growing dynamically as many of the technologies employed are becoming mainstream.

Figure 2: Evolution of the Number of the Environmental Markets' Companies (as of 31. December)



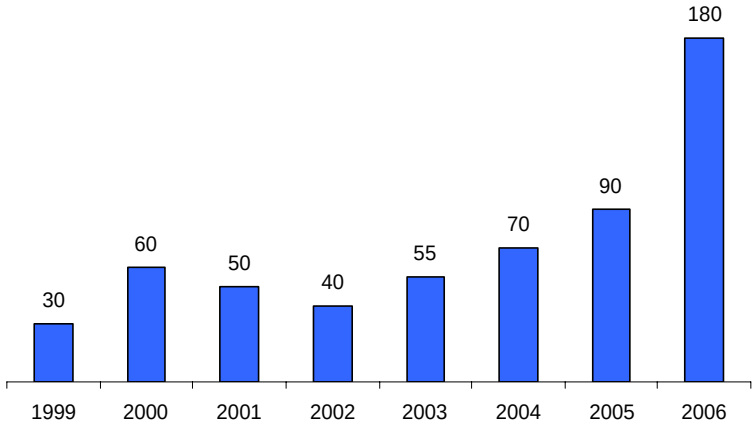
Source: Impax Asset Management 2007 Estimates

Since the beginning of the 21st century, the number of Environmental Markets stocks has more than doubled. During the year 2006, the increase in the number of the quoted companies has been the most significant (430 stocks) despite a strong consolidation taking place across all three Environmental Markets sub-sectors. In the first quarter of 2007, the number of companies stands very close to 500.

The size of the sector is quite large, with annual spending in excess of USD 120 billion, and growing by up to 30% per annum (Vontobel, 2007). This represents a compelling backdrop to the search for investment opportunities. There are also significant opportunities in the unquoted sector, which are however out of the scope of this study.

Now that we know the estimated number of companies operating on the Environmental Markets, let us take a look at the value of these markets. Looking at Figure 3 we can see that despite the steady growth in number of companies during the last eight years, the value of the Markets has actually been diminishing between years 2000 and 2003, whereas it picks up from there on, doubling in year 2006. This can be explained by the tight correlation of the Markets' value to the evolution of equity markets which have been in recession at the beginning of the century and started to recover in 2003 (for detailed explanation of the EM companies' performance, please refer to section 9.2.5. Environmental Funds' Historical Performance).

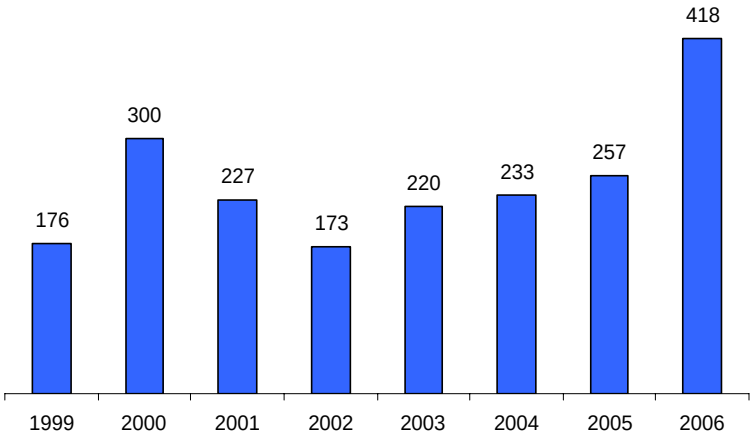
Figure 3: Environmental Markets' Market Value Evolution (in EUR billion)



Source: Impax Asset Management 2007 and own calculations

As depicted in Figure 4, the Environmental Markets universe comprises mostly small and medium size companies. However, the average size (market capitalization) of companies has grown rapidly in the past year, reaching EUR 418 million. This reflects the strong growth of the Environmental Markets and a very good performance of the Environmental Markets' stocks.

Figure 4: Average company size evolution (in EUR million)



Source: Impax Asset Management 2007 and own calculations

Of course, not all Environmental Markets companies are profitable. However, the profitable portion shows two year historic earnings growth of 24%, and forecast growth rates of between 20% and 30% depending on the sub-sector in question (Impax AM, 2007, Vontobel, 2007, Financiere de Champlain, 2007). Similarly, the margins of these businesses

can vary dramatically, with, for example, some of the more capital intensive businesses achieving high margins and some of the less capital intensive making comparatively tight margins. As such, there is no hard and fast rule, but an investor would typically see a range from around 6% to upwards of 20%.

The current price/earnings ratio (P/E) of the profitable companies is around 21x and the forward multiple falls to 17x, implying impressive growth, as discussed above (Impax AM, 2007).

3. Alternative Energy Sector

3.1. Market Size and Growth

The alternative energy sector is one that arouses great interest in the investment community. Finding a clean and renewable energy that could potentially replace the multi-billion dollar oil industry is comparable to the quest for Holy Grail. Today, alternative energy markets are already large and growing rapidly. In 2005 they generated about USD 50 billion revenues in comparison to USD 240 billion revenues generated by the conventional energy markets (ex fuels) (Impax AM, 2007). The growth of clean energy markets reflects its growing acceptance. Global wind and solar markets reached USD 11.8 billion and USD 11.2 billion in 2005 – up 47% and 55%, respectively, from a year earlier. The market for biofuels hit USD 15.7 billion globally in 2005, up more than 15% from the previous year (REN 21, 2006).

3.2. Market Participants

The size and rapid growth of Alternative Energy Markets has attracted a wide array of companies. The majority of the players are start-ups with important R&D costs, typically small and mid sized companies, but one can also find large corporations that invest in renewable energy without the field necessarily becoming their core business. A particularly interesting example is General Electric, which has built up an alternative energy business generating over USD 4 billion of revenues in 2006 (General Electric, 2006). We could furthermore name multinationals like Archer Daniels Midland, BP, Sharp and Toyota who lead the way with large divisions dedicated to solar, wind power, ethanol, and hybrid electric vehicles, among other technologies.

State governments throughout the world are playing a key role, too, competing feverishly to become clean energy hubs that attract economic development and jobs. The sector also includes smaller private and public companies and single purpose projects. The Silicon Valley venture firms that financed Internet and wireless telecom revolutions – among them Draper Fisher Jurvetson, Kleiner Perkins Caulfield & Byers, Mohr, Davidow Ventures and VantagePoint Venture Pertners – have begun placing increasingly bigger bets on clean energy (Whittell, 2006).

3.3. Promising Investment Clusters

This section provides an overview of the three key Alternative Energy Markets:

- Renewable Energy,
- Distributed Energy and
- Energy Efficiency.

Key to successful investments in sustainable energy lays in focus on these three investment clusters. In each cluster we will identify the segments with the greatest growth potential. We will look at the entire value chain of the markets as promising investment opportunities can be found not only at the level of the core product (e.g. fuel cells), but often also at upstream and downstream stages of the value chain (e.g. hydrogen processing using reformers). Often, products and technologies that enable the success of a core product (enabling technologies such as catalyst and membrane materials) and can be used in a wide range of applications are particularly attractive.

3.3.1. Renewable Energy

The efficient use of renewable energy sources (hydro, wind, wave, tidal, biomass, solar PV, solar thermal, geothermal) offers considerable long-term market potential from a financial, environmental and social perspective. They have an advantage over fossil fuels in that they have significantly smaller negative effect on humankind and the environment. However, only 2.7% of worldwide demand for energy is currently met using renewable energy sources, of which hydropower represents 90% (IEA, 2006b). The reason for this slow market diffusion is that many of the technologies have not yet or are only just reaching maturity and initial costs are relatively high. However, costs will continue to fall sharply in the coming years and competitiveness will grow as a result of increasing research and development efforts and achieving economies of scale as production volumes rise. Competitiveness is achieved earlier on in regions without an existing electricity grid. These are mainly regions in emerging economies in which electricity is currently produced using energy-inefficient diesel generators.

Increasing Competitiveness

In industrialized nations the cost of base load electricity generation in gas-fired and nuclear power plants is 3 to 6 cents/kWh (Teschler, 2006). This shows that, in addition to

hydropower, which has been cost-competitive for decades now, especially wind and geothermal energy have attractive future market potential. Furthermore, as production of electricity becomes increasingly decentralized, electricity prices become more volatile and industrialized nations implement environmental and climate policies, market potential will continue to increase.

Wind Energy

Wind energy has now reached a competitive level of pricing and produces electricity at 4 cents/kWh at favorable locations (Teschler, 2006). After developing well over the last few years, the market for wind parks will continue to grow by 25% on average each year. The markets in India, China, Norway, North Africa and France will experience higher growth rates as will the market for offshore wind parks over the medium term (BTM Consult, 2007a).

In addition to wind turbine manufacturers such as Suzlon (India), Vestas Windsystems (Denmark), and Gamesa (Spain), investment opportunities also present themselves at the upstream and downstream stages of the value chain. Developers and operators of wind parks of the caliber of Plambeck Neue Energien (Germany) and Denker&Wulf (Germany) have made a significant contribution to the growth of Germany's wind energy market and are now entering new markets such as France and Italy (Plambeck Neue Energien, 2006). At the same time, more and more established utilities companies are moving into the market, especially in the USA.

There is still a great deal of innovative potential to be exploited by suppliers to the wind industry, e.g. new rotary blade materials and designs, the development of light, directly powered generators, and the servicing and grid integration of offshore wind parks. The value of the wind energy market over the next five years is estimated to reach USD 132.4 billion (BTM Consult, 2007b).

Photovoltaics

Photovoltaics, i.e. the direct use of sun light for electricity generation, are only competitive in niche markets today. However, there is also evidence of rapid development, leading to attractive prices as a result of sharply falling production costs. The currently small market achieves average growth rates of 30 to 40% per annum. Around 40% of the total capacity is sold to emerging economies (IEA, 2006a). As a result of the lack of grid

infrastructure and the consequently greater competitiveness of this technology, this percentage may rise further. Grid distributed applications represent the largest growth segment in OECD countries (IEA, 2006b). This segment is profiting considerably from state incentive schemes in place in leading industrial nations, above all Japan[7] and Germany. Companies such as Solarworld (Germany) and Suntech Power (US) specialize in the design, development, manufacturing and sale of photovoltaic cells, modules and systems.

In addition to wind and photovoltaics, other segments of the renewable energy market such as geo-thermal energy, solar heat, new forms of hydropower and biomass use are also expected to show attractive growth rates. Many of these technologies are currently being developed by small, private companies and will only emerge from niche markets in the medium to long term. Therefore, selecting attractive companies currently requires detailed knowledge of the development of the market and strategies of the companies concerned.

Figure 5 provides a comparison of the principal renewable power technologies:

Figure 5: Renewable Power Technologies

Renewable Type	Technology	Global Resource	Predictability	Economics
Hydro	•••	••	•••	•••
Wind	••	•••	•	••
Wave	•	•••	•	
Tidal	•	••	••	
Biomass	••	•••	•••	•
Solar PV	••	•••	••	•
Geothermal	•••	••	•••	••

Source: Whittell 2006. In the table, one dot means “low”, “weak” or “unfavourable”, three dots means “high”, etc. More information on the concrete renewable type technologies can be found in Annex 1: Technologies for renewables.

Power Electronics

Manufacturers of power electronics and electronic measurement and communications systems will profit as they provide complementary technologies for wind turbines and solar cells. Power electronics are required to process the electrical energy produced to monitor and manage network power quality, particularly in the case of distributed generation. Measurement and communications systems determine the quantity and quality of the

[7] The Japanese government has approved a target of 4.8 gigawatt of installed PV capacity, corresponding to annual growth rates of 46% (Halal, 2006).

electricity fed into the grid and communicate these data online to the network operators. Thus they reduce operational and administrative costs and increase the competitiveness of distributed energy systems.

Storage Technologies

In off-grid applications, e.g. in remote rural areas in emerging economies that are to be newly electrified, demand increases for micro-grids and storage technologies. Energy can be stored using new battery technologies or hydrogen. Hydrogen has an advantage in that it can be used at the same time to treat drinking water, a major additional benefit in emerging economies. Also, as electricity is needed also when there is no wind blowing or the sun is not shining, the importance of energy storage is particularly high.

3.3.2. Distributed Energy

Distributed energy systems allow the use of heat and electricity and thus increase energy efficiency from an average of 40% to up to 80% (Beckerhof, 2006). Furthermore, they increase security of supply and eliminate high energy costs at peak load times.

Change of Paradigm

Industrialized nations are driving the trend towards distributed energy systems as a result of advancing market liberalization and increasing demand for power quality and combined heat and power generation. Centralized power plants and distribution systems will make way for an extremely distributed structure over the longer term.

In contrast, the development of distributed electricity production in emerging economies is a direct result of the electrification; or extended electrification of regions with no or only some existing energy infrastructure. Although the driving forces in these cases are primarily different, many of the newly emerging technologies can serve both markets and profit accordingly from both developments. According to estimates from the US Department of Energy, distributed energy systems will secure a market share of 20% to 30% of new capacity by 2008 (DOE, 2007). Industry estimates are somewhat higher at 30% to 40%.

Within the distributed energy market, applications differ in terms of their performance, the cost of electricity, their availability, their typical duration and the ratio of electricity to heat sold. Therefore, the segment ranges from small UPS systems (uninterruptible power

systems) for IT infrastructure with an output of 1 kW to large systems for the combined use of heat and power in office complexes with 500 to 1,000 kW of output. Systems for combined heat and power generation with an output of 5 to 500 kW and distributed energy systems in non-electrified regions of emerging economies represent the most attractive markets in terms of sustainability.

As the demand for such applications grows, companies are developing innovative servicing and technology solutions to reduce cost and improve performance which include UPS outsourcing, flywheels and fuel cells. As an example of a company active in this field we could name a British company Chloride.

Technology Fields

As a result of this paradigm change, various technology segments are experiencing significant growth. In addition to conversion technologies, power electronics, innovative storage systems and measurement and communications technology will profit.

Conversion Technology

In the energy conversion segment, natural gas-fired technologies such as fuel cells, Stirling engines and gas-fired combustion engines harbor interesting market potential in addition to the wind parks and photovoltaic power plants already mentioned. They produce low levels of CO_2 and NO_x emissions and profit from the gas distribution infrastructure already in place. While gas-fired combustion engines are more technologically mature, Stirling engines offer a higher degree of efficiency at lower emission levels (Teschler, 2006). As is the case with fuel cells, the small number of moving parts brings along a considerable reduction in maintenance costs. Over the longer term, fuel cells have the greatest cost-cutting potential, but not all technical problems have been solved to allow permanent practical application.

The price of the natural gas required and the price of electricity in the specific market have an important influence on the commercial viability and market diffusion of these systems. Relatively low natural gas prices and rising electricity prices increase commercial viability and reduce the pay-back period. For example, current prices in the state of New York and California make micro turbines competitive (Beckerhof, 2006). Factoring in the benefits

of additional heat generation, lower emissions and greater security of supply increases commercial viability quite significantly.

Power Electronics

As is the case with the use of renewable energy sources, power electronics process the energy generated to network specifications and feed it into the grid. Decisions are made using innovative metering and control systems and the relevant data is forwarded to the necessary players using communications applications. This technology segment may experience significantly higher growth rates than the individual electricity and heat generation technologies as it is required in every system regardless of the energy conversion technology chosen.

Energy Storage

Energy storage is another segment to grow hand in hand with distributed energy systems. In this instance, the technologies differ from one another in terms of their typical storage capacity and relevant areas of application. While flywheels and supercaps only offer a solution to short power cuts and are used mainly in the UPS (uninterruptible power supply) and power quality segments, new innovative batteries and hydrogen storage systems offer sufficient capacity for distributed applications. Larger storage systems based on hydrogen or pumped storage hydropower plants make it possible to store surplus electricity while demand is low and then to feed this into the network when demand rises or there is a possibility of supply bottlenecks. This reduces peak load production using fossil fuels.

3.3.3. Energy Efficiency

With high and potentially rising fossil fuel prices, energy consumers are strongly motivated to make investments in products and services that can reduce their energy usage. Nowadays, it becomes possible to avoid energy costs and environmental and social impacts associated with any kind of energy provision. Therefore, this level represents the last stage of the journey from primary energy, conversion and transportation to useful energy and is responsible for more than half of the losses that occur; on average 33% of the primary energy is lost at this level. Avoiding such inefficiency would result in savings of around $187 billion

a year in the USA alone (Makower, Pernick, Wilder, 2006). This shows the magnitude of the market potential for providers of energy-efficient technologies and services at this level.

But where exactly do the largest losses occur, and where is the greatest potential to reduce these losses cost-efficiently?

Potential of Demand Segments

An analysis of the typical user segments (mobility, households, commercial and industry) and primary product segments reveals that the greatest potential to increase energy efficiency lies in segments which account for a high proportion of energy consumption and, at the same time, harbor immense potential for energy savings. These segments are interesting as they are relatively strongly influenced by the key trends.

Space heating and mobility harbor the greatest market potential (SAM, 2002). The two segments have a technical efficiency potential of more than 50% and, at the same time, account for a large proportion of total energy consumption. The industrial sector is already investing large amounts in energy efficiency measures and according to the International Energy Agency (IEA, 2006a), between 2005 and 2020, efficiency measures could turn an estimated 18% rise in global industrial energy consumption into an 8% fall.

Space Heating

It is possible to satisfy the demand for space heating more efficiently by choosing new heating systems, better thermal insulation or a better energy management system. Distributed systems for small scale combined heat and power generation can increase the energy efficiency of a building by a factor of two (Beckerhof, 2006). Interesting new products include technologies such as micro turbines and fuel cell systems – as mentioned above in the context of distributed energy systems – as well as products using solar heat.

As an alternative to the increased efficiency of energy systems, the consumption of heat in buildings can also be reduced further with better thermal insulation using new innovative materials (e.g. Kingspan (Ireland)) or with intelligent energy management systems[8]. Energy contracting companies employ this strategy. They supply under contract

[8] Wall, cylinder and pipe insulation can reduce the energy required for space and water heating dramatically. In many countries, low levels of thermal energy loss are a standard requirement in building design.

electricity and heat for the building at an agreed price and therefore endeavor to keep their own costs low by making efficient energy savings[9].

Also simple thermostats to regulate domestic heating can save a lot of energy. Furthermore, smart electricity meters that facilitate variable customer pricing are already supplying established markets in many countries. Also utility companies are increasingly installing advanced meters to allow remote reading and facilitate efficient delivery of services. We could name meter companies such as Itron (US) and Techem (Germany) as examples of companies active on this particular market.

Mobility

Within this segment of demand, 86% of energy is spent on road vehicles. Of this, just less than 80% is consumed by automobiles, vans and all-terrain vehicles. They are responsible for 76% of all carbon monoxide emissions and around half of all nitrogen oxide emissions world-wide (IEA, 2006b). Pressure to reduce these emissions continues to increase sharply. In the USA for instance, the states of California, New York and Massachusetts have passed a law prescribing a defined sales quota of zero-emission vehicles from 2004 onwards (SAM, 2002). The automotive industry's response to these trends is a growing range of electric, hybrid (e.g. Toyota Prius) and fuel cell vehicles.

Low carbon fuels can also lead to significant reductions in CO_2 emissions. Natural gas (methane) has been used for several decades in larger vehicles such as buses or trucks. More recently, biofuels such as bioethanol and biodiesel have started to gain market share, driven predominantly by legislative targets. A particular advantage of biofuels is that they can be blended with standard fuels with only limited engine modifications. Biopetrol (Germany) and Abengoa (Spain) are two biofuel market leaders.

Manufacturers of the necessary enabling technologies will also profit greatly. Regardless of which technology is used and will succeed in the competitive market in the longer term, power electronics will be required in every vehicle. Revenues in this market segment could rise by 40% per annum over the longer term (Impax AM, 2007). Other attractive technologies include new battery technologies, reformer technologies that process the fuel and super capacitors.

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[9] More than 250,000 buildings in Germany are now served by contracting partners. In theory, the potential of suitable contracting projects in Germany is estimated to be 1.2 million properties, corresponding to an investment volume of up to EUR 90 bn. (www.bmu.de).

Figure 6 provides a comparison of alternative energy innovations in the mobility sector:

Figure 6: Mobility Sector Technologies

Transport Option	Technology	CO_2 Reduction	Infrastructure	Economics
Bioethanol/Biodiesel	•••	•	•••	••
Advanced biofuels	•	•••	•••	•
Pyrolysis/Gasificatio	•	••	••	•
Hybrids	•••	•	•••	••
Hydrogen	•	••		•

Source: Whittell 2006. In the table, one dot means "low", "weak" or "unfavorable", three dots means "high", etc.More detailed description of the clean fuels from the table can be found in the Annex 2: Transportation Fuels.

Figure 7 provides a summary of investment areas within the three investment clusters.

Figure 7: Alternative Energy Sector Promising Investment Clusters

		Technologies	Target markets	Players
Renewable Energy	Wind		-Onshore -Offshore	Suzlon, Vestas, Gamesa
	Photovoltaics	-Crystalline -Thin film	-On-grid centralized -On-grid distributed	Solarworld, Suntech Power, Evergreen Solar
	Hydroelectric Power	-Pump storage -Run-of-river -Wave energy	-Distributed and renewable energy	Canadian Hydro Developers
Distributed Energy	Combined heat and power generation	-Fuel cells -Stirling engines -Microturbines -Gas engines	-Distributed energy -UPS	FuelCell Energy, General Electric, Ballward Power, Sulzer Hexis
	Energy Storage	-Flywheels -Baterries -Supercaps	-Distributed energy -UPS -Transport -Portable	Active Power, A123Systems, Chloride, Evercel, Valence Technology Medis Technologies
	Power Electronics	-Power semiconductors -System integrators	-Distributed and renewable energy -Transport -UPS	Hemlock Semiconductor, American Superconductor
Demand-Side Efficiency	Facility Management	-Contracting -Heating systems -New materials, insulation -Energy management systems -Measurement and communication systems -Smart cards	-Industry -Households	Itron, Techem, Kingspan, Silicon Energy
	Mobility	-Hybrid electric drive -Super capacitors -Reformers -Power electronics	-Vehicle manufacturers	Honda, Toyota, Impco, Enova, Biopetrol, Abengoa

4. Water Sector

4.1. Market Size and Growth

Water is a key component of prosperity, health, stability and development. Today, the water sector faces issues such as increased water shortages spurred by demographic growth and changing climate, ageing infrastructure, water pollution, and people demanding higher quality of water services.

These trends are changing the demands on those responsible for managing water and redefining the water market. The impact of the shift of emphasis towards more efficient and cleaner delivery of services in the water market spurred the emergence of companies which are able to satisfy these needs.

The total annual turnover of the companies developing, providing and employing clean technologies and services for water sector is estimated to have reached USD 50 billion in 2005. It is still a very small part in comparison to the conventional water market whose total annual turnover is estimated to have amounted to USD 400 billion in 2005 (Impax AM, 2007). The fact that sustainable water management will probably be one of the most pressing needs to address in the near future is reflected in the double digit growth of the "clean" water sector which is estimated at 30% annually (SAM, 2006).

4.2. Market Participants

Up to very recently, the water sector was dominated by water utilities with the different local and municipal authorities seeking to operate largely autonomous utilities. Nowadays the emphasis is more on increased efficiency, cost savings and flexibility. One expression of this is endeavors to compare (benchmark) the efficiency of different utilities. Another symptomatic trend is regional concentration, in some cases pronounced, on a smaller number of utilities. Networks are also extending internationally to an increasing extent, with a small number of multinational utilities in a constant process of merging and re-merging.

However, as the water sector faces the current challenges described above the role of utilities tends to decline as they are not able to cope with all of the issues alone. Therefore, they started outsourcing large parts of their businesses and/or demanding new products and services. Small companies started emerging in order to fill in the gap in sectors such as water treatment, water metering, water management & engineering and others. Some of them either

grew organically and/or externally by acquiring their competitors or they became bidding targets of large industrial manufacturers wanting to enter the niche markets. In fact, corporate activity has dominated the water sector during the last couple of years with companies such as Siemens, Danaher or General Electric making significant acquisitions.

4.3. Promising Investment Clusters

We can identify four promising investment clusters with great upside potential where investors can also contribute to the sustainable use of water:

- Water distribution and management
- Advanced water treatment
- Demand-side efficiency
- Water in agriculture

4.3.1. Water distribution and management

Water distribution and sewers

Water infrastructure is still weak and increasingly ageing. Drinking water pipes and sewers are the lifeline of water provisions and disposal of wastewater. They account for around 80% of the costs of the entire water infrastructure (Water Infrastructure Network, 2001). Since most pipe networks were laid at the beginning of the 20th century[10], but replacement work has been neglected in recent years, many pipes are in a very bad shape. One result of this is increased water loss[11].

Most drinking water pipes and sewers are laid by traditional construction companies (e. g. Bouygues and FCC). In industrialized countries this involves investment of at least USD 100 billion every year (WTO, 2000). Rising standards, the emergence of alternative technologies for laying pipes and sewers, and increasingly complex locations are prompting more and more companies to specialize in a particular field. One example is Insituform,

[10] Drinking water pipes can be expected to last between 50 and 100 years depending on their quality, type of ground they are laid in and various other factors (USEPA, 2005).

[11] In the United States alone, leaks in the pipe network mean that around 15 to 20% of drinking water is lost during transportation (ca. USD 800 million worth of water goes to waste every year). In less highly developed industrialized nations the losses are even higher at 20 to 40%, although here illegal withdrawals from pipe networks are common practice and increase the losses through leaks (IWMI, 2000).

which focuses on pipe rehabilitation using sliplining, another one is Watts Water Tech Company. A number of different techniques are used for laying water pipes: repairing and replacing pipes by excavating or using trenchless technology, cement mortar linings, sliplining and long pipe relinings. New methods for identifying damage (for example endoscopic inspections and repairs) play an important role. Discovering and repairing damage at the right time helps to avoid major damage resulting from burst pipes.

Water Management and Engineering

Ever-scarcer water resources have to be intelligently managed. In the future terrestrial information and satellite systems will increasingly be used to optimize withdrawals and distribution. Consultancy firms such as Tetra Tech focusing on the management of large river catchment areas or ecosystems have reported very good sales in these areas in recent years (Tetra Tech, 2006).

4.3.2. Advanced Water Treatment

Wastewater Treatment

The volume of the worldwide wastewater treatment business is estimated at USD 10 billion a year, growing at 10 to 15% annually (FAO, 2000). Even so, only 5% of wastewater is currently treated (SAM, 2006). While the main aim of wastewater treatment used to be preventing the pollution of waterways, nowadays the emphasis is increasingly on enabling wastewater to be reused (e. g. for flushing toilets, irrigation or groundwater recharge). Enhanced treatment technologies are constantly emerging as developments progress. Biological techniques are being optimized, and physical processes (e.g. membranes) are becoming increasingly viable from an economic point of view. Companies working with membranes include Pall and Zenon (which was acquired by GE in 2006). Another important player with membrane technologies is HyFlux (Singapore). Not only this, but new problem substances (such as endocrine active substances) are constantly being discovered which today's treatment plants cannot deal with.

Disinfection

Disinfection of drinking water is the most common treatment method used by water utilities. Of all water used in residential areas, 80% is disinfected. Even so, 80% of all infectious diseases are still spread by undisinfected water. The disinfection business, worth around USD 5 billion, is growing at an annual 10 to 15%. So far chlorination has been predominant, with approximately 85% of the market (Helmut Kaiser Consultancy, 2005). Recently, however, this process has hit the headlines, with new research forging a link between the use of chlorine gas and the formation of undesirable by-products such as trihalomethane, which are suspected of being carcinogenic. Given the potential risks, the market share of disinfection by chlorine is likely to fall to around 50% in the next five or ten years (General Electric, 2007).

An efficient and recognized alternative is irradiation with ultraviolet light; a technique offered by for example Trojan Technologies (which was acquired in 2004 by Danaher). Adsorption techniques (such as the one offered by Calgon Carbon Corporation) and membrane-based processes are additional alternatives. However, newer methods have the disadvantage that they do not guarantee permanent disinfection (preventing water in the mains from being reinfected). For this reason, combined methods, for example using chlorine dioxide, will become popular as a means of protecting water in the mains network. There will also be increasing calls for the disinfection of wastewater, which is already commonplace in the United States.

Desalination

With water scarce in many southern countries, desalination has become very important. Not only is desalination used as a means of making drinking water from seawater and brackish water (a mixture of salt and fresh water). Desalination is also increasingly a necessary component of wastewater treatment. There are currently over 13 000 smaller and larger desalination plants in operation in 120 countries, removing salt from 30 million cubic meters of water every day. The market, currently worth approximately USD 5 billion, is forecast to grow to USD 70 billion by 2020 (Helmut Kaiser Consultancy, 2005). As things stand at present, thermal desalination methods (distillation) have a 74% market share, while reverse osmosis accounts for 22% of the business, in terms of the volume of water treated. However, reverse osmosis is clearly gaining ground. Even though desalination has long been

possible from a technological point of view, it is not yet in widespread use. The main reasons for this are high energy consumption and considerable production costs of between USD 0.5 to 1.5 per m3 (compared with USD 0.1 to 0.25 per m3 for conventional water treatment) (Environmental Business International, 2005). In recent years the production costs have fallen 10% a year, and experts reckon the potential for further savings has not yet been exhausted. In future we can therefore expect to see a substantial increase in investment in desalination. Companies involved in this field include Kurita Water (Japan) and GE Ionics (US).

Monitoring

The main aim here is to monitor the quality of water either permanently or by means of random samples. With the introduction of tougher legislation, especially in the EU, technologies for monitoring the quality of water are becoming increasingly important. Methods for identifying water losses are also steadily gaining in importance. The biggest players in this field include Danaher and Water Corp.

4.3.3. Demand-Side Efficiency

Raising demand-side efficiency is the quickest and cheapest way of ensuring that water resources are used more sparingly. Demand-side efficiency means providing the same service using less water without sacrificing convenience.

Sanitary Installations

The average person uses 60 m^3 of potable water a year, 20% of which for showering (SAM, 2006). While a normal shower head uses around 20 liters of water a minute, a high-efficiency shower head mixes air with the water to halve the water consumption without any noticeable reduction in effect. In this way around 6 m3 of water per person per year can be saved. Extrapolating this example to the 450 million people in the EU gives potential savings of some 2.7 billion cubic meters of potable water a year. Assuming an average water price of EUR 2.2 per cubic meter (including wastewater treatment) and factoring in savings on hot water (EUR 2.2 per cubic meter), no less than EUR 11 billion could be saved every year (IWMI, 2000).

Given rising water tariffs, there are huge incentives for consumers to use efficient household fittings – provided that each household's water use can be billed fairly and

transparently. Companies producing more efficient sanitary equipment involve Geberit or Aqua Art AG. However, with these savings lowering the consumption of water while infrastructure costs remain the same, the price of water would rise again in the medium term.

Decentralized Treatment

The market for decentralized wastewater treatment systems is growing rapidly at around 20% per year. The reason is clear: as the price of water rises, it makes much more economic sense for industry to invest in recycling gray water[12]. These systems are also becoming increasingly attractive for household use, where they can also bring economic benefits. The biggest player in this field is Purecycle.

Water utilities, on the other hand, are often skeptical when it comes to water-saving technologies. Their main argument is the high overheads of pipe networks, which have to be in place in any case. If efforts to save water result in lower water sales, utilities have to charge higher prices for water, which is not politically attractive. On the other hand, there will be no increase in the overall annual costs paid by consumers for water. If actively communicated, water-saving can thus be a sensible move for utility companies.

Water Meters

To pass on the costs of water to the consumer in line with the "user pays" principle, there must be a reliable way of metering water consumption. This requires water meters which can not only measure water consumption for a whole apartment block, but can break water usage down into individual households. Nowadays the technology exists to read meters automatically and is produced by companies such as Techem and Badger Meter. The whole process is similar to billing central heating costs on an individual household basis.

[12] Gray water is water that has been used for one purpose but can be reused for another purpose without, or with minimal, purification.

4.3.4. Water in Agriculture

Irrigation

Precipitation is subject to great seasonal and regional variation. For this reason, irrigation is often used in agriculture. Currently around 18% of agricultural land worldwide – producing some 40% of the world's food – is irrigated. The irrigated area is likely to increase sharply in the coming years (FAO, 2000). Investment related to agricultural irrigation currently runs to around USD 35 billion a year. The most common way of irrigating land is by flooding (ditch irrigation). However, this wastes a large amount of water and carries the risk of increased soil salinity. Much more efficient are technologies such as micro irrigation (drip irrigation), which uses 30 to 70% less water, minimizes the risk of increased soil salination, and boosts agricultural yields by between 20 and 90% (Postel, 2001). Other alternatives include sprinkler equipment: high pressure sprinklers, which spray water inefficiently over plants and allow a large amount of it to evaporate, and low pressure sprinklers, which are much more targeted and efficient by comparison. Even though sprinklers currently account for only 10 or 15% of the market, and micro irrigation a mere 1%, the market share of these technologies should grow substantially (Lindsay, 2006). In this area innovative startup companies are developing new techniques, for example for measuring soil moisture content exactly and managing the amount of water used for irrigation in line with this. Eurodrip SA and Lindsay are two examples of companies active in this sector.

Figure 8 provides a summary of investment areas within the four investment clusters.

Figure 8: Water Sector Promising Investment Clusters

		Technologies	Target markets	Players
Distribution and mananagement	Water Distribution	Open/Closed, various materials, sliplining/long pipe	Water mains and sewer networks	Instituform, Watts Water Tech
	Management & Engineering		Public sector, agriculture, companies	Stantec, Tetra Tech
Advanced Water Treatment	Water Treatment	Physical/biological/chemical/chemicals	Drinking/wastewater	GE (Zenon), Kemira, ITT
	Disinfection	Chlorine/ozone/peroxide/chlorine dioxide/membranes/UV/adsorption/distillation/filtration	Drinking/wastewater	Pentair, BWT, Calgon Carbon, Danaher
	Desalination	Distillation/reverse osmosis/nanofiltration/electrodialysis/ion exchange	Sea water/wastewater	GE, Kurita, Esco Tech, Pall, Whatman
	Monitoring		Quality/quantity	Danaher, Horiba, Dionex
Demand-side efficiency	Sanitary installation		Industry/households/public sector	Geberit, Aqua Art AG
	Decentralized treatment	Use of rainwater/biological treatment/chemical/physical treatment/disinfection	Industry/households/public sector	Purecycle
	Metering	Water meters/reading instruments/evaluation	Owner occupied & rental acommodation/industry	Techem, Badger Meter
Water in Agriculture	Irrigation	Microirrigation/low pressure sprinklers	Agriculture	Eurodrip SA, Lindsay

5. Waste Management Sector

5.1. Market Size and Growth

Waste management is an essential service. In societies where there is a high level of regulation and enforcement, it is a sophisticated industry using advanced technologies. In societies with little or no regulation or enforcement, waste tends to be treated indiscriminately. In Europe the level of environmental regulation is high, however unlike trade regulations, there are no common standards for waste management. European legislation on waste sets minimum standards which member nations must meet, they are free however to exceed these standards in order to follow their own political and environmental agendas. The result is that within Europe national regulations differ and there is no single market.

The market may be split between the **industrial and commercial sector** and the **municipal sector**. In most European countries the municipalities have a statutory duty to deal with household waste, which they either do themselves or use private sector contractors. They have no such duty in respect of industrial and commercial waste. The municipal sector is therefore typified by long term contracts which tend to be 5 to 10 years for collection and often in excess of 20 years for treatment and disposal. The industrial and commercial sector tends to be a much more short term market, with contracts in excess of a couple of years being rare.

The waste management market has shown steady growth in recent years. This is despite the moves afoot in many countries to minimize the volume of waste entering the market. However, volumes continue to show year-on-year increases in most countries with no suggestion of any major reversal in the amount of waste being generated.

The aggregate revenues of companies with technologies for sustainable waste management and recycling were at least USD 35 billion in 2005 (Impax AM, 2007). In contrast, the aggregate annual revenue for the conventional waste sector are of the order of USD 155 billion (Impax AM, 2007). The four key sustainable waste management sub-sectors (which are further discussed in section 5.3. Promising Investment Clusters) have been experiencing double digit growth, driven by external influences such as economic growth, the activities of consumers towards waste minimization or the impact of legislation.

5.2. Market Participants

The waste management market can be further subdivided into **non-hazardous waste** and **hazardous waste**. The former tends to be a local business, as the relatively low unit cost of treatment makes transport a significant part of the overall cost. Hazardous waste treatment costs tend to be higher making it a more regional business. Both the public and the private sector are active in the waste market. The degree of privatization varies across Europe; it is high in the UK and France but lower in Germany, the Netherlands and Belgium. Advancing European legislation is necessitating substantial investment in new infrastructure. This combined with budgetary constraints is driving privatization initiatives in many European countries.

Within the private sector, consolidation of the industry has been a feature for many years. The new infrastructure requirements and the long term nature of the business have recently attracted private equity groups.

Within the national markets a further distinction may be made between **"collection, transfer and recycling"** and **"treatment and disposal"** (Frost & Sullivan, 2006). The former has historically had low barriers to entry and hence has been made up of many small participants. Increasing recycling requires greater investment in infrastructure which is moving this market towards the larger players. Treatment and disposal has high barriers to entry as facilities tend to be capital intensive and projects have long gestation periods. These activities are therefore the domain of well capitalized companies, and are populated by a few large players, often multinationals.

5.3. Promising Investment Clusters

We can identify four promising investment clusters with great upside potential where investors can also contribute to the sustainable management of waste:

- **Non-Hazardous Waste Management**
- **Hazardous Waste Management**
- **Recycling**
- **Environmental Consultancy**

5.3.1. Non-Hazardous Waste Management

Although the waste management market should not be considered as low-tech, this has effectively been the case until recently in a large number of markets. Reliance on a simple collection and disposal to landfill approach led to a lack of interest in innovation within the market aside from ways to reduce storage and transport costs for the end-user. In Europe, the passage of EU Landfill Directive[13] in 1999 changed all this with Governments and the market forced to address the issue of alternative treatment for waste. The result has been the accelerated emergence of sectors such as sorting/separation services, thermal treatment and biological treatment. Technical development of these sectors can be seen for example in the arrival of Mechanical Biological Treatment (MBT) concept or waste-to energy projects.

Among companies that are participating in this ongoing shift towards higher value technologies are Shanks (UK) and Lassila & Tikanoja (Finland), both utilizing MBT, or the Energy Developments Company (Australia) which runs waste-to-energy projects.

5.3.2. Hazardous Waste Management

Hazardous waste management is subject to increasing regulatory pressure and companies that are able to secure planning permission for the processing of these wastes are able to develop very profitable businesses. For example in the US, the generators are liable from "cradle to grave" for their medical waste[14]. Stericycle (US) took advantage of this business opportunity and offers hospitals, blood banks and pharmaceutical manufacturers (plus smaller customers such as medical and dental offices, laboratories and corporations) medical waste management services. In Europe, Seche Environnement (France) is a leader in hazardous waste treatment, whereby it assists its clients with the compliance among others

[13] EU Landfill Directive restricts the use of landfill for the disposal of waste and encourages the development of alternative technologies. This Directive was passed due to the growing scarcity of free landfill (europa.eu.int/eur-lex/pri/en/oj/dat/1999/l_182/l_18219990716en00010019.pdf).

[14] The roots for this legislation can be found in the Medical Waste Tracking Act which was passed by the United States Congress in 1988. This act was a response to the incidents in 1987 where medical waste, such as vials of blood and syringes, washed up on the shores of Ocean and Monmouth counties in New Jersey, and some Long Island beaches, during the summer of 1988. The incident sparked unprecedented numbers of local swimming bans. The act provided for more systematic tracking of medical waste, and budgeted money for studies of waste-related disease promulgation. The studies indicated that disease is most threatening at the time when the waste is created, but afterwards the threat lessens with time. During the lifetime of the act, the EPA stipulated that medical waste disposal must be done by incineration. It expired June 21, 1999. (www.epa.gov)

with the Restriction of Hazardous Substances Directive (RoHS) which was adopted in February 2003 by the EU[15].

5.3.3. Recycling

Recycling Systems and Deposit Schemes

The enormous amounts of waste generated by the world's more economically developed populations pose major challenges for society. People around the world are increasing their consumption of products and services every year as the global standard of living increases. The situation in the EU is an example of the inability to fulfill the goals that have been set relative to waste management. The EU has set a target that each inhabitant should not generate more than 300 kilograms of waste on average per year. The reality however, is that the average in the EU today is more than 500 kilograms per inhabitant per year (Tomra, 2006).

And despite an increased focus on efforts to reuse and recycle in recent years, the majority of waste is unfortunately still being dumped at landfills. A number of research studies in Europe and the USA show in fact that more than 60 percent of household waste is being taken to landfills (Frost & Sullivan, 2006). Over the past five to ten years there has been no significant change in this pattern.

Although this backdrop can appear rather grim, there are nevertheless a number of positive developments and trends that in the long run can play a major role in increasing the rate of recycling. For example, politicians are now placing greater attention on the waste issue and enacting stricter waste regulations and recycling requirements. The EU in particular has dramatically increased its ambition level for recycling through such instruments as its Packaging Directive. Increased fees have also been implemented, making it more difficult and expensive to landfill waste that could otherwise be recycled. At the same time, many corporations and organizations are becoming more aware of their own social responsibilities and are actively working toward reducing their negative impacts on the environment.

The fact that recycling in many cases makes sense from a financial point of view is also another important trend. While in the past recycling was considered to be a costly

[15] The RoHS directive took effect on July 1, 2006, but is not a law; it is simply a directive. This directive restricts the use of six hazardous materials in the manufacture of various types of electronic and electrical equipment (www.europa.eu).

endeavor, the fact of the matter is that it is often cheaper to reuse and recycle than it is to utilize new materials. An illustration of this is the savings one achieves in the form of lower energy use and costs from recycling iron, aluminum, plastic and paper compared to creating these materials from primary resources. In this way recycling not only contributes to fulfilling environmental requirements, it also leads to increased value creation through more efficient resource utilization.

In response to recycling commitments, local governments are putting in place systems that involve reverse-vending machines[16], collection and registration systems, logistics and materials processing. The only integrated service supplier and market leader is Tomra (Norway).

End of Life Vehicles and Electric & Electronic Equipment Recycling

Today, the recycling market is moving closer and closer to the concept of Producer Responsibility. This concept means that producers should increasingly take responsibility for their products once they become waste and ensure that their products are increasingly designed for recycling. This concept started emerging in 2002 when new waste legislation started to emerge. This legislation is represented by two directives:

1) **End-of-Life Vehicles Directive (ELV)** – sets collection, recycling and recovery targets for end of life vehicles (ELVs). From 2007 it is the producer's responsibility to provide free take back of all ELVs and to recycle and re-use them accordingly[17].
2) **Waste Electrical and Electronic Equipment Directive (WEEE)** – sets collection, recycling and recovery targets for all types of electrical goods. The directive imposes the responsibility for the disposal of waste electrical and electronic equipment (WEEE) on the manufacturers of such equipment. This means that households should have the possibility of returning WEEE to the manufacturers free of charge and the latter are obliged to use the collected waste in an ecological-friendly manner, either by ecological disposal or by reuse/refurbishment of the collected WEEE.

[16] In 2002, Germany followed the Scandinavian example and introduced deposit scheme for all beverage containers, which led to widespread installation of reverse vending machines (www.letsrecycle.com).

[17] By January 1st 2006, 85% of a vehicle's weight is to be recycled or recovered; 5% of the waste can be used as fuel. By 2015, 95% of a vehicle's weight is to be recycled or recovered; 10% of this waste can be used as fuel (http://www.defra.gov.uk/environment/waste/topics/elvehicledir.htm).

As the ELV and WEEE Directive come into force[18], automotive and electrical/electronic original equipment manufacturers (OEM) are also seeking ways of outsourcing the burden of compliance with these regulations. Interesting business models are emerging to take advantage of this opportunity, e.g. LKQ (US) and Universal Salvage (UK) are already working with several global automotive companies in this regard.

Commodity Production Using Recycled Material

On the background of growing importance of recycling, companies starting emerging that can take advantage of the increasing availability of recycled materials, which are in most cases cheaper than original materials. Examples of such companies are Mayr-Melnhof (Austria) and Caraustar Industries (US). Both companies produce all cardboard and packaging products from recycled materials.

5.3.4. Environmental Consultancy

Legislation regarding waste is quite complex and evolving fast. Therefore, companies often need assistance with making sure that they comply with the regulations in order to stay clear of possible fines, legal action or misguided transactions. Environmental consultancy companies ensure the dissemination of good environmental technologies and practices and facilitate their integration into company activities. Two leading environmental consultancy companies are RPS Group (UK) and TetraTech (US).

Figure 9 gives a summary of the waste sector promising investment clusters.

[18] The WEEE Directive obliged the twenty-five EU member states to transpose its provisions into national law by 13 August 2004. Only Cyprus met this deadline. On 13 August 2005, one year after the deadline, all member states except for Malta and the UK had transposed at least framework regulations. As the national transposition of the WEEE Directive varies between the member states, a patchwork of requirements and compliance solutions is emerging across Europe (www.europa.eu).

Figure 9: Waste Sector Promising Investment Clusters

	Technologies	Target Markets	Players
Non-hazardous waste management	Biological treatment: MBT, Home Composting, Community Composting, Anaerobic Digestion	Households/Industry/Commercials	Shanks, Lassila & Tikanoja
	Thermal Treatment: Energy from Waste, Incineration, Pyrolysis, Gasification	Industry/Commercials	Energy Developments
Hazardous waste management	Incineration, Neutralization, Chemical Oxidation, Reduction, Stabilization	Households/Industry/Commercials	Stericycle, Seche Environnement
Recycling	Reverse Vending Machines, Deposit Schemes	Packaging Directive, Industry, Commercials	Tomra
	Automotive parts recycling	End-of-Life Vehicles Directive (ELV), Original equipment manufacturers (OEMs)	LKQ, Universal Salvage
	Electrical/Electronical Equipment recycling	Waste Electrical & Electronic Directive (WEEE), Original equipment manufacturers (OEMs)	TES-AMM
	Commodity production using recycled material	Households/Industry/Commercials	Mayr-Melnhof, Caraustar Industries
Environmental Consultancy	Design, Waste logistics, Compliance	Industry/Commercials	RPS Group, TetraTech

6. Analyzing the Environmental Markets' Business Model

The previous sections described the broad spectrum of the three environmental markets' sub-sectors, most of which are experiencing sustained high growth rates. For investors to profit by committing capital to these markets, they must understand the features of the business models that are particular to the Sectors. We can distinguish three key business models:

- Technology/Product development
- Project development and ownership
- Services

6.1. Technology/Product Development

New technology lies at the heart of many of the investment opportunities in the three Sectors. When deciding about a particular investment in Environmental Markets investors and portfolio managers should pay strong attention to **(1)** the protection of the firm's intellectual property as competitors might be able to replicate or encircle weak intellectual property; **(2)** the business model designed to commercialize the technology; **(3)** the expected return on capital required to reach the target functionality. Developing a new technology can require very high investments and investors at different stages in the development of these businesses may realize very different returns; and **(4)** the management team's experience and track record in developing similar businesses. Management must have sufficient understanding of the particular market. In order to better understand this business model, we will look at a concrete example of a company that follows this model.

6.1.1. Case Study Vestas Wind Systems A/S

Vestas started to manufacture wind turbines in 1979 in Denmark and has been one of the largest suppliers to the wind industry ever since. Since its stock market flotation in 1998, the company has grown rapidly, particularly on the back of strong demand in Germany and the United States. Vesta's first commercial turbines delivered a maximum of 55kW of power and were designed for onshore use only. Today, the company is supplying machines generating up to 4.5MW and is a pioneer in the development of turbines suitable for offshore environments (Vestas, 2006). Between 1998 and 2006, Vestas' market capitalization has

grown from ca. DKK 1.3 billion (EUR 100 million) to DKK 59 billion (EUR 7.9 billion) and its share price has increased at an annualized growth rate of ca. 27%, although it has been volatile over this period (Vestas, 2006).

6.2. Project Development and Ownership

Investors should distinguish carefully the risk and return characteristics in the three phases of a project: development, construction and operation. Project success is a function *inter alia* of **(1)** the scale and quality of the underlying resource to be exploited; **(2)** the reliability of the technology applied to the resource; **(3)** the terms of the contracts drawn up to govern the different aspects of the project and especially the degree to which they accurately allocate the risks and returns among the contracting parties; and **(4)** the strength of the project's stakeholders. Successful investing in projects requires an expert understanding of these issues plus a detailed analysis of the investment's cashflow.

Again, we will demonstrate the application of this business model on a concrete example in order to gain a better understanding of its functioning in practice.

6.2.1. Case Study Canadian Hydro Developers Inc.

Canadian Hydro Developers (CHD) is a developer, owner and operator of power plants based in Canada utilizing wind, hydro and biomass power. Currently, the company operates 18 facilities and has an ownership interest in a net 230MW power generation capacity. CHD's business model is to raise capital which it then deploys to fund (a) project development and (b) equity stakes in those projects that have been successfully developed. Listed on the stock market since 1990, the company therefore offers investors exposure to all three phases of a project (development, construction, operation). Over the past 6 years, CHD's share has grown at ca. 18% p.a. and its market capitalization is currently C$ 770M (EUR 540M) (www.finance.google.com, 14.4.2007).

6.3. Services

The rapid growth of the Sectors has already stipulated the development of a broad range of related service businesses. Many of these, such as financial services and consultancy, are familiar from other sectors of the economy. The analysis of the service businesses in the

Sectors is similar to that in other sectors. Market analysis, company strategy, the strength of the management team, and the investment characteristics of the specific opportunity are the key.

Once more, we will illustrate the application of this business model on practical example of a company active in the field of services.

6.3.1. Case Study Chloride Group Plc

Founded over 100 years ago, Chloride initially built a global presence in battery manufacturing and supply. Recently, however, the company has reoriented its business towards power management solutions for industrial customers. Chloride's market is expanding rapidly as industrial electricity consumers realize the economic value of power quality for critical operations such as manufacturing, Chloride Group plc continues to sell products (such as back-up power systems, advanced switches and software) into this market, but is increasingly offering services based on remote monitoring and diagnostic services to support customers' power management in real time. Over the past four years, Chloride's share price has grown at a compound average of 14.5% p.a., and its market capitalization is currently GBP 410M (EUR 611M) (www.sharecast.com, 14.4.2007).

7. P.E.S.T. Factors

Having defined the Environmental Markets, explored the promising business opportunities they offer and defined the business models they represent, we will now scrutinize the key factors which have major influence on their development without repeating the factors already mentioned above. These could be divided into political, economic, social and technological factors (thus P.E.S.T. factors) and are explored in the following section.

7.1. Political Factors

Governments and powerful lobbies are pushing for more responsible activity. Reasons behind these moves are not only ideological. Environmental business practice is essential to long term business activity and sustainable development.

The European Commission describes the environment as relating *"to every aspect of the world we share and depend on for our survival. It influences everything we do: how we live, work and play, our health, our safety and the quality of our lives."* (European Commission, 2002). As a result the EC is pushing for laws and regulations aiming to improve research and technology in the environmental field and add restrictions and incentives for businesses to carry out their activity in an environmentally friendly manor.

These trends are also observed in the United States despite the country regularly being criticized for not signing the Kyoto treaty. Such measures include the Bush administration's efforts to push the US energy bill, which promises tax breaks on hybrid vehicles and which was finally adopted in 2005. Furthermore, Bush himself proposed an initiative that calls for a 22% increase in clean-energy research and a goal of replacing at least 75% of U.S. Middle East oil imports by 2025 (though he offered no substantive funding to do these things) (Makower, Pernick, Wilder, 2006). Many believe these measures are insufficient; however they definitely represent a first step and will encourage altering consumer patterns.

However, environmental policy is still at an early stage. It is about 40 years old and still has a long way ahead. For now, policy is usually used as a response from social pressures. Environmental issues are only just starting to be understood. Gerstenfeld suggested in 1994 that *"During the coming decade (1994-2004), slowly, rationality is likely to take the lead in environmental policy-making. Such a message doesn't excite the media, nor does it make headlines. But in a confused, motley, multifaceted field of fundamental importance to us*

all, it is a major signal of hope." (Gerstenfeld, 2002). Gerstenfeld was probably right as big progress has been achieved, mostly in the European Union.

Regulations, Tax/Subsidy

As policy evolves, economic players develop new technological tools to respond to the new legislations. Supporting that idea, Michael Porter affirmed *"that environmental regulation could under certain circumstances offer firms innovation opportunities, which in turn would outweigh any costs of compliance"* (found in Koehler, 2004).

For instance industries like ethanol rely heavily on government regulation. Ethanol in the United States is a competitive energy source, as it benefits from advantageous taxation. The Federal blending tax credit of USD 0.51/gallon essentially provides for the premium pricing to gasoline. Without it, we could expect prices to be as much as USD 0.50/gallon lower, hurting the economics of the industry (Impax AM, 2007). In short, without subsidies, biofuels in the US would be uneconomical. Crude oil needs to be at USD 80 per barrel in order for ethanol to be competitive / economical without subsidy. With the 51 cent subsidy, ethanol is economic at USD 55. These developments have enabled the development of more efficient renewable fuel and advances in technology. Europe has failed to do so with ethanol and may be losing advance in the field as a result.

Clearly, a big part of the late innovations in environmental technology directly stem from new regulations. A study by Norberg-Bohm (Norberg-Bohm, 2000) found that of twenty key innovations in the past 30 years, only one was funded entirely by the private sector and the rest were totally public. In that sense, government is a strong vector for the growth of Environmental Markets.

Current developments

Other factors are pushing governments to help emerging clean tech companies. For a start several groups are now lobbying governments for more research in renewable energy. Following the London bombings in 2005 suggestions were made that green lobbies in the United States are using the war on terror as an argument to develop eco-friendly energy (Ingham, 2005). They claim that the United States' dependency on oil politically weakens the country as it relies on the Middle East. As a result the US may have been subject to pressures limiting the extent of their war on terrorism in order not to threaten relationships with oil-rich countries. For example, Bush admitted in his 2006 State of the Union address: *"We're hooked*

on oil from the Middle East, which is a national security problem and an Economic Security problem."(www.whitehouse.gov/news/releases/2006/01/20060131-10.html, 19.1.2007).

Also, lawmakers in the US Congress, primarily from farm states, are pushing federal government to require that 25% of the nation's energy come from renewable sources, like ethanol and solar power, by 2025 (the so-called 25 by 25 plan) (www.25x25.org, 29.4.2007). The idea is that "home-grown" US energy from corn and soybeans can offset the nation's growing dependence on oil imports, while relieving consumers and businesses suffering from high energy costs.

European Union is not lagging behind. Lately, EU energy ministers rejected the European Commission's proposal to introduce a binding target for renewable energy to represent 20% of the energy share by 2020. However, they did win backing for the share of biofuels in the EU member states' fuel mix to increase to 10%, and to increase energy efficiency by 20% by 2020. Within waste, European Commission recently proposed strict limits on rubbish generation, with the aim of stabilizing EU waste production at 2008 levels by 2012.

Rising oil prices are another factor pushing governments to react as those economies that rely heavily on imported oil will suffer more and more as prices keep on rising. Similar issues concerning water and waste are acting as catalysts for governments to encourage research on water and waste management.

7.2. Economic Factors

Economics have often been an argument against environmental practices as the latter are seen to be more expensive. This argument is no longer valid. Extracting fossil resources instead of renewable resources is cheaper in many cases. Oil is the most mediated example. However prices of oil resulting from the resource's continued depletion have severely risen and can be expected to keep increasing on the long term as the scarcity of the resource increases. Ethanol, a renewable alternative[19] has proved to be economically viable in Brazil for instance where *"today ethanol accounts for 40 percent of the fuel sold in Brazil"* (http://earth-policy.org).

Similar examples can be found in other countries. Several other renewable sources such as recycled scrap metal are becoming more competitive than mined material. Such economic factors, often enhanced by regulations, such as the EU's End of Life Vehicle

[19] Ethanol is renewable; its environmental attractiveness has since been contested however.

directive[20] or the Waste Electrical and Electronic Equipment Directive, are making recycling businesses more and more attractive.

Furthermore, the combination of rising prices for oil and natural gas (which is partly due to increasing global supply and demand dynamics) with the decline of production costs due to market growth, economies of scale and technology advances makes some of the clean technologies price-competitive with their conventional rivals – and in some cases cheaper. This is true mainly for wind power and biofuels in the U.S. where in 2006, electric utility customers buying wind power in at least three U.S. states paid less, for the first time, than those purchasing the conventional power mix (mostly natural gas and nuclear) from the same utilities (Makower, Pernick, Wilder, 2006). At times over the past year, the price of biodiesel dipped below that of petroleum diesel in some states.

Finally, competition for customers is another factor, for instance *"Toyota's and Honda's relentless improvement in powertrain technology is enabling them to offer truly new alternatives (the 2006 Lexus RX 400h luxury hybrid) and upsize their products while improving fuel economy (2005 Honda Odyssey)."* (Merrill Lynch, 2005)

Increasing Correlation between Financial Performance and Environmental Performance

For now, the debate has mainly been focused on companies active on Environmental Markets. But environmental progress can only be achieved by using a collective view. In summary, there should be a shift for all companies to adopt more responsible business practices. This shift will mainly be achievable if all economic agents take an active part. One central question to that shift within the industry is whether it can be profitable to adopt environmental ways of carrying out a business. Such ways can include tighter control to avoid catastrophes, but also aiming to eliminate waste, and shorten resources requirements.

Several studies[21] have shown that such progress can improve long term financial performance. However, this assumption is hard to prove. What is certain is that, avoiding major crisis such as the Exxon Valdez oil spill helps avoid short term cash outflows resulting from litigation and de-pollution as well as it helps preserving brand image. As a result most public companies now publish reports on corporate responsibility and sustainability and several companies are even making definite progress within the field. This shift can only be

[20] The ELV aims to force car manufacturers to take cars back and ensure their recycling by 2007
[21] such as research on The Correlation Between Sustainability and Financial Performance by the CMER research group from INSEAD or Koehler, A. (2004) Capital Markets and Corporate Environmental Performance

expected to gain on importance in the future following competition pressure and tightening legislation. Also, non-governmental bodies such as Greenpeace have the power to put pressure on companies by mobilizing public opinion.

Present Blue Chips Giving the Example

Currently, several major companies are actively pursuing important changes to re-invent themselves and be more sustainable in the future.

Case Study: Toyota's Lean Management

Toyota is an early example of environmental success. Since the 1960's Toyota has implemented what has later been termed as "lean management" (Womack, Jones, Roos, 1990). It started off with a re-engineering of the manufacturing process, by tightening control flows and aiming for minimum waste as a result. The term 'Waste' here is used in a vast sense as the limited use of resources, idle time and storage space. Interestingly enough, Toyota's lean practices originated from a desire to improve manufacturing processes and were then extended to management, as a result of their waste reduction policy. Apart from a distinct increase of efficiency, lean management has clearly shown several environmental virtues such as the reduction of excess material waste.

One may say that lean management may increase efficiency but will not necessarily have an impact on financial performance. This idea is half true as Toyota's case has shown how environmental performance can be associated to financial performance, and also how the idea that mass production and waste creation is not necessarily the most performing in the long term. Companies like Toyota which have been pioneers in waste reduction can afford to be further pioneers in the use of renewable energy and of recycled materials as their management and design can afford less affluent power needs and environmentally friendly products. It is probably not a coincidence that Toyota is also a leader in hybrid vehicles.

The Environment as a Marketing Tool

A further incentive for companies to offer products and services that benefit the environment is the marketing advantage they can gain from it. Polls by the EU show that more than 70% of Europeans see the Environment as a top three priority for European policy (www.europa.eu, 19.11.2006).

Also the success of several environmental products such as Ecover in the UK shows that there is a keen interest from consumers in the Environment. Therefore, the use of a product's environmental attractiveness as a feature is a growing attribute and can be expected to be increased in the future.

7.3. Social Factors

Demographics

Population increase has been impressive during the last two centuries and is expected to keep on until it reaches a peak of about 10 billion around 2200 (http://www.census.gov/ipc/www/world.html, 27.11.2006). With increasing population, huge increases in consumption, in particular since 1950, have very strongly accelerated the depletion of natural resources. Up until now, development has been synonymous with consumption and there are few signs that this habit is going to change. As a result, one can expect the current depletion of resources to accelerate in the next years as human population increases and bigger numbers increase their consumption patterns. Changes in our habits are becoming obviously necessary and it is often claimed that three planets would be necessary to respond to the demand for resources if the entire world population were to consume as much as the United States (www.defra.gov.uk, 14.3.2007). One of the main questions raised is how this change will be implemented as it is unlikely that people voluntarily decide to consume less and that developed countries voluntarily decide to reduce their growths in order to support a growing world population.

In order to meet the requirements of an increasing population, there will be little other choice than adopting more responsible activity. Social pressures will force industries to act more responsibly. Shifts in consumer preferences will probably also encourage the development of environmentally responsible goods and services.

Education

To achieve these goals in production and consumption patterns, one needs to involve governments, companies and consumers. A general level of awareness has already been largely achieved and is to be continued. General education on environmental matters has been increasing steadily since Neil Armstrong saw signs of pollution around the earth from the moon. Education on the importance of the environment and the impact that man's activity can

have on it will increase and lead to more responsible business practices in the future. Timing is critical to correct economic trajectory, however social pressures, adding to environmental policy will probably have an increasing effect on changing the business environment. However, other rectifications are necessary in our use of technology.

7.4. Technological Factors

Revolutionized Industries Were Achieved by New Players

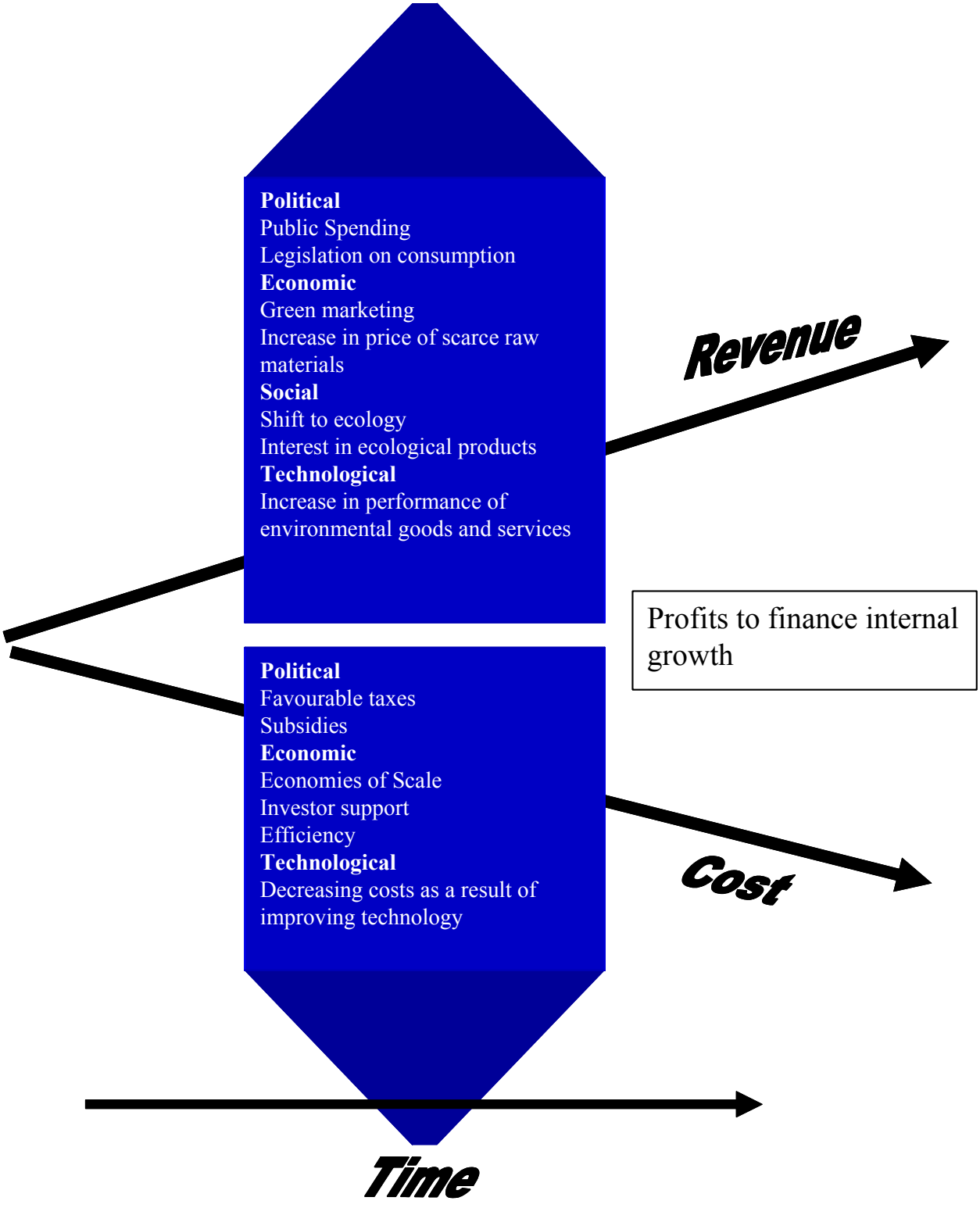
During the research and extensive discussions with investment managers, one of the apparent questions was to challenge **whether traditional polluting companies will re-invent themselves to become "green" companies, or whether, new industries will emerge from start-ups**. A short look in the past and the growth of the car industry reminds us that major car manufacturers once were the products of a few entrepreneurs. Did they know after creating their first cars that they were at the start of the leading corporations of their nation? The major railway companies did not invent cars nor did they buy car manufacturers out at some stage. One big question evolving from the past is whether oil manufacturers, several of which figure among the leading companies in the world will severely suffer and decline once a new source of energy becomes the norm or whether they will re-invent themselves. One could think that if fuelling cars remains an activity where one goes to a pump for refill, then oil companies may remain in control of their distribution network. This is not what happened when the road industry replaced rail however, and one may very well imagine that a totally different infra-structure is put in place. For instance, Stuart Energy a listed Canadian hydrogen company, which has now been bought out by Hydrogenics, a world leader in fuel cells, had imagined a home refueling platform, where hydrogen was obtained from the hydrolysis of water and supplied to the vehicle from the house garage. In fact, when one looks back at the past and our imagination of the future, one is often surprised. No one would have imagined 150 years ago what our cities look like today. Few would have imagined 15 years ago that we would be able to communicate on mobile phones around the world and send pictures, emails or instantly download music. As technological innovation permanently accelerates, it is unwise to aim to correctly forecast the future, but probably even less wise to assume that the future will stay the same.

Can the Old Players Keep on Dictating the Economy?

Having said this, it is hard to imagine, the likes of Shell, Exxon, Total and BP let a group of revolutionaries get hold of the energy market using wind, tidal-power and hydrolyzing water. Most major energy companies have a renewable energy department. Some are even considered to be leaders in certain fields. BP for instance is a widely acknowledged investor in the hydrogen economy. Other players on the other hand seem to be less advanced. Similar patterns can be observed in other industries. For instance, General Electric is also committed to environmental business: *"We're investing in an environmentally cleaner technology because we believe it will increase our revenue, our value, and our profits. We're launching Ecomagination not because it's trendy or moral but because it will accelerate our growth and make us more competitive,"* said Jeff Immelt, GE's CEO (Immelt, 2005).

The main change with comparable statements 10 years ago is that business leaders now seem to consider the environment a profitable business activity.

Figure 10: P.E.S.T. Factors Affecting Environmental Markets Companies



Source: own model

8. How to Invest in the Environmental Markets

Now that we have gained an understanding of the three markets, reviewed the business opportunities that these markets present and the factors by which they are influenced, we will turn our attention to the means of how to participate on their growth.

Principal types of investment that can provide exposure to the three Sectors described above are direct investments and funds.

8.1. Direct Investments

Opportunities for direct investment can be categorized as:

8.1.1. Quoted Securities

Many large power companies and many large, diversified industrial companies have some exposure to the Sectors. The drawback to gaining exposure to the Sectors through such companies is, however, that the part of their division dedicated to Environmental Markets tends to be relatively small in comparison to their core business activity. As a result, the impact that any rapid growth of the Sectors may have on company profits is likely to be diluted by other divisions of these companies.

However, as already mentioned, there are also "pure play" smaller companies whose main business lies in one of the Sectors. The attraction of investing in companies in industries that have the potential to grow rapidly is that you may hit the jackpot. One could pick the future industry leader, the equivalent of Microsoft or eBay. But, as many of the investors sadly learned during the dot-com boom and bust, finding the ultimate winner is no easy task.

8.1.2. Privately Held Start-Up Companies

The riskiest investments in the Sectors are the venture-funded, privately held start-up companies that often have unproven technologies but offer the potential for high returns, should these technologies prove successful but also big losses should the opposite happen. Venture capital investments in such companies rose by 36% in year 2006 (BNPP AM, 2007). Many of the top names in venture capital investing have funds dedicated to clean technology or significant investments in this field. Such funds may be riskier than investing in other vehicles and are typically illiquid, so the investor should not expect to realize returns for at

least 10 years. Gaining entry into such fund also may prove challenging as it usually requires millions of euros as initial investment (Douglass, 2006). That is also the reason why it is typically big institutional investors who invest in this type of funds.

8.2. Funds

Another option is to purchase a portfolio of stocks through an investment in a mutual fund, closed-end fund, exchange traded fund (ETF) or through an experienced investment manager who specializes in the socially responsible investing (SRI). In principle, such funds offer several advantages including specialized investment manager expertise, economies of scale and diversification of risk. They offer the potential for attractive returns if growth in the Sectors takes off, and may diversify away some of the risk to the portfolio of companies that may not survive in the longer term. In addition, given the long-term horizon of commercial viability, such investments have the ability to cushion disappointments in segments that have the potential to produce disappointing returns. Furthermore, majority of the funds does not require high initial investments and are therefore optimal also for smaller, non-institutional investors.

But there are also disadvantages that come along with ownership of such funds in the form of investment management fee that investors must pay to cover administration cost, e.g. for providing investors with financial statements, and for employing custodial and accounting services. Furthermore, the investor is also charged subscription and redemption fees.

9. Environmental Mutual Funds

Having seen the difficulties and risks connected with the direct investments, mutual funds seem to be the most attractive way to invest in Environmental Markets. Therefore, the following sections will be devoted to the study of this type of investment.

9.1. Environmental Mutual Funds in the SRI Context

Environmental mutual funds form a subgroup of the socially responsible funds. In order to be able to position those in the context of socially responsible investments (SRI) we need to clarify the meaning of the SRI concept[22].

Socially Responsible Investment (SRI), sometimes also denoted as Sustainable and Responsible Investment is an approach where extra-financial issues are used to select the investment target and assess its performance in addition to the usual financial criteria. The mentioned extra-financial considerations cover environmental (E) and social (S) issues as well as corporate governance (G). Investors use these ESG criteria for two main reasons:

1) to enhance the performance of investment portfolios (to varying degrees across companies, sectors, regions, asset classes and through time)

and/or

2) to align investments social and ethical objectives

Figure 11 maps the basic concept of socially responsible investing. Looking at the Figure we can see that the differences between the "mainstream" or "classical" investments and socially responsible investments can be found on three main axes:

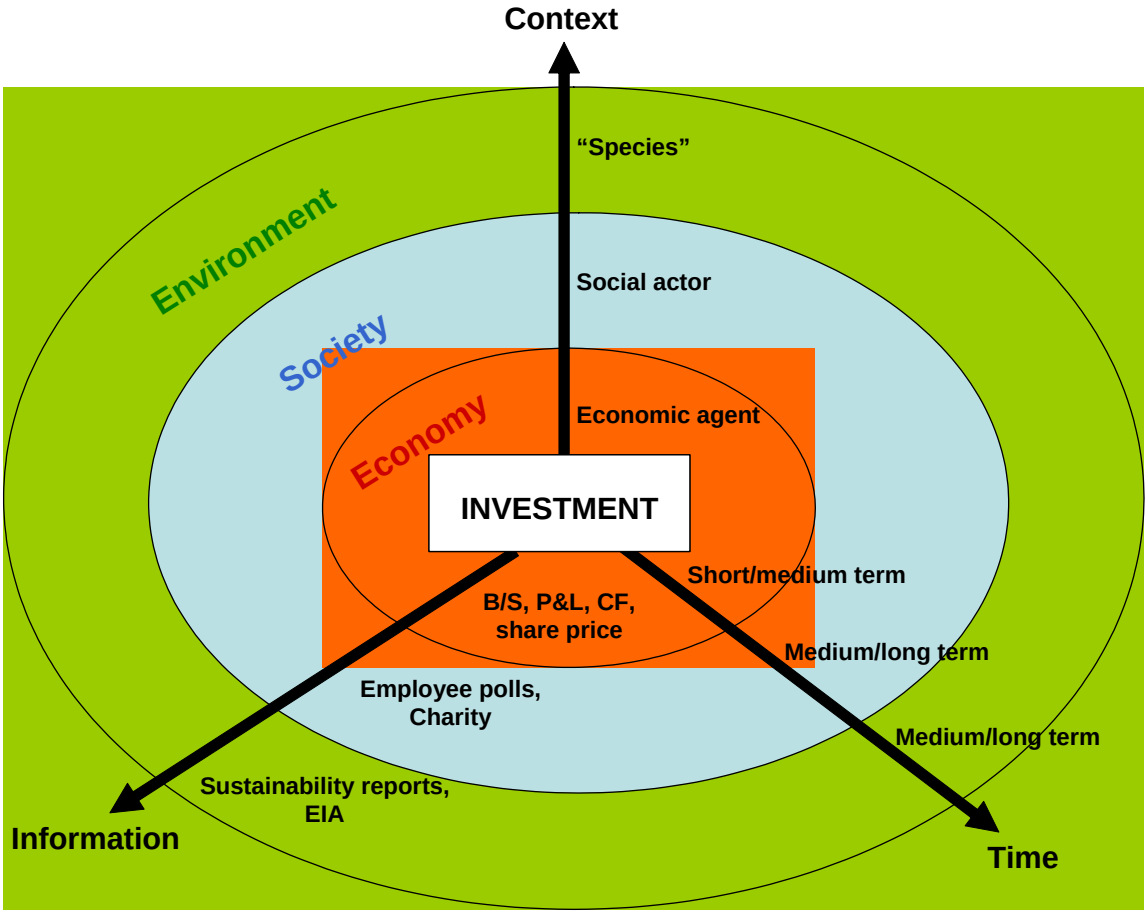
1) **Context:** Contrary to the mainstream investor, who looks at the investment target as being only an economic agent playing an active role in the economy, socially responsible investor goes further, positioning the target into the society (social actor) and the environment ("species") as a whole. He therefore examines the whole value

[22] The information on socially responsible investing (concept, approaches, etc.) comes from personal interviews with Eric Borremans, the Head of Socially Responsible Investments at BNP Paribas.

chain of the company, with all its possible impacts not only on the economy, but also on the society and the environment.

2) **Information:** When analyzing an investment opportunity on the economy level, the investor's main source of information are the company's financial statements (balance sheet, profit and loss statement, cash flow statement) and information on the share price development in order to asses its financial health and investment attractiveness. Socially responsible investor would also scrutinize company's sustainability reports, the results of employee polls (which show the employees satisfaction with their working conditions, management, etc.) the company's charitable activities, company's certification (ISO certificates), etc.
3) **Time:** While "mainstream" investor conducts his financial analysis mostly on short to medium term basis, socially responsible investor looks at longer time spans which typically exceed 10 years.

Figure 11: SRI concept



Source: own model

9.1.1. SRI Investment Approaches

SRI encompasses a wide range of investment approaches when forming an investment portfolio. These approaches are based on the so-called social screening and are depicted in the Figure 12. Investors or portfolio managers exercise screening on two main axes.

The first one is the **sector axe**. Here, the decision is made about which sector is appropriate for the investment purpose. There are two types of screening.

Firstly, **positive screening** involves making investments in sectors believed to have high and positive social and/or environmental impact. At the end of this thematic approach the portfolio might include sectors such as renewable energy, waste management, etc.

Secondly, **negative screening** excludes certain sectors from investment consideration based on social and/or environmental criteria. For example, many socially responsible investors screen out tobacco, alcohol, weapon and other "harmful" industries.

The second axe is the **stock axe**. On this axe, the investor makes a choice of a particular stock. Again, two types of screening are utilized.

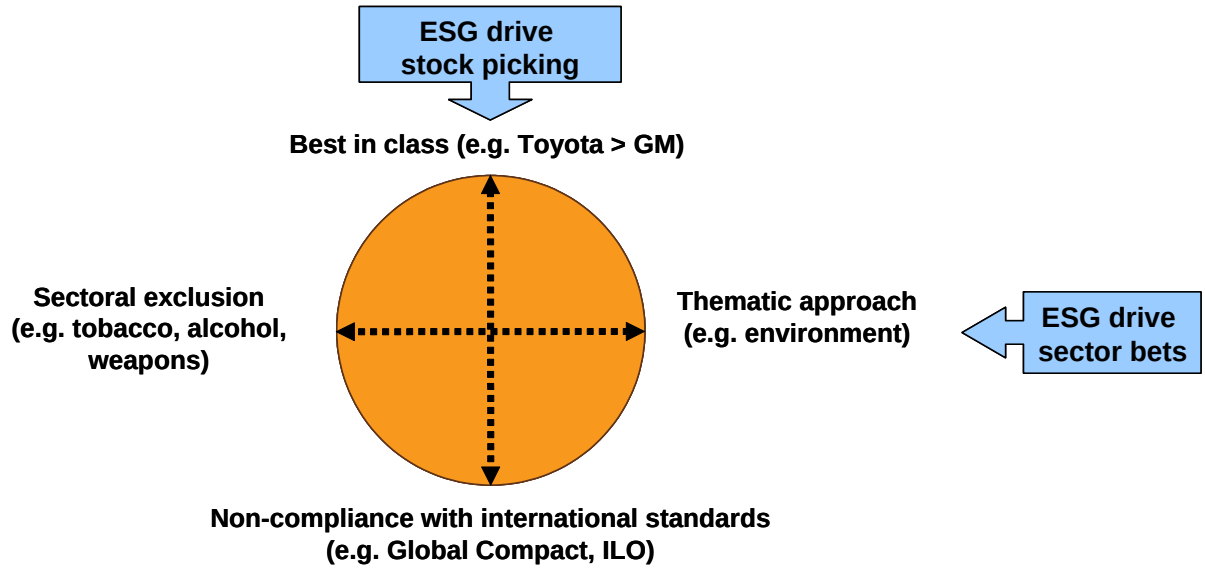
Positive screening serves for the identification of best in class companies. Investors often look for those companies whose records exceed both the standards set by law and the performance of others in their industry group. For example, Toyota might be preferred to General Motors because of higher quality corporate governance. This process may allow for some flexibility. For example, an investor may chose to include in his portfolio a company with past environmental problems, but that is now showing a commitment to improve, along with a strong record in the areas of worker relations and community involvement.

Negative screening involves avoiding the stocks of companies based on either the products or services they produce, or in response to a poor record in pertinent areas of social and environmental performance. Social investors often avoid companies engaged in military contracts, the production of arms, tobacco, oil, gas, nuclear energy, etc. Companies which are in breach of international standards, such as International Labor Organization decrees (ILO), human rights, Global Compact[23] will be excluded. Companies operating in countries with poor human rights record and oppressive regimes, such as Burma and China, may also be listed as undesirable.

[23] The United Nations Global Compact is an initiative to encourage businesses worldwide to adopt sustainable and socially responsible policies, and to report on them (www.unglobalcompact.org).

Investors can apply either one of the screening types separately or their combination in order to select the sectors and particular stocks for their portfolios.

Figure 12: SRI Investment Approaches



Source: own model

9.1.2. Dark Green vs. Light Green Funds

Now that we have gained an understanding of the main concepts and investment approaches of socially responsible investment, let us take a closer look at environmental mutual funds.

In the same way environmental activists can be divided into "dark greens" and "light greens" depending on their degree of radicalism, environmental mutual funds are often divided into categories of environmental commitment.

Dark green funds apply the strictest screening criteria. Their portfolios are free of companies with ties to oil, coal, nuclear power, and environmental policies which are of detriment to the environment or animal testing practices. They are most likely to invest in small and medium size companies that offer products and services that benefit the environment, such as alternative energy, recycling, clean air and water, pollution prevention and conservation.

Light green funds avoid strict negative screening criteria and commonly use a positive "best of sector" approach to include companies from a wider range of sectors (not

only environmental markets described above). They very often include companies that are working to improve previously bad environmental records.

Of course, environmental funds move on the scale of green taking different forms of the green shade, with dark green funds representing one extreme (the strictest, hence the most positive) and light green funds standing for the other extreme (the most lenient, hence the least positive).

The irony is that many of the environmental mutual funds do not label themselves as being neither green nor socially responsible even though they use environmental criteria to select particular stocks into their portfolios. This poses question just who is green?

9.1.3. Who Defines Which Fund is Socially Responsible?

The issue here is that there is no regulatory body for socially responsible funds so it's up to the individual funds to define themselves. Because SRI mutual funds have no common standards, definitions, or codes of practices, this may undermine the investors' confidence in them. Investors' disappointment might stem for example from the lists of companies in some of the fund portfolios (McDonalds, Wal-Mart, Exxon, etc.).

While SRI funds remain unregulated in the US, in Europe this is starting to change. A broader European standard is currently being developed in order to promote confidence in Corporate Sustainability and Responsibility Research (CSRR) groups. While the establishment of this SRI research/rating quality standard was motivated partly by the European Commission, the end goal is to make the standard a fully international one.

It is worth noting that as a reaction to socially responsible investments several mutual funds were created in order to contrast with the trend in SRI investing. For example, the Vice Fund (VICEX) was founded in 2002 with the investment approach of investing in defense stocks, alcohol, tobacco and gambling industries. This fund has outperformed the S&P 500 index and the majority of SRI mutual funds (Gross, 2005).

9.2. Environmental Mutual Funds in Europe

In this study we will concentrate only on European open-end environmental mutual funds which invest solely in the companies covered by our definition of Environmental Markets. The FERI database (Feri FundFile, 2007) was used in order to identify all the environmental SRI mutual funds by, first of all, identifying all SRI funds (by choosing the "Fund Feature SRI" option) and secondly by selecting as a further sub-category "Environment". FERI

database identified eighty European environmental mutual funds altogether[24]. Then, the investment approach and portfolio holdings of each of the eighty funds were studied in detail in order to eliminate all "best of class" environmental funds and all environmental funds which cover other sectors than the three Environmental Markets' sectors. By doing this, 23 such funds which represent EUR 2.6 billion in terms of assets under management (as of 31.december 2006) were eliminated. Furthermore, each of the funds was assigned one of the following three investment categories depending on the sector into which individual funds invest:

- Monothematic – Energy: funds investing solely in the alternative energy sector
- Monothematic – Water: fund investing solely in the water sector
- Multithematic – Water/Energy/Waste: funds investing in a combination of the three sectors

As of the end of 2006, no such mutual fund was created that would concentrate solely on the waste sector. Figure 13 gives an overview of all the 27 environmental mutual funds, showing the investment company which manages the fund, fund's name, fund's inception date, net subscription[25] (in EUR millions), fund's assets under management (in EUR millions), the sectors into which the fund invests (fund type) and the fund's domicile. All the information is as of 31.12.2006.

[24] As of 31.12.2006
[25] Net subscription is equal to subscription of new assets minus redemption of assets already managed by the fund.

Figure 13: Environmental Mutual Funds Overview (data as of 31.12.2006)

Company	Fund Name	Inception date	Net subscription (M EUR)	AUM end 2006 (M EUR)	Fund type (sector)	domicile
Pictet & Cie	Pictet Water Fund	2000	1676,3	2942,3	Monothematic - Water	Luxembourg
Black Rock MLIM	MLIIF-New Energy Fund	2001	1801,3	2292,1	Monothematic - New Energy	Luxembourg
Julius Baer Group	SAM Sustainable Water Fund	2001	533,5	894,6	Monothematic - Water	Luxembourg
Allianz Group	dit-Global Eco Trends	2006	332,4	382,4	Multithematic - Water/En/Waste	Luxembourg
Financiere de Champlain	Performance Environnement	2005	147,2	256,7	Multithematic - Water/En/Waste	France
Unicredit Group	Activest EcoTech	1990	97,6	211	Multithematic - Water/En/Waste	Luxembourg
Vontobel Group	Vontobel Fund-Global Trend New Power Tech	2001	54,4	134,8	Monothematic - New Energy	Luxembourg
KBC Bank and Insurance Holding Company	KBC ECO Fund Alternative Energy	2000	87,9	123	Monothematic - New Energy	Belgium
Bank Sarasin & Cie	Sarasin New Energy Fund	2000	64	120,6	Monothematic - New Energy	Luxembourg
SNS Reaal Group	ASN Milieu & Waterfonds	2001	60,3	112,1	Monothematic - Water	Netherlands
Impax Group plc	Impax Environmental Markets (Ireland) Fund	2004	44,8	98,1	Multithematic - Water/En/Waste	Ireland
ING Group	ING (L) Selectis Alternative Energies Growth	2006	75	75,9	Monothematic - New Energy	Luxembourg
Julius Baer Group	SAM Smart Energy Fund	2003	32,7	57,6	Monothematic - New Energy	Luxembourg
Caisse d'Epargne Group	Energies Renouvelables	2005	30,2	54,6	Monothematic - New Energy	France
Sparkassen Gruppe (Austria)	ESPA STOCK UMWELT	2001	13,6	44,3	Multithematic - Water/En/Waste	Austria
Aviva Group	OHRA New Energy Fonds Inc	2000	25,3	42,9	Monothematic - New Energy	Netherlands
Commerzbank AG	ADIG Fund New Power	2001	0,9	34,6	Monothematic - New Energy	Luxembourg
Alm Brand A/S	Alm. Brand Invest - Milieu Teknologi	1999	2,2	26	Multithematic - Water/En/Waste	Denmark
Credit Suisse Group	CS Equity Fund (Lux) - Future Energy	2006	23,6	23,9	Monothematic - New Energy	Luxembourg
BNP Paribas	Parworld Environmental Opportunities	2006	21,1	22,7	Multithematic - Water/En/Waste	Luxembourg
Aviva Group	OHRA Milieutechnologie Fonds Inc	1997	6,2	20,6	Multithematic - Water/En/Waste	Netherlands
Triodos Bank NV	Triodos Renewables Europe Fund	2006	9	9,2	Multithematic - Water/En/Waste	Luxembourg
Martin Maurel Compagnie Financiere	Praetor Global Fund - Waters	2005	-21,2	9	Monothematic - Water	France
Banca Sella Group	Gestnord Azioni Ambiente	1994	1,6	6	Multithematic - Water/En/Waste	Italy
Societe Generale	Ocean Fund - Equities Environment	2006	4,2	4,7	Multithematic - Water/En/Waste	Luxembourg
Financiere de Champlain	Performance Environnement International	2006	4	4,3	Multithematic - Water/En/Waste	France
Financiere Meeschaert	MAM Actions Environnement	2001	0,3	2,8	Multithematic - Water/En/Waste	France

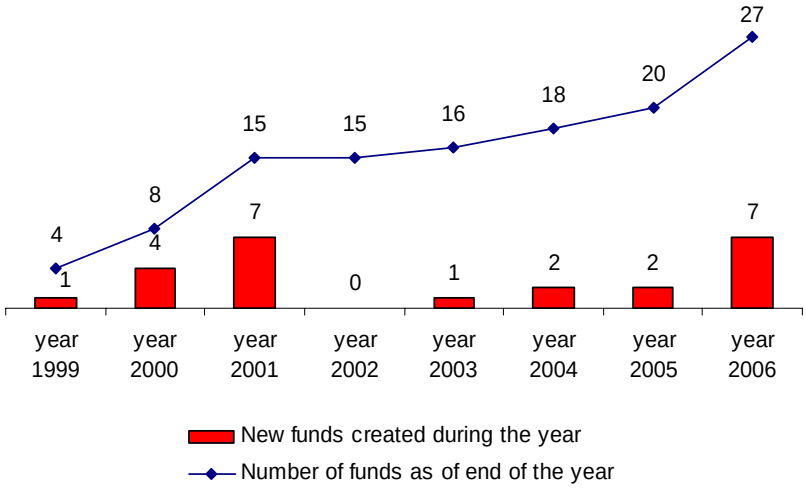
Source: FERI Database (Feri FundFile), 2007

9.2.1. Look at the History

The first European environmental mutual fund Activest EcoTech was founded in 1990 by Unicredit Group. It invests in all three environmental sectors (water, energy, waste) and as of 31.december 2006 occupied 6th place among all 27 environmental mutual funds in terms of assets under management. In 1994, a second fund Gestnord Azioni Ambiente was created by Banca Sella Group, also investing in all three sectors. By the end of 1999, only four environmental funds existed, all being multithematic.

The beginning of the 21st century was marked by a relatively strong growth in number of environmental funds. In 2000, four new funds were created among which the first monothematic fund, Pictet Water Fund, founded by Pictet & Cie. This fund is invested purely in the water sector and is number one among all 27 funds in terms of assets under management (EUR 2,94 billion as of 31.december 2006). In 2001, seven new funds appeared which represented a record number of new funds. This record was repeated in 2006 when seven new funds were founded and the total number of funds reached 27.
Following figure summarizes the development in number of European environmental funds.

Figure 14: Development in number of funds



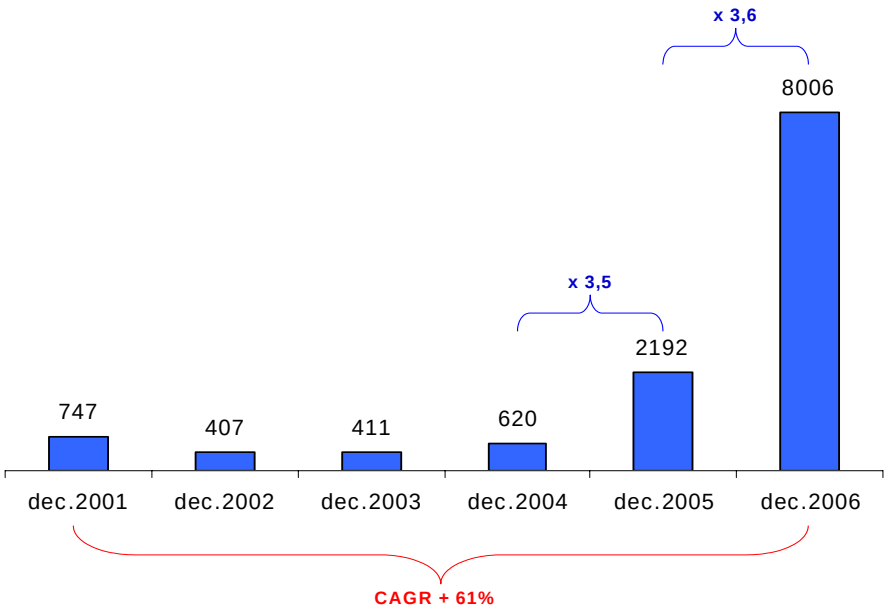
Source: FERI Database (Feri Fund File), 2007 and own calculations

It is worth noting that even though 45% of all funds were created since the beginning of the year 2002, they represent only two from ten most important funds (in terms of assets under management).

9.2.2. Evolution of Assets Under Management (AUM)

From the evolution of assets under management (see Figure 15), we can clearly see that the environmental funds are from the investors' point of view getting more and more attractive. The compound annual growth rate (CAGR) of their assets amounts to 61% over six years time span (2001-2006) showing that the funds' assets grew on average by 61% each year. The funds' assets were multiplied by 3.6 between December 2005 and December 2006 reaching more than EUR 8 billion at the end of 2006 vs. EUR 747 million in December 2001. Decrease in funds' assets between years 2001 and 2003 was due in particular to the investors' loss of confidence in equity markets in general after the dotcom bubble burst in 2001. This trend is in line with the general trend in all European investment funds.

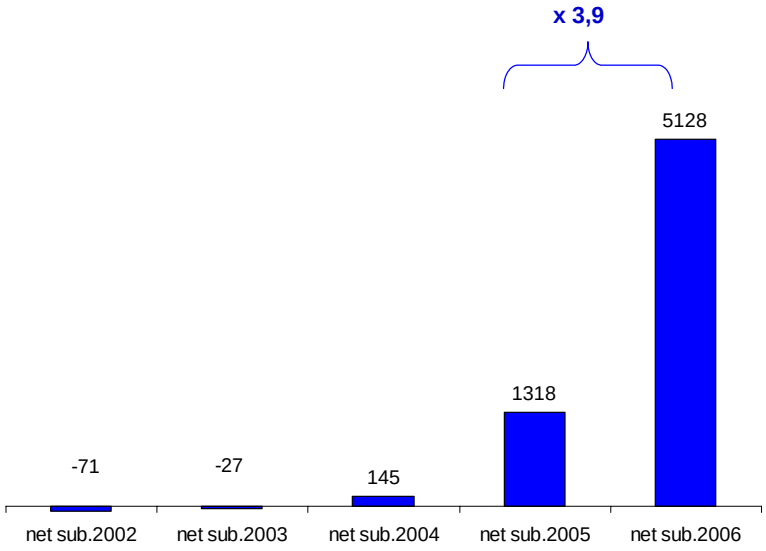
Figure 15: Evolution of the funds' total assets in EUR millions



Source: FERI Database (Feri Fund File), 2007 and own calculations

Growing interest from the investors can also be seen from the development of net subscription into these funds which is depicted in Figure 16. Net subscription increased between years 2005 and 2006 3.9 times! In 2006, the amount of new net assets subscribed by European environmental funds represents 70% of all new net assets subscribed by all European SRI funds (BNPP AM, 2007). Hence, European environmental funds seem to be the most attractive subgroup of all socially responsible mutual funds in Europe.

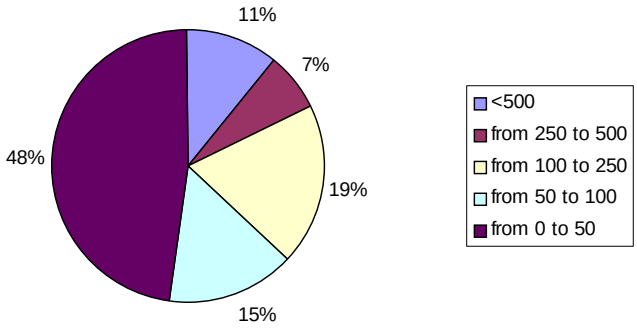
Figure 16: Funds' net subscription in EUR millions



Source: FERI Database (Feri Fund File), 2007 and own calculations

The average size of a fund is EUR 297 million (own calculations), but as we can see from Figure 17, the discrepancy in fund size is very high with almost half of the funds having assets below EUR 50 million.

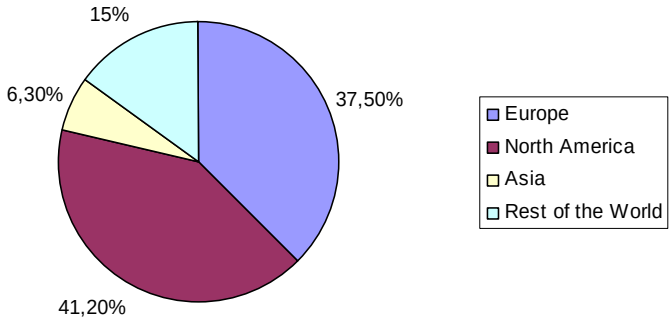
Figure 17: Division of funds by number of assets under management



Source: FERI Database (Feri Fund File), 2007 and own calculations

Looking at the geographical breakdown of funds' assets we can see that the funds place their assets internationally. Investments in North America seem to be the most attractive, attracting 41.2% of all assets. Second comes Europe with 37.5% and the rest is split between Asia and the rest of the world with 15% and 6.3%, respectively.

Figure 18: Geographical assets allocation



Source: FERI Database (Feri Fund File), 2007 and own calculations

9.2.3. Multithematic vs. Monothematic Funds

Now, we will take a closer look at the different types of funds (monothematic vs. multithematic). First of all, we will compare them in terms of assets under management and fund number.

Figure 19: Share of different types of funds on total assets (EUR 8 B - end 2006)

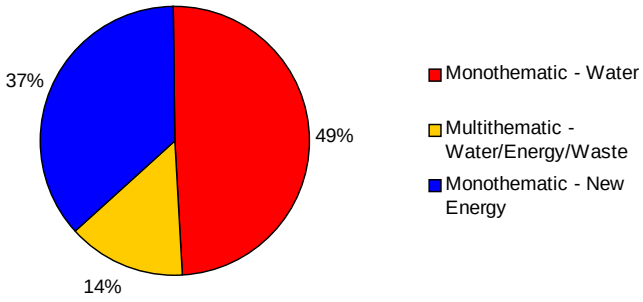
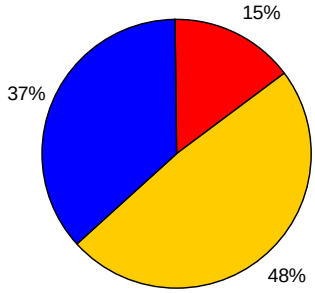


Figure 20: Division of fund number by fund type (27 funds - end 2006)



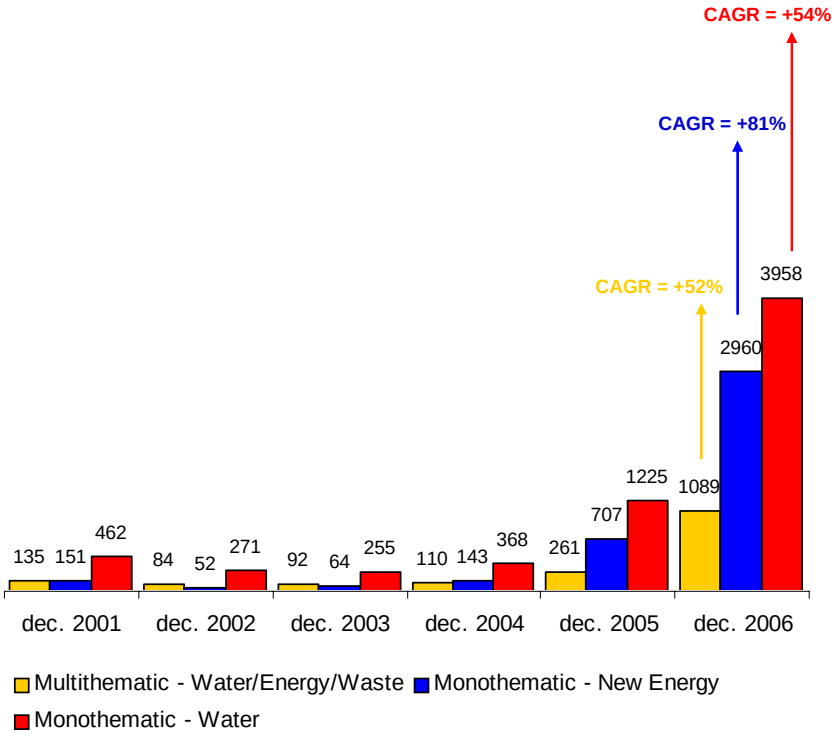
Source: FERI Database (Feri Fund File), 2007 and own calculations

Figures 19 and 20 clearly show that the multithematic funds are predominant in terms of their number as their represent 48% of all funds, but their significance in terms of assets under management is in comparison with monothematic funds much more limited (14% vs. 37% for energy funds and 49% for water funds). Water funds are the obvious leader among all funds,

being strongly supported by Pictet Water Fund which with its EUR 2.94 billion represents 37% of all funds' assets. New Energy funds are led by MLIIF New Energy Fund which has EUR 2.29 billion assets under management, representing 28% of all funds' assets. Hence, the division of assets among the funds is extremely uneven with only two funds representing 65% of all assets. The ten biggest funds manage assets of almost EUR 7.5 billion, which is to say that 37% of all funds represent 93% of all assets.

Let us have a look at the growth rates of each fund type. As is shown in Figure 21, funds which place their assets in the alternative energy sector have experienced the strongest growth of their assets under management in the five year period (31.12.2001-31.12.2006). Their compound annual growth rate reached 81% whereas the assets of both the water sector and multisectors (mix of energy/water/waste) grew by 54% and 52% on a yearly basis, respectively.

Figure 21: Assets by different fund types



Source: FERI Database (Feri Fund File), 2007 and own calculations

9.2.4. Domiciles and Top 10 Investment Companies

Looking at the funds' domiciles we can see that majority of funds are domiciled in Luxembourg (51.9%), second comes France (18.8%) and third Netherlands (11.1%). Also in terms of assets under management Luxembourg clearly leads with 90% of all assets. The

leadership of Luxembourg could be explained by its favorable tax regime where there is almost a zero taxation of investments on the mutual fund level.

Figure 22: Domicile by number of funds

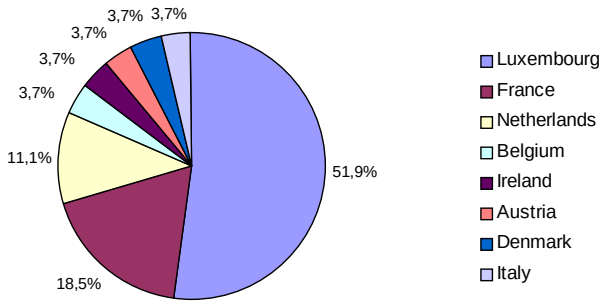
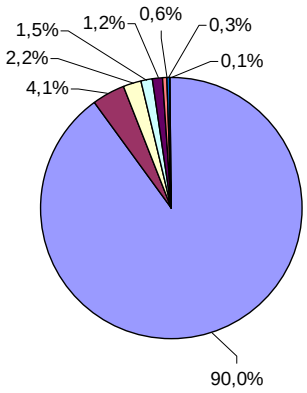


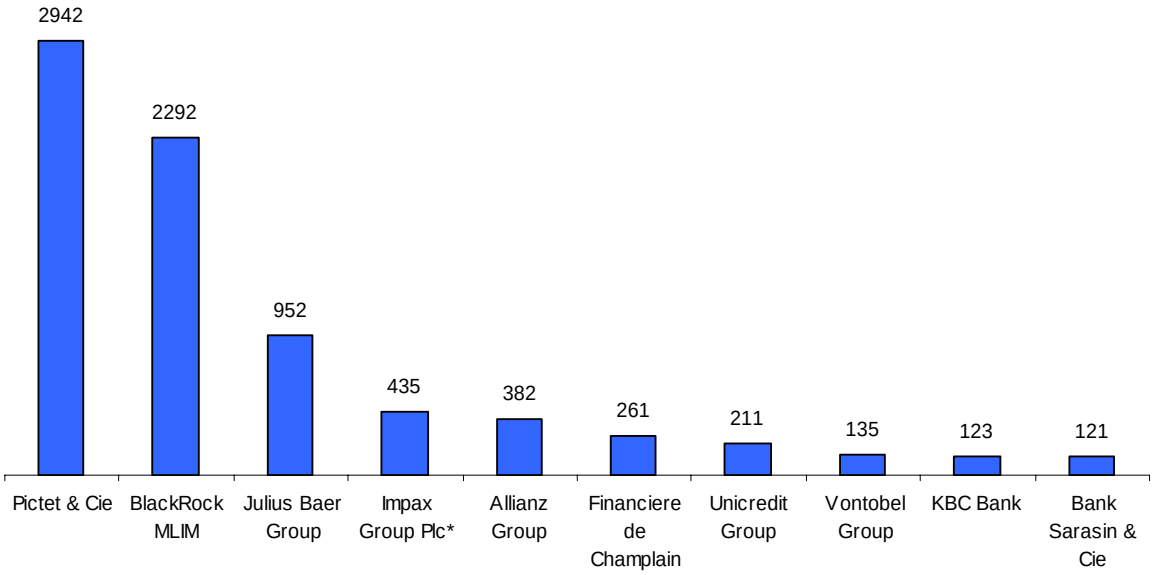
Figure 23: Domicile by assets (AUM)



Source: FERI Database (Feri Fund File), 2007 and own calculations

In the European market, the top ten fund promoters (out of 24) represent 94% of all funds' assets under management. Pictet & Cie and BlackRock Merril Lynch are the unambiguous leaders, managing the top two environmental funds in terms of assets under management.

Figure 24: Top 10 European environmental fund investment companies in terms of AUM (in M EUR) as of 31.12.2006

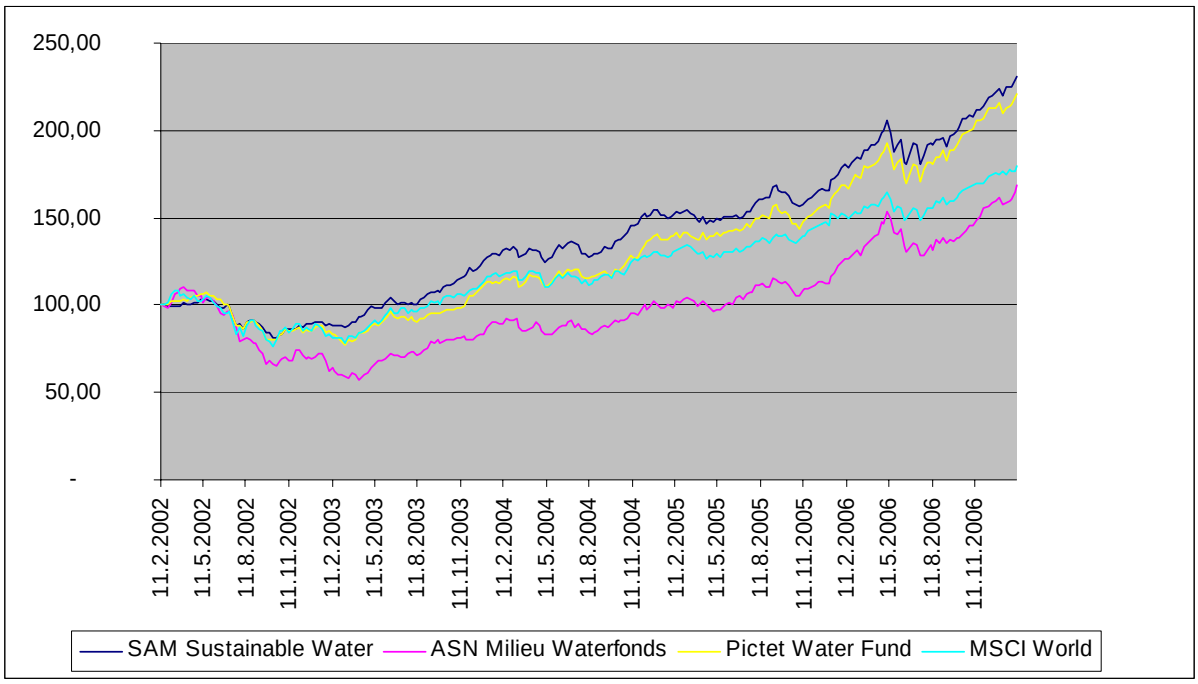


Source: FERI Database (Feri FundFile), 2007 and own calculations
*The figure includes Environmental Markets Plc Investment Trust's AUM in the amount of EUR 337 M. It is a closed end fund which follows the same investment approach as Impax Environmental Markets Ireland Fund (an open end mutual fund).

9.2.5. Environmental Funds' Historical Performance

Before examining the risk and return characteristics of the environmental mutual funds, let us first explore their performance over the last five years[26]. Figures 25, 26 and 27 show the evolution of the funds' weekly net asset values for the period of February 2002 until February 2007. The performance commentaries are based mostly on the data analysis and on information from fund managers.

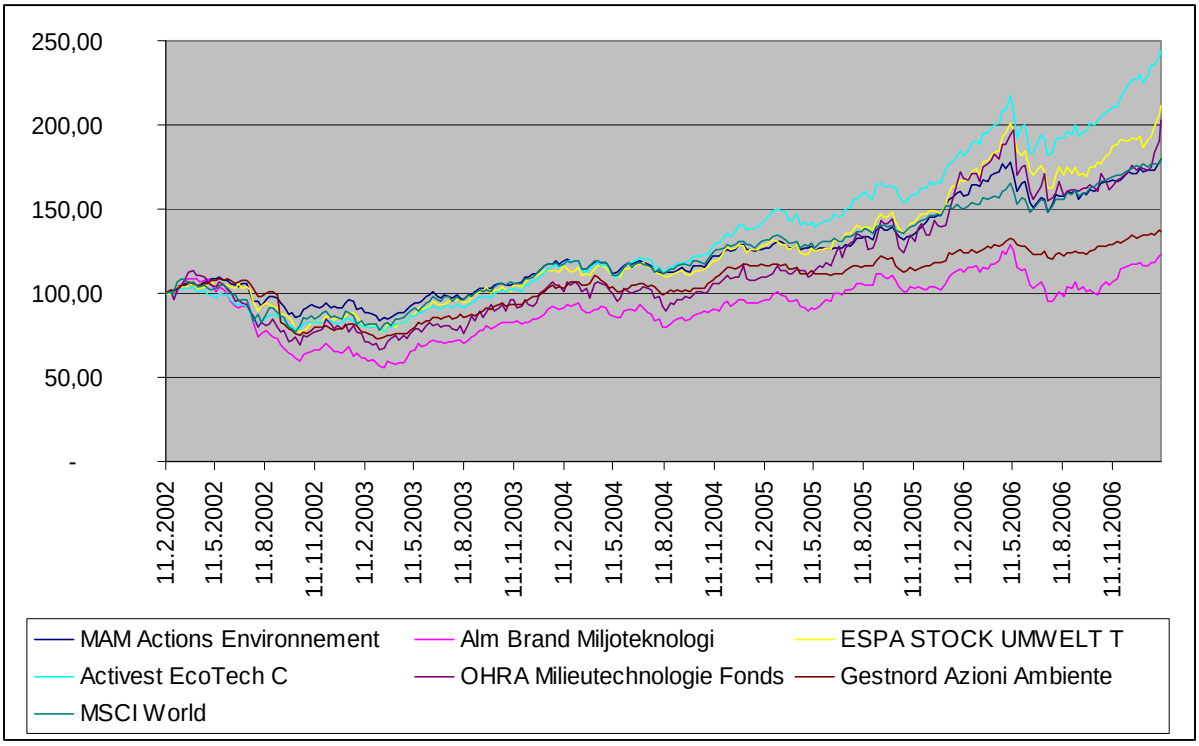
Figure 25: Water funds vs. MSCI World – five year performance



Source: Lipper Fund Database, 2007

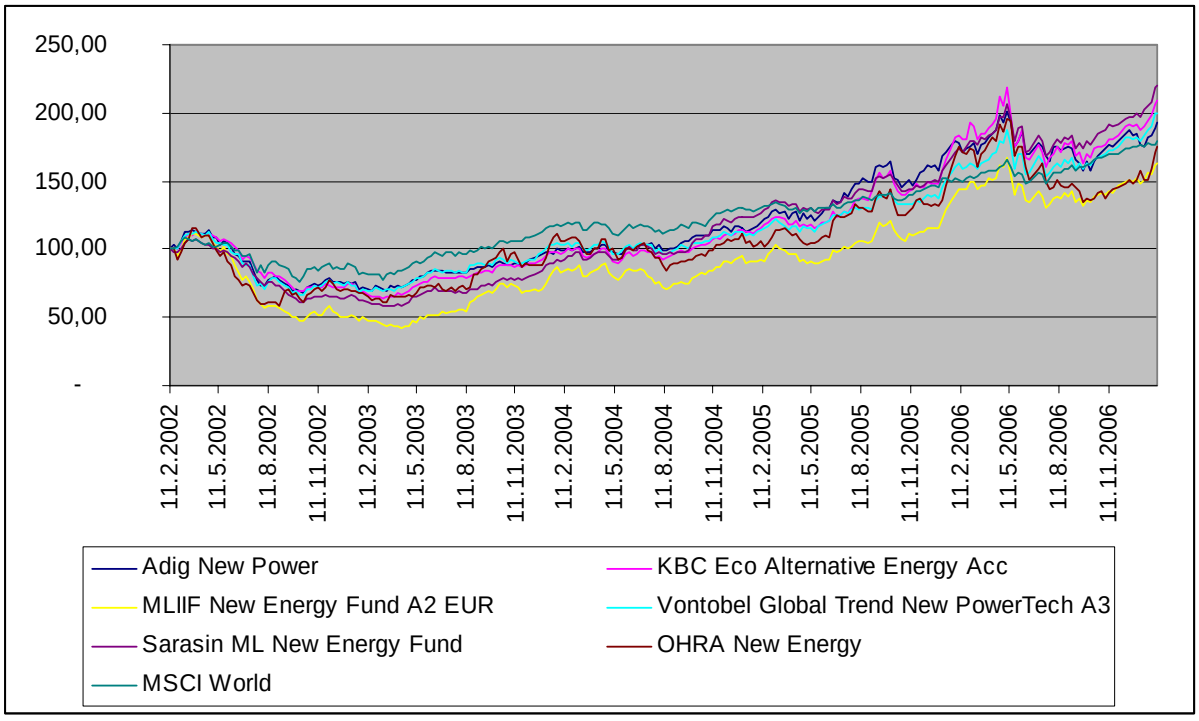
[26] Most of the information contained in the performance commentaries comes from personal interviews with the fund managers.

Figure 26: Multithematic funds vs. MSCI World – five year performance



Source: Lipper Fund Database, 2007

Figure 27: Energy funds vs. MSCI World – five year performance



Source: Lipper Fund Database, 2007

Year 2002

The geopolitical situation was uncertain and there were concerns about the prospects for the global economy. Stock markets around the world were suffering from a dearth of buyers which caused a downward drift in the price of equities. Prices of growth oriented stocks have fallen in particular.

During 2002, Environmental Markets companies typically reported solid financial results and good prospects. The attraction of the sector for larger companies was clearly demonstrated by the acquisition by General Electric of Jenbacher (Austrian producer of clean, distributed energy engines) and Osmonics (producer of water filters) at very high premiums (around 30%) (General Electric, 2002).

Despite the good fundamentals, Environmental Markets stocks posted a weak performance. This can be largely attributed to a de-rating of the sector, as investors have been unwilling to pay a premium for companies that are able to sustain above-average growth in revenues and earnings. This lead to a significant fall in the companies' valuation multiples.

Energy

It has been a difficult year for the energy sector overall and the power equipment sub-sector has been particularly weak. The principal disappointment in this arena was the delay in the adoption of the new Energy Bill in the US which would bring along government support for the wind industry and increased Federal assistance for the development of fuel cells, the switch to clean fuels and the acceleration of energy efficiency programs.

Although the main renewable energy markets expanded strongly during the period (e.g. solar sector grew by 33%), uncertainty about future growth and margin pressure have affected share prices.

Water

In 2002, the planet experienced the second warmest year on record. This led to major water shortages, for example in India, and significant water supply disputes, for example over extractions from the Colorado River. In this environment, progress to tighten water quality legislation was made both in North America and Europe.

Municipal demand for new non-chemical water treatment technologies continued to grow rapidly. On the other side, the suppressed capital expenditure of the industrial sector has negatively affected providers of ultra-pure water.

Waste

Europe and the US promoted the outsourcing of waste collection and disposal to the private sector. The waste management industry showed signs of consolidation as Seche Environnement increased its market share in France through a merger with hazardous waste company Tredi Environnement (Seche Environnement, 2002). Other resource management markets performed well.

Year 2003

As the global economy has revived and capital spending budgets have increased, the majority of the Environmental Markets companies have seen a pickup in their fortunes in orders, profitability and share price performance. Alongside the positive news from the three sectors, the Environmental Markets companies have seen a partial re-rating.

Energy

The prices of alternative energy stocks were driven not only by financial performance but also by news flow, which has consistently highlighted the need for substantial investment in alternative energy solutions. Although the blackouts (e.g. August 2003 in the US) were the primary driver of share prices, the backdrop of high oil, increased concern about climate change, energy security, and urban air quality have all been positive for the companies operating in the alternative energy market.

Water

In the water sector, regulators on both sides of Atlantic have been turning their attention to non-bacterial environmental contaminants. As new threats to human health and the natural environment continued to emerge, and as legislation was brought into force, industrial companies started to feel the need to spend more capital on environmental technology solutions. This gave a boost to multi-technology water treatment companies whose growth was also supported by the expanding semiconductor industry which has high demand for ultra pure water equipment.

M&A activity was the key driver of value in the water sector. The dynamics of the industry has been shifting as the two French utilities (Veolia Environnement and Suez) have both started to dispose of their treatment technology and water chemicals assets to focus on the outsourcing market. A number of new players emerged alongside General Electric, as ITT

Industries acquired the UV disinfection company Wedeco and Pentair increased its water portfolio with the acquisition of Everpure from Veolia Environnement (Impax EM, 2003).

Waste

As legislation started to bite and technology costs declined, more and more attractive investment opportunities started to appear. As local authorities sought to comply with the Government targets, the market for recycling and composting bins has been growing rapidly.

Year 2004

After a modest start to 2004, the Environmental Markets companies finished the year strongly as the anticipated slowdown in North America failed to materialize, capital spending remained buoyant and corporate activity, particularly in Environmental Markets stimulated the valuations. During the year, both prices and price volatility of key commodities such as oil, steel and copper increased substantially, with Brent Crude at one point rising to all-time high of $51 per barrel.

Energy

The photovoltaic market experienced a boom year principally due to strong growth in Germany where the government amended the renewable energy law to extend and raise the volume of price guarantees for solar power producers (Neuhoff, Sellers, 2006). The wind market was flat as the growth in the UK, India and Australia failed to compensate for weakness in Germany and the US. In other renewables markets, there has been increased interest in biofuels and geothermal energy due to the high oil price.

In the engine markets, high energy prices focused both customers and original equipment manufacturers on more efficient products, a dynamic illustrated by the success of the hybrid vehicles introduced by Toyota and Honda (Toyota Motors, 2004).

Utilities continued to spend capital on automated meter reading, data management systems and other utility software to increase the efficiency of their networks, improve the service to customers and reduce the risk of electrical blackouts.

Water

Corporate activity dominated the water sector during the year with most of the large industrial manufacturers making significant acquisitions – Siemens acquired US Filter,

Danaher Corp bought Trojan Tech, General Electric bought Ionics and Pentair acquired Wicor.

The water markets continued to offer good growth prospects on the back of infrastructure capital spending and the need to comply with new environmental standards.

Waste

It was a good year for investing in European waste & recycling sector, as legislation on landfills, packaging and hazardous waste began to have an impact. Seche Environnement (France) and Lassila & Tikanoja (Finland) were the best performers as both companies increased margins in their domestic markets.

The concept of Producer Responsibility continued to emerge in the drafting of new waste legislation and is now enshrined in regulations for packaging, end-of-life vehicles and waste electrical and electronic equipment.

Year 2005

The key event for Environmental Markets during 2005 was hurricane Katrina, which swept through the Gulf of Mexico and long the Florida coast, causing an estimated USD 75 billion in damage, crippling US oil infrastructure, and causing an oil price spike to almost USD 70 per barrel (Impax EM, 2005). The impact of Katrina was profound. It highlighted again the developed world's dependence on oil and its vulnerability to a disruption to supply. Also, with some scientists claiming link with climate change, it raised environmental issues to the top of the political agenda, driving a further tightening of environmental policy. As a consequence, the attention of mainstream investors turned back towards the Environmental Markets sector and in particular alternative energy, creating a strong IPO environment and driving growth in share prices.

Political tensions further exacerbated concerns over the security of energy supply during the year. In particular, the standoff between the UN and Iran over the latter's nuclear program has raised the prospect of sanctions and a cut-off of oil supply from Iran (which controls 11% of global reserves) as a potential reaction.

Energy

High oil prices and security of supply issues led to considerable advances in Government policy for alternative energy. After extensive delays, the US Energy Act finally came into force, bringing with it USD 14.5 billion of tax credits for domestic energy

production and including extensive support for wind, solar, fuel cells and other alternative energies (BMU, 2006). Outside the US, Spain approved a revised energy plan requiring 12% contribution of renewables by 2010, including an increase in target for wind power from 13 000 MW to 20 000 MW (IEA, 2006). China has also announced aggressive new plans for renewable energy.

At the corporate level, fuel cell stocks were generally weak amid concerns about the timeline for commercial viability and volume sales. In other markets, the US utility spending on automated meter reading technology had a boom year. Finally, the solar sector also performed strongly, with five new IPOs during the year.

Water

The water sector also received a lot of attention during 2005, with torrential rains in some regions and droughts in others. In the US, a series of tropical storms caused widespread flooding and overwhelmed water treatment infrastructure. In contrast, plans for large desalination projects were frequently in the news, in particular in the Middle East and Asia, where water scarcity is likely to become acute in the medium term.

At the corporate level, GE launched its "ecomagination" strategy, forecasting strong growth in water treatment and declaring an intention to make further acquisitions in the sector (www.ecomagination.com). Corporate activity was once again a key theme for the sector when 3M aquired Cuno and Parker Hannifin acquired Domnick Hunter following a bidding war with Eaton Corporation (Impax EM, 2006). Each acquisition was made at a high multiple, and the multiples of comparable stocks rose in response.

Waste

2005 was a relatively quiet year for the waste sector. At the European level, the most material legislative change was the tightening of emissions controls on incinerators (www.europa.eu.int). This is positive as it will force substandard operators out of the market and will favor "quality" companies like Seche Environnement. There were also structural changes underway in Europe. Utilities such as RWE and Brambles have started to exit the waste sector, typically replaced by private equity funds attracted by the sector's strong cash flow and capacity for leverage.

Year 2006

As the fundamentals of the alternative energy, water and waste sectors continued to strengthen, many companies active in this space were able to deliver superior earnings growth, and their shareholders were rewarded with attractive returns

The oil price was an important driver of performance during the first half of 2006, which saw a rapid rise to just below USD 80 per barrel, fuelled by political tensions in the Middle East, disputes and attendant concerns about security of energy supply. This drew investors' attention once again to alternative energy investments, and was accompanied by a flurry of new issues, noticeably in the biofuels and solar sectors.

The second half of the year was dominated by the growing international consensus on the science of climate change and the need to take action, by high profile power cuts and water shortages that highlighted the urgent need for investment in infrastructure, and by increased legislative support in each the three investment sub-sectors. This underpinned a strong recovery that followed the equity market correction in the middle of the year, which affected small companies in particular.

Energy

Continued high oil prices and concerns over security of supply led to further strengthening of political support for renewables during 2006, with France and Spain increasing feed-in tariffs for solar and biomass respectively and the US announcing an ambitious USD 2.8 billion subsidy scheme for solar in California and an extension of the Production Tax Credit for wind power for another year to the end of 2008 (IEA, 2006b).

High oil prices also led to significant investment in biofuels during the year, with multiple fund raisings in the US and Europe.

Water

2006 was a year of increased awareness of water scarcity, with much of Southern England suffering a hose-pipe ban from April and compulsory water metering introduced in some areas. However, this issue extends far beyond the UK, with UN studies showing that 40% of the world's population is already experiencing water shortages, and that the problem is escalating (UN, 2006).

Another key feature for the year was the inadequate state of water infrastructure and many water utilities were criticized for failure to reduce leakage rates and were forced to commit to substantial additional investment. In the US, following the mid-term elections,

several states have lodged plans for significant investment in water infrastructure, while China announced plans to invest USD 175 billion on pollution mitigation over the next five years (Impax Environmental Markets, 2006). Finally, corporate activity continued, with General Electric acquiring Zenon Environmental and Honeywell completed acquisition of First Technology after a bidding war with Danaher. Both acquisitions were closed at substantial premiums (about 40%).

Waste

The legislation continued to tighten in the waste sector during 2006. In particular, the Restriction of Hazardous Substances Directive now imposes tougher restrictions on the materials and processes used in manufacturing, while the Waste Electrical & Electronic Equipment Directive requires compulsory levels of recovery and recycling of a wide range of complex products. The sector's transition to integrated waste disposal schemes also continued.

Corporate activity remained strong in 2006, with Spanish Group FCC buying the non landfill gas division of Waste Recycling Group at a record multiple, and Severn Trent Water spinning off Biffa on a relatively high multiple. Furthermore, Transpacific Industries acquired Waste Management New Zealand, commencing the likely consolidation of the Australasian market.

In the support services market, the environmental consultants performed strongly.

9.3. Environmental Funds' Risk and Return Characteristics

Having reviewed the funds' historical performance and main trends underpinning this performance we will now turn to the examination of their risk and return characteristics. Our aim is to verify empirically whether the environmental mutual funds outperformed the general stock market (as represented by MSCI World Index) over the defined study period.

Hypothesis 1: Environmental mutual funds outperformed the general stock market represented by MSCI World Index over the defined study period.

9.3.1. Methodology

As mentioned above, the FERI database (Feri FundFile) was used to identify a population of all environmental mutual funds in Europe. Of the 80 funds identified as environmental funds by the database, 53 funds were eliminated as they either applied the "best of class" approach described in the section 9.1.1., or their portfolios included companies which did not comply with the Environmental Market definition from the section 2. The 27 remaining funds were then divided into three groups according to the Environmental Markets' sub-sector they invest in. As no fund invests solely in the waste sector, three groups of funds could be identified:

(1) Alternative energy funds – ten funds were identified that invest purely in the alternative energy sector.
(2) Water funds – four funds were identified that invest purely in the water sector.
(3) Mixed or multithematic funds – thirteen funds were identified that invest purely in the combination of the three Environmental Markets' sectors of alternative energy, water and waste.

Furthermore, from the ten alternative energy funds only six had been established long enough to provide sufficient data (five years of weekly prices) for analysis. These were:
Alternative Energy funds:

- Adig New Power Fund
- KBC Eco Alternative Energy Fund
- MLIIF New Energy Fund
- Vontobel Global Trend New PowerTech Fund
- Sarasin New Energy Fund
- OHRA New Energy Fund

ING Selectis Alternative Energies Growth (2006), Energies Renouvelables (2005), CS Equity Fund Future Energy (2006) and SAM Smart Energy Fund (2003) were eliminated.

From the four water funds, Praetor Global Fund Waters was eliminated due to its late establishment in 2005. Hence, the following three funds were kept:
Water funds:

- SAM Sustainable Water Fund
- ASN Milieu Waterfonds

- Pictet Water Fund

Of the thirteen mixed funds, only six provided sufficient (long enough) data for the analysis. These were:

Mixed funds:

- Alm Brand Miljoteknologi
- Espa Stock Umwelt
- Activest EcoTech
- OHRA Milieutechnologie Fonds
- Gestnord Azioni Ambiente
- MAM Actions Environnement Fund

Dit-Global Eco Trends (2006), Performance Environnement (2005), Parworld Environmental Opportunities (2006), Triodos Renewables Europe (2006), Ocean Fund Equities Environment (2006), Performance Environnement International (2006) and Impax Environmental Markets (2004) were eliminated because of their short history.

Mutual fund prices were expressed in terms of net asset value (NAV). This measure represents the per-share value of a fund's assets, which in this case was primarily the common stock of company from one of the three sectors (alternative energy, water, waste).

Weekly closing quotes for each fund's NAV were obtained from Lipper Fund Database (Reuters) for the period February 11, 2002 through February 7, 2007. It is important to note here that none of the funds pays dividends; hence the NAVs did not have to be dividend-adjusted. Then, weekly holding period return series for each fund were constructed and used to calculate means and standard deviations of returns over the five-year study period. Weekly holding period return = (Ending price – Beginning price) / Beginning price. The total compounded return, or time-weighted rate of return, was computed as the difference between the individual fund's NAV at the end and at the beginning of the study period, further divided by the NAV at the beginning of the period. The result was then annualized.

The risk-free interest rate was proxied by the three-month London Interbank Offer Rate (LIBOR). The stock market performance was measured relative to MSCI World Index. Bloomberg Financial Services was the source of both the 3M LIBOR and the benchmark financial data.

9.3.2. Measures

One could find several studies which examined the performance of environmental mutual funds, but the authors of these studies never defined the investment universe of the funds studied (e.g. White, 1995 or M'Zali, Turcotte, 1998). Therefore, after a closer scrutiny of the funds they have chosen, one realized that the authors mixed dark green funds with light green funds and hence completely different investment approaches and what is even worse, completely different sectors. In this study we will examine the financial performance of environmental funds whose investment universe follows our definition of Environmental Markets, hence dark green funds.

Furthermore, majority of the environmental funds' studies almost always ignored risks borne by the investors investing in the funds under examination (e.g. Hinden, 1992; Joly, 1992; Oekologische Briefe, 1992; Proell-Hoelzl, & Scherer, 1993). Nevertheless, traditional financial theory holds that investors prefer less risk to more risk and greater returns to lesser returns (cf. Brealey & Myers, 1991; Elton & Gruber, 1991). High returns do not necessarily imply good investments, if the risks incurred in obtaining those returns were excessive. As the performance must be evaluated relative to the risks borne in its achievement, in this study the risk is included in evaluating mutual fund performance. Risk-adjusted returns are the appropriate standard of comparison for evaluating investment alternatives.

Risk measures

Financial economists measure risk in two ways (cf. Elton & Gruber, 1991). **Total risk** refers to an asset's variability of returns over time, and is measured by the **standard deviation of returns**. This measure is most appropriate when an asset is held alone (White, 1995). Most financial assets, however, are held in portfolios. Profits on one investment may balance out losses on others, reducing variability in overall returns. This process, known as diversification, depends on the extent to which asset returns are correlated with each other. The risk associated with assets held in portfolios is called **portfolio risk** (White, 1995). A standardized measure of an asset's portfolio, or **systematic risk**, is its **beta coefficient**. Beta coefficients are based on correlations between an asset's return series and that of a benchmark market index, such as MSCI World Index. Beta coefficients were computed as the slope of the regression line between each fund's weekly excess return series above the risk-free rate (we deduct the risk-free rate performance from the fund's performance) and stock market index

MSCI World excess return above risk-free rate, also called the equity market premium (once again, we deduct the risk-free rate performance from the MSCI World index performance) (M'Zali, Turcotte, 1998). Risk measures are shown later in Figure 25.

Performance measures

Fund performance was measured using five methods of portfolio evaluation. Two of these, the Sharpe ratio and the differential return ratio, were based on standard deviation of returns and evaluate performance relative to **total risk**. The Treynor and Jensen ratios were very similar, but used beta coefficients to evaluate performance in light of **portfolio or systematic risk** (Elton & Gruber, 1991). Total risk measures are most appropriate for individuals committing a large portion of their wealth to a particular investment opportunity, for example, investors purchasing environmental mutual funds out of ethical concerns for the Earth. More traditional investors generally rely on systematic risk measures.

Sharpe ratio

As a basis for choosing between investments, the total return of a fund is rather a blunt instrument. Investors reasonably expect to know how much risk had to be taken on in order to achieve the return and, indeed, if they would have been better off putting their cash into a risk-free asset instead. Sharpe ratio seeks to address these questions in a single performance ratio. It is sometimes referred to as "excess return to variability," since this measure is calculated by dividing the difference between a particular investment's return and the return on a risk-free asset by the investment's standard deviation of returns (Elton, Gruber, 1991). There is no absolute definition of a "good" or "bad" Sharpe ratio, beyond the thought that a fund with a negative Sharpe would have been better off investing in risk-free asset. But clearly the higher the Sharpe ratio the better: as the ratio increases, so does the risk-adjusted performance.

Numerically, this expression is:

$$\mathbf{Sharpe_Y = (R_Y - R_F)/ \sigma_X}$$

Where: $Sharpe_Y$ = Sharpe ratio of mutual fund Y

R_Y = return on mutual fund Y

R_F = risk-free rate

σ_Y = standard deviation of returns on mutual fund Y

Differential Return

Another total risk measure is the differential return measure (D_σ). This measure expresses a fund's excess return to variability relative to that earned on a market index (White, 1995). Positive differential return indicates a fund outperformed the index on a total risk-adjusted basis, while negative differential return indicates underperformance.

Numerically, this expression is:

$$\mathbf{D_\sigma = R_Y - \{R_F + [(R_X - R_F) / \sigma_X]\ \sigma_Y\}}$$

Where: D_σ = differential return of mutual fund Y

R_X = return on benchmark portfolio X

R_Y = return on mutual fund Y

R_F = risk-free rate

σ_X = standard deviation of returns on benchmark portfolio X

σ_Y = standard deviation of returns on mutual fund Y

Treynor Ratio

Investors evaluating a particular fund as part of a diversified portfolio might be interested in a fund's excess return to portfolio risk, or the Treynor measure. Similar in construction to Sharpe's measure, this measure scales a fund's excess return above the risk-free rate by its beta coefficient; hence it makes a use of systematic risk, while the Sharpe ratio uses total risk (standard deviation of returns). Again, the higher the measure, the better the performance on a risk-adjusted basis.

Numerically, this expression is:

$$\mathbf{TreynorY = (R_Y - R_F)/ \beta_Y}$$

Where: TreynorY = Treynor ratio of mutual fund Y

R_Y = return on mutual fund Y

R_F = risk-free rate

β_Y = beta coefficient of mutual fund Y

Jensen Alpha

Jensen Alpha (Dβ) corresponds to the differential return measure described above when risk is measured by beta (M'Zali, Turcotte, 1998).
Numerically, this expression is:

$$\mathbf{D\beta = R_Y - \{R_F + [(R_X - R_F)\,\beta_Y\}}$$

Where: $D\beta$ = Jensen Alpha of mutual fund Y
R_X = return on benchmark portfolio X
R_Y = return on mutual fund Y
R_F = risk-free rate
β_Y = beta coefficient of mutual fund Y

This measure is used to scale the extent to which a manager has added value to the returns that could have been expected from a benchmark portfolio with the same degree of sensitivity to movements in the market. It is designed to test whether a fund has achieved a better performance than its beta would suggest: a positive Jensen Alpha indicates an active management style with superior stock-picking ability; a negative figure is produced if returns are less than the fund's beta, and thus falling short of the benchmark.

Information Ratio

So called because it assesses the degree to which a manager uses skill and knowledge to enhance returns, this is a versatile and useful risk-adjusted measure of actively-managed fund performance. It is calculated by deducting the returns of the fund's benchmark from the fund's overall returns, then dividing the result by its Tracking Error (which is a measure of the volatility of those excess returns) (www.investopedia.com). In this way, we arrive at the value, per unit of extra risk assumed, that the manager's decisions have added to what the market would have delivered anyway. The higher the Information Ratio the better.
Numerically, this expression is:

$$\mathbf{IR_Y = (R_Y - R_X)/TE}$$

Where: IR_Y = Information ratio of mutual fund Y
R_X = return on benchmark portfolio X

R_Y = return on mutual fund Y

TE = tracking error (standard deviation of $R_Y - R_X$)

9.3.3. Statistical Tests

Hypothesis 1 was tested by comparing the above mentioned performance measures against the performance of a benchmark index. In general, the null hypothesis was:

H_0: Mean risk-adjusted performance measure ≥ Risk adjusted benchmark measure, is tested against the alternative

H_A: Mean risk-adjusted performance measure < Risk adjusted benchmark measure in a one-tailed test. Student's t statistics was used as a test statistic due to small sample size.

9.3.4. Findings

Figure 28 summarizes returns and risks for the mutual funds and the benchmark index examined in this study. The five-year period was marked by favorable market conditions. The annualized return on the overall stock market (as proxied by the MSCI World Index) was 12.46% p.a., whereas all three sectors performed even better. Water funds outperformed the overall stock market by 3% p.a., achieving an average annualized return of 15.46% p.a.. This sector was followed by the alternative energy funds with a 13.21% p.a. average increase and lastly by the mixed funds whose annualized return amounted on average to 12.92% p.a. This result is confirmed by the mean weekly returns, with water funds taking the lead with 0.30%, followed by alternative energy and mixed funds having 0.29% and 0.27%, respectively.

Water funds did not only achieve the highest annualized total return, but succeeded to achieve the lowest total risk (as measured by standard deviation of returns) which reached 2.06%. Alternative energy funds had the highest volatility of returns (3.06%), followed by mixed funds with 2.29% and lastly by MSCI World with 2.11%. The slightly higher standard deviations of the two types of funds (energy and mixed) comparing to MSCI World could be explained as follows: firstly, these funds contain fewer stocks, on average, than a broadly

based equity index[27] and we know that increasing the number of securities in a portfolio decreases total risk up to a point. Secondly, the very nature of environmental mutual funds would lead them to invest in smaller, newer firms. Such firms often have higher standard deviations of returns relative to companies included in the MSCI World index. Lastly, the constituent assets of environmental mutual funds are more highly concentrated within certain specific industries (energy, water, waste). Restricting investment set reduced ability to reduce risk through diversification as the funds are not able to take advantage of all possible investment opportunities.

Beta coefficients (systematic risk) ranged from a low of 0.31 to a high of 1.12. Once again, alternative energy stocks showed the highest average beta, followed by water and mixed funds. However, the average betas were in all cases less than their respective market beta of 1.0, with alternative energy funds moving the closest with the index (mean beta of 0.92) followed by water funds (mean beta of 0.62) and lastly by mixed funds (mean beta of 0.57). R-squared which indicates how closely correlated the funds are to the benchmark (MSCI World Index) were also quite high, reaching on average 0.4356 for energy funds, 0.4579 for water funds and 0.33379 for mixed funds.

[27] Environmental mutual funds examined contain on average 85 stocks in their portfolios (Feri FundFile, own calculations).

Figure 28: Characteristics of Environmental Mutual Funds

	Mean Return (Weekly)	Total Return p.a.	Standard Deviation of Returns	Beta MSCI World
Alternative Energy				
Adig New Power	0,29%	14,07%	2,79%	0,82
KBC Eco Alternative Energy	0,32%	15,89%	2,74%	0,93
MLIIF New Energy Fund	0,25%	10,28%	3,63%	1,03
Vontobel Global Trend New PowerTech	0,31%	14,86%	2,78%	1,12
Sarasin ML New Energy Fund	0,34%	17,08%	2,46%	0,83
OHRA New Energy	0,21%	7,05%	3,98%	0,77
Mean Alternative Energy	**0,29%**	**13,21%**	**3,06%**	**0,92**
Water				
SAM Sustainable Water	0,34%	18,19%	1,74%	0,62
ASN Milieu Waterfonds	0,23%	10,97%	2,54%	0,51
Pictet Water Fund	0,33%	17,22%	1,91%	0,72
Mean Water	**0,30%**	**15,46%**	**2,06%**	**0,62**
Mix				
MAM Actions Environnement	0,24%	12,46%	1,87%	0,74
Alm Brand Miljoteknologi	0,12%	4,30%	2,68%	0,60
Espa Stock Umwelt	0,31%	16,14%	2,17%	0,44
Activest EcoTech Fund	0,37%	19,59%	1,99%	0,66
OHRA Milieutechnologie Fonds	0,34%	15,18%	3,56%	0,66
Gestnord Azioni Ambiente	0,23%	9,89%	1,44%	0,31
Mean Mix	**0,27%**	**12,92%**	**2,29%**	**0,57**
Benchmark Portfolios				
MSCI World Index	0,25%	12,46%	2,11%	1

Note: The mean weekly return of the risk-free rate (3M LIBOR) was 0.052% and its standard deviation was 0.029%.

Source: own calculations

9.3.5. Hypothesis Testing

Hypothesis 1 was tested by comparing the mean risk-adjusted performance measures described above. Figure 29 depicts the values of these measures for all individual funds and

the benchmark. The hypothesis was tested using the Student's t-statistics. The following sections present the findings.

Sharpe ratio

Both the Environmental funds and the MSCI World Index reached positive Sharpe ratios, with alternative energy funds having a Sharpe mean of 0.082, water funds reaching 0.127 and mixed funds 0.102. MSCI World posted a Sharpe ratio of 0.094. Hence, only the mean Sharpe ratios of the water and mixed funds managed to exceed the Sharpe ratio of MSCI World Index. However, their out-performance is not statistically significant (p values of 0.182 and 0.358, respectively). The relative underperformance of alternative energy funds in comparison to MSCI World is also not statistically significant (p value of 0.169).

SAM Sustainable Water fund reached the highest Sharpe (0.165), indicating that it has generated the best return per unit of total risk taken on, almost the double comparing to the benchmark (MSCI World).

Differential return

Alternative energy funds underperformed the MSCI World index by 0.051%. However, this underperformance is not statistically significant (p value of 0.137). Both water and mixed funds outperformed the MSCI World index on a total risk-adjusted basis, but again, this outperformance was not statistically significant (p values of 0.218 and 0.486, respectively).

Actives Eco Tech Fund posted the best total risk-adjusted performance, earning 0.127% more than the benchmark.

Jensen's Alpha

Using systematic risk measure (Jensen's Alpha), the funds' returns outperformed MSCI World, with water funds' average returns exceeding the benchmark by 0.1258%, mixed funds by 0.1037% and alternative energy funds by 0.0551%. The funds'outperformance was statistically significant on a 5% level of significance for energy and water funds and on a 10% level of significance for mixed funds.

The only fund with negative Jensen Alpha was Alm Brand Miljoteknologi (-0.0528%).

Treynor Ratio

Another measure using systematic risk in order to asses the funds' performance is Treynor measure. On the basis of this measure, all funds out-performed the MSCI World index, whose Treynor equaled to 0.0020 over the study period. Mixed funds showed the highest excess performance per unit of systematic risk (mean of 0.0041), which is not surprising seeing their beta which is significantly lower than the other two fund types while its mean weekly return was only slightly lower. Mixed funds were followed by water funds with an average Treynor of 0.0040 and lastly by energy funds with an average Treynor of 0.0026. The funds' out-performance of the MSCI World index was statistically significant, with 95% confidence interval for energy and water funds and a 90% confidence interval for mixed funds.

Information Ratio

Water funds managed to show the highest average information ratio over the study period (0.0388), however, this out-performance of MSCI World index was not statistically significant. On the other hand, the average information ratio of energy funds, which was the second highest (0.0227), was statistically significant on a 5% level of significance.

Out of all fifteen funds, five funds had negative information ratio due to their negative excess return above the MSCI World index. Activest Eco Tech Fund reached the highest information ratio. This shows that the fund manager of this fund succeeded in adding the highest value to the fund's performance per unit of extra risk assumed.

Figure 29: Environmental Mutual Fund Performance

	Sharpe Measure	Differential Return (Total Risk) MSCI World	Treynor Measure MSCI World	Jensen Diffential Return Index MSCI World	Information Ratio MSCI World
Alternative Energy					
Adig New Power	0,087	-0,019%	0,0030	0,0799%	0,0200
KBC Eco Alternative Energy	0,100	0,016%	0,0029	0,0895%	0,0376
MLIIF New Energy Fund	0,056	-0,137%	0,0020	0,0001%	0,0020
Vontobel Global Trend New PowerTech	0,092	-0,005%	0,0023	0,0348%	0,0384
Sarasin ML New Energy Fund	0,115	0,053%	0,0034	0,1200%	0,0486
OHRA New Energy	0,040	-0,214%	0,0021	0,0064%	-0,0105
Mean Alternative Energy	**0,082**	**-0,051%**	**0,0026**	**0,0551%**	**0,0227**
t-statistics	-1,06	-1,23	2,65	2,78	2,40
significance			**	**	**
Water					
SAM Sustainable Water	0,165	0,123%	0,0046	0,1637%	0,0640
ASN Milieu Waterfonds	0,072	-0,056%	0,0036	0,0816%	-0,0061
Pictet Water Fund	0,144	0,095%	0,0038	0,1321%	0,0584
Mean Water	**0,127**	**0,054%**	**0,0040**	**0,1258%**	**0,0388**
t-statistics	1,16	0,97	6,53	5,26	1,72
significance			**	**	
Mix					
MAM Actions Environnement	0,103	0,017%	0,0026	0,0467%	-0,0041
Alm Brand Miljoteknologi	0,025	-0,186%	0,0011	-0,0528%	-0,0525
Espa Stock Umwelt	0,120	0,057%	0,0059	0,1741%	0,0278
Activest EcoTech Fund	0,158	0,127%	0,0047	0,1832%	0,0737
OHRA Milieutechnologie Fonds	0,080	-0,049%	0,0043	0,1545%	0,0261
Gestnord Azioni Ambiente	0,124	0,043%	0,0057	0,1168%	-0,0111
Mean Mix	**0,102**	**0,002%**	**0,0041**	**0,1037%**	**0,0100**
t-statistics	0,42	0,04	2,73	2,78	0,57
significance			*	*	
Benchmark Portfolios					
MSCI World Index	0,094	0,000%	0,0020	0,0000%	0,00

Notes: *p < 0.1, **p < 0.05, ***p < 0.01

Source: own calculations

9.3.6. Conclusions

Our hypothesis predicted that environmental mutual funds would outperform the general stock market over the five-year study period. This hypothesis was tested by comparing the mean risk-adjusted performance of the selected funds with that of the MSCI World Index. Regardless of whether investors were concerned with total risk or portfolio risk,

the hypothesis could not be rejected. The Environmental mutual funds outperformed MSCI World on portfolio risk-adjusted basis, their outperformance being statistically significant on a 10% level of significance for mixed funds and a 5% level of significance for water and alternative energy funds. However, their out- or under-performance could not be confirmed on the total-risk adjusted basis.

10. Risks

No overview of an investment opportunity is complete without a comment on risk. Conceptually, risk analysis in the three Environmental Sectors is no different to risk analysis of any other investment opportunity in different areas of the economy (such as interest rate risk, currency risk, demand risk, etc.). However, there are also a number of risks which are specific to the investments in Environmental Markets. We will review the most important of these risks in the next sections.

10.1. Equity risk

"*Equity risk is the risk that one's investments will depreciate because of negative stock market dynamics*" (www.investopedia.com). As the Environmental Markets' sectors are specialized sectors with essentially small and medium sized companies, they might tend to be more volatile than general, broadly based stock market indices. As a consequence investors may experience higher variability in returns than investing in stock markets in general and, in particular, may experience higher levels of losses in the event of stock market falls. We could see the confirmation of this fact in the section 9.3.4., where we examined the risk and return characteristics of the European environmental mutual funds.

10.1.1. The Risk of an Environmental Bubble

Recent hype in the last three years has sent several environmental stocks soaring. For example, in the French market, some companies such as Sechilienne-Sidec have had remarkable performances. Some others are following. However, high hopes sometimes replace solid fundamentals. One can reasonably forecast a renewal of the late 90's bubble at some stage. For instance, if the hydrogen economy were to kick off, probably, all hydrogen stock prices would start soaring way higher than earnings. It is not likely that all manufacturers would come out victorious or be profitable. Further deception could then send prices back to a crashing stage.

Figure 30: Price History of Ballard company

Source: www.yahoo.finance.com

Ballard, a major hydrogen company is an extreme example. It saw its stock price multiplied by four in two months time and further divided by twenty in the five following years.

10.2. Commodity Risk

Commodity risk reflects the risk that commodity prices will change which would have further impact on the output prices. All Environmental Markets' sectors are exposed to the commodity risk with some sub-sectors being more vulnerable to commodity price moves than others. Currently, it is the energy sector which is being strongly impacted by the price evolution of commodities such as crude oil, silicon and steel. This does not mean that other sectors are immune to commodity risk. On the contrary, there is a number of other commodities and inputs which have an impact on development and competitiveness of the three sectors, however, due to limited space, we will look at the three commodities mentioned above which currently represent the most pressing and the most discussed issues.

10.2.1. Crude Oil Prices

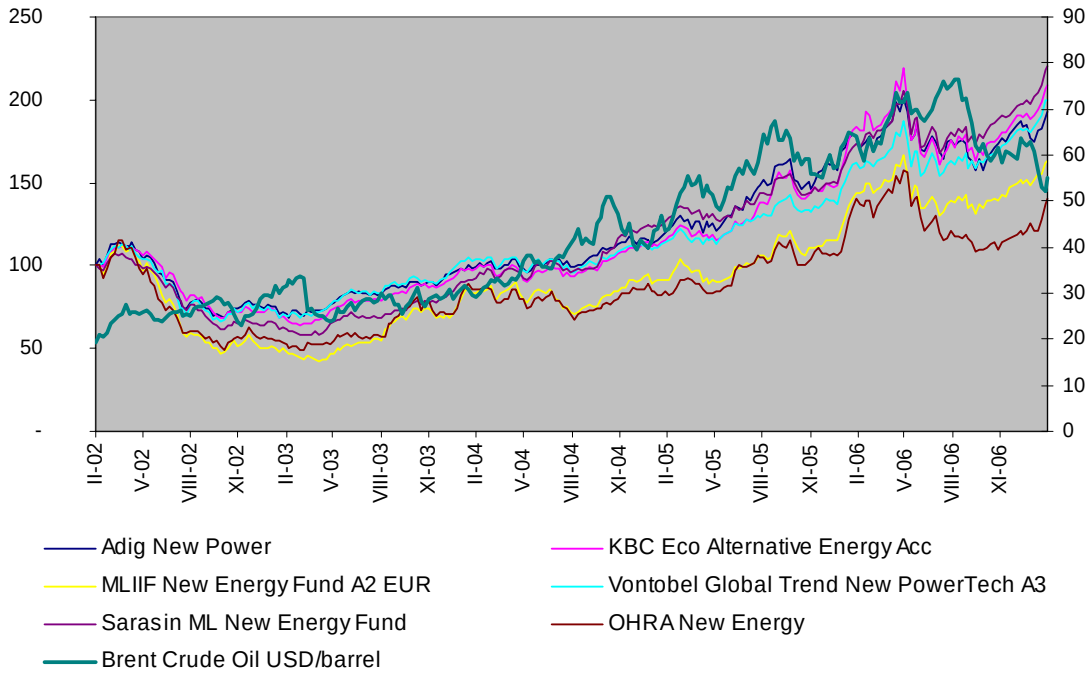
In seeking to replace conventional energy, alternative energy products and services may experience reduced sales if the price of oil, gas and/or coal falls. Of course, markets with legally binding targets (such as the renewable energy market in Europe) or that provide

savings or "value added" independent of fossil fuel prices (such as smart electricity meters) may have minimal risk in this area.

Figure 31 shows the NAVs evolution of all the monothematic energy environmental mutual funds (for the list of these funds, please refer to the section 9.3.1.) against the oil price over the five year study period (February 2002-February 2007). As one can see, there has been a relatively tight correlation between the two over this period, up to the decline from the USD 75/76 oil price peaks in August 2006. After this point the funds' NAVs continued to grow, while the oil price marked the beginnings of the volatility that has characterized its progress in the past 8 months. This trend can clearly be seen from the Figure 32 which depicts one-year period from February 2006 until February 2007.

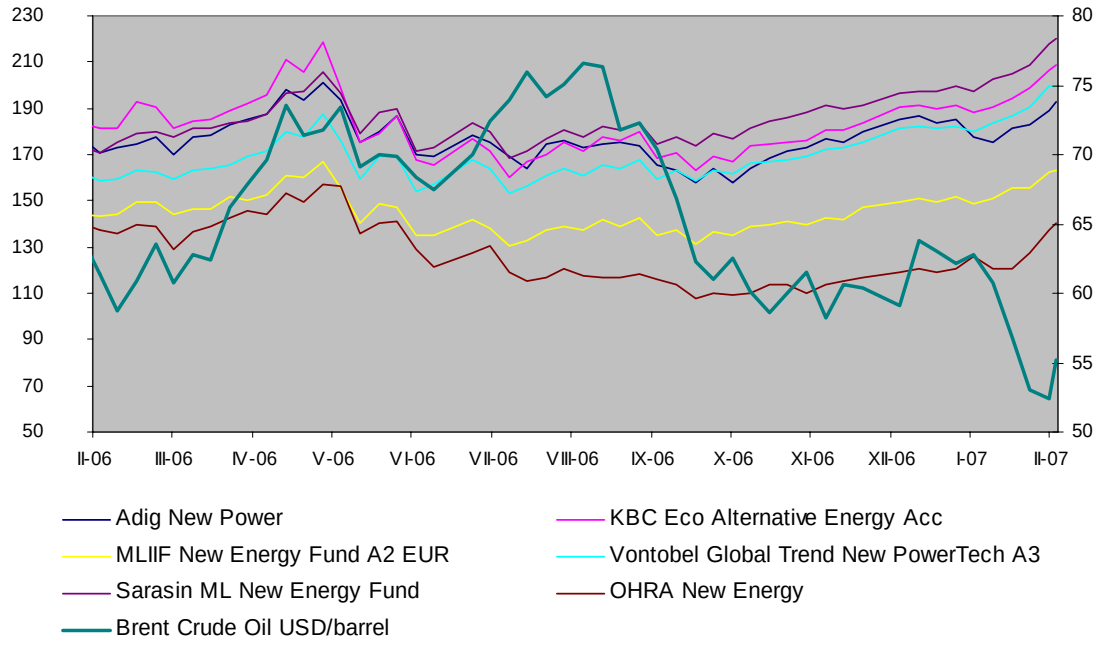
One of the reasons for the apparent decoupling of the Environmental funds' performance from the evolution of the oil price could be the fact that the new environmental technologies that have become available are an increasingly favorable option in the face of volatile oil prices. Furthermore, the funds' performance was supported by the blackouts and water shortages which were numerous in the second half of the year 2006 bringing in legislative support for Environmental Markets and helping the Environmental Markets' Companies to recover from the mid year stock market correction.

Figure 31: Five year correlation: Energy Funds' NAVs vs. Brent Crude Oil



Source: Lipper Fund Database for funds' NAVs and Bloomberg Financial Services for Brent Crude Oil prices, 2007

Figure 32: One year correlation: Energy Funds's NAVs vs. Brent Crude Oil



Source: Lipper Fund Database for funds' NAVs and Bloomberg Financial Services for Brent Crude Oil prices, 2007
Note for Figures 27 and 28: Left axes depicts the evolution of the funds' NAVs, right axes depicts the evolution of Brent Crude Oil price

10.2.2. Expensive Silicon for Solar Sector

A shortage of silicon is casting a cloud over the growth of solar energy. In most solar cells, silicon – the second most abundant element in the Earth's crust (just think of sand) – serves as the medium that converts sunlight (photons) into electricity (electrons). But the supply of processed polysilicon, the cells' main ingredient, has been bottlenecked due to growing demand and limited supply with only five manufacturers representing 88% of global polysilicon production (Makower, Pernick, Wilder, 2006). The strong demand for silicon which does not only come from the solar but also from the semiconductor sector, has recently more than doubled the price of silicon. Knowing that silicon prices represent up to half of a solar cell's cost, one can easily imagine the extent of the negative impact this has had on the price of solar energy and hence its competitiveness to conventional energy. This has pushed a number of firms to work on development of solar cell technologies that use a fraction of silicon needed for conventional cells (e.g. Kyocera, Evergreen Solar, etc.).

10.2.3. Expensive Steel for Wind Market

Steel is the most important commodity used to build wind turbines and towers onto which the turbines are attached (www.windpower.org). Lately we could assist at the soaring prices of steel. One of the main reasons for these price hikes can be seen in the strong demand for steel especially from emerging markets such as China and India where the steel is used primarily for construction means (Mange, 2007). The appetite for steel in these countries is extremely strong as their real-estate markets are currently booming. If this trend continues, this could lead to even further increases in steel prices hikes which would make the electricity produced from wind less cost-competitive in comparison to other energy sources.

10.3. Political Risk

Political risk can be defined as follows: "*Political risk can be defined as the likelihood that political forces will cause drastic changes in a country's business environment that will adversely affect the profit and other goals of a particular business enterprise*" (enbv.narod.ru/text/Econom/ib/str/261.html, 2007). More easily, it is "*the financial risk that a country's government will suddenly change its policies"* (http://investor.realnetworks.com/glossary.cfm?FirstLetter=p).

In fact, the markets described above are dependent to some extent on government policies. These take many forms, from financial incentives and R&D support through to deployment support. All these have the aim to "balance the playing field" between conventional and Environmental Markets' companies and we have already discussed them in detail in the section 7.1. If such policies were to be diluted or completely removed, investments in the three sectors described above may suffer. The loss could be enormous, in some cases leading to a complete crash in share prices, in a worst-case scenario to a complete closure of businesses.

Therefore, the role of the government is to provide a stable framework of incentives so that private companies can make long-term decisions. Policy frameworks should be designed to treat support to all environmental technologies in a "technology-neutral" way. This means that the support should not be addressed specifically to a concrete technology because this

might restrict the development of alternative solutions[28]. The dangers of public officials "picking winners" should point to this as the starting point in most sectors.

It is worth noting that interviews with potential and current investors in the Environmental Markets showed that the existence of government policies aimed to support the development of the three sub-sectors, and hence of political risk, is the main reason that discourages new investors from their investments. They question the sustainability of businesses that cannot (financially) stand on their own feet and have to rely on the external help.

Of course, political risk does not stop on the country level and does not only cover government policies. The risk of terrorism and political instability also make part of political risk and should be taken into consideration while making investment decisions in the Environmental Markets.

10.4. Regulatory Risk

The regulatory risk is defined as *"risk that the regulators will change the current rules or impose new rules, and herewith negatively impact investment in the regulated sector"* (www.harperrisk.com/ArtGlossary/ArtGlossqr.htm).

As already mentioned, regulation is among key drivers of all three Environmental Markets' sectors. Environmental regulation is a very complex issue, taking many forms, such as various directives, regulations, conventions, physical limits, legally binding targets, quotas, and tradable emission allowances. The ability of individual countries[29] to set their own legislation makes environmental regulation a very complex field. This is further complicated by the rapid rate of change in legislation resulting from the increased profile of environmental issues. And it is the changes in the legislation or its interpretation that can have a significant and far reaching impact on Environmental markets.

However, regulatory risk and political risk can be at least partly diversified by investing in multithematic environmental funds which invest across all three sub-sectors of the Environmental Markets.

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[28] A good example is the current discussion in the Czech Republic on government policies supporting one specific technology for the production of biofuels although numerous experts claimed also alternative technologies to be even more cost efficient.

[29] and indeed Regions in countries such as Belgium.

10.5. Environmental Risk

Environmental risk is a risk of occurrence of expected and unexpected environmental events or processes which have economic, administrative and other impacts on the economy. These include water scarcity, rising global temperatures, ice melt, environmental catastrophes such as hurricanes (e.g. Katrina in 2006), floods, earthquakes, fires, etc. The occurrence of these events or processes, especially if they are brutal and not anticipated, leads to global unrest while it clearly shows our vulnerability and insufficient energy, water and waste management. Furthermore, it incites local and international institutions and authorities to act, which usually takes form of international treaties (such as Kyoto Protocol), conventions, regulation, policies, etc. which have as a goal to combat the effects of these events and processes and to prevent new ones from occurring. In most cases, these new legislative norms bring direct or indirect support to the development of environmental technologies and thus benefit environmental markets. Currently, this risk is becoming more and more pronounced due the rising frequency of occurrence of the above mentioned events and processes. Therefore, the investor should be aware of the impact they might have on his investments.

11. Conclusions

What are Environmental Markets? What are the factors that have an impact on their development? How to invest in them? Were these investments profitable in the past? What are the risks connected with these investments? These were the main questions to which this thesis tried to find answers.

First of all, personal interviews with the market participants and current institutional and private investors revealed the ambiguity of the topic of Environmental Markets, pointing to a non-existence of a clear definition of Environmental Markets. However, with their help we arrived at fulfilling our first goal which was to define the universe of Environmental Markets. We came to the conclusion that Environmental Markets could be defined as a set of companies which develop and promote new technologies to address environmental problems. More specifically, quoted companies active in the markets for cleaner and more efficient delivery of products and services of energy, water and waste.

Once having defined Environmental Markets, detailed examination of the three sub-sectors followed. The latter represent very exciting and dynamically developing sectors of the economy, reaching double digit growth over the last five years. They are represented by companies of all market capitalizations with the prevalence of small and medium size enterprises.

The support to the further development of Environmental Markets comes from policy makers worldwide who appear determined to act to improve energy security, enhance and extend water supplies, encourage more efficient use of resources and, in particular, combat climate change. Rising population growth, the increasing correlation between financial and environmental performance, environmental technologies becoming more and more cost efficient and hence competitive, all give a stimuli for the further growth of the three sectors. This trend should continue to provide a stable foundation for further expansion of the Environmental Markets' companies.

Seeing this, we have posed ourselves a question how to participate on the potential growth of Environmental Markets' companies. Two principal types of investment were identified which enable to gain exposure to the Environmental Markets' companies. Firstly, direct investments, which consist of the purchase of the Environmental Markets' companies shares and of participating in the venture fund investments.

Buying shares of a specific company directly requires a deep knowledge of the concrete sector and technology in order to make the right decision at the right time. However,

the investor is exposed to a great amount of risk holding only one title in his portfolio and hence having no diversification whatsoever. Of course, the attraction of this type of investment is the potential that one may hit the jackpot and pick the future industry leader.

The possibility of investing in venture funds belongs to the riskiest type of Environmental Markets investment as these funds invest in privately held, unquoted start-up companies that have often unproven technology. Therefore, they offer the highest potential for huge returns, but also huge losses. These investments are typically illiquid and very long-term. Furthermore, venture funds are open only for very solvent investors with at least a several millions of EUR of investable assets. That is also the reason why this type of investment is undertaken rather by institutional than private investors.

Due to these difficulties, mutual funds represent the most attractive way in which to invest in Environmental Markets and at the same time designate the second principal way of Environmental Markets investment. They offer the advantage of specialized investment manager expertise, economies of scale, liquidity and most importantly, diversification. The disadvantage comes in the form of fees the investor must pay for the mentioned benefits.

Because of the attractiveness of mutual funds to investors, we have decided to identify and further examine the universe of European mutual funds which invest solely in the companies covered by our definition of Environmental Markets. This task proved to be very challenging as, once again, a clear definition of environmental mutual fund is missing. We have started our selection knowing that Environmental mutual funds form a subgroup of the socially responsible investment funds (SRI funds). The concept of socially responsible investment is based on an approach where in addition to usual financial criteria, the extra-financial considerations are used to select the investment target and asses its performance. These extra-financial considerations cover environmental, social and corporate governance issues. While choosing investments into the portfolio, investment manager can use a wide range of investment approaches. They are all based on the so-called social screening which can take form of positive or negative screening, depending if one looks for the companies or sectors which are believed to have high and positive economic, social and environmental impact (positive screening) or avoiding sectors and companies with negative impacts on the economy, society and environment (negative screening). One can apply either one of the screening types separately or their combination in order to select concrete sectors and stocks for the portfolio.

Based on the chosen approach, one could divide environmental mutual funds into two main groups: “dark green” and “light green” funds. Dark green funds are thematic funds

applying the strictest screening criteria and investing solely in sectors and companies that offer products and services with high social and environmental benefits. On the other hand, light green funds are less strict when selecting sectors and stocks and very often include companies that are working to improve previously bad environmental records.

The issue that further complicates the funds' selection is the fact that there is no regulatory body for socially responsible funds so it's up to the individual funds to define themselves.

However, after carefully scrutinizing the investment approaches and portfolios of mutual funds recognized as environmental by Feri financial database, we arrived at 27 environmental mutual funds in Europe whose investment approach and portfolios comply with our definition of Environmental Markets. Three main fund types were identified depending on the sector they invest in: funds investing solely in the alternative energy or the water sector (monothematic funds) and funds investing in the combination of the three sectors (multithematic funds). No fund investing solely in the waste sector could be identified. Having looked at the funds' history, evolution in assets under management, geographical allocation, domiciles and investment companies which manage them, we have turned our attention to their risk and return characteristics. Our aim was to verify empirically whether the funds outperformed the general stock market (represented by MSCI World Index) over the five-year study period. Our hypothesis predicted the funds' out-performance over the equity index. It was tested by comparing the mean risk-adjusted performance of the selected funds with that of the MSCI World Index. We came to the conclusion that regardless of whether the investors were concerned with total risk or portfolio (systematic) risk, the hypothesis could not be rejected. The environmental mutual funds outperformed the index on portfolio (systematic) risk-adjusted basis, their out-performance being statistically significant on 10% level of significance for mixed funds and 5% level of significance for water and alternative energy funds. However, their out- or under-performance could not be statistically confirmed on the total risk- adjusted basis.

As no overview of investment opportunity is complete without a comment on risk, we have concluded with the overview of risks connected to the investments into Environmental Markets. Conceptually, risk analysis in the three Environmental Sectors is no different to risk analysis of any other investment opportunity in different areas of the economy (such as interest rate risk, currency risk, demand risk, etc.). However, a number of risks were identified which are specific to the investments in Environmental Markets. These include equity risk, commodity risk, political and regulatory risks and environmental risk.

Political and regulatory risks are the most important risks to take into consideration while deciding about Environmental Markets investments. As these markets are dependent to some extent on government policies and legislation, their dilution, removal or changes in definitions and interpretations could have far reaching impact on the Environmental Markets' companies, in the worst case scenarios leading to a complete closure of businesses. Therefore, the role of governments and regulators is to design the support and environmental legislation in a "technology-neutral" way.

All these risks can be at least partly diversified by investing in multithematic environmental funds which invest across all three sub-sectors of the Environmental Markets.

All in all, the value added by this thesis is in defining and exploring sectors which have so far been "untouched" by academics not only in the Czech Republic but internationally. Therefore, it is a pioneer study in this field of research whereby its topic contributes to the theme of sustainable development.

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13. Annex

13.1. Annex 1: Technologies for Renewables

Hydro: Currently the largest source of renewable power. Large scale projects can generate predictably at over 1 000MW for 50 years or more. The Three Gorges dam in China will generate over 18 000MW. Significant potential remains for small and micro-scale hydro.

Wind: A single wind turbine can generate up to 5MW of power. Wind farms (arrays of turbines) are now being built offshore, where economies of scale are potentially greater and planning constraints are typically lower than for onshore projects.

Wave: Potentially one of the largest energy resources. However, developing cost-effective, reliable technology that can survive in the extreme marine environment has proven difficult. In 2006, the first commercial scale wave devices were tested.

Tidal: Also a large potential source of predictable energy without proven technology. Installation of devices in areas of strong current is particularly challenging.

Biomass: Can produce energy through proven combustion processes or using advanced technology such as gasification or pyrolysis (please, refer to Annex X: Transportation fuels). However, biomass has a lower energy density than fossil fuels, and access to adequate quantities of feed stock can be a barrier to commercialization.

Solar Photovoltaic (PV): Panels traditionally made with silicon, which releases electrons (i.e. electricity) when exposed to sunlight .The cost and availability of silicon is currently problematic. Alternative materials may generate at lower costs but most have disadvantages.

Solar Thermal: Solar energy is collected to provide heat, which is typically transferred to a water tank using a heat exchanger. This is proven technology that is already economic without subsidy in low-latitude countries.

Geothermal: Some geological formations trap heat that can be tapped directly to provide large-scale heating. In addition, the low-level heat of the ground may be harnessed with heat pumps for domestic scale heating. Both are highly predictable energy sources (though with limited potential in much of Western Europe).

Source: IEA website

13.2. Annex 2: Transportation Fuels

Bioethanol: Alcohol produced by fermentation of sugars may be mixed with petrol or used alone in modified petrol engines. Suitable feed stocks are agricultural crops (e.g. corn, sugar beet) in temperate regions and sugar cane in the tropics.

Advanced Bioethanol: Cellulose in woody plant matter may be broken into fermentable sugars by heating or applying specialized enzymes. In this way, a high proportion of the energy in the biomass is used, and ethanol yields can be more than doubled without competing with food uses.

Biodiesel: Vegetable oils may be used directly in diesel engines, and performance is improved if the oil is processed further (trans-esterification). Normal agricultural crops include oil seed rape, sunflower and oil palm (in the tropics).

Pyrolysis: Organic matter burned with limited oxygen yields a range of solid, liquid and gaseous fuels. Pyrolysis may be used to concentrate the energy content of biomass for transportation to larger processing facilities.

Gasification: As an extension to pyrolysis, biomass can be turned into a combustible gas, which can be burned directly or converted to high quality liquid fuels. In many cases these synthetic fuels are more efficient than the fossil fuels they can replace.

Hydrogen: Hydrogen, which produces no pollution when burned directly, is best thought of as an energy carrier rather than a fuel. It is produced (using energy) either through electrolysis of water or as a by-product of a number of chemical processes.

Source: IEA website