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A Quantitative Analysis

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Abbreviations

$	US-Dollar
ABWR	Adanced Boiling Water Reactor
ACR	Advanced Candu Reactor
AEO	Annual Energy Outlook
AHWR	Advanced Heavy Water Reactor
ANOVA	Analysis of Variance
bl	barrel
bn	billion
BP	British Petroleum
Btu	British Thermal Unit
BWR	Boiling Water Reactor
CANDU	CANada Deuterium Uranium
CCS	Carbon, capture and storage
CFC	Carbon Fiber Reinforced Carbon
CGAEF	Calvert Global Alternative Energy Fund
CGAEX	Calvert Global Alternative Energy Index
CO_2	Carbon dioxide
CSR	Corporate Social Responsibility
DOE	Department of Energy
EERE	Energy Efficiency and Renewable Energy
EIA	Energy Information Administration
EPR	European Pressurized Reactor
ETF	Exchange Traded Fund
EUR	European Utility Requirements
FBR	Fast Breeder Reactor

GE	General Electric
GHG	Greenhouse gas
GW	Gigawatt
HFC	hydrofluorocarbons
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IGCC	Integrated Gasification Combined Cycle
IPCC	Intergovernmental Panel on Climate Change
km^2	square kilometres
LWR	Light Water Reactor
m^2	square metres
MSCI	Morgan Stanley Capital International
MW	Megawatt
MWe	Megawatt electric
NEI	Nuclear Energy Institute
Nox	Nitrogen oxides
NRC	Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
OECD	Organisation for Economic Co-operation and Develp-ment
OPEC	Organisation of the Petroleum exporting countries
ORC	Opinion Research Corporation
PFC	Perfluorocarbons
PHWR	Pressurized Heavy Water Reactor
ppm	parts per million
PV	Photovoltaic
PWR	pressurized water reactor
Qu	Quadrillion
R&D	Research and Development
rpm	revolutions per minute

SF6	Sulfur Hexafloride
Sig.	Signifcance
S&P	Standard & Poor's
SPSS	square kilometres
SRI	Socially Responsible Investing
t	tons
TW	Terawatt
US	United States
WEO	World Energy Outlook
WNA	World Nuclear Association

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Introduction

Since the end of the 19th Century/the beginning of the 20th Century petroleum has been a very important energy source for people and industry.

It is used to make a wide range of products and also for heating and mean of transport.

Historical events as the oil embargo in 1973 and the Iraqi invasion of Kuwait in 1990 are only two of many examples causing the increase in oil price in the last four decades. Also terrorism and economic crisis are responsible for the high peak in oil prices.

Because petroleum is notably going to reach its peak one day, the energy industry started to concentrate on finding alternatives to use in case high oil prices and also in case there is no oil left in the future. Alternatives are energy from biomass, geothermal energy, hydro energy, solar energy, nuclear energy and wind energy. Of course oil is still the number one leader in providing fuel for daily use (gas, heating, etc.).

In the following the thesis is divided in four parts: Part A is about Alternative Energy in general where we get introduced to each alternative. Part B gives us a brief view about investment in alternatives. Part C contains Environment and Climate Change, and finally our main part PART D shows information about forecast efficiency, how this is used and calculated and whether forecasts made by agencies (in our case it is the EIA) are inefficient.

Part A: Alternative Energy

1. Overview of Alternative Energy

In the following we will get an overview of the alternative energy produced.

1.1. Biomass

Biomass is composed of corn kernels, corn stalks, soybean, animal fasts, prairie grasses, hardwood and algae.

It is also made of dead trees, tree branches, yard clippings, wood chips, bark, saw-dust from lumber mills, tires and crops which are left over.

First waste good, tree branches and other scraps should be gathered together. Then the waste from factories and farms is brought to a biomass power plant. The biomass is then dumped into huge hoppers. This is then burned in a furnace.

The harvested biomass should be dry, because wet biomass would either require an input of energy for drying or if combusted it would decrease the efficiency of sensible heat production.

Wood is the largest biomass energy resource nowadays. It can be used for fuels and power production.

Biomass is expected to offset the petrochemical dependence and it can provide fuels and chemicals comparable to those derived from petroleum, but it cannot fully re-place the huge volumes of petroleum and other fossil fuels (NREL, Biomass Energy Basics, 2008).

There will be diverse technologies needed in the long run to make use of the different energy sources. The most common technologies involve chemical, biochemical and thermo-chemical conversion processes.

Biomass can be turned into a flammable gas by biomass gasifiers. To remove impurities, biogas can be cleaned and filtered before it is burned.

Co-firing biomass can be substituted for a portion of coal in an existing power plant boiler. For the near future it is the most economic measure.

Biomass is the largest U.S. source of renewable energy. NREL researchers are working to improve and expand these technologies for building biomass economy.

1.2. Geothermal energy

Geothermal power flows from the earth's mantle, reaching the surface in the form of hot springs, geysers, and volcanoes (American Energy, The renewable path to energy security, Worldwatch Institute, September 2006).

Geothermal systems are designed to bring underground heat to the surface and convert it to useful forms of energy (American Energy, The renewable path to energy security, Worldwatch Institute, September 2006).

In the United States of America, more than 600,000 geothermal heat pumps are operating today and the market is growing. The annual growth rate is 15% (American Energy, The renewable path to energy security, Worldwatch Institute, Center for American Progress, September 2006).

Geothermal electric capacity totaled 8,932 MW in 24 countries by the end of 2005 and produced 57 billion kWh of power annually.

The U.S. is leader in Geothermal electric and thermal heat installed capacity. This energy is equivalent to the energy of more than 60 million bl of oil and prevents the emission of 22 million t of CO_2.

Extracting Geothermal energy is nearly free of emissions. Lower temperature resources can be converted into electricity by advanced technologies.

Geothermal energy is used as source of direct heat for industry or as district heating. 90 per cent of the population of Iceland enjoys affordable geothermal central heating (BP Global, 2008, www.bp.com).

1.3. Hydro energy

Hydrogen is the most available element. It is also a versatile source of energy and can be fetched from every source. The dependence of oil would be reduced, and air pollution and GHG emissions would be abolished (EurActiv.com, Wasserstoff und Brennzellen: falsche Versprechungen? 27 Oktober 2006).

Generally, hydrogen is produced from fossil fuels (e.g. natural gas and coal). Hydrogen is also produced from the electrolysis of water, where the electricity needed for this can comes directly from the existing grid or from wind, nuclear, and solar energy (PV cells).

High efficiencies can be achieved by fuel cells which are powered by hydrogen. They also have a variety of uses in stationary and mobile applications. It can create paradigm shifts and distributed power generation.

Hydrogen may have a substantial role in the future energy market if current targets for reducing technology costs can be met. The governments have to give high priorities reducing CO_2 emissions, improving energy security and also to R&D.

Hydropower is the leading renewable electrical energy source in the U.S. (81% of total renewable electricity generation). It is also the least expensive source of electricity in the U.S. (efficiencies of 85 to 92 percent during production). Only 0.6 cents are needed to pay for operating and maintaining the plant for every kWh of electricity produced. The capital cost of the dams and structures and the environmental damage are not counted.

China will have more installed hydropower capacity than any other country in the world in 2030 (IEA, WEO 2004).

Countries in Europe and the US have developed more than 80% of the capability of their economically-viable hydropower. Therefore hydropower is a vital platform for economic growth.

1.4. Solar energy

Life would not exist on earth without the sun. The sun's energy is used in many different ways (solar hot water, solar thermal electricity).

There are lots of energy innovations taking place in the expanding solar industry. There are incremental improvements in solar electricity (e.g. silicon-based solar PV) and non-silicon forms of solar electricity (e.g. nanotechnology-based innovations and CIGS (copper, indium, gallium, selenium)). The Solar energy industry is expanding by more than 30% per year since the mid-1990s.

The sunlight can be changed directly to electricity using solar cells. These cells are also called PV cells which are made of silicon, a special type of melted sand.

Solar PV was invented at Bell Labs in the 1950s and commercialized in the 1970s. It was a niche industry powering space satellites, but then it moved to a mainstream business with BP, GE, Sharp and Shell. Since the mid-1990s the solar industry has annual growth rates in the range of 30% to 60%.

The sunlight strikes the solar cell. The electrons are knocked loose then, which move toward the treated front surface. Between the front and back an electron imbalance is created. Electricity occurs between the negative and positive sides when the two surfaces are joined by a connector.

These solar cells are arranged together in a PV module and these are grouped together in an array.

Concentrating solar power systems, passive solar heating and daylighting, PV systems, solar hot water, solar process heat and space heating and cooling are technologies that have been developed to gain electricity and heating power from solar energy.

Solar power technologies (e.g. individual home systems and large-scale concentrating solar power systems) are able to help meet growing energy needs and provide diversity and reliability in energy supplies.

1.4.1. High temperature

The opening of specialized niche markets for the solar power industry is predicted over the next decade.

One third of all PV systems are produced in the U.S., which is the largest percentage of any country. PV use silicon-based semiconductor materials to convert sunlight directly into electricity. It can be stored or used immediately.

A flat plate collector is the most common type of PV array. PV cells produce about 1 watt of energy. A module is made up by about 40 cells.

The capital costs range from $5 to $12 per watt. PV systems have no operating costs.

Silicon-based solar PV technologies are considered to continue dominating the market for some time. Concentrating Solar Power is troughs, dishes, and power towers.

An advantage is the utilization of the same technologies and equipment used by conventional central station power plants. Concentrating solar power is then the most cost-effective solar option for the production of large scale electricity generation.

These kind of solar power offer the lowest-cost solar electricity for large-scale power generation (>= 10 MW).

1.4.2. Technologies

In the following we take a look on Solar Thermal, PV and Concentrating Solar Power.

1.4.2.1. Solar Thermal

Solar thermal technologies use heat energy of the sun to heat water or air for space heating, pool heating and water heating.

These collectors can be set on the roof of a building or another place that exposures to the sun. This solar energy type enables getting power even when the utility power is disrupted. And it is a good method to save money on electric or fuel bills (replacing water heater with a solar water heating system). Homes can save 85% on utility bills by using home solar heating (Thermomax Industries, April 2009).

Additionally, using solar energy is environmentally friendly, does not pollute and is also free. And you can also integrate solar energy with wood stove and demand boiler to produce 100% of a required thermal loads.

1.4.2.2. Photovoltaics

PVs are solar cells, which convert sunlight directly into electricity, and they are often used to power calculators and watches. Solar cells are made of semiconducting materials.

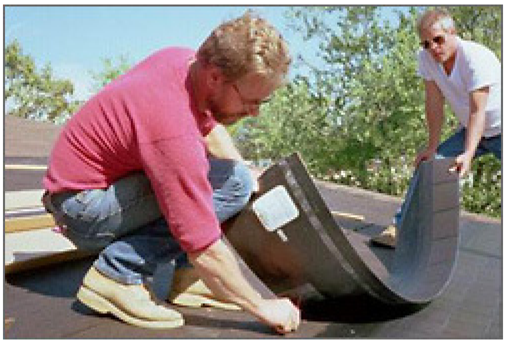
The solar energy knocks electrons loose from their atoms when sunlight is absorbed by these materials, and this allows the electrons to flow through material to produce electricity. This process of converting light to electricity is called the PV effect (NREL, 2008).

Solar cells are combined into modules that hold about 40 cells, and about 10 of these modules are set in PV arrays that can measure up several meters on a side.

Flat-plate PV arrays can be mounted at a fixed angle facing south, or on a tracking device (NREL, 2008). So they can capture the most sunlight over the day. To provide enough for a household, 20 PV arrays are needed.

Thin film solar cells use layers of semiconductor materials only a few micrometers thick. Thin film technology has made it possible for solar cells to now double as roof-top shingles, roof tiles, building facades, or the glazing for skylights or atria (NREL, 2008). Shingles (solar cell version) are installed on the rooftop and offer the same protection and durability as ordinary asphalt shingles.

Figure 1.1. Shingles



Source: NREL, 2008

Concentrating collectors operate with concentrated sunlight, and are built into concentrating collectors that use a lens to focus the sunlight onto the cells. An advantage is using very little of the expensive semiconducting PV material while collecting much sunlight as possible.

The disadvantage is the limited use of concentrating collectors to the sunniest parts of the country, because the lenses must be pointed at the sun.

Concentrating collectors can be mounted on simple and sophisticated tracking devices. But the sophisticated tracking devices limit the use to electric utilities, industries, and large buildings.

A typical commercial solar cell has an efficiency of 15% (i.e. 1/6 of the sunlight striking the cell generates electricity). When the efficiency is low, larger arrays are needed, which cause higher cost.

The first solar cells in the 1950s had an efficiency of less than 4 per cent.

1.4.2.3. Concentrating Solar Power

Figure 1.2. Concentrating Solar Power

Source: NREL, 2008

Concentrating solar power systems are a new generation of power plants which use the sun as a heat source.

Main types of concentrating solar power systems are parabolic-trough, dish/engine, and power tower.

Parabolic-trough systems concentrate the sun's energy through long rectangular, u-shaped mirrors which are tilted toward the sun, focusing sunlight on a pipe that runs down the center of the trough. This heats the oil flowing through the pipe. The hot oil then is used to boil water in a conventional steam generator to produce electricity (NREL, 2008).

A dish/engine system uses a mirrored dish that very looks like a satellite dish. The dish-shaped surface collects and concentrates the sun's heat onto a receiver, which absorbs the heat and transfers it to fluid within the engine (NREL, 2008). The heat produces mechanical power that is then used to run a generator or alternator to produce electricity (NREL, 2008).

A power tower system uses a large field of mirrors to concentrate sunlight onto the top of a tower, where a receiver sits. Molten salt flowing through the receiver is heated then. The salt's heat is used to generate electricity through a conventional steam generator. Molten salt retains heat efficiently, so it can be stored for days before being converted into electricity. So electricity can be produced on cloudy days or even several hours after sunset (NREL, 2008).

1.5. Nuclear energy

Nuclear energy is the largest source of carbon-free generation and provides 20% of the electricity in the United States. The nuclear power industry prevents the emission of millions of tons of carbon dioxide and other GHGs.

Nuclear energy is a base load generation source that does not cause air pollution or GHG emissions, but the problem of waste disposal is ignored.

1.5.1. The process of nuclear power

There are four processing steps to convert Uranium from an ore to solid ceramic fuel pellets: mining and milling, conversion, enrichment, and fabrication.

Uranium is milled and processed after mining to create uranium oxide. Then a conversion plant removes impurities and the material is chemically converted. Uranium is made usable by enrichment.

Then a fuel fabricator presses the uranium into solid, ceramic pellets and inserts them into rods making a fuel assembly (Nuclear Energy Institute, Nuclear Energy: Just the facts, 2008). These are then transported to the nuclear plant and loaded into the reactor.

The uranium fuel comes as small, ceramic pellets inserted and sealed into long, vertical metal alloy tubes or rods. Then nuclear fission produces energy to heat water in the reactor. It also creates steam that powers generators to produce electricity.

Nuclear fuel cannot explode because of its solid material enriched at a low level.

Electricity is generated without producing GHGs. After a cooling period, nuclear power plants used fuel safely and securely on site in steel and concrete vaults (Nuclear Energy Institute, Nuclear Energy: Just the facts, 2008).

Figure 1.3. Nuclear power plant

Source: www.nei.org, 2008

Then used fuel containers are transported to a permanent repository or a recycling facility.

The development of advanced fuel-cycle technologies is efficient and reduces wastes.

Though a federal repository is needed, e.g. a deep geologic repository is considered to be the best method of managing used nuclear fuel and recycling by-products.

1.5.2. Nuclear Energy Technologies

This section shows an overview about Advanced Nuclear Power Reactors and Small Nuclear Power Reactors.

1.5.2.1. Advanced Nuclear Reactors

These have been operating in Japan since 1996. Newer reactors have simpler designs which reduce capital cost. These are also safer and fuel-efficient.

The nuclear power industry has been developing and improving reactor technology for more than fifty years.

There are four generations of reactors: Generation I (reactors developed in the 1950s-60s), Generation II (typified by the present US fleet), Generation III (and 3+) are the Advanced Reactors. The first are operated in Japan. Generation IV are at concept stage and will not be operated before 2020.

Reactor suppliers in North America, Europe, Japan, Russia and South Africa have a dozen new nuclear reactor designs at advanced stages of planning.

Generation III reactors have a standardized design for each type of expedite licensing, reduce capital cost and reduce construction time. They also have a simpler design and a higher availability. The possibility of core melt accidents is also reduced.

Light Water Reactors

Advanced Boiling Water Reactor (ABWR) is derived from a GE design. The other type is System 80 which is an advanced PWR, which is not now being promoted for sale.

The U.S. Nuclear Regulatory Commission (NRC) gave final design certification for both types in May 1997 (WNA, 2008). Both exceeded the safety goals by several orders of magnitude. The NRC approvals were the first generic certifications to be issued and are valid for 15 years (WNA, 2008).

In Japan, the first two ABWRs (Kashiwazaki Kariwa 6 & 7) have been operating since 1996 and are expected to have a 60 year life (WNA, 2008). These units cost about US-$ 2000 per kW to build, and produce power at about 7 US-cents per kWh. Future ABWR units are expected to cost US-$ 1700 per kW.

Smaller versions will have standardized features which cause cost reductions.

In Europe, several designs are being developed to meet the EUR of French and German utilities, which have stringent safety criteria (WNA, 2008). A large EPR was developed by Areva NP (formerly Framatome ANP). The EPR was confirmed in 1995 as the new standard design for France. It is expected to provide cheaper power and has fuel burn-up of 65 GWd/t and the highest thermal efficiency (36%) of any LWR. Its availability is 92% over a 60-year service life. The EPR also has four separate, redundant safely systems.

Heavy Water Reactors

The ACR incorporates some features of the pressurized water reactor while retaining the low-pressure heavy water moderator.

Adopting light water cooling and a more compact core reduces capital cost. The reactor has higher thermal efficiency because it is run at higher temperature and coolant pressure.

ACR is moving towards design certification in Canada, with a view to following in China, USA and UK (WNA, 2008).

India is developing the AHWR which is a 300 MWe reactor moderated by heavy water at low pressure. The calandria, a reactor core which is a shell-and-tube unit used as a thermosiphon reboiler for distillation or evaporation, has 500 vertical pressure tubes and the coolant is boiling light water circulated by convection. A burn-up of 24 GWd/t is envisaged. It is designed for 100 year plant life and is expected to utilize 65% of the energy of the fuel (WNA, 2008).

Each AHWR fuel assembly will have the fuel pins arranged in three concentric rings once it is fully operational.

Fast Neutron Reactors

The FBR is a type of Fast Neutron Reactor. This reactor uses the uranium-238 in reactor fuel as well as the fissile uranium-235 isotope used in most reactors.

About 20 liquid metal-cooled FBRs have already been operating, some since the 1950s, and some supply electricity commercially (WNA, 2008).

FBRs can utilize uranium at least 60 times more efficiently than a normal reactor, but they are expensive to build (WNA, 2008). Therefore research work on the 1450 MWe European FBRs has almost ceased.

Any surplus plutonium, which is not in pure form, can be used as the cores of new reactors. Used fuel can be recycled indefinitely, with on-site reprocessing and associated facilities (WNA, 2008).

1.5.2.2. Small Nuclear Power Reactors

They are built because there is a revival interest in small and simpler units for electricity generation from nuclear power. There is also a need to reduce capital costs.

The size of reactor units has grown from 60 MWe in the 1950s to more than 1600 MWe these days, with corresponding economies of scale in operation (WNA, 2009), but there is a move to develop smaller units. The IAEA defines "small" as under 300 MWe, but generally 500 MWe is considered as "small".

Generally, modern small reactors for power generation are expected to have greater simplicity of design, economy of mass production, and reduced costs. Many are also designed for a high level of passive or inherent safety in the event of malfunction (WNA, 2009).

Table 1.1: Nuclear power plants in commercial operation						
Reactor type	**Main countries**	**Number**	**GWe**	**Fuel**	**Coolant**	**Moderator**
Pressurised Water Reactor (PWR)	USA, France, Japan, Russia	264	250.5	Enriched UO2	water	water
Boiling Water Reactor (BWR)	USA, Japan, Sweden	94	86.4	Enriched UO2	Water	Water
Pressurised Heavy Water Reactor (PHWR), 'CANDU'	Canada	43	23.6	Natural UO2	Heavy water	Heavy water
Gas-cooled Reactor	UK	18	10.8	Natural U (metal)	CO2	graphite
Light Water Graphite Reactor	Russia	12	12.3	Enriched UO2	Water	Graphite
Fast Neutron Reactor (FBR)	Japan, France, Russia	4	1.0	PuO2 and UO2	Liquid sodium	None

Source: Nuclear Engineering International Handbook 2007

1.6. Wind Energy

Wind energy is a source of power for many thousands of years. There are early records of windmills dating back to Persian times. Wind was used to grind corn, pump water and facilitate worldwide travel in sailing ships throughout the middle ages.

Thanks to the oil crisis in the 1970s the interest in wind energy grew. Large machines for electricity generation have been developed.

Wind is generated by complex mechanisms involving the rotation of the earth, heat energy from the sun, the cooling effects of the oceans and polar ice caps, temperature gradients between land and sea and the physical effects of mountains and other obstacles. The windiest places are in the coastal regions of America, Europe, Asia and Australasia (Gordon, 2001).

Wind has established itself as the world's fastest growing new source of power as more wind farms are being installed in more countries around the world than at any time in the 20-year history of commercially viable wind power (Kahn, 1999).

Part B: Investment in Alternative Energy

2. Investment

Investors have some options to allocate their assets to alternative energy. First, there are large established conglomerates that have divisions operating in well-established growth markets (nuclear, hydroelectric and wind energy). Also the smaller publicly listed companies develop energy technologies, e.g. biomass and solar energy. And there are privately held, non-listed companies which develop experimental technologies, e.g. nanotechnology-based solar panels.

2.1. Large companies

GE became a world leader in solar power when it took over AstroPower, which is a key player in the wind-turbine industry and providing equipment for nuclear industries. Companies like BP and Royal Dutch Shell, which have alternative energy divisions, intend to double its revenues through the sale of environmentally cleaner technologies. However, these alternative energy divisions position themselves as truly diversified energy providers and tend to be relative small compared to their core businesses. Expected rapid rates of growth in solar and wind energy markets are often reflected by stock prices.

By considering investment in alternatives, one should consult an investment professional to determine whether it is a good time to purchase such a stock.

2.2. Small publicly listed companies

If you invest in a young company in a rapidly growing industry, then you may be in luck and win. But such a company is not easy to find.

Stocks are highly volatile and if we are ready to take an additional risk, so this should be considered only for the riskiest part of the portfolio we have.

Another option is to purchase a portfolio of stocks through an investment in a mutual fund, closed-end fund, ETF or in a socially responsible investing (SRI) through an experienced investment manager (Wells Fargo Bank, 2005).

Adopting pooled investment strategies offers the potential for attractive returns if growth in the alternative-energy sector takes off, and may diversify away some of the risk to the portfolio of companies that may not survive in the longer term (Wells Fargo Bank, 2005). Such investments have the ability to have disappointing returns.

2.3. Privately Held Start-Up Companies

The venture-funded, privately held start-up companies are the riskiest investments in the alternative energy sector. These companies often have unproven technologies but offer the potential for high returns if these technologies become successful.

In such companies, venture capital investments rose by 21 percent in the first half of 2005 (Wells Fargo Bank, 2005). Many of these companies dedicated their funds to clean technology or significant investments. Large institutional investors increase the demand for such clean-energy funds.

To gain success as an individual investor, you need to be accredited. Fore example, you and your spouse must have over $1 million investable assets or earn more than $300,000 per year. If you are unmarried, you must earn more than $200,000 p.a.

Then you have to consider whether such an investment is suitable for particular needs and circumstances. For at least 10 years, returns should not be expected to be realized. Because of the big challenge, investing in an ETF or sector mutual fund may be the best way in investing in alternative energy.

2.4. Calvert Investments

The increasing demand for energy cannot only be met by fossil fuels. Therefore alternative energy will be an important part to filling the gap between supply and demand (Calvert Investments, 2009).

Calvert is one of the largest social responsible mutual fund firms in the U.S. It has 15 million US-$ in assets under management.

There are two funds that allow individual and institutional investors to pursue a broad range of investment objectives within a single fund family (CSRwire, Calvert Investments, 2007).

The majority of investors in the U.S. are concerned about climate change and therefore interested in alternative energy investments.

2.4.1. The Fund

The new “Calvert Climate Change/Alternative Energy Survey”, which was conducted for Calvert by Opinion Research Corporation (ORC) and queried 1,094 investors, found that three out of four U.S. investors are concerned about global warming and climate changes.

Also nearly 85% agreed that alternative energy investments (wind, solar, hydro, etc.) support the environment and generate profit at the same time.

However, only 20% of the investors who use a financial professional responded affirmatively when asked if they had discussed investing in alternative energy with a financial advisor (CSRwire, Calvert Investments, 2007).

2.4.2. Calvert Launches Global Alternative Energy Fund

The Calvert Global Alternative Energy Fund invests in a broad universe of U.S. and non-U.S. stocks (CSRwire, Calvert Investments, 2007). Calvert announced the launch of the Calvert Global Alternative Energy Fund (CGAEX) on May 31, 2007 (Calvert Special Report, 2007). The Fund seeks out companies that are alternative energy market leaders and those who are building a significant presence in the energy sector (CSRwire, Calvert Investments, 2007).

Many investors of Calvert believe that this fund will meet their investment strategy needs and that it offers exposure to alternative energy with diversification for socially and non-socially responsible global investors (CSRwire, Calvert Investments, 2007).

It seeks to provide long-term growth of capital by investing in companies that are involved in alternative energy technology and production (Calvert Special Report, 2007).

“Calvert believes that companies across the spectrum of industries must acknowledge and act now to address the climate change crisis,” says Bennett Freeman, Calvert’s Senior Vice President for Social Research and Policy. “Global warming is already at the forefront of Calvert’s company analysis and environmental advocacy. Now, with the launch of this new fund, we are aligning our investment strategies and policy goals by offering our shareowners the opportunity to invest directly in climate change solutions.” (CSRwire, Calvert Investments, 2007).

The investment objective of the CGAEF is a long-term growth of capital.

The Fund's portfolio manager is the Dublin-based KBC Asset Management International Ltd., which has a strong global reputation international investing, manages $145 million in alternative energy funds (Calvert Special Report, 2007). It seeks out stocks that are market leaders in alternative energy or are significantly involved in production, exploration, discovery or distribution of alternative energy (CSRwire, Calvert Investments, 2007).

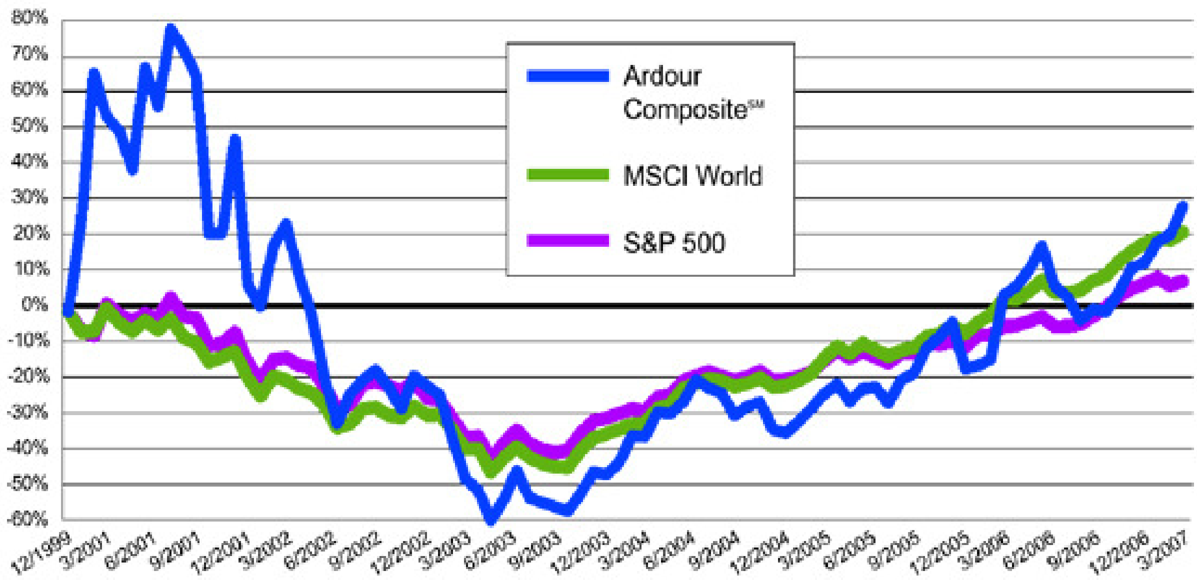
The stock markets may experience periods of volatility and instability. The Fund tends to be more volatile than other mutual funds (Calvert Special Report, 2007).

The future of the planet depends on increased investment in generating sources of alternative energy because of the growing world population and declining supplies of traditional energy sources (oil, coal, …).

Alternative energy has developed to as one of the fastest growing market sectors in the past few years (Calvert Special Report, 2007).

The graph below shows that Alternative energy is an attractive investment opportunity.

Figure 2.1. Indexes



Source: Calvert Investments, 2007

Alternative Energy stocks, represented by Ardour Composite Global Alternative Energy IndexSM, have significantly outperformed the broad-based global stock market, represented by the MSCI World Index, and the U.S. stock market, represented by the S&P 500, based on cumulative returns over the period since the Ardour index was conceived in December 31, 1999 (Calvert Investments, 2007).

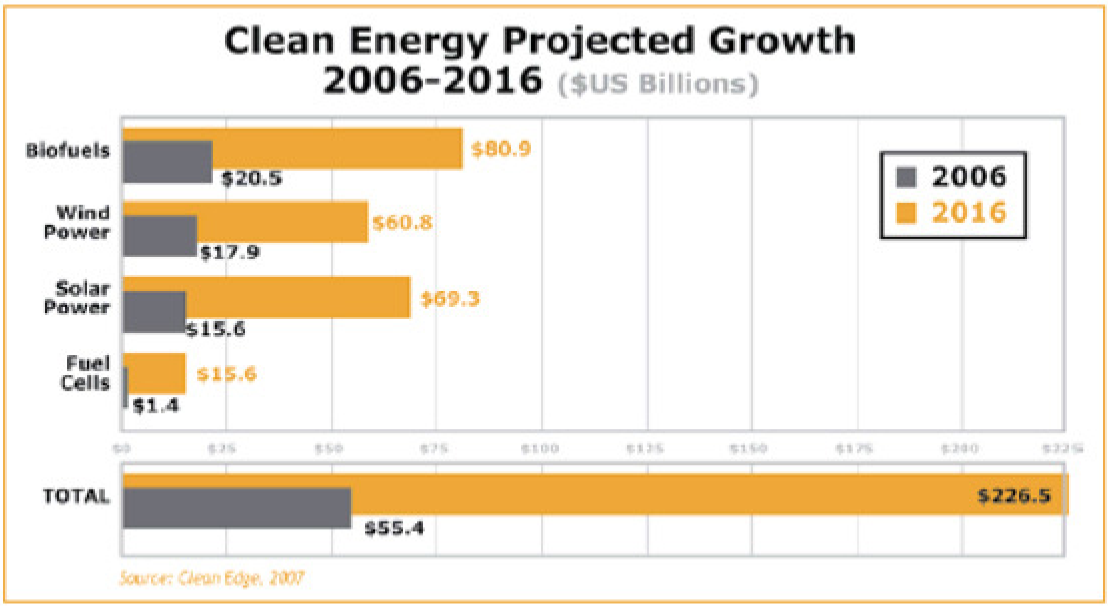
As of March 31, 2007, Alternative Energy stocks generated a cumulative return of 30.14%, compared with 22.77% for the global stock market which made 22.77% and the U.S. stocks which made 8.88% since end of December 1999 (Calvert Investments, 2007).

2.4.3. Future

The alternative energy sector's outlook is believed to be strong. Annual revenue for four key clean-energy technologies (Biofuels, Wind Power, Solar Power, Fuel Cells) increased nearly 39 percent in 2006 (see Figure 2.2. below).

The four energy technologies will amount approximately $226.5 bn within a decade (Calvert Investments, 2007).

Figure 2.2: Revenue Growth



Source: Calvert Investments, www.calvert.com/alternativeenergy/appealinginvestment.html

The energy sectors can be risky. Therefore possible increases in clean energy revenue do not necessarily indicate positive results for investing in funds.

2.4.4. Caution of risks

There are also risks to take even having optimistic prospects for alternative energy. Obsolescence of existing technology, short product life cycles, falling profits and prices, competition from new market entrants and general economic conditions, fluctuations in energy prices and supply and demand of alternative energy fuels, energy conservation, success of exploration projects and tax and other government regulations and policies can affect this sector significantly.

PART C: Environment and Climate Change

In the following chapter we focus on the relation of alternative energy to our environment. Global warming and climate change are major issues nowadays that cannot be just ignored.

The use of alternative energy is more efficient than the use of petroleum and other fossil fuels. These fuels damage the economy and ecosystems. The cost of repairing damages is not included in the energy price.

Alternative energy technologies though are emissions-free at the point of use and energy efficiency reduces energy consumption, which emits fewer emissions. These technologies contribute to least-cost strategies to meet emission reduction standards complying with air quality regulations (US DOE EERE, 2008).

3. Climate Change

Climate Change is risky for global ecosystems, the world economy and population. Not only human activities, but emissions and GHGs (e.g. CO_2) damage the environment. For the society and economy it is important to have a clean, secure and sufficient supply of energy (Department for Business, Enterprise & Regulatory Reform, 2008).

Based on the National Center for Atmospheric Research GHG concentrations in the atmosphere are now higher than at any time in at least 750,000 years (Hilton et al., 2008).

A 2002 study published in the Journal of the American Medical Association determined that exposure to air pollution poses the same risks of dying from lung cancer and heart disease as does living with a smoker (Worldwatch Institute, 2006).

In the United States pollution from power plants causes nearly 24,000 premature deaths every year. The medical expenses are more than $160 billion per year because of air pollution from power plants alone (Worldwatch Institute, 2006).

Acid rain is the result of sulfur emissions caused primarily from the burning of coal in power plants to produce electricity. This rain damages crops, forests and buildings. Also lakes and rivers are then made too acidic. Nitrogen oxides (NO_x) form ground-level ozone, or smog, caused of combining with other chemicals (Worldwatch Institute, 2006).

Coal and oil contain toxic mercury, arsenic, etc. Mercury damage causes problems with the central nervous system and may also damage reproductive, immune and cardiovascular systems. Withdrawal of surface water from power plants can kill fish, larvae and other organisms (Worldwatch Institute, 2006).

Global emissions must be reduced to avoid catastrophic climate changes. The use of alternative energy will provide an important means to reduce the toxic emissions.

3.1. Approach based on the Stern Review on the economics of climate change

Climate change is serious problem. The climate is changing very fast, which results of GHGs caused by human activities.

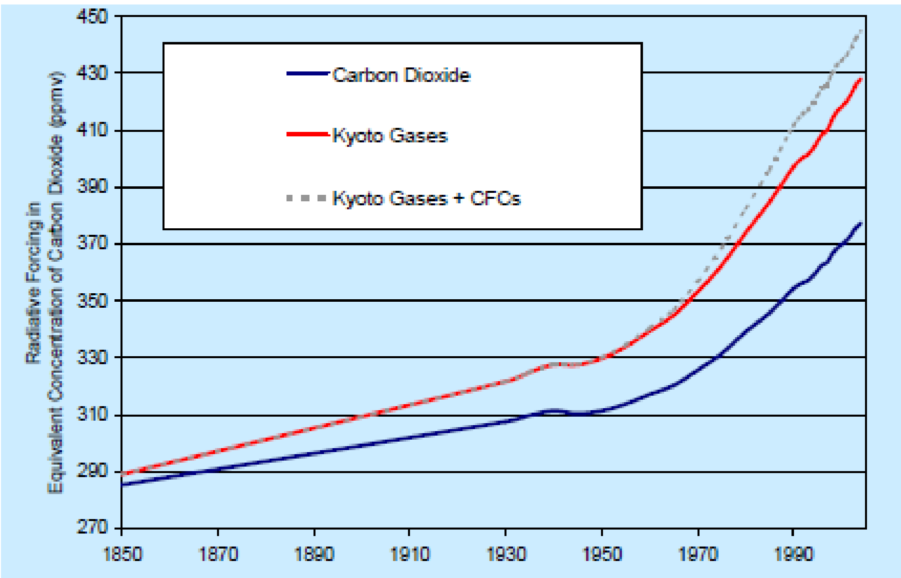
A doubling of pre-industrial levels of GHGs is very likely to commit the earth to a rise of between 2 – 5°C in global mean temperatures, which will probably be reached between 2030 and 2060 (Stern, N., 2006).

High temperatures cause plants and soils to soak up less carbon from the atmosphere and cause permafrost to thaw, potentially releasing large quantities of methane (Stern, N., 2006).

Since around 1750 (pre-industrial time) carbon dioxide concentrations have increased by over one third 280 parts per million (ppm) to 380 ppm today (Figure 3.1) as a result of burning fossil fuels, deforestation, and other changes in land use.

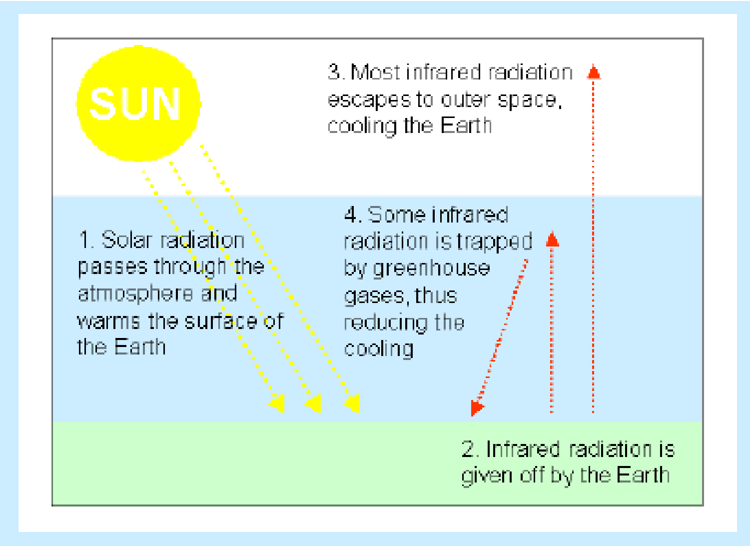
The figure shows the warming effect of greenhouse gases in terms of the equivalent concentration of carbon dioxide (CO_2). The blue line is the value for CO_2. The red line shows the value of six Kyoto GHG (CO_2, methane, nitrous oxide, PFCs, HFCs and SF_6), and the grey line includes CFCs. The rate of the GHG levels per year is variable, but increasing.

Figure 3.1: Rising levels of GHG



Source: Stern, N. (2006)

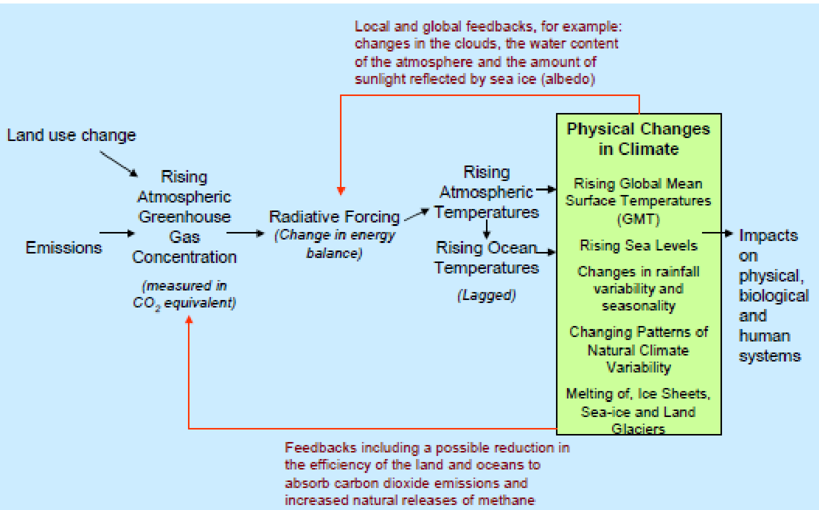
Figure 3.2: The Greenhouse Effect



Source: Stern, N. (2006)

The Greenhouse effect shows the evidence that the rising levels of GHGs will have a warming effect on the climate through increasing infrared radiation (heat energy) trapped by the atmosphere.

Figure 3.3: The link between GHG and climate change



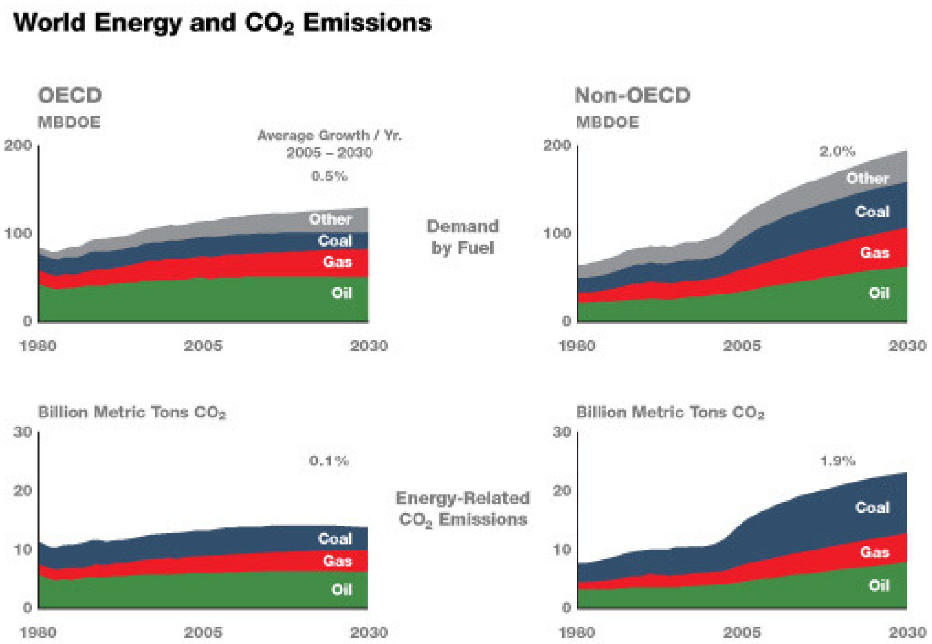
Source: Stern, N. (2006)

The feedbacks in the atmosphere act to amplify or dampen the direct warming. Water vapour is the main positive feedback, which is a very powerful GHG itself. A warmer atmosphere holds more water vapour and traps more heat (Stern, N., 2006).

The externalities associated with GHG emissions let the climate changes. These are global in its causes and consequences and the impacts are long-term and persistent. There also are pervasive uncertainties and risks (irreversible changes with non-marginal economic effects).

3.2. World Energy and CO_2 emissions

Figure 3.4: World Energy and CO_2 Emissions



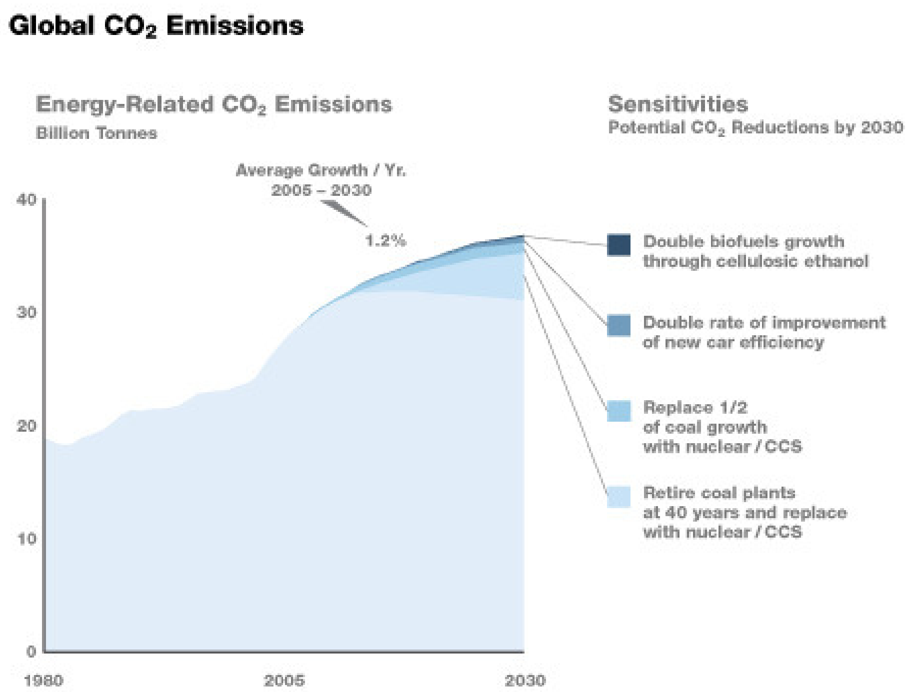
Source: Exxon Mobil, 2008

In Non-OECD countries the growth in energy demand will be much more pronounced. They reflect a large population base with rapidly rising economic prosperity. CO_2 emissions are expected to increase as well if the anticipated fuel mix powering economic expansion is given.

Overall energy demand growth is expected to be at 0.5 % per year in the OECD Member countries.

In the non-OECD there is much stronger growth expected in the need for energy (consistent with faster growing populations and economies).

Figure 3.5: Global CO_2 Emissions



Source: Exxon Mobil, 2008

Energy-related CO_2 emissions are expected to increase globally at about 1.2 percent annually to 2030 with approximately 37 billion tonnes despite of assumptions for energy intensity improvements (Exxon Mobil, 2008).

Doubling the expected rate of improvement in new vehicle fuel economy would reduce CO_2 emissions by approximately 1 percent in 2030.

If one half of the growth in coal for power generation is replaced with a “low carbon” alternative energy, e.g. nuclear or IGCC with carbon capture and storage, that would reduce CO_2 in 2030 by about 3 percent (Exxon Mobil, 2008).

Adding 125 more nuclear plants would be required from the replacement of this coal capacity with all nuclear plants.

3.3. Impacts on the environment

In the following we will take a look on benefits, advantages and disadvantages of alternative energy.

3.3.1. Benefits and Advantages

With a growing alternative energy industry, the cost per kWh will decrease for this energy. Also alternative power generators will become capable of supplying more power from less sun and wind, which make them more reliable (ABS Alaskan Alternative Energy Products and information, 2008).

Water, wind and solar power are all non-emission power sources, and there is no harmful exhaust or toxic and radioactive waste produced when using alternative energy generators. There is no noise made by solar panels and underwater turbines. Even the noisiest wind turbine would be unnoticeable, compared to noise an engine generator makes (ABS Alaskan Alternative Energy Products and information, 2008).

Renewable energy or Alternatives produce little waste, so they are generally regarded as more environmentally-friendly than other sources (The Institution of Engineering and Technology, 2008).

3.3.2. Disadvantages

Companies are involved in reputational risk if they do not do something about reducing emissions and do not manage their impact on global warming as a result of increasing public concern about climate change which is an important point for long-term economic growth and financial health.

It will take some time until alternative energy sources will be the only sensible source of electrical power.

3.4. Biomass

Biomass is a waste and so it has to be removed before it causes an environmental hazard (except the cultivation of energy crops like firewood or sugar cane for conversion into alcohol for the consumption in cars).

The conversion into alcohol causes more organic waste but the burning of the alcohol in cars causes less environmental pollution than petrol (The Institution of Engineering and Technology, 2008).

3.5. Geothermal Energy

More cooling towers are required (25 compared with 3 for comparable output) because of lower temperatures associated with geothermal energy. Also the provision of water for both injection and cooling (in excess of 100 kilograms per second) could cause problems, as could contamination of any water courses into which the reject water flowed (The Institution of Engineering and Technology, 2008).

Noxious chemicals (arsenic or sulphur) may be dissolved in the hot water (that drives the turbine), which also cause problems (The Institution of Engineering and Technology, 2008).

3.6. Hydro Energy

This sort of energy has some disadvantages. The hydroelectric power generated through large-scale dam projects has potential impact on wildlife (dam's effect on fish) and agriculture. It may also displace the local population, but though also GHG emissions (Wells Fargo Bank, 2005).

The industry is trying to design plants which are kinder to aquatic life.

Water released from dams contains little suspended sediment which can lead to greater erosion downstream and prevent sediments from enriching farm land through irrigation (Wells Fargo Bank, 2005).

3.7. Solar Energy

The environmental effects of such a system are essentially nil apart from, possibly, visual intrusion (The Institution of Engineering and Technology, 2008).

The pollution caused during heating or boiling is very small and normally restricted to the visual amenity and the large use of land mass (0.1 km^2 for 10 MW output).

Other hazards can be found, particularly where high temperatures are required. These use more land than the lower temperature systems. Also there is a hazard to personnel entering the lens system, since a high temperature system normally uses a focusing arrangement. If this system also incorporates a tracking arrangement to follow the sun, so there is a danger of the system failing and allowing the focused beam to damage property or personnel (The Institution of Engineering and Technology, 2008).

3.8. Wind Energy

The sterilization of land could be a problem caused by windmills. A wind farm would measure over 500 m^2, whereas a single large coal fired power station measures only about 1 m^2 of land.

Real problems are visual intrusion and noise, even it can be minimized. The use of shallow areas of the sea could be a solution, but it is a more costly one.

Noise comes from the mechanical transmission of the turbine and aerodynamic noise, but is only significant when it is close to the tower.

Also hazards to wildlife (e.g. birds) and TV interference are a problem. But as the blades rotate slowly (30-60 rpm) and are highly visible, it is not becoming a big problem anymore (The Institution of Engineering and Technology, 2008).

3.9. Nuclear Energy

Nuclear power plants do not burn anything, so they produce no combustion byproducts into the atmosphere. Uranium atoms fission or split in a chain reaction, which is a clean, non-polluting process. They help protect the air quality and to mitigate climate change, because they do not produce GHGs during electricity generation.

Nuclear power plants provide excellent habitat for wildlife and plants because of their cleanliness and safeness (Nuclear Energy Institute, 2008).

In the U.S the nuclear energy industry prevents millions of tons of CO_2 emissions every year by using nuclear power instead of fossil fuel-based plants (Nuclear Energy Institute, 2008).

Worldwide, about 430 nuclear power plants reduced world's CO_2 emissions by about 500 million metric tons of carbon during 1997.

PART D: Forecasting of alternative energy generation

The main part of my thesis is to deal with past forecasts and analyzing these data to see if today's forecast is related to the past forecast. If this is the case, so then the forecast is meaningless and not reliable.

Before taking a deeper look on this case, I want to give some statistical background to understand what I have done to get my results analyzing projections of alternative energy.

4. Forecasting Efficiency

In the following I will explain briefly the forecasting efficiency, based on the article „Forecasting Efficiency: Concepts and Applications" by William D. Nordhaus in 1987 (published in The Review of Economics and Statistics, Vol. LXIX, No. 4, November 1987). The article introduced the concept of forecast efficiency, in which the forecast contains all information available at the time of the forecast.

Forecasting is important when making investment decisions, government plan budgets or when individuals are making saving decisions based on the forecasts of future incomes.

Based on my data I want to show if forecasts are biased, erratic, unreliable, or also reasonably efficient.

There are two ways to research the forecasting efficiency.

First, there is the concept of "Forecast efficiency", which measures the extent to which information is incorporated into forecasts (Nordhaus, W., 1987). There are two testable propositions about efficient forecasts.

Second, we can examine forecast efficiency by looking at forecast revisions.

Efficiency is closely related to statistical sufficiency. A forecast is efficient if it minimizes the loss function subject to available information (Nordhaus, W., 1987). It is used to distinguish strong from weak efficiency in the empirical tests that follow.

A strongly efficient forecast minimizes the loss function when all information is available at time t. A forecast is strongly efficient if $E\{({}_tu_T)^2|I_t$ is minimized, where It is all information available at time *t* (Nordhaus, W., 1987).

Weak efficiency pertains to forecasts that efficiently incorporate information about past forecasts. A forecast is weakly efficient if it minimizes $E\{({}_tu^2{}_T)|J_T\}$, where J_T is the set of all past forecasts (Nordhaus, W., 1987).

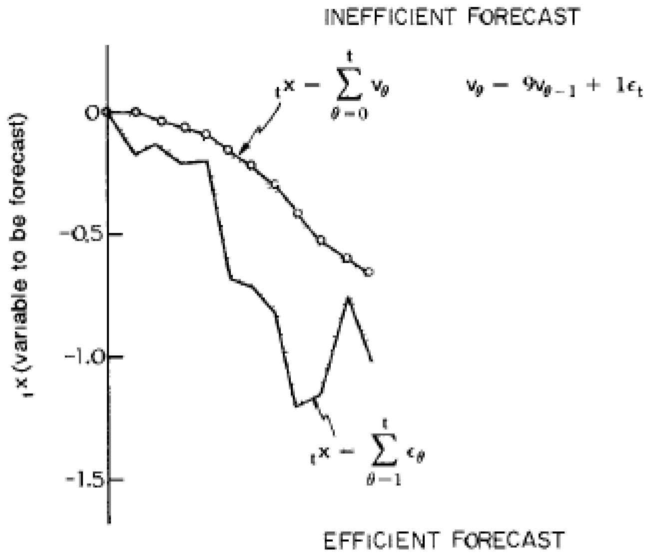
Past forecasts are likely to play a very important role in determining current forecasts. Forecasters tend to have a certain consistency in their views of the world, so that recent forecasts will go far in explaining current forecasts (Nordhaus, W., 1987).

Powerful set of tests can be used to investigate whether forecasts are weakly efficient.

4.1. Tests for weak efficiency

If forecasts steadily move up or down, then forecasters have not efficiently incorporated past information (see 4.1).

Figure 4.1: Efficient and Inefficient Forecasts



Source: Nordhaus, W., 1987

Above the efficient forecasts appear jagged because of incorporating all news rapidly. Inefficient forecasts are smoother and more consistent than efficient forecasts. Inefficient forecasts allow news to step in at a rate of 10% per period. Shaded area shows conditional absolute forecast errors at every point of forecast period (Nordhaus, W., 1987).

And now let us move to the main part showing the forecast revisions for alternative energy (Biomass, Geothermal, Hydro, Solar, Wind and Nuclear).

4.1.1. Biomass – Projections and Revision

Table 4.1: Biomass - Energy capacity and generation in GW							
	1996	**1998**	**2000**	**2002**	**2004**	**2006**	**2008**
2010	14.4	12.59	14.77	12.76	11.73	10.95	11.43
2015	16.18	13.09	16.17	14.13	12.92	11.55	13.45
2020		13.31	17.08	15.21	14.5	12.31	17.33

In the table above you see the following: I took the forecast data (EIA Annual Energy Outlooks 1996 to 2008) for the years 2010, 2015 and 2020. In the columns you see the year of the outlooks and what each forecasted for 2010, 2015 and 2020.

Although I searched for a very long period, unfortunately it was not easy to find lots of data to analyze from 1970 to 1990, so I could only took outlooks from 1996 to 2008 based on the U.S. energy market.

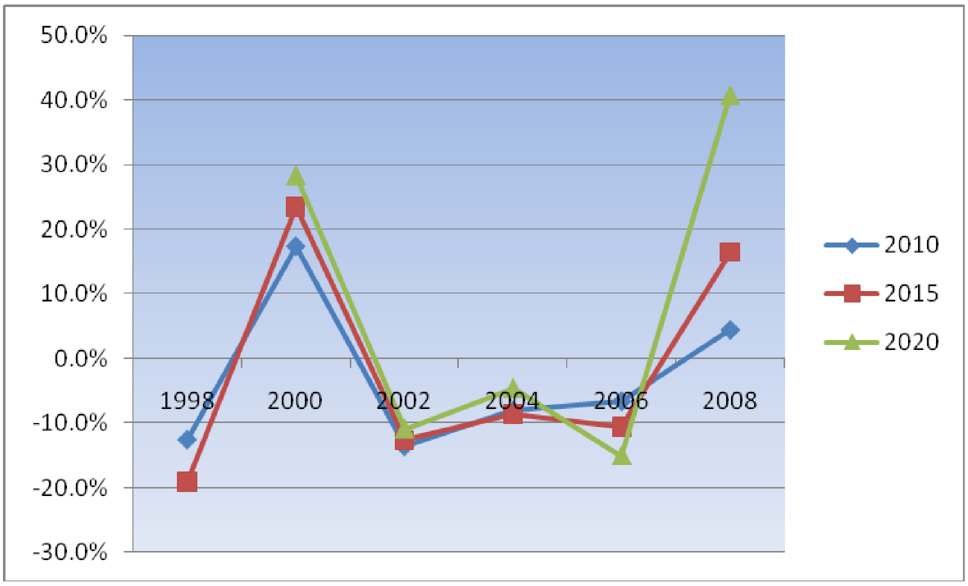
The changes for the three years calculated in Microsoft Excel are:

Table 4.2: Changes of the forecasts in %

	1998/1996	**2000/1998**	**2002/2000**	**2004/2002**	**2006/2004**	**2008/2006**
2010	-12.6%	17.3%	-13.6%	-8.1%	-6.6%	4.4%
2015	-19.1%	23.5%	-12.6%	-8.6%	-10.6%	16.5%
2020		28.3%	-10.9%	-4.7%	-15.1%	40.8%

The table contents the changes of the data from one year to the next one (in our case a two-year-period). The graph below shows us the changes of the forecasts for the years 2010, 2015 and 2020.

Figure 4.2: Changes of the forecasts over the years (in %)



We see the changes are steadily going up and down, so therefore we there is no efficient result, especially between 2000 and 2002 and between 2006 and 2008.

4.1.1.1. Autocorrelation analysis in SPSS

Now we want to see the forecast efficiency with help of the autocorrelation and significance using a statistics programme named **Statistical Package for the Social Sciences** (SPSS).

We have an autocorrelation between two variables. Therefore it is a bivariate correlation. We use a two-tailed test when we a relationship is expected, but the direction of the relationship is not predicted. The normal distribution is useful for making formal tests of weak efficiency.

Pearson's coefficient requires parametric data because it is based upon the average deviation from the mean (Field, A., 2005).

Table 4.3: Autocorrelation 2010

		year_2010_a	year_2010_b
year_2010_a	Pearson Correlation	1	-.562
	Sig. (2-tailed)		.324
	N	5	5
year_2010_b	Pearson Correlation	-.562	1
	Sig. (2-tailed)	.324	
	N	5	5

We have a negative autocorrelation but no significance (0.324>0.05) at usual significance level.

Below we see the Kolmogorov-Smirnov Test which compares the scores in the sample to a normally distributed set of scores with the same mean and standard deviation.

Table 4.4: Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2010_a	.361	5	.032	.754	5	.032
year_2010_b	.267	5	.200*	.918	5	.515

a. Lilliefors Significance correction

*. This is a lower bound of the real significance

The test is non-significant if p>0.05 and shows us that the distribution of the sample does not differ significantly from a normal distribution.

However, a test is significant if p<0.05 which tells us that the distribution is significantly different from a normal distribution.

The test statistic for the Kolmogorov-Smirnov-Test is denoted by D (Field, a., 2005). The 2010a scores D(5) = 0.361, so it is non-significant (p>0.05) and did not significantly deviate from normality. The same applies also for 2010b D(5)=0.267.

As already done for 2010 we also show the autocorrelation for 2015.

Table 4.5: Autocorrelation 2015

		year_2015_a	year_2015_b
year_2015_a	Pearson Correlation	1	-.597
	Sig. (2-tailed)		.288
	N	5	5
year_2015_b	Pearson Correlation	-.597	1
	Sig. (2-tailed)	.288	
	N	5	5

Above we also do not have significance at the usual significance level.

Table 4.6: Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2015_a	.374	5	.021	.771	5	.046
year_2015_b	.326	5	.089	.808	5	.094

a. Lilliefors Significance correction

The 2015a scores D(5) = 0.374, so it is non-significant (p>0.05) and did not significantly deviate from normality. The same applies also for 2015b D(5)=0.326.

In the case for 2020, we got a high correlation (almost 1), which is not good, and so we have a significance of 0.017 (less than 0.05). That tells that the forecast is not normally distributed and also correlating which is not efficient.

Table 4.7: Autocorrelation 2020

		year_2020_a	year_2020_b
year_2020_a	Pearson Correlation	1	.941*
	Sig. (2-tailed)		.017
	N	5	5
year_2020_b	Pearson Correlation	.941*	1
	Sig. (2-tailed)	.017	
	N	5	5

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.8: Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2020_a	.326	5	.089	.808	5	.094
year_2020_b	.288	5	.200*	.856	5	.213

a. Lilliefors Significance correction

*. This is a lower bound of the real significance

We now take a look on the data for consumption in Qu Btu per year.

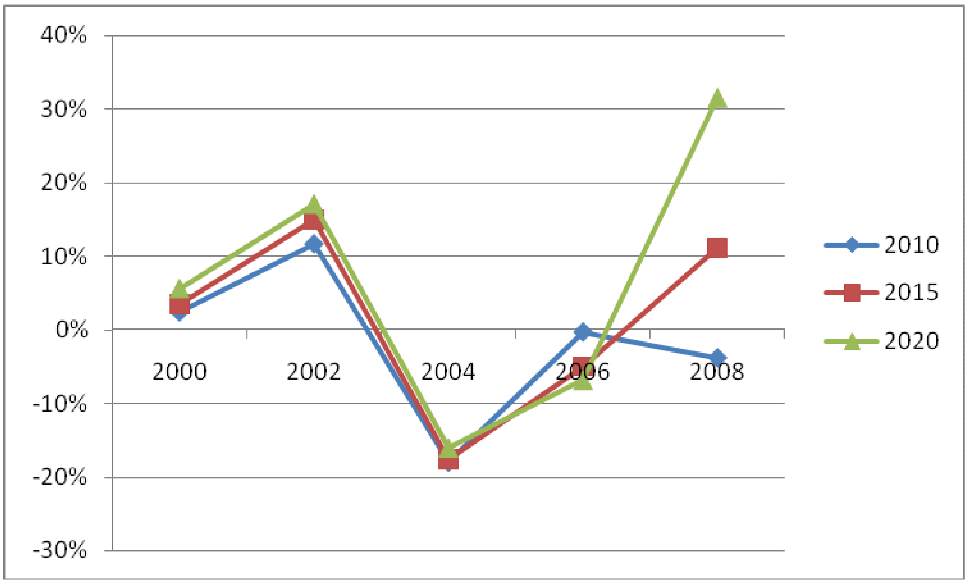
Table 4.9: Forecasts of Biomass consumption in Qu Btu/year

	1998	**2000**	**2002**	**2004**	**2006**	**2008**
2010	3.35	3.43	3.83	3.14	3.13	3.01
2015	3.48	3.6	4.14	3.41	3.24	3.6
2020	3.53	3.73	4.37	3.67	3.42	4.5

Source: EIA, Outlooks 1996–2008

Table 4.10: Changes of the forecasts over the years in %					
	2000/1998	**2002/2000**	**2004/2002**	**2006/2004**	**2008/2006**
2010	2%	12%	-18%	0%	-4%
2015	3%	15%	-18%	-5%	11%
2020	6%	17%	-16%	-7%	32%

Figure 4.3: Changes of the forecasts for consumption (in %)



The changes go also steadily up and down for consumption which is not very reliable in my opinion.

In the following three cases (2010, 2015 and 2020) we have not got significant data. So there is no real evidence showing inefficiency for the data collected. But despite of these results, I do not think that the little data I have will show us something reliable.

Table 4.11: Autocorrelation 2010

		year_2010a	year_2010b
year_2010a	Pearson Correlation	1	-.410
	Sig (2-tailed)		.590
	N	4	4
year_2010b	Pearson Correlation	-.410	1
	Sig (2-tailed)	.590	
	N	4	4

Table 4.12: Autocorrelation 2015

		year_2015a	year_2015b
year_2015a	Pearson Correlation	1	-.284
	Sig (2-tailed)		.716
	N	4	4
year_2015b	Pearson Correlation	-.284	1
	Sig (2-tailed)	.716	
	N	4	4

The autocorrelation for the projected consumption of 2015 is also not significant here.

Table 4.13: Autocorrelation 2020

		year_2020a	year_2020b
year_2020a	Pearson Correlation	1	-.299
	Sig (2-tailed)		.701
	N	4	4
year_2020b	Pearson Correlation	-.299	1
	Sig (2-tailed)	.701	
	N	4	4

Furthermore we have no significant result.

4.1.1.2. Revision of Biomass compared to the prices of crude oil

In this chapter we want to show the development of forecasts for biomass energy capacity compared to the development of oil prices over the same years.

Table 4.14: Energy capacity and generation in GW

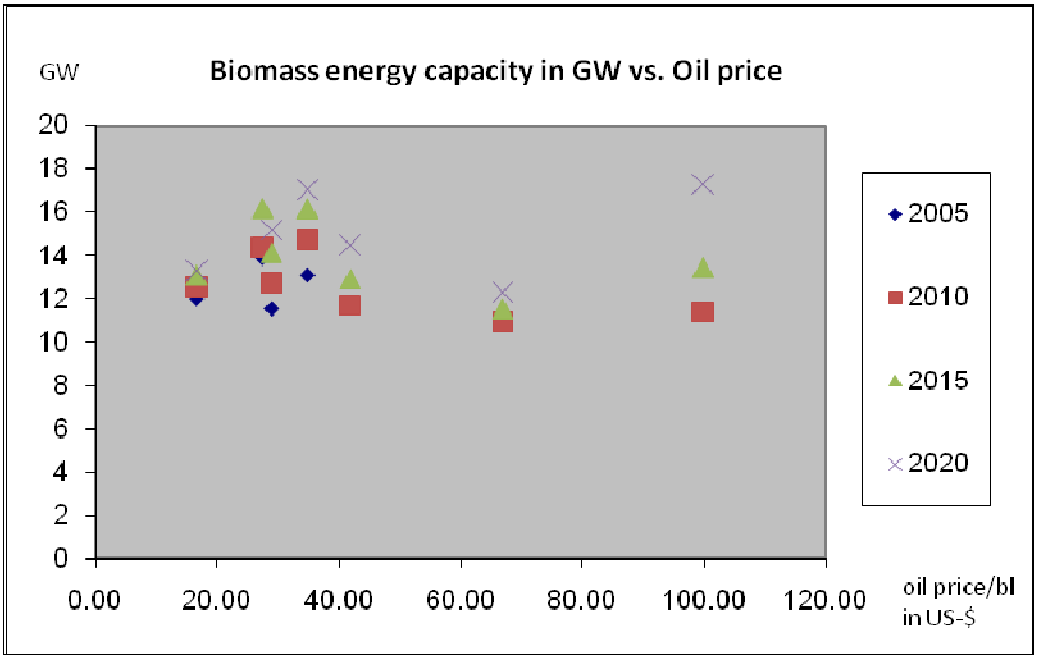
	1996	1998	2000	2002	2004	2006	2008
Oil price	27.54	16.69	34.92	29.06	42.02	67.03	**100**
2005	13.85	11.99	13.08	11.54			
2010	14.4	12.59	14.77	12.76	11.73	10.95	11.43
2015	16.18	13.09	16.17	14.13	12.92	11.55	13.45
2020		13.31	17.08	15.21	14.5	12.31	17.33

The oil data (crude oil) was taken from BP's Statistical Review of World Energy (June 2008).

The oil price per barrel decreased between 1996 and 1998, but increased again in 2000. In 2002 it got less, but since then the oil price started increasing rapidly.

The forecast for biomass in 1996 for the years 2005 to 2020 shows an increase over the years, the same also for 1998, but the forecasted Qu Btu are less than forecasted in 1996. In 2000 the forecasted capacity increases again. In 2002 the projected capacity is less than in 2000, but though in all cases an increase of biomass energy generation is projected for 2010, 2015 and 2020.

Figure 4.4: Biomass energy capacity vs. Oil price



1996 is our base year: in 1998 the oil price was less than two years before and the biomass forecast was less than in 1996 for 2010, 2015 and 2020. In 2000 the oil price increased again and so also the forecast for biomass. In 2002 the price of oil declined again and so the forecast for biomass energy capacity. But for 2004 and 2006 where the oil price was again very high, the projected biomass capacity did not increase, but was less than in the other years. Only in 2008, where the oil price reached approximately 100 US-$, the forecast for 2010 was still less, but for 2015 and 2020 EIA forecasted a higher biomass capacity.

So in my opinion, it could be a relation there between oil and biomass energy, but it do not need to be this case. As we have seen for 2004 and 2006, despite the high oil price, the capacity for biomass was not projected to increase.

4.1.2. Geothermal energy – Projections and Revision

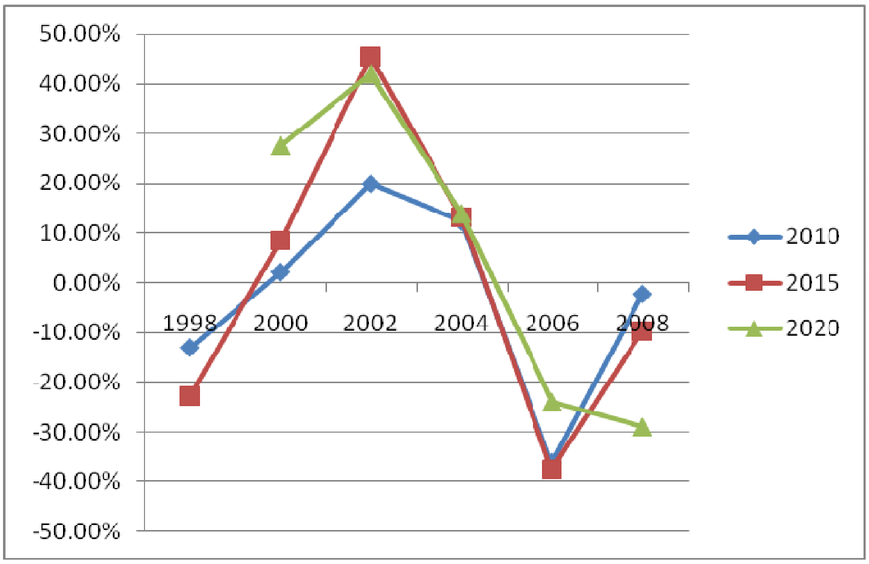
In the following chapter we want to revise the forecast efficiency for Geothermal energy.

Table 4.15: Energy capacity and generation in GW							
	1996	**1998**	**2000**	**2002**	**2004**	**2006**	**2008**
2005	3.08	2.93	2.89	3.05			
2010	3.36	2.92	2.98	3.57	4.01	2.56	2.5
2015	3.72	2.87	3.11	4.52	5.11	3.19	2.88
2020		2.94	3.75	5.32	6.06	4.61	3.28

As also done in the Biomass chapter, we also show here the changes of the forecasts for 2010, 2015 and 2020 in the chosen outlooks of 1996 to 2008.

Table 4.16: Changes of the forecasts over the years in %						
	1998/1996	**2000/1998**	**2002/2000**	**2004/2002**	**2006/2004**	**2008/2006**
2010	-13.10%	2.05%	19.80%	12.32%	-36.16%	-2.34%
2015	-22.85%	8.36%	45.34%	13.05%	-37.57%	-9.72%
2020		27.55%	41.87%	13.91%	-23.93%	-28.85%

Figure 4.5: Changes of the forecasts in %



The forecast changes for 2010 increase between 1998 and 2002, but decline between 2004 and 2006 and then the change increases again. The same can also be seen in the forecasts for 2015 and 2020. We have here also steady changes, which I think are not reliable results.

4.1.2.1. Autocorrelation analysis in SPSS

In the following we also want to revise the data for Geothermal energy as we did for Biomass energy. We compute the autocorrelation and then you can determine the probability of the observed correlation. So we conduct a significance test. We test the hypotheses:

Null hypothesis: r = 0 = Forecasts correlate

Alternative hypothesis: r <> 0 = Forecasts do not correlate

Table 4.17: Autocorrelation 2010

		year_2010a	year_2010b
year_2010a	Pearson Correlation	1	-.061
	Sig (2-tailed)		.923
	N	5	5
year_2010b	Pearson Correlation	-.061	1
	Sig (2-tailed)	.923	
	N	5	5

For 2010 you see we have a negative correlation (almost 0), and the significance is bigger than 0.05 as usual significance level, so we reject the Null Hypothesis, which says that the data is not correlating.

Table 4.18: Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2010a	.273	5	.200*	.893	5	.374
year_2010b	.190	5	.200*	.947	5	.718

a. Lilliefors Significance correction

*. This is a lower bound of the real significance

As already mentioned in the last chapter the test is non-significant if $p>0.05$ and shows us that the distribution of the sample does not differ significantly from a normal distribution.

The test statistic of 2010a scores $D(5) = 0.273$, so it is non-significant ($p>0.05$) and did not significantly deviate from normality. The same applies also for 2010b $D(5)=0.190$.

Also for 2015 we have no relation between the data and also there is no significance.

Table 4.19: Autocorrelation 2015

		year_2015a	year_2015b
year_2015a	Pearson Correlation	1	.159
	Sig (2-tailed)		.799
	N	5	5
year_2015b	Pearson Correlation	.159	1
	Sig (2-tailed)	.799	
	N	5	5

Table 4.20: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2015a	.182	5	.200*	.986	5	.962
year_2015b	.186	5	.200*	.963	5	.831

a. Lilliefors Significance correction

*. This is a lower bound of the real significance

2015a (0.182) is non-significant (p>0.05). The same applies also for 2015b D(5)=0.186.

Table 4.21: Autocorrelation 2020

		year_2020a	year_2020b
year_2020a	Pearson Correlation	1	.723
	Sig (2-tailed)		.277
	N	4	4
year_2020b	Pearson Correlation	.723	1
	Sig (2-tailed)	.277	
	N	4	4

There is a positive autocorrelation, but no significance. Only 52.27% of the data are correlated.

Table 4.22: Test of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2020a	.270	4	.	.900	4	.430
year_2020b	.237	4	.	.941	4	.662

a. Lilliefors Significance correction

The test statistic of 2020 did not significantly deviate from normality.

Also for 2020 the data is not correlated, so we assume that the data is probably efficient in the case of Geothermal energy. But because of the little data we have, it is not convincing.

We briefly analyze the data also for the case of consumption.

Table 4.23: Consumption in Quadr. Btu/year

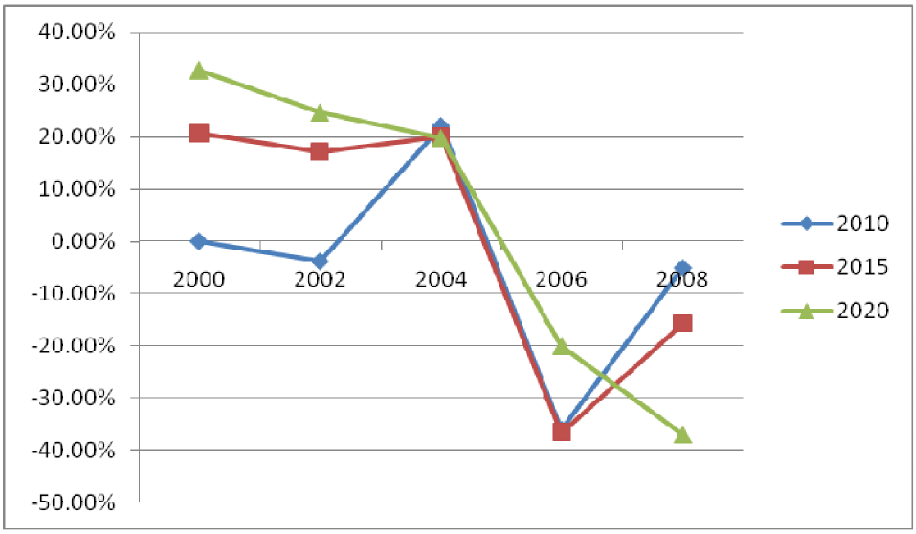
	1998	**2000**	**2002**	**2004**	**2006**	**2008**
2010	0.52	0.52	0.5	0.61	0.39	0.37
2015	0.53	0.64	0.75	0.9	0.57	0.48
2020	0.58	0.77	0.96	1.15	0.92	0.58

Source: EIA, Annual Energy Outlooks 1996-2008

Table 4.24: Changes of the forecasts in %

	2000/1998	**2002/2000**	**2004/2002**	**2006/2004**	**2008/2006**
2010	0.00%	-3.85%	22.00%	-36.07%	-5.13%
2015	20.75%	17.19%	20.00%	-36.67%	-15.79%
2020	32.76%	24.68%	19.79%	-20.00%	-36.96%

Figure 4.6: Changes of the forecasts in %



The revision shows that the changes are steady for 2010 between 2002 and 2004 and also between 2004-2006 and 2006-2008.

Table 4.25: Autocorrelation 2010

		year_2010a	year_2010b
year_2010a	Pearson Correlation	1	-.467
	Sig (2-tailed)		.533
	N	4	4
year_2010b	Pearson Correlation	-.467	1
	Sig (2-tailed)	.533	
	N	4	4

Table 4.26: Autocorrelation 2015

		year_2015a	year_2015b
year_2015a	Pearson Correlation	1	.274
	Sig (2-tailed)		.726
	N	4	4
year_2015b	Pearson Correlation	.274	1
	Sig (2-tailed)	.726	
	N	4	4

Table 4.27: Autocorrelation 2020

		year_2020a	year_2020b
year_2020a	Pearson Correlation	1	.856
	Sig (2-tailed)		.144
	N	4	4
year_2020b	Pearson Correlation	.856	1
	Sig (2-tailed)	.144	
	N	4	4

2010 data have a negative relationship, and is not significant. 2015 data are also not significant.

2020 data have a higher correlation than the other two years, but also there is no significance.

Despite there is no significance I see no efficiency in any of these projections.

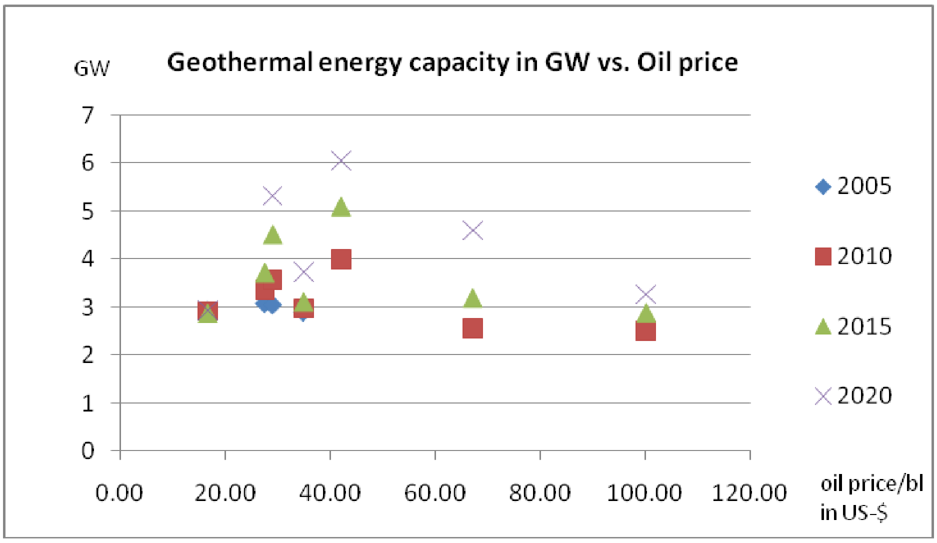
4.1.2.2. Revision of Geothermal energy compared to the prices of crude oil

Table 4.28: Energy capacity and generation in GW							
	1996	**1998**	**2000**	**2002**	**2004**	**2006**	**2008**
Oil price	27.54	16.69	34.92	29.06	42.02	67.03	**100**
2005	3.08	2.93	2.89	3.05			
2010	3.36	2.92	2.98	3.57	4.01	2.56	2.5
2015	3.72	2.87	3.11	4.52	5.11	3.19	2.88
2020		2.94	3.75	5.32	6.06	4.61	3.28

Source: EIA, Annual Energy Outlooks 1996-2008, BP Statistical Review of World Energy, June 2008

The forecast for Geothermal energy does not depend on the oil price in my opinion, because I don't see any significant changes comparing both information. In the year 2006 and 2008, the oil price was very high, but though EIA did not project more Geothermal energy capacity for 2010, 2015 and 2020 compared to the years before.

Figure 4.7: Geothermal energy capacity vs. Oil price



4.1.3. Hydro Energy – Projections and Revision

I took again the forecast-data for the years 2010, 2015 and 2020 for Hydro energy. The data is also based on the EIA Annual Outlooks from 1996 to 2008.

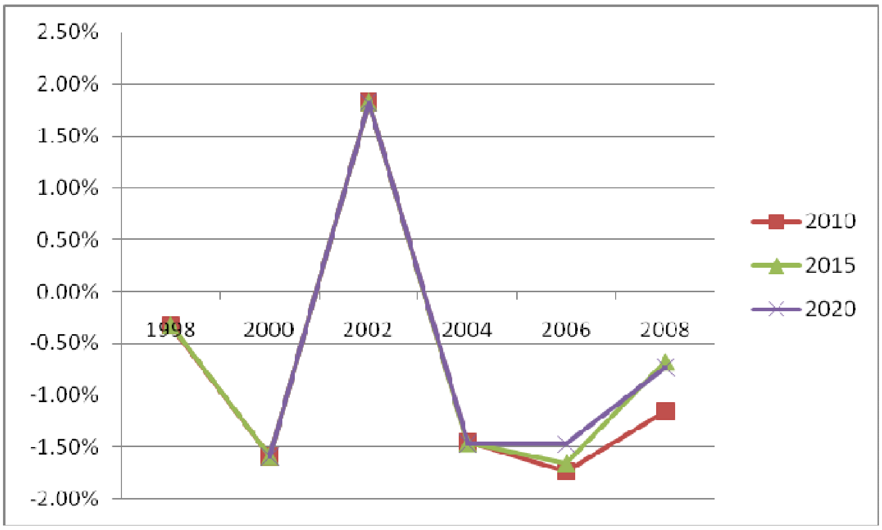
Table 4.29: Conventional Hydro - Energy capacity and generation in GW							
	1996	**1998**	**2000**	**2002**	**2004**	**2006**	**2008**
2010	80.97	80.71	79.43	80.88	79.71	78.33	77.43
2015	80.97	80.71	79.43	80.88	79.7	78.38	77.85
2020		80.71	79.43	80.88	79.7	78.53	77.96

In the table the forecasts are very similar in each outlook.

The changes for the three years calculated in Excel are the following:

Table 4.30: Changes of the forecasts in %						
	1998/1996	**2000/1998**	**2002/2000**	**2004/2002**	**2006/2004**	**2008/2006**
2010	-0.32%	-1.59%	1.83%	-1.45%	-1.73%	-1.15%
2015	-0.32%	-1.59%	1.83%	-1.46%	-1.66%	-0.68%
2020		-1.59%	1.83%	-1.46%	-1.47%	-0.73%

Figure 4.8: Changes of the forecasts in %



Source: EIA, Annual Energy Outlooks 1996-2008

There is a high positive change rate in all three forecast years in the year 2002, which does not look very efficient.

4.1.3.1. Autocorrelation analysis in SPSS

Now we want to see the forecast efficiency with help of the autocorrelation and significance using SPSS again.

Table 4.31: Autocorrelation 2010

		year_2010a	year_2010b
year_2010a	Pearson Correlation	1	-.359
	Sig (2-tailed)		.553
	N	5	5
year_2010b	Pearson Correlation	-.359	1
	Sig (2-tailed)	.553	
	N	5	5

Below we see the Kolmogorov-Smirnov Test which compares the scores in the sample to a normally distributed set of scores with the same mean and standard deviation, which show that the 2010 statistics are also not significant.

Table 4.32: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2010a	.388	5	.013	.684	5	.006
year_2010b	.303	5	.151	.799	5	.080

a. Lilliefors significance correction

Table 4.33: Autocorrelation 2015

		year_2015a	year_2015b
year_2015a	Pearson Correlation	1	-.434
	Sig (2-tailed)		.465
	N	5	5
year_2015b	Pearson Correlation	-.434	1
	Sig (2-tailed)	.465	
	N	5	5

We do not have significance in our autocorrelation here (0.465 > 0.05) at usual significant level.

Table 4.34: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2015a	.295	5	.180	.742	5	.025
year_2015b	.310	5	.131	.782	5	.057

a. Lilliefors significance correction

Also here the statistics are not significant.

Table 4.35: Autocorrelation 2020

		year_2020a	year_2020b
year_2020a	Pearson Correlation	1	-.459
	Sig (2-tailed)		.541
	N	4	4
year_2020b	Pearson Correlation	-.459	1
	Sig (2-tailed)	.541	
	N	4	4

Table 4.36: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2020a	.318	4	.	.779	4	.069
year_2020b	.432	4	.	.661	4	.004

a. Lilliefors significance correction

All three autocorrelations are negative and not significant. Now we take a look on the consumption in conventional hydroelectric.

In the case of consumption we see the following:

Table 4.37: Conventional hydroelectric - consumption in quadrillion Btus

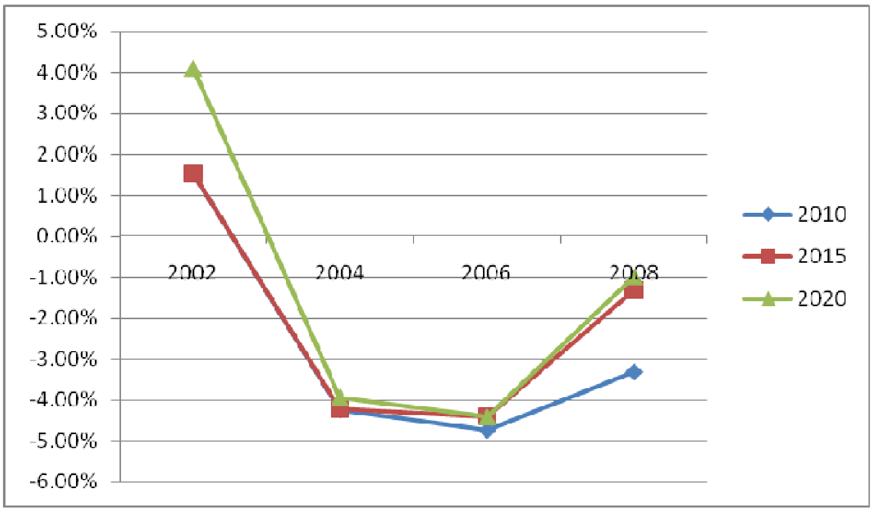
	2000	**2002**	**2004**	**2006**	**2008**
2010	3.26	3.31	3.17	3.02	2.92
2015	3.26	3.31	3.17	3.03	2.99
2020	3.17	3.3	3.17	3.03	3

Source: EIA, Annual Energy Outlooks 1996-2008

Table 4.38: Changes of forecasts in %

	2002/2000	**2004/2002**	**2006/2004**	**2008/2006**
2010	1.53%	-4.23%	-4.73%	-3.31%
2015	1.53%	-4.23%	-4.42%	-1.32%
2020	4.10%	-3.94%	-4.42%	-0.99%

Figure 4.9: Changes of the forecasts in %



Also here we see steady changes which look inefficient.

Table 4.39: Autocorrelation 2010

		year_2010a	year_2010b
year_2010a	Pearson Correlation	1	-.237
	Sig (2-tailed)		.847
	N	3	3
year_2010b	Pearson Correlation	-.237	1
	Sig (2-tailed)	.847	
	N	3	3

Table 4.40: Autocorrelation 2015

		year_2015a	year_2015b
year_2015a	Pearson Correlation	1	-.477
	Sig (2-tailed)		.683
	N	3	3
year_2015b	Pearson Correlation	-.477	1
	Sig (2-tailed)	.683	
	N	3	3

Table 4.41: Autocorrelation 2020

		year_2020a	year_2020b
year_2020a	Pearson Correlation	1	-.430
	Sig (2-tailed)		.717
	N	3	3
year_2020b	Pearson Correlation	-.430	1
	Sig (2-tailed)	.717	
	N	3	3

In all three cases we see a negative autocorrelation and no significance.

4.1.3.2. Revision of Hydro Energy compared to the prices of crude oil

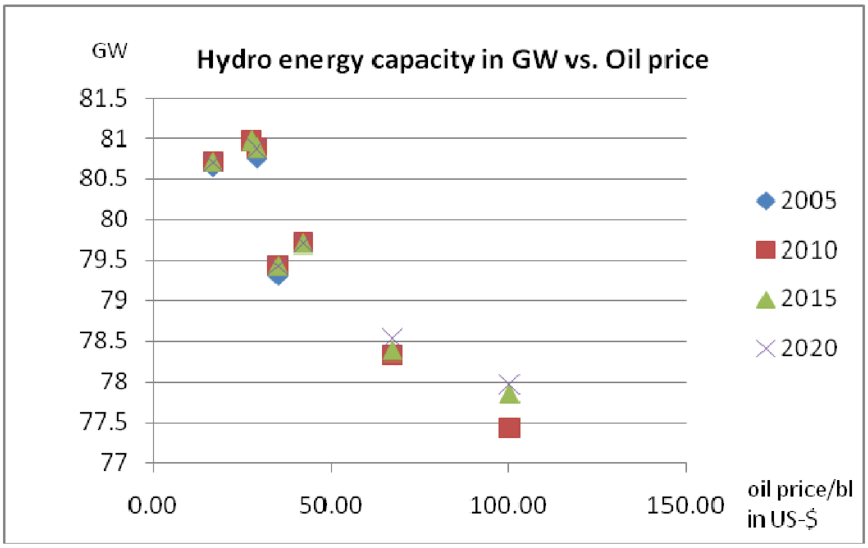
Table 4.42: Conventional Hydro - Energy capacity and generation in GW

	1996	1998	2000	2002	2004	2006	2008
Oil price	27.54	16.69	34.92	29.06	42.02	67.03	**100**
2005	80.92	80.65	79.31	80.76			
2010	80.97	80.71	79.43	80.88	79.71	78.33	77.43
2015	80.97	80.71	79.43	80.88	79.7	78.38	77.85
2020		80.71	79.43	80.88	79.7	78.53	77.96

Source: EIA, Annual Energy Outlooks 1996-2008, BP Statistical Review of World Energy, June 2008

The forecast for hydro energy also does not depend on the oil price in my opinion. Despite the increase in oil in 2000, 2004, 2006 and 2008 the energy capacity for conventional hydro is not rising, but declining a bit. And so I think that the generation of hydro capacity does not really depend on the oil price.

Figure 4.10: Hydro energy capacity vs. Oil price



4.1.4. Revision and projections of Solar Energy

In the following table we see the forecast-data (Annual Energy Outlooks 1998 to 2008) for the years 2010, 2015 and 2020.

Table 4.43: Solar Thermal Energy generating capability and generation in GW

	1998	2000	2002	2004	2006	2008
2010	0.46	0.4	0.36	0.43	0.47	0.54
2015	0.51	0.44	0.39	0.47	0.48	0.8
2020	0.56	0.48	0.41	0.49	0.5	0.82

Source: EIA, Annual Energy Outlooks 1998-2008

There were no significant growth projected in 1998 to 2008 for the years 2010, 2015 and 2020.

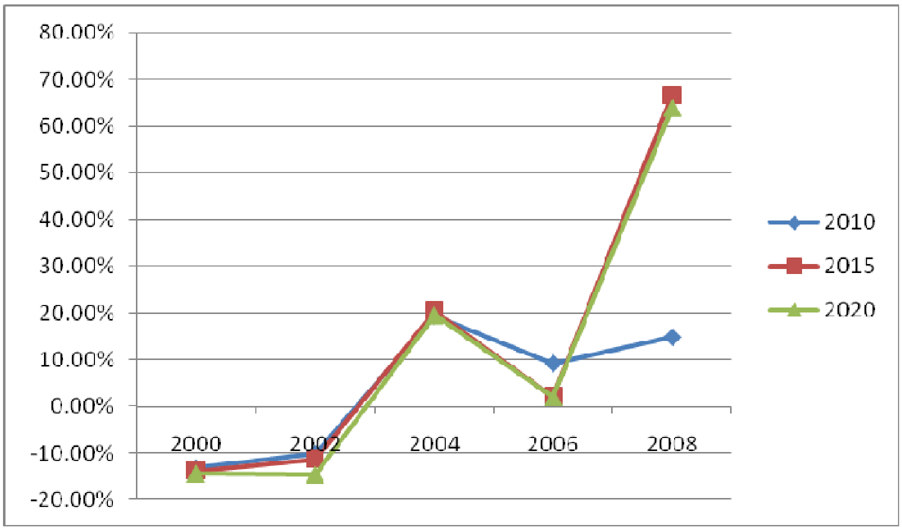
Unfortunately I also did not have much data to analyze for Solar energy, so I could only took the forecasts from the AEO of 1998 to 2008.

In the following we see the changes over the outlook years and the graph below the Table 4.45.

Table 4.44: Changes of the forecasts over the years in %					
	2000/1998	**2002/2000**	**2004/2002**	**2006/2004**	**2008/2006**
2010	-13.04%	-10.00%	19.44%	9.30%	14.89%
2015	-13.73%	-11.36%	20.51%	2.13%	66.67%
2020	-14.29%	-14.58%	19.51%	2.04%	64.00%

Below the changes are illustrated in a graph. The interpretation of these changes will be discussed in the autocorrelation section.

Figure 4.11: Changes of the forecasts in %



Now we want to see the forecast efficiency with help of the autocorrelation and significance using SPSS.

4.1.4.1. Autocorrelation analysis in SPSS

Table 4.45: Autocorrelation 2010

		year_2010a	year_2010b
year_2010a	Pearson Correlation	1	.343
	Sig (2-tailed)		.657
	N	4	4
year_2010b	Pearson Correlation	.343	1
	Sig (2-tailed)	.657	
	N	4	4

We know already that Pearson's coefficient is based upon the average deviation from the mean (Field, A., 2005).

11.76% of the data are correlated. 88.24% of the variability will still be accounted for by other variables.

The statistic data below are not significant.

Table 4.46: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2010a	.277	4	.	.890	4	.382
year_2010b	.269	4	.	.898	4	.419

a. Lilliefors significance correction

The Lilliefors test is a test named after Hubert Lilliefors and it is an adaption of the Kolmogorov-Smirnov test. You use it to test the null hypothesis (i.e. the data correlate which means that the data are significant).

As for 2010 we can interprete the same for 2015 and 2020. The data do not correlate signifcantly.

Table 4.47: Autocorrelation 2015

		year_2015a	year_2015b
year_2015a	Pearson Correlation	1	.097
	Sig (2-tailed)		.903
	N	4	4
year_2015b	Pearson Correlation	.097	1
	Sig (2-tailed)	.903	
	N	4	4

Table 4.48: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2015a	.238	4	.	.923	4	.556
year_2015b	.253	4	.	.896	4	.412

a. Lilliefors significance correction

Table 4.49: Autocorrelation 2020

		year_2020a	year_2020b
year_2020a	Pearson Correlation	1	.136
	Sig (2-tailed)		.864
	N	4	4
year_2020b	Pearson Correlation	.136	1
	Sig (2-tailed)	.864	
	N	4	4

Table 4.50: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2020a	.229	4	.	.943	4	.674
year_2020b	.279	4	.	.867	4	.288

a. Lilliefors significance correction

In the following we take a look on energy of PV.

Table 4.51: PV Energy generating capability and generation in GW

	1998	2000	2002	2004	2006	2008
2010	0.22	0.54	0.5	0.54	0.7	0.74
2015	0.38	0.77	0.61	0.86	0.82	0.91
2020	0.56	1.26	0.73	0.9	0.97	1.35

Source: EIA, Annual Energy Outlooks 1998-2008

Table 4.52: Changes of the forecasts in %

	2000/1998	2002/2000	2004/2002	2006/2004	2008/2006
2010	145.45%	-7.41%	8.00%	29.63%	5.71%
2015	102.63%	-20.78%	40.98%	-4.65%	10.98%
2020	125.00%	-42.06%	23.29%	7.78%	39.18%

Figure 4.12: Changes of the forecasts in %

Between 2000 and 2002 the change does not look so efficient, but in the following years the data changes are not very steady.

Table 4.53: Autocorrelation 2010

		year_2010a	year_2010b
year_2010a	Pearson Correlation	1	-.723
	Sig (2-tailed)		.277
	N	4	4
year_2010b	Pearson Correlation	-.723	1
	Sig (2-tailed)	.277	
	N	4	4

The autocorrelation is negative and not significant (0.277>0.05) at usual significance level.

Table 4.54: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2010a	.276	4	.	.945	4	.682
year_2010b	.332	4	.	.818	4	.138

a. Lilliefors significance correction

Table 4.55: Autocorrelation 2015

		year_2015	year_2015b
year_2015	Pearson correlation	1	-.918
	Sig (2-tailed)		.082
	N	4	4
year_2015b	Pearson correlation	-.918	1
	Sig (2-tailed)	.082	
	N	4	4

The autocorrelation is very negative for the forecast of 2015, and also not significant (0.082>0.05) at usual significance level.

Table 4.56: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2015	.184	4	.	.977	4	.882
year_2015b	.232	4	.	.931	4	.599

a. Lilliefors significance correction

Table 4.57: Autocorrelation 2020

		year_2020a	year_2020b
year_2020a	Pearson correlation	1	-.886
	Sig (2-tailed)		.114
	N	4	4
year_2020b	Pearson correlation	-.886	1
	Sig (2-tailed)	.114	
	N	4	4

Also for 2020 the autocorrelation is negative and not significant.

Table 4.58: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2020a	.258	4	.	.920	4	.537
year_2020b	.280	4	.	.934	4	.621

a. Lilliefors significance correction

Both statistic data in the table above are not significant.

4.1.4.2. Revision of Solar energy compared to the prices of crude oil

In the following I show a brief overview of the development of the forecasts for Solar energy compared to the development of oil prices. At the first we take a look on Solar Thermal energy and then we go further to Solar PV.

Table 4.59: Solar Thermal Energy generating capability and generation in GW

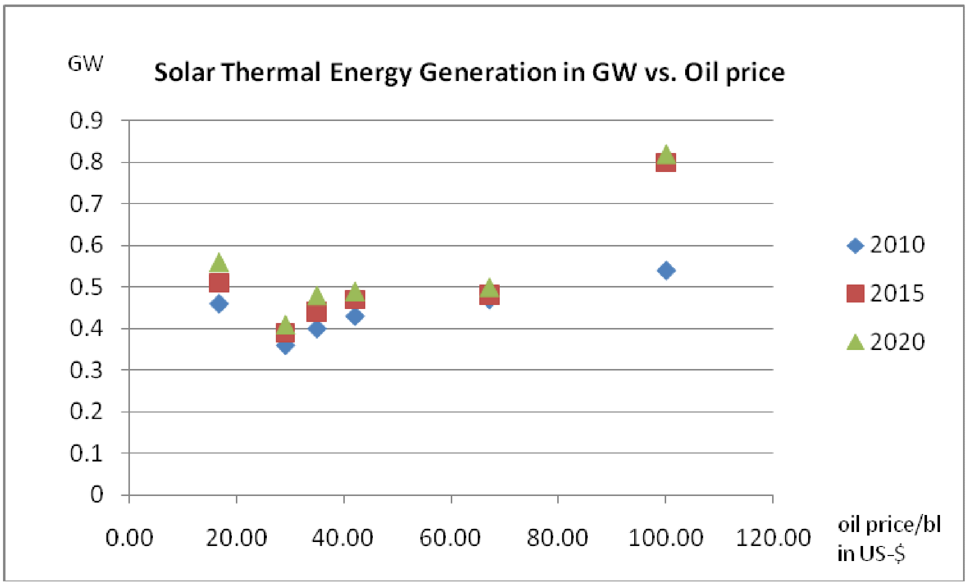
	1998	2000	2002	2004	2006	2008
Oil price	16.69	34.92	29.06	42.02	67.03	**100**
2010	0.46	0.4	0.36	0.43	0.47	0.54
2015	0.51	0.44	0.39	0.47	0.48	0.8
2020	0.56	0.48	0.41	0.49	0.5	0.82

Source. EIA AEO 1998-2008 and BP Statistical Review of World Energy, June 2008

The Solar thermal energy capacity is projected to increase from 2010 to 2020 in the Outlooks 1998 to 2008, but the projected generating capability in GW varies.

Reasons for the forecast increase in Solar thermal energy capacity could be the high oil price which made people and industries switch to alternatives in the years, especially in the years 2004 to 2008.

Figure 4.13: Solar thermal energy capacity vs. Oil price



The oil price got higher of the years, the projected Solar thermal energy capacity was higher at the price of 16.69 in 1998. In 2008 the oil price was about 100 US-$/bl and so for 2010, 2015 and 2020 a higher energy capacity was forecasted.

Table 4.60: PV - Energy generating capability and generation in GW

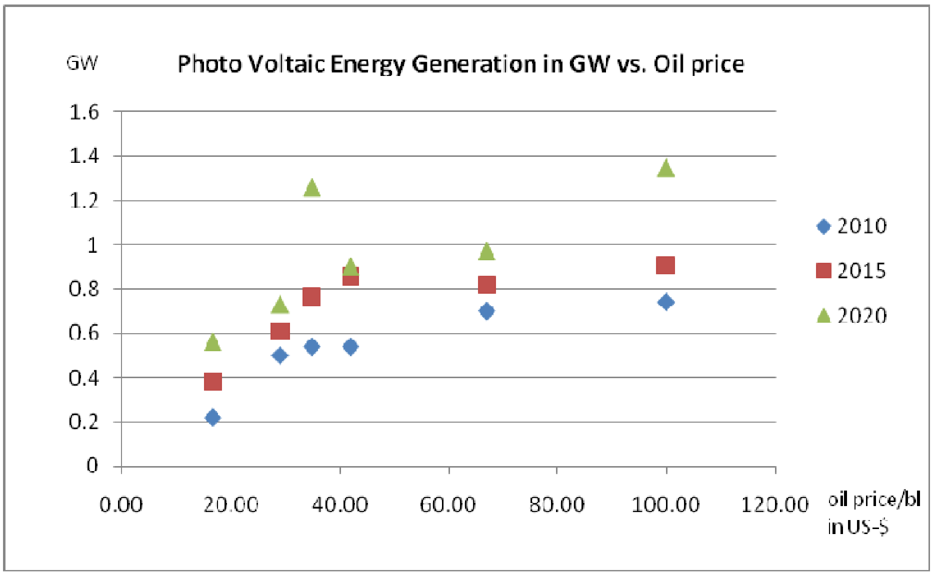
	1998	2000	2002	2004	2006	2008
Oil price	16.69	34.92	29.06	42.02	67.03	**100**
2010	0.22	0.54	0.5	0.54	0.7	0.74
2015	0.38	0.77	0.61	0.86	0.82	0.91
2020	0.56	1.26	0.73	0.9	0.97	1.35

PV energy is projected to grow for 2010 in all outlooks (1998 to 2008), but for 2015 and 2020 there are some ups and downs featured.

In 2000 the oil price is higher than in 1998, and the PV energy generation was projected to increase for 2010, 2015 and 2020. We can see this also for the outlooks 2004, 2006 and 2008.

The graph shows us that it seems that the higher the oil price, the higher the forecast for PV generation.

Figure 4.14: PV energy generation compared to oil price



4.1.5. Wind Energy – Projections and Revision

Now we will take a look on wind energy and its forecasted capacity in GW.

Table 4.61: Wind - Energy capacity and generation in GW							
	1996	**1998**	**2000**	**2002**	**2004**	**2006**	**2008**
2010	5.1	3.33	5.07	7.65	8.01	16.27	25.65
2015	11	3.68	5.4	8.46	10.48	17.71	29.68
2020		4.06	5.49	9.06	13.39	18.81	33.73

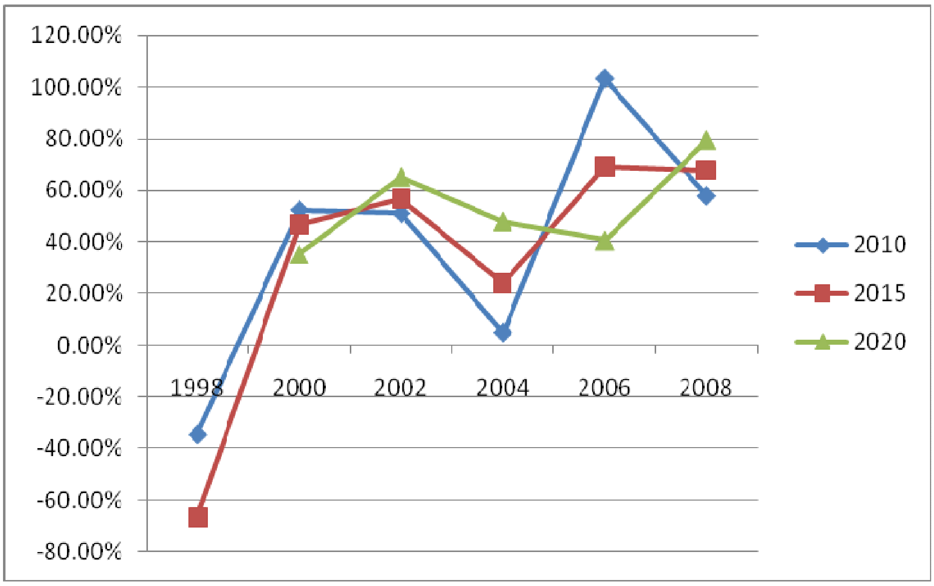
Source: EIA, 1996-2008

And here we see the changes over the years. In 2004 the capacity is projected to jump from 8.01 to 16.27 (for 2010), 10.48 to 17.71 (2015) and 13.39 to 18.81 (2020). For 2020 the capacity forecast jumps from 18.81 in 2006 to 33.73 in 2008.

These big changes in the forecasts do not seem efficient in my opinion. Maybe these were projected because of the economic crisis and the high oil price, nevertheless this big jump within two years is not convenient for me, which we also can see within the changes below in Table 4.63 and Figure 4.15.

Table 4.62: Changes of the forecasts						
	1998/1996	**2000/1998**	**2002/2000**	**2004/2002**	**2006/2004**	**2008/2006**
2010	-34.71%	52.25%	50.89%	4.71%	103.12%	57.65%
2015	-66.55%	46.74%	56.67%	23.88%	68.99%	67.59%
2020		35.22%	65.03%	47.79%	40.48%	79.32%

Figure 4.15: Forecast changes



The changes for all three forecast years are steady between 1998 and 2000, 2002 and 2004 and also between 2004 and 2006.

4.1.5.1. Autocorrelation analysis in SPSS

Table 4.63: Autocorrelation 2010

		year_2010a	year_2010b
year_2010a	Pearson Correlation	1	-.267
	Sig (2-tailed)		.664
	N	5	5
year_2010b	Pearson Correlation	-.267	1
	Sig (2-tailed)	.664	
	N	5	5

We have a negative and a non-significant autocorrelation.

Table 4.64: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2010a	.268	5	.200*	.923	5	.551
year_2010b	.217	5	.200*	.969	5	.868

a. Lilliefors significance correction

*. This is a lower bound of the real significance

The statistic data (0.268 and 0.217 > 0.05) are not significant.

Table 4.65: Autocorrelation 2015

		year_2015a	year_2015b
year_2015a	Pearson Correlation	1	.088
	Sig (2-tailed)		.887
	N	5	5
year_2015b	Pearson Correlation	.088	1
	Sig (2-tailed)	.887	
	N	5	5

We have here almost no correlation and no significance.

Table 4.66: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2015a	.190	5	.200*	.896	5	.386
year_2015b	.285	5	.200*	.815	5	.106

a. Lilliefors significance correction

*. This is a lower bound of the real significance

Also for 2020 we have a negative correlation which is not significant.

Table 4.67: Autocorrelation 2020

		year_2020a	year_2020b
year_2020a	Pearson Correlation	1	-.616
	Sig (2-tailed)		.384
	N	4	4
year_2020b	Pearson Correlation	-.616	1
	Sig (2-tailed)	.384	
	N	4	4

Table 4.68: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2020a	.224	4	.	.955	4	.748
year_2020b	.230	4	.	.929	4	.590

a. Lilliefors significance correction

In the following a brief overview for the consumption of wind in Qu Btu/year is shown.

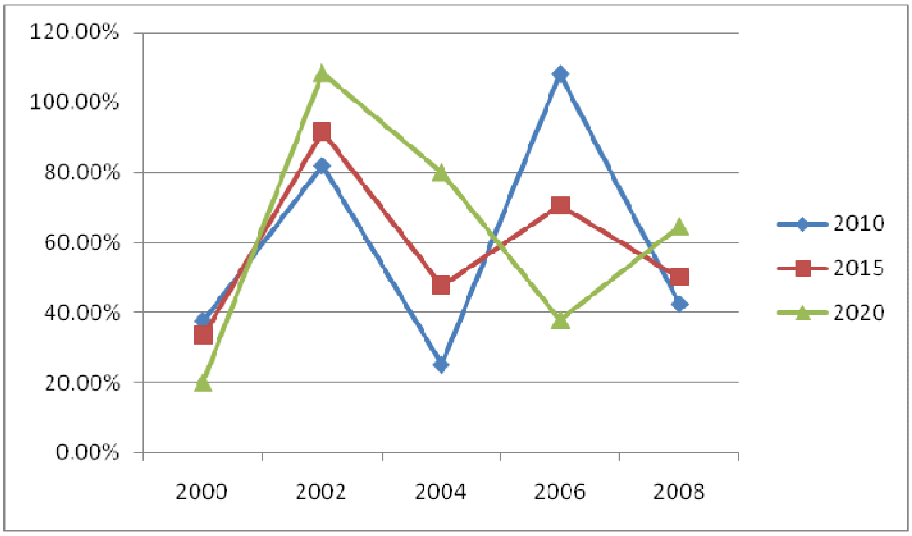
Table 4.69: Consumption in Qu Btu/year

	1998	2000	2002	2004	2006	2008
2010	0.08	0.11	0.2	0.25	0.52	0.74
2015	0.09	0.12	0.23	0.34	0.58	0.87
2020	0.1	0.12	0.25	0.45	0.62	1.02

The EIA outlooks show an increase in consumption for wind over the years. The increase of 2002 is approximately twice the data we had in 2000. The forecasts increase over the years 2004 to 2008.

Table 4.70: Changes					
	2000/1998	**2002/2000**	**2004/2002**	**2006/2004**	**2008/2006**
2010	37.50%	81.82%	25.00%	108.00%	42.31%
2015	33.33%	91.67%	47.83%	70.59%	50.00%
2020	20.00%	108.33%	80.00%	37.78%	64.52%

Figure 4.16: Changes of the forecasts in %



In the figure above we have also steady ups and downs which are not efficient.

Table 4.71: Autocorrelation 2010

		year_2010a	year_2010b
year_2010a	Pearson Correlation	1	-.880
	Sig (2-tailed)		.120
	N	4	4
year_2010b	Pearson Correlation	-.880	1
	Sig (2-tailed)	.120	
	N	4	4

Table 4.72: Autocorrelation 2015

		year_2015a	year_2015b
year_2015a	Pearson Correlation	1	-.939
	Sig (2-tailed)		.061
	N	4	4
year_2015b	Pearson Correlation	-.939	1
	Sig (2-tailed)	.061	
	N	4	4

Table 4.73: Autocorrelation 2020

		year_2020a	year_2020b
year_2020a	Pearson Correlation	1	-.448
	Sig (2-tailed)		.552
	N	4	4
year_2020b	Pearson Correlation	-.448	1
	Sig (2-tailed)	.552	
	N	4	4

All three autocorrelations are negative and not significant.

4.1.5.2. Revision of Wind energy compared to the prices of crude oil

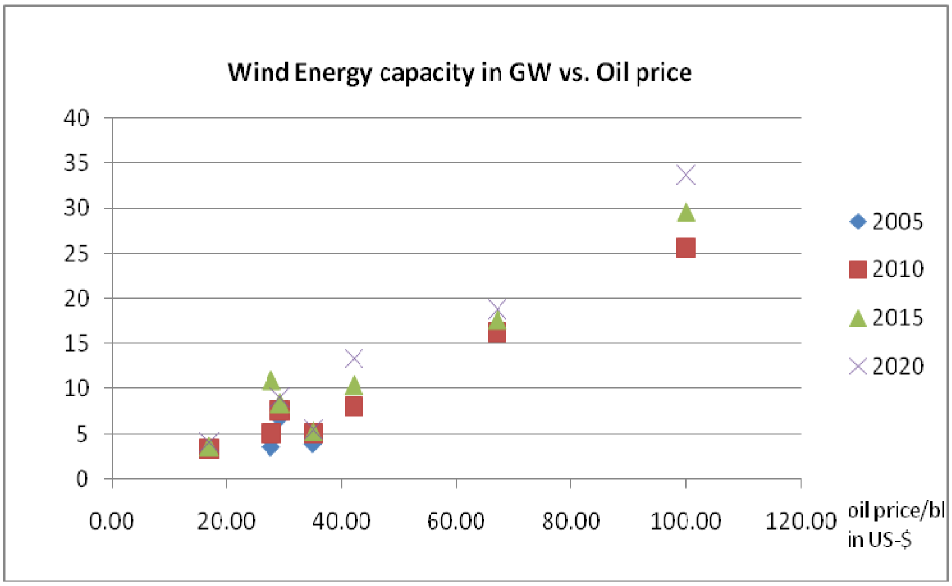
Table 4.74: Wind Energy capacity and generation in GW and Crude oil price in US-$

	1996	1998	2000	2002	2004	2006	2008
Oil price in US-$	27.54	16.69	34.92	29.06	42.02	67.03	**100**
2005	3.57	3.31	3.89	6.82			
2010	5.1	3.33	5.07	7.65	8.01	16.27	25.65
2015	11	3.68	5.4	8.46	10.48	17.71	29.68
2020		4.06	5.49	9.06	13.39	18.81	33.73

Source: EIA, Annual Energy Outlooks 1996-2008, BP Statistical Review of World Energy, June 2008

The forecast for wind energy depends on the oil price here, because I see significant changes when comparing both data. While the oil price increased, the capacity for wind energy also increased (Figure 4.1). Wind energy is a very big player in the energy sector. Wind energy has great chance to be a major supplier of energy in the future.

Figure 4.17: Wind energy compared with the oil price development



The oil prices could be a significant factor that driving the wind energy capacity up or down.

4.1.6. Nuclear Energy – Projections and Revision

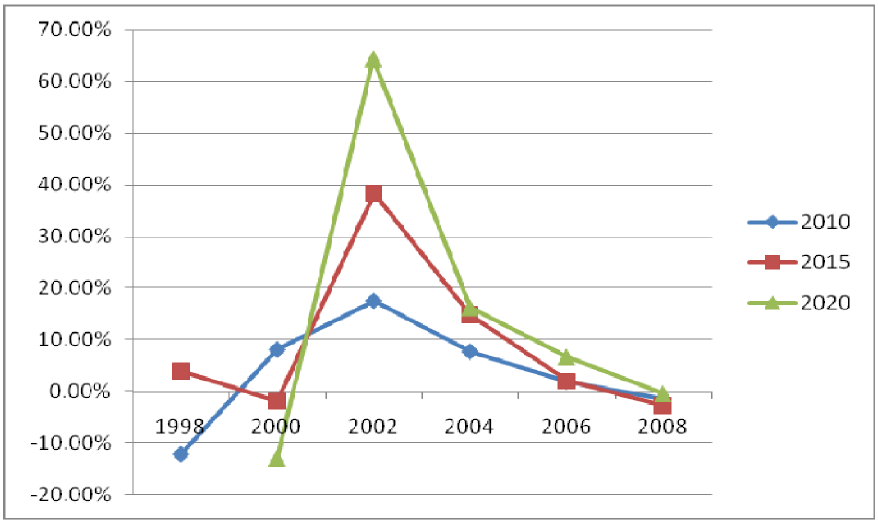
Finally we reached the last chapter showing alternative energy. Below we see the forecasts for electricity generation by nuclear energy.

Table 4.75: Electricity generation in billion kWh							
	1996	**1998**	**2000**	**2002**	**2004**	**2006**	**2008**
2010	660	580	627	737	794	809	797
2015	500	520	511	707	812	829	807
2020		490	427	702	816	871	868

1996, 1998 and 2000 outlooks did not project a growth in electricity generation, but 2002 to 2008 outlooks show us an increase. The reasons for the growth of Nuclear electricity generation could be here the economic situation after 9/11 and the increase in oil prices.

Table 4.76: Changes of the forecasts in %						
	1998/1996	**2000/1998**	**2002/2000**	**2004/2002**	**2006/2004**	**2008/2006**
2010	-12.12%	8.10%	17.54%	7.73%	1.89%	-1.48%
2015	4.00%	-1.73%	38.36%	14.85%	2.09%	-2.65%
2020		-12.86%	64.40%	16.24%	6.74%	-0.34%

Figure 4.18: Changes of the forecasts in %



In all three forecasted years with projections we see a peak of change in 2002.

We now go further to the autocorrelations to see how efficient the projections we have are.

4.1.6.1. Autocorrelation analysis in SPSS

Table 4.77: Autocorrelation 2010

		year_2010_a	year_2010_b
year_2010_a	Pearson correlation	1	.110
	Sig (2-tailed)		.860
	N	5	5
year_2010_b	Pearson correlation	.110	1
	Sig (2-tailed)	.860	
	N	5	5

We have a low autocorrelation here which is non-significant.

Table 4.78: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2010_a	.226	5	.200*	.950	5	.735
year_2010_b	.212	5	.200*	.945	5	.698

a. Lilliefors significance correction

*. This is a lower bound of the real significance

The normality test also shows us that the statistic data are not significant.

Table 4.79: Autocorrelation 2015

		year_2015_a	year_2015_b
year_2015_a	Pearson correlation	1	-.058
	Sig (2-tailed)		.927
	N	5	5
year_2015_b	Pearson correlation	-.058	1
	Sig (2-tailed)	.927	
	N	5	5

For 2015 we get a negative correlation. Also here there is no significance.

Table 4.80: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2015_a	.281	5	.200*	.823	5	.123
year_2015_b	.278	5	.200*	.840	5	.164

a. Lilliefors significance correction

*. This is a lower bound of the real significance

Table 4.81: Autocorrelation 2020

		year_2020_a	year_2020_b
year_2020_a	Pearson correlation	1	-.450
	Sig (2-tailed)		.550
	N	4	4
year_2020_b	Pearson correlation	-.450	1
	Sig (2-tailed)	.550	
	N	4	4

Table 4.82: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
year_2020_a	.325	4	.	.828	4	.164
year_2020_b	.279	4	.	.925	4	.563

a. Lilliefors significance correction

Again, because of the few data we have, a negative correlation exists and the statistics are not significant.

We take a look on the energy production forecasts over the years with help of the annual energy outlooks of 1996 to 2008 by EIA.

Table 4.83: Energy production in quadrillion BTUs

	1996	**1998**	**2000**	**2002**	**2004**	**2006**	**2008**
2010	6.3	6.36	6.7	7.87	8.29	8.44	8.31
2015	5	5.12	5.45	7.55	8.48	8.66	8.41
2020		4.09	4.56	7.49	8.53	9.09	9.05

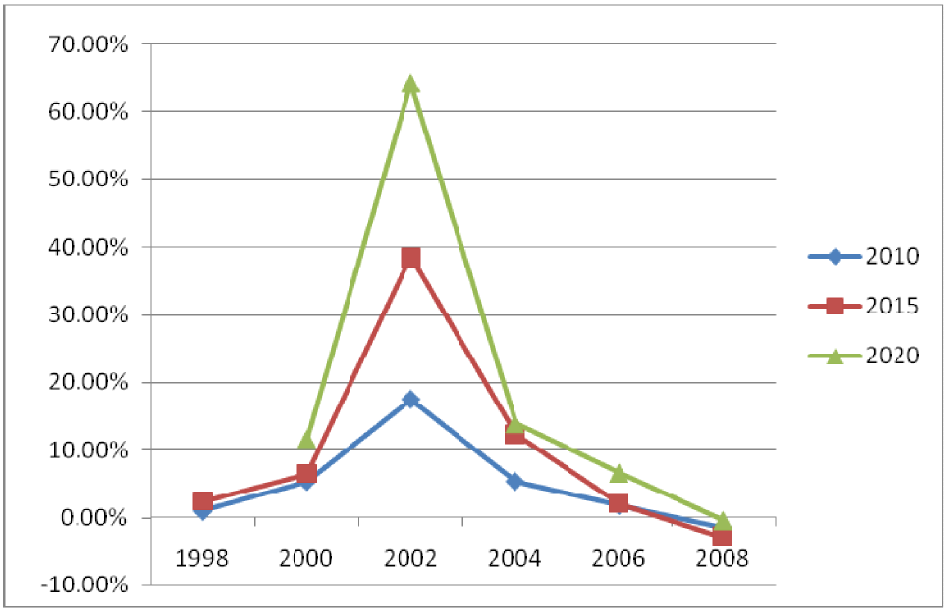
Source: EIA, Annual energy Outlook 1996-2008

We see an increase in nuclear energy production for 2010 to 2020 over the outlook years.

Table 4.84: Changes of the forecasts in %						
	1998/1996	**2000/1998**	**2002/2000**	**2004/2002**	**2006/2004**	**2008/2006**
2010	0.95%	5.35%	17.46%	5.34%	1.81%	-1.54%
2015	2.40%	6.45%	38.53%	12.32%	2.12%	-2.89%
2020		11.49%	64.25%	13.89%	6.57%	-0.44%

Above the peak for energy production is projected in the Annual Energy Outlook 2002, and then we see a decline.

Figure 4.19: Changes of the forecasts in %



The figure is not persuading me of its efficiency, because the changes are steady.

Table 4.85: Autocorrelation 2010

		year_2010_a	year_2010_b
year_2010_a	Pearson correlation	1	.120
	Sig (2-tailed)		.847
	N	5	5
year_2010_b	Pearson correlation	.120	1
	Sig (2-tailed)	.847	
	N	5	5

Table 4.86: Autocorrelation 2015

		year_2015_a	year_2015_b
year_2015_a	Pearson correlation	1	.060
	Sig (2-tailed)		.923
	N	5	5
year_2015_b	Pearson correlation	.060	1
	Sig (2-tailed)	.923	
	N	5	5

Table 4.87: Autocorrelation 2020

		year_2020_a	year_2020_b
year_2020_a	Pearson correlation	1	-.129
	Sig (2-tailed)		.871
	N	4	4
year_2020_b	Pearson correlation	-.129	1
	Sig (2-tailed)	.871	
	N	4	4

For all three cases we have no significance and almost no correlation.

4.1.6.2. Revision of Nuclear energy compared to the price of crude oil

In the following I just want to show a brief overview comparing electricity generaton with the oil price of 1996 to 2008.

As the oil price declined from 27.54 US-$ in 1996 to 16.69 US-$ in 1998, the projection for Nuclear electricity generation in 2005 also declined. The oil price increased in 2000 and the same happened with Nuclear Electricity generation. But in 2002 the oil price was less than in 2000 and for nuclear electricity generation a higher capacity was projected.

In the case of 2010 the projected capacity for nuclear electricity declined in 1998 but kept increasing for the years 2000 to 2008 as the oil price also kept increasing (except of in the year 2000 the oil price declined).

In 1998, 2002 to 2006, the forecast for nuclear electricity generation in 2015 increased, but the oil price was not higher (years 1998 and 2002) than in the year before in all cases.

For 2020, even the oil price increased in 2000 and 2008, the nuclear electricity generation was projected to decline (in case of 2008 it declined only a bit, but in case of 2000 the forecast was about 63 bn kWh less than in 1998 with the less oil price). Therefore we cannot really tell if the forecast is efficient or inefficient. But in my opinion it does not make sense that Nuclear energy should lose of its generation while the oil price keep rising.

Table 4.88: Nuclear Electricity generation in billion kWh

	1996	1998	2000	2002	2004	2006	2008
Oil price in US-$/bl	**27.54**	**16.69**	**34.92**	**29.06**	**42.02**	**67.03**	**100**
2005	680	600	674	759			
2010	660	580	627	737	794	809	797
2015	500	520	511	707	812	829	807
2020		490	427	702	816	871	868

Source: EIA, Annual Energy Outlooks 1996-2008 and Statistical Review of World Energy, June 2008

Figure 4.20: Nuclear energy electricity generation and crude oil price

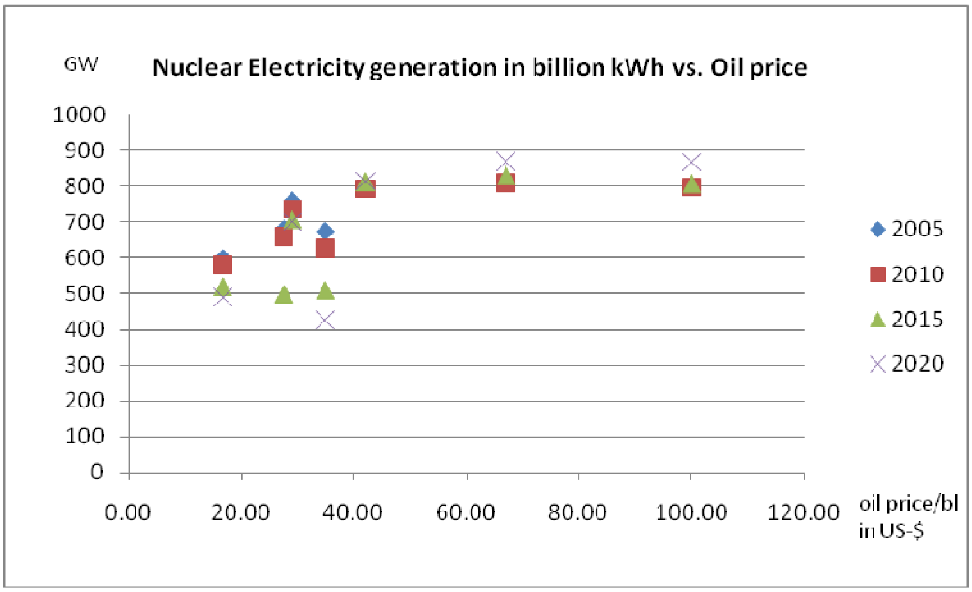


Table 4.89: Nuclear energy production in quadrillion BTUs							
	1996	**1998**	**2000**	**2002**	**2004**	**2006**	**2008**
Oil price in US-$/bl	**27.54**	**16.69**	**34.92**	**29.06**	**42.02**	**67.03**	**100**
2005	6.5	6.87	7.2	8.1			
2010	6.3	6.36	6.7	7.87	8.29	8.44	8.31
2015	5	5.12	5.45	7.55	8.48	8.66	8.41
2020		4.09	4.56	7.49	8.53	9.09	9.05

Source: EIA, Annual Energy Outlooks 1996-2008 and Statistical Review of World Energy, June 2008

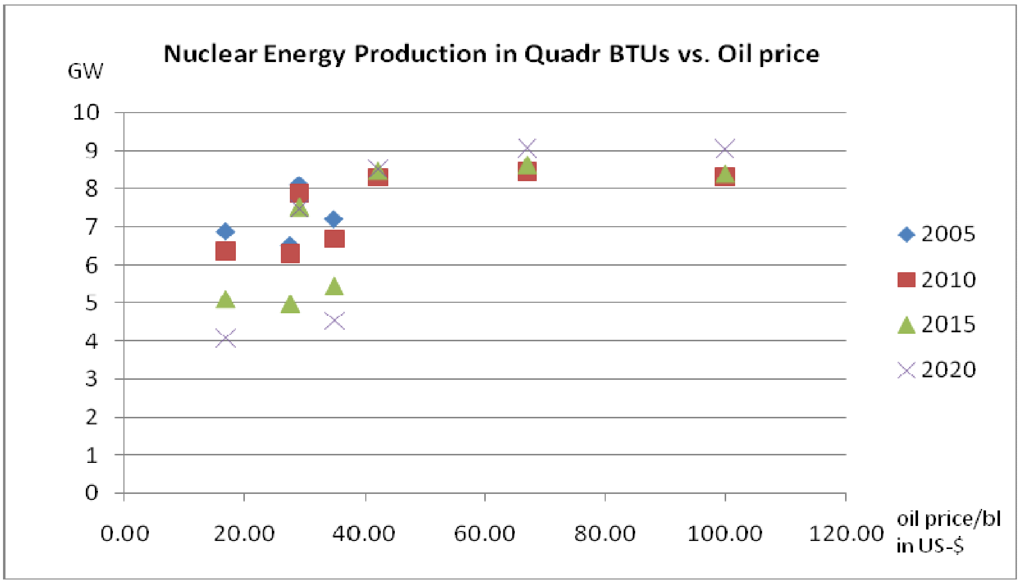
The oil price is not high in 1996, 1998 and 2002. EIA forecasts an increase of nuclear energy production for 2005 in all outlooks, desregarding the oil price.

For 2010, 2015 and 2020 the forecasts are also kept increasing, but for 2008 these declined a bit, though the oil price was at highest level.

It makes sense that nuclear production increases when the oil price increases. That would possibly mean that with a higher oil price the nuclear industry tries to produce more to be prepared to swap easier to Nuclear energy if the oil reserves keep getting less and more expensive.

Therefore I see a relation of the oil price and the nuclear energy production. The growth of the oil price maybe affects the energy production.

Figure 4.21: Nuclear energy production compared to crude oil prices



4.2. Conclusion

The economy and industry is going the right direction to innovate alternative technologies, which are more efficient and make less waste than petroleum and other fossil fuels. Our journey in the world of Alternative Energy showed us several good and bad aspects of Biomass, Geothermal energy, Hydro power, Wind energy, Solar energy and Nuclear power.

New innovations cost time and money, and because of the risky investments in volatile stocks it is not sure how profitable it would be to invest in alternative energy nowadays. Investment decisions should be considered carefully.

Alternative energy is mainly very environment-friendly and clean. It is also infinite because we can take it from the sun (solar energy), wind, water (hydro power), earth (geothermal energy), wood (biomass) and uranium (nuclear energy).

The main part of forecast efficiency was a challenge. Energy forecasts are used to guide investments in the development of these natural resources and for infrastructure projects. They play a big role helping making decisions in budgeting and planning processes for numerous businesses. An unbiased forecast does not systematically over- or underestimate the actual value. The forecast process is complex and if the forecasts move steadily up and down, then we cannot accept an efficient result.

The data used in my research is less than expected unfortunately, so therefore the outcome is not very clear.

The autocorrelations show non-significance and almost no relation between the forecast data which should mean that the data is efficient. But the revision of the changes showed the data moving very often steadily up and down, which is a sign that the projections are not efficient.

It is also not exactly clear if we can say for sure that crude oil prices are affecting the outcome of projections of alternative energy production and capacity, but in my opinion it is easier for the energy industries and people to switch to alternatives if they are unsatisfied with the fact that oil and gasoline prices are getting higher and higher. Therefore I see a trend of forecasting more use of alternatives as higher crude oil prices get.

But nevertheless it is still the beginning of alternatives getting more integrated as big fuel supplier. The world is unfortunately still too dependent of petroleum, even the prices for crude oil increasing over the last years, but there is hope that our next generations will benefit more of alternative energy in the future.

PART V. Appendices

Regression

The following chapter is based on Chapter 5 of "Discovering Statistics using SPSS" by Andy Field (Second Edition, 2005)

My thesis does not focus on regression, but I dealt with this chapter a little while and I add this just for information and I will not go too much into detail, because this is not going to be a statistic lecture.

After measuring relationships between two variables, we can take a further step and look at predicting one variable from another. We try to predict an outcome from one (simple regression) or more (multiple regression) predictor variables.

The regression shows the predictive power of variables which is not told in using correlations. We fit a linear model (a straight line) in regression and want a model that best describes our data.

Straight lines

Straight lines can be defines by two things:

a) The slope (or gradient) of the line (b_1) and

b) The point at which the line crosses the vertical axis of the graph (intercept of the line b0)

Y_i is the outcome that we want to predict and X_i is the i^{th} participant's score on the predictor variable (Field, A., 2005). b_1 is the gradient and b_0 is the intercept of the straight line fitted to the data. These two parameters are known as the regression coefficients. The residual term ϵ_i represents the difference between the score, which is predicted by the line for participant I and the score that I actually obtained.

$$Y_i = (b_0 + b_1 X_i) + e_i$$

We can describe the nature of the relationship by the gradient of the line. A line having a gradient with a positive (negative) value describes a positive (negative) relationship.

Least squares

With help of the method of least squares we can find the line that best fits the data. When any line is fitted to a set of data, there will be small differences between the values predicted by the line and the data that were actually observed. We use the line to predict values of Y from values of the X-variable because we are interested in the vertical differences between the line and the actual data. Data points sometimes fall exactly on the line, others above the line (positive) and others below (negative) the line. These differences are indicated between the model fitted to these data and the collected data, which are called residuals.

Goodness-of-fit: Sum of squares R and R^2

With help of the goodness of fit we see how well the line fits the actual data. Using the mean as a model, we can calculate the difference between the observed values and the values predicted by the mean (Field, A., 2005). We square the differences which give us the sum of squared differences and this is known as the total sum of squares. There is still some inaccuracy represented by the differences between the observed data and the value predicted by the regression line. We square the differences before they are added up so that the directions do not cancel out and then we get the sum of squared residuals (residual sum of squares). This value represents the degree of inaccuracy when the best model is fitted to the data. The proportion of improvement is calculated by dividing the sum of squares for the model by the total sum of squares. The result is the value of R^2 which we can multiply with 100 to get the percentage expression of this value.

Interpretation of a simple regression

We used SPSS to make a simple regression

Table: 0.1 Biomass forecast for 2010 - Energy capacity and generation in GW

Oil price	Forecast
27.54	14.4
16.69	12.59
34.92	14.77
29.06	12.76
42.02	11.73
67.03	10.95
80	11.43

0.2. Table: Correlations

		Biomass_Forecast	Oil_price
Biomass_Forecast	Pearson Correlation	1	-.609
	Sig (2-tailed)		.146
	N	7	7
Oil_price	Pearson Correlation	-.609	1
	Sig (2-tailed)	.146	
	N	7	7

model does not correlate and is not significant.

0.3. Table: Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.609[a]	.371	.245	1.26855

a. Predictors : (constant), Oil_price

This summary table provides the value of R and R^2 for the model that has been derived. R has a value of 0.609 and because there is only one predictor, this value represents the simple correlation between the oil prices and the forecast for biomass generation in GW. The value of R^2 is 0.371, i.e. the oil price can account for 37.1% of the variation in the forecast for biomass generation. If we want to find out why we have these forecasts, we can look at the variation in oil price. There can be also many other factors explaining the variation, but in our model we have only the oil prices explaining 37.1% of it. This means that 62.9% of the biomass forecasts cannot be explained by the oil prices. Therefore, there must be other variables influencing the forecasts.

0.4. Table: ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.750	1	4.750	2.952	.146[a]
	Residual	8.046	5	1.609		
	Total	12.796	6			

a. Predictors: (Constant), Oil_price

b. Dependent variable: Biomass_Forecast

Above we have the analysis of variance (ANOVA). It tells us whether the model results in a significantly good degree of prediction of the outcome variable (Field, A., 2005). We see the various sums of squares and degrees of freedom. The average sum of squares (mean squares) is calculated by dividing the sums of squares by the associated degrees of freedom. The F-Ratio is the most important part. It is calculated by dividing the Mean Square of Regression by the Mean Square of the Residual and the associated significance value of that F-Ratio. F is 1.609 and is not significant because in the column Sig. the value is 0.146 which is more than 0.05). It says that there is more than a 5% chance that an F-ratio this large would happen by chance alone. We can conclude that our regression model does not result in significantly better prediction of biomass generation than if we used the mean value of biomass generation. We can say that the regression model overall does not predict biomass generation significantly well.

Parameters of the model

We see in the table below the beta values and their significance.

0.5. Table: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	14.061	.945		14.875	.000
	Oil_price	-.031	.018	-.609	-1.718	.146

a. Dependent variable: Biomass_Forecast

B_0 is 14.061 and this tells us that when the oil price is 0, the model predicts that there will be 14.061 GW of biomass generated. B_1 represents the gradient of the regression line which is -0.031, which shows the change in the outcome associated with a unit change in the predictor (AF). If our predictor (oil price) is increased by one unit, then our model will predict that -0.031 GW will be generated for biomass.

That means that if we increase the oil price to 100, the model projects -3.1 (-0.031 x 100 = -3.1) less GW in biomass. The observed significance is 0.146 which is more than 0.05 and so we can say that the oil prices make no significant contribution to the biomass generation forecast.

Summary

Biomass, geothermal, hydro, wind, solar and nuclear energy are alternative energies we can find in the nature and which are supposed to be infinite.

Hydropower is a leading renewable electrical energy source in the U.S. and also the least expensive one there. Solar energy and wind energy are environment-friendly and free sources of renewable energy.

There are some companies which also specialize in developing alternative energy technologies (e.g. GE, BP, Royal Dutch Shell) to double their revenues.

Investing in such companies can be risky because stocks are highly volatile. Another option is to purchase a portfolio through an investment in funds. The venture-funded, privately held start-up companies are the riskiest investments because of their unproven technologies.

In case of the environment, the use of alternative energy is more efficient than using petroleum or other fossil fuels which cause big damage in the economy and ecosystems. Alternatives are emissions-free and the cost per kWh decreases with a growing industry of alternative energy.

Water, wind and solar energy are non-emissions power sources with no harmful and less waste. But hydro energy for example has disadvantages because the dams have impact on wildlife and water released from dams lead to greater erosion downstream.

Solar energy needs more land if high temperatures are required and also wind energy causes a sterilization of land by windmills. Noises and hazards to wildlife are also negative aspects. Nuclear power plants are very clean and safe.

Regarding forecast efficiency we can tell that if changes of the projections are steadily going up or down, then it should mean no efficiency.

In our case most of the outcome of most of the projected data shows no correlation which would mean efficiency (due to the few data collected), but the changes show the opposite.

But regarding the relation between crude oil prices and the projections we can say that the prices affect high or low projections of the capacity or production of alternative energy.

Zusammenfassung

Biomasse, Geothermie, Wasserkraft-, Wind-, Solar- und Nuklearenergie sind alternative Energien, die wir von der Natur beziehen können und die nicht als endlich gesehen werden.

Wasserkraft ist in den Vereinigten Staaten die führende erneuerbare elektrische Energie und auch die am günstigsten dort. Solarenergie und Windenergie sind umweltfreundlich und frei aus der Natur beziehbare erneuerbare Energien.

Es gibt einige Unternehmen, die sich auch auf die Entwicklung alternativer Energien konzentrieren (z.B. GE, BP, Shell) um ihre Umsätze zu steigern. Aber es ist riskant in solchen Gesellschaften zu investieren, weil die Aktien sehr volatil sind. Eine andere Option wäre ein Portfolio über ein Investmentfond zu kaufen. Die neugegründeten privaten Kapitalanlageunternehmen sind eine sehr riskante Investition aufgrund ihrer unerprobten Technologien.

Bezüglich Umwelt ist die Nutzung alternativer Energien effizienter als die Nutzung von Erdöl und anderen fossilen Brennstoffen, da diese große Zerstörung in der Wirtschaft und im Ökosystem anrichten. Alternative Energien sind emissionsfrei und die Kosten per kWh sinken auch mit Wachstum dieser Industrie.

Wasser-, Wind- und Solarenergie haben keine emissionsreichen Kraftquellen und richten kaum Schäden an. Wasserkraft hat einige Nachteile, wie beispielsweise, dass die Dämme große Belastungen auf wild lebende Tiere haben und das Wasser aus den Dämmen sorgt flussabwärts für große Erosion.

Solarenergie braucht viel Platz bei Bedarf nach höheren Temperaturen. Auch Windkraftwerke brauchen viel Platz. Weitere negative Aspekte sind Lärm und Gefährdung von Vögeln. Atomkraftwerke sind dagegen sehr sauber und sicher.

Das Testen der Effizienz von Vorhersagen alternativer Energien zeigte in der Arbeit, das die Revision der Veränderungen steil auf und abgeht, sodass wir vermuten können, dass keine Effizienz besteht, obwohl die Autokorrelationen fast überall das Gegenteil zeigen, aber das liegt daran, dass nur sehr wenige Daten für den Test genommen werden konnten.

Der steigende/sinkende Ölpreis beeinflusst die Vorhersage hinsichtlich höher/niedriger Kapazität und Produktion alternativer Energien.

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