MSc Program
Renewable Energy in Central and Eastern Europe

The Attractiveness of Renewable Energy Investments for Sovereign Wealth Funds

A Master's Thesis submitted for the degree of
"Master of Science"

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Affidavit

I, **MARKUS WANKO**, hereby declare

1. that I am the sole author of the present Master's Thesis, "The Attractiveness of Renewable Energy Investments for Sovereign Wealth Funds", 84 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

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ABSTRACT

Financing significant changes in the current power generation systems globally will require enormous capital. At the same time sovereign wealth funds reach unprecedented levels of resources. Hence the core question of the present study is whether renewable energy is an attractive asset class for sovereign wealth funds to invest in. The method of approach applied is both a quantitative empirical one, by analyzing past performance of various renewable energy assets and comparing it to the investment requirements of sovereign wealth funds, as well as a qualitative one by including non financial strategic objectives of sovereign wealth funds. The result is that from a pure financial performance and risk/return basis, the assets do not necessarily constitute an attractive asset class. It can be concluded therefore that other factors, in particular diversification of their respective economies as well as political and ecological considerations, will have to play an important role to step up funding for renewable energy by Sovereign Wealth Funds.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND DEFINITIONS

Abbreviations frequently used in energy in general and renewable energy:

AC - alternating current

bbl - barrel

BCF - billion cubic feet

Bcfd - billion cubic feet per day

BTL - Biomass-to-liquid

Btu - British thermal unit

CPV - Concentrated PV

CSP - Concentrated Solar Power

DC - direct current

EIA - U.S. Energy Information Administration (statistical arm of U.S. Department of Energy)

FT - Fischer-Tropsch process of converting methane, biomass, or coal to liquid fuels

GHG - Greenhouse gas (e.g., CO2, methane)

GTL - Gas-to-liquids conversion

GW - gigawatt

GWh - gigawatt-hour

IEA - International Energy Agency

kV - kilovolt

kWh - kilowatt hour

kWp - peak kilowatt

LNG - liquefied natural gas

LV - low voltage

MBD - Millions of barrels per day

MWh - megawatt hour

MWp - peak megawatt

NIMBY - Not In My Backyard

OPEC - Organization of Petroleum Exporting Countries

PV – photovoltaic

SEGS - Solar Electric Generating Station

TBtu - trillion Btu

TCF - trillion cubic feet

TCF - Trillion cubic feet (dry natural gas)

V - volts

W - Watt

Abbreviations frequently used in Finance:

Returns and yields:

- HPR: Holding Period Return
- TSR: Total Shareholder Return
- IRR: Internal Rate of Return
- ROE: Return on Equity
- DY: Dividend yield

- bp: basis points

Cost of energy:

- STMC: Short Term Marginal Cost
- LTMC: Long Term Marginal Cost
- LCOE: Levelized Cost of Energy

1. BACKGROUND

Sovereign Wealth Funds ("SWFs") constitute very large pools of capital. At the end of 2012, the assets under management ("AuM") of the top 60 funds amounted at US$ 5.2 trillion. The top ten funds alone accounted for US$ 4 trillion.[1]

The Sovereign Wealth Fund Institute defines SWF as: "[…] a state-owned investment fund or entity that is commonly established from balance of payments surpluses, official foreign currency operations, the proceeds of privatizations, governmental transfer payments, fiscal surpluses, and/or receipts resulting from resource exports. The definition of sovereign wealth fund exclude, among other things, foreign currency reserve assets held by monetary authorities for the traditional balance of payments or monetary policy purposes, state-owned enterprises (SOEs) in the traditional sense, government-employee pension funds (funded by employee/employer contributions), or assets managed for the benefit of individuals".[2]

Transition of our power generation base to a system with a significantly higher share of renewable generation is one of the largest projects currently undertaken globally, requiring very significant funding needs. In Germany alone, it is estimated that the shift to a renewable energy economy will require investment in excess of EUR 200 billion.[3] On a global level, the renewable energy sector investment volume reached US$ 257 billion in the year 2011 alone, a six fold increase from the 2004 levels.[4] On a global level, this process will certainly require trillions of EUR of funding capacity.

[1] Sovereign Wealth Fund Institute, http://www.swfinstitute.org/fund-rankings/; retrieved on December 18, 2012

[2] Sovereign Wealth Fund Institute, http://www.swfinstitute.org/what-is-a-swf/; retrieved on November 12, 2012

[3] Heinrich Boell Stiftung, http://energytransition.de/2012/10/key-findings; retrieved June 9, 2013

[4] Frankfurt School - UNEP Collaborating Centre for Climate & Sustainable Energy Finance: Global trends in renewable energy investment 2012

Therefore, it is logical to look at the large pool of funds that SWFs constitute as potential investors. However given the specific profile, investment strategy and structure of SWFs it is not clear if the sector is attractive. The thesis should contribute to a better understanding of this very question.

2. RESEARCH QUESTION AND SCOPE

Against this background, the proposed research question is: **Is renewable energy an attractive asset class for SWFs?**

As will be demonstrated, Sovereign Wealth Funds share a diverse picture of objectives and requirements. Generally however, economic attractiveness is an important criterion. This attractiveness is the result of a competitive risk / reward trade-off. Therefore considering the performance (i.e. reward) and risk of investments in renewable energy companies will be one important part of the analysis. Attractiveness however is broader than immediate financial return in the eyes of many principals at the helm of Sovereign Wealth Funds. It will therefore also be attempted to present a more holistic picture of the objectives of Sovereign Wealth Funds and then compare these objectives with the opportunities provided by the renewable energy sector.

In terms of quantitative analysis, the study needs to be limited to listed equity investments, since only in these cases, publicly available performance statistics are available. Qualitative considerations will also be made regarding unlisted companies and project level infrastructure investments.

Regarding the variety of Sovereign Wealth Funds, a brief introduction will cover the entire spectrum of Sovereign Wealth Funds, the qualitative analysis of investment objectives and requirements will focus on funds based in the GCC (Gulf Cooperation Council), i.e. funds deployed cash generated by oil and gas sales of the middle Eastern oil producing nations.

3. METHODOLOGY

The analysis will first define and describe renewable energy and its relevant subsectors, both from an asset class as well as from a technology perspective.

The key dimensions of risk/return will be described. In a quantitative analytical section, the performance of renewable energy indices as well as individual companies will be analyzed and benchmarked with general equity market returns. The analysis will reflect value appreciation/depreciation as well as dividend yields. Following the analysis of returns, the different elements of risk involved with investments in renewable energy assets will be discussed. In order to demonstrate the corporate developments and the reasons for certain performance outcomes, case studies will be presented that describe the development of companies active in different segments of the renewable energy sector.

Regarding the objectives and performance requirements of Sovereign Wealth Funds, little published evidence is available. The analysis rests on the actual empirical outcome, i.e. the investment activity of certain funds in the sector, as well as the author's experience as an employee of a Sovereign Wealth Fund.

A review of existing literature will be performed as part of the thesis project covering particularly two dimensions: (i) generally known standard texts on the investment performance and portfolio construction, such as

a. Analysis of Investments and Management of Portfolios (Keith C. Brown und Frank K. Reilly)
b. Pioneering Portfolio Management: An Unconventional Approach to Institutional Investment (David F. Swensen)

as well as (ii) literature specifically dealing with the investment process and performance of renewable energy investments.

c. The Handbook of Infrastructure Investing (Michael Underhill)

The return analysis of selected renewable energy equities and equity portfolios vs. traditional portfolios will based on reliable market sources, in particular on Bloomberg and Bloomberg New Energy Finance, complemented by Datastream and Reuters.

4. RENEWABLE ENERGY ASSET CLASSES

4.1. TYPE OF UNDERLYING ASSET

Investments can be made in a variety of different assets. The decision on which types of assets a fund desires to invest in should follow an asset allocation process. It should initially be derived from an objectives statement, that helps the management of the fund to clarify the principals' investment objectives. These should include the time horizon of the pay outs from the fund, the desired return and tolerable risk levels. It could also include ethical statements relating to the strategic focus on certain sectors or the exclusion of other sectors, such as (typically9 military, tobacco, gambling or alcohol.

From an institutional investor perspective, the asset spectrum can be divided into (i) companies (i.e. an organization with indefinite life, typically developing and commercializing a technology or a series of renewable energy projects), (ii) individual projects or (iii) funds (i.e. a compilation of a portfolio of different underlying investment opportunities). In the case of companies, an important distinction from an investment perspective is whether they are listed at a stock exchange or not. In the following, a few examples of listed and unlisted companies and funds will be provided.

4.1.1. LISTED EQUITIES

Listing of a company's shares at a stock exchange creates certain advantages for investors. Most significantly, it creates a market for the stocks and – depending on certain criteria affecting the liquidity of the shares – the investor can sell the shares typically without the requirement to find a bilateral counterparty and without the underlying company's or other shareholders' consent. This is a very significant difference to investments in private companies, particularly in the usual case where private shareholders are tied to the investment by shareholder agreements. Another advantage is the visibility into corporate developments. In order to help create a fair market place, listed companies are typically required to implement strict transparency procedures. They typically need to publish quarterly financial statements, inform the market about material events that could impact the share price and also typically voluntarily provide management guidance on the likely development for the current and following year. Large financial service industries have been created around the support and coverage of listed companies with several investment banks and brokers providing research coverage on the underlying companies and sectors.

The following types of companies that are engaged in the renewable energy spectrum can be discerned:

- Pure play renewable developers/owners
- Incumbent utilities, IPPs
- Technology companies

4.1.1.1. Pure play renewable developers/owners

Within the pure plays, subsidiaries of incumbent utilities and independent developers can be differentiated. While the incumbents typically have several decades of history, along with the organizational structure and processes that are typical for (initially) state run, monopolistic enterprises, the later ones have been started within the last couple of years from scratch.

4.1.1.1.1. Subsidiaries of incumbent utilities

This refers to developers/owners that are (partially) held by utilities, either through acquisition or (partial) spin off of internal operations. Examples include:

- ***EDP Renovaies***: the company is an Iberian renewable energy company with its headquarters in Madrid. It is involved in the design, management and operation of power plants that generate electricity using renewable energy sources. The company was established in 2007 by parent company Energias de Portugal which is Portugal's biggest utility company based in Lisbon. The company is currently the third largest generator of wind energy after Iberdrola Renovables and Nextera Energy Resources. EDPR's main business include wind farms and mini hydro energy activities and also exploring other renewable technologies.

  The company had 820 employees in 2010 which generated 289.9 million EUR in operating income. Geographically the company operates in three major areas: North America, South America and Europe. In alone it owns more than 180 wind farms across this region. It is also developing and at different stages of development of these resources in the UK, Canada and Italy. Since 2006 to 2010 the company had been steadily increasing its production capacity by a compounded annual growth rate of more than 47%. Though it is mainly focused on onshore wind energy it also looking to develop other opportunities and closely follow the technological and regulatory developments of other renewable energies like offshore wind, wave energy and solar thermal. It is also working with its developers to improve the output and efficiency levels of its wind farms.

- ***EDF Energies Nouvelles***: This is a listed company on the Paris stock exchange that deals with renewable energy owned by the utility company Electricite de France. EDF EN is essentially involved in the production of wind power in the United States and Europe. It also invests in solar energy and also has interests in biofuels and ocean power. In terms of ownership the company is 50% owned by the state utility company Electricity de France, 25% publicly traded and the remaining 25% is owned by founder Paris Mouratoglou and his family. The largest sources of revenue approximately half come from EnXco which is the company’s wholly owned subsidiary that builds, manufactures and operates wind and solar projects under its own trading name in the United States.

  The company initially was started by the founder Paris Mouratoglou in 1990 as SIIF. The initial company developed small scale solar and hydroelectric projects in France and its overseas territory. It is not until 1999 that SIIF ventured into the development of wind power which was later to become the dominant business of the company.

  In the recent past the company has embarked on a diversification strategy to move away from overreliance on its core wind energy business. this has lead particularly to the increase in investment in solar energy. Other renewable energy sources include biomass where EDF EN has a 25% interest in a Belgian ethanol produce called Alco and also a small olive waste run electricity generating plant in southern Italy.

  The company has over 2028 employees and in 2010 it made a profit of EUR 85.6 million from EUR 1,573 million in revenues generated from its operations.

4.1.1.1.2. INDEPENDENT DEVELOPERS

Independent developers have typically started out as small companies developing one or a few individual projects, examples include:

- ***Solar Millennium:*** This is a German company founded in 1998 and involved in concentrated solar power. It has its headquarters in Erlangen Germany and is primarily involved in the design and development of solar thermal power plants. The particular activity involves site selection, planning, design, project development and the construction of parabolic trough power plants. It was initially founded as Solar Century Management GmbH but it was renamed in March 1999 to Solar Millennium GmbH. There company issued an IPO in the July of 2005. The company went under liquidation in 2012.

- ***Greentech Energy System***: This particular company develops, constructs and operated a wide range of renewable energy projects such as water and sludge treatments, biogas and biomass, hydroelectric, solar power and wind power. It operates in Germany, Denmark, Norway, Italy, Poland and Spain.

4.1.1.2. INCUMBENT UTILITIES, IPPS

While it is fair to say that initially utilities have been skeptical towards the development of renewable energy infrastructure, most have amended their strategy to incorporate renewables as an integral part of their generation strategy. While incumbents can hence also provide exposure to renewables, typically renewable power generation accounts only for a fraction of overall power output and an even smaller fraction of total revenues, since incumbents typically have also distribution revenues, which are generation technology agnostic. Examples include:

- ***Iberdrola***: This a Spanish multinational with a workforce of around 31,330 serving over 31.67 million customers in four continents. The company decided on an aggressive growth and international plan in 2001 which saw it become Spain's largest energy group by market capitalization and global leader in the wind energy market. It is also amongst the largest utility companies by market capitalization.

  The company came into existence on November 1,1992 as a result of the merger between Hidroelectrica Espanola and Iberduero some of Spain's oldest utility company. Hence, Iberdrola has a long standing exposure to (large) hydro projects. The company had total assets of EUR 96.989 billion by the end of 2012, in the same year the company generated revenues of EUR 34.20 billion, operating income of EUR 7.726 and profit of EUR 2.804 billion. The company has its headquarters in Bilbao, Spain[5]

- ***Nextera:*** The Florida based subsidiary of NextEra Energy Inc is probably currently the largest owner and operator of solar and wind electricy in terms of assets globally. The company owns over 85 wind facilities in 17 states in the US and three Canadian provinces. NextEra Energy resources also co-owns and operates Solar energy Generating Systems (SEGS) which is the world's largest solar power plant. Apart from solar and wind the company also generates power from natural gas, oil and nuclear fuel. The total combined capacity of the company's facilities is 18.9 gigawatts (GW)[6]

4.1.1.3. TECHNOLOGY COMPANIES

Although most renewable generation technologies are not new, it is technological advances that are driving cost down and improve competitiveness versus traditional power generation. Development and commercialization of technology is therefore clearly an essential element in the current state of the renewables landscape. Examples of technology companies include:

- ***Siemens:*** The German multinational electronic and engineering conglomerate with headquarters in Munich is the largest Europe based electrical and electronics engineering company. It is primarily involved in the fields of energy, transportation, healthcare and industry. The company is organized into five main divisions: infrastructure and cities, energy, healthcare, Industry and Siemens Financial Services (SFS). The company operates in nearly 190 countries with a workforce of approximately 360,000.

  The company also engages in the research and development of renewable energy resources especially solar and wind based plants. The company is quite old being by Werner von Siemens in 1881. The company had EUR

[5] http://www.iberdrolarenewables.us/; retrieved on January 16, 2013

[6] http://www.nexteraenergyresources.com/home/index; retrieved on January 16, 2013

108.28 billion in assets as at 2012, total equity was EUR 30.73 billion generating revenues of EUR 78.29 billion and a net income of EUR 4.458 billion.[7]

- ***GE:*** The general electric energy division works to develop and innovate ideas that would provide sustainable energy sources for the future. The division is part of the larger general electric company and is mainly involved in the exploration of sustainable energy resources such as solar, wind and thermal plant. The company designs, develops and manufacture turbines and other plants for use in hydro or electric plant. They are also involved in the development of electric cars that would use fuel cells in their locomotion.

- ***Abengoa:*** This is a Spanish technology company that is involved in telecommunication, transportation, energy and the environment. The company has its headquarters in Seville Spain. The core business of the company is the biotechnology in which it has specialized in the development of innovative technologies to produce bio chemicals and bio fuels and also the promotion of sustainability of raw materials. The technologies include second generation biofuels, concentrated solar power and desalination. The company has approximately 26,500 employees in more than 80 countries. In the year 2012 the company had a profit of EUR 125 million from revenues of EUR 7.783 billion and an asset base of EUR 20.545 billion. The operating income was EUR 774.6 million for the same year.[8]

Given the significant construction effort in certain renewable technologies, particularly in off shore wind projects, some construction companies also provide exposure to renewable energy, e.g.

- ***Hochtief:*** Hochtief AG an international construction company based in Essen, North Rhine- Westphalia Germany. It has over 70,000 employees across the globe and has assets of around EUR 15 billion.

4.1.2. Unlisted Companies

[7] http://www.siemens.com/entry/cc/en/; retrieved on January 19, 2013

[8] http://www.abengoa.com/web/en/index3.html; retrieved on January 19, 2013

This group can typically be divided in project developers and technology companies. An example for developer would be:

- ***9REN***: The Company is a leading renewable energy company established in April 2008. It is principally focused on the development, design, operation, upgrading and ownership of solar thermal, photovoltaic, wind and mini wind power plants and provision of turnkey project management for third parties. The company has constructed over 200 MW of photovoltaic power plants. The company is relatively small with a staff of 130 people in the group offices located in Italy and Spain. Internationally the company is expanding to capture opportunities in Israel where it is developing photovoltaic rooftop projects.

An example of an unlisted technology company woud be:

- ***Amonix:*** this is a solar power system developer. It is based in California and mainly focuses on the manufacture of concentrated photovoltaic (CPV) for commercial solar power systems made especially for dry and sunny climate. The difference between CPV systems and ordinary photovoltaic modules is that the CPV would first convert sunlight into electrical energy by the use of optical concentrators to focus the sun's radiation before the light is absorbed by the photovoltaic cells. CPV systems produce more energy per megawatt (MW) compared to traditional PV system. Amonix has approximately 70 MW of CPV solar power systems distributed across the globe. The largest CPV power plant in the world is the Alamosa Solar Generating project which is owned by Cogentric Energy. Amonix has demonstrated a photovoltaic module efficiency of 36.2% under normal concentrator operating conditions.

4.1.3. FUNDS

The funds spectrum can be differentiated into infrastructure funds, that typically buy and hold mature infrastructure assets, i.e. generating low but stable returns and venture capital funds, that build a portfolio of high risk, potentially high return investments in typically early stage technology companies. There are a number of venture capitalists that deal specifically in green energy. Below is a list of a few of the venture capitalist funds and their principle interests

- ***GE Financial services:*** this particular division of General Electric majorly focuses on investing in emerging companies through its energy technology ventures. The energy technology ventures are a joint venture between GE, NRG Energy and ConocoPhillips. GE financial services focuses on equity investment in companies that pursue innovative ideas and technologies in the energy and water value chain. The company invests up to $5 million in each company it considers but can also exceed this particular limit partnering with other top tier venture capital investors in various areas of emerging technology. The company principally focuses on Europe and North America equity and debt investments.

- ***Renewable Energy Venture Capital (REVC) Fund***: this is an initiative of the Australian government that has been in existence for the past 13 year. The fund is managed by Southern Cross venture partners (SXVP). The Australian government pledged $100 million investment which is matched dollar for dollar by the Softbank china venture capital and consequently creating a $200 million fund solely dedicated to renewable energy. The fund basically aims at fostering the governments renewable energy strategy and some of its goals include
    - Increasing the number of renewable energy and enabling technology firms that would be successful both in Australia and overseas markets
    - Enhancing skills and management capability of the Australian renewable energy sources and the boasting technology company by providing active investment management (Australian Renewable Energy Agency (ARENA))

- **Draper Fisher Jurvetson** DFJ is a venture capital firm that backs entrepreneurs globally that show high growth potential in many sectors not only in the renewable energy sector but also in information technology, nanotechnology, clean energy and life sciences.

Infrastructure funds include, e.g.:

- **First Reserve**: First Reserve is an energy-focused private equity and infrastructure investment firm with $23.1 billion of raised capital. Its exposure includes gas, oil and transmission assets, but also renewable energy assets, such as Abengoa or 9Ren New Energies.

4.2. Types of Renewable technologies

Most types of renewable electricity generation are directly or indirectly related to the sun's radiation. This radiation is maintained by the continuous nuclear fusion between hydrogen atoms, which is expected to continue for another five billion years. Although obviously only a tiny proportion of total solar radiation is captured by the earth, this radiation still accounts for about 9,000 times current rate of consumption of nuclear and fossil fuels.[9] In the following we shall briefly describe the key technologies PV, CSP, On and Offshore wind and other technologies.

4.2.1. Solar Technologies

4.2.1.1. Photovoltaic Power Generation ('PV')

This particular technology makes use of the suns radiation to generate electricity using specialized cells called photovoltaic cells. The technology is applied either on a small scale, mainly on residential housing rooftops ('rooftop') with a capacity in the single/double digit kW range or commercial scale with large PV power plants reaching in excess of 100 MW capacity. A key area of technological development is increasing the efficiency of the solar cell electricity conversion capacity. Concentrated solar cell power is one of the ways in which conversion capacity has been achieved by key players in the field of commercial solar cell development. Another major challenge for the field is the high initial cost of installation of solar power stations as compared to other forms of energy. However, the continual improvement in the areas of efficiency would ultimately lead to more efficient cost effective photovoltaic cells that can be used in power generation. Commercial viability is approaching, with the technology reaching 'grid parity', i.e. breakeven of levelized cost of energy of PV compared with residential power tariffs. In recent years, this trend has been supported by a rapid decline in cost of

[9] Godfrey Boyle, Renewable Energy Technologies for Electricity Generation; in: Harnessing Renewable Energy in Electric Power Systems, Theory, Practice, Policy; Earthscan 2010

polysilicon, a key component of PV modules and consequently PV modules. In Germany, installed system prices for solar PV plummeted by 66% from 2006 to mid-2012.[10]

4.2.1.2. CONCENTRATED SOLAR POWER

Concentrated solar power is a technology, where solar energy is used to heat a fluid (oil, water) which then drives a conventional steam turbine. The solar energy collection can be achieved with different systems (linear Fresnel lenses, parabolic trough, parabolic dish and solar tower systems). It requires a high degree of solar irradiation. Because of the concentration feature, a high degree of direct irradiation is required, which makes the technology less suitable for dusty and cloudy areas.

Commercial viability: The rapid decline of PV module prices has had a negative commercial impact on Concentrated Solar Power. Under certain environmental and design parameters, concentrated solar power and utility scale PV installations are in competition. The example of the solar facility at Blythe, California, which was originally planned with CSP technology, and was switched to PV, also driven by changes in the Californian subsidy scheme, underlines this point. “Currently, base-load electricity generated by CSP plants located where there are good solar resources costs two to three times that from existing fossil-based technologies without carbon capture and storage. CSP generation costs are on a par with photovoltaic and offshore wind, but are significantly more expensive than onshore wind.”[11]

Since CSP plants can be designed to include thermal storage capacity which allows them to run for several hours without sunshine, they could also serve as base load providers and are typically considered as dispatchable.

One interesting variety of CSP plants, particularly in situations with existing gas generation facilities, is the introduction of Hybrid CSP with gas generation. In this technology, both steam generated by burning gas as well as by a hot conductor liquid heated by CSP is used to drive a turbine. This technology is particularly interesting in

[10] Heinrich Boell Stiftung; http://www.boell.org/web/index-The-German-Energy-Transition.html; retrieved December 18, 2012

[11] EASAC: Concentrating solar power: its potential contribution to a sustainable energy future; EASAC policy report 16; November 2011; ISBN: 978-3-8047-2944-5, page 1

situations where continuous power output is required. Also, collocation typically allows certain advantages compared to stand alone, in particular the shared use of a turbine and generator.

4.2.2. WIND

Wind technologies can be categorized further into on shore and off shore wind technologies. The onshore wind technologies are usually located as the name suggests on the land. Originally providing capacities of a few kW, modern on shore turbines generate power with a capacity in excess of 2 MW. Wind farms have become common sources of energy in many parts of Europe and North America. Wind energy is quite independent of other sources of energy as it does not require any fossil fuels except for lubrication purposes and hence fluctuations in the oil market would not affect the energy production. These wind mills are often found at sea shores or on mountainous areas where there is a lot of wind which can be estimated using meteorological records and analysis.

Off shore wind plants are usually located on the ocean or lake where there is considerable movement of breeze by convection currents. This movement of air is then harnessed to turn the turbines that generate electricity for consumption by various stakeholders. While onshore wind is a very established sector with sufficient experienced players in all stage of the value chain, off shore is still a nascent industry that needs to overcome significant development hurdles.

4.2.3. OTHER TECHNOLOGIES

Other technologies include geothermal, biomass, tidal wave and waste to energy. Geothermal energy is generated by using the volcanic activity below the earth surface. The very high temperatures involved in the volcanic activities in certain areas of the world can be harnessed to produce power. This can be done by using the high temperature to heat up steam that is then used to turn turbines for electricity generation. Biomass involves the burning or gasifying or biomass, e.g. wood, straw, waste to generate steam and in turn drive a turbine and generator.

4.2.4. COST COMPARISON

When considering renewables as an investable asset class, its economics need to be properly understood. Whereas many countries have introduced economic support initiatives, ranging from feed in tariffs, to green certificates, ROCs, quotas etc., economic competitiveness will be a key prerequisite for long term sustainability. For investors, it is therefore critically important to determine the generation cost of renewable versus conventional technologies.

One of the parameters of comparing generation technologies is cost per MWh generated electricity. Cost can be defined in various ways depending on the purpose of the underlying decision. For instance, short term marginal cost ('STMC') is used for taking production decisions between existing plants. STMC neglect the capital cost and compare marginal cost of generating an extra unit of electricity. Since the capital investment decision has already been made, it is appropriate to ignore these cost and solely focus on the question which existing plant can contribute the highest cash flow.

The most commonly used measure when comparing different segments is LCOE. LCOE (levelized cost of energy) measures the average cost per unit of energy produced over the life time of the power plant. It includes capital cost, fuel cost, fixed operating cost, and the value of tax credits or carbon prices as applicable. LCOE analysis allows different energy generation technologies to be compared. "Specifically, LCOE is defined as the dollar per megawatt hour ($/MWh) price for an inflation-adjusted, fixed-price power off-take agreement that, taking into account all project-specific costs, offers the sponsor and/or the project developer the minimum equity return necessary to undertake the project." [12]

The graph below shows the boundaries of LCOEs for different generation technologies. They are indicated as a band from low to base to high case in $/MWh, demonstrating that the specific features of individual plants, such as load profile, location, specific technology employed, financing assumptions etc. have a significant impact on levelized

[12] Bloomberg LCOE Methodology Summary, retrieved on June 22, 2013

cost.[13] Indeed, the major shortcoming of the LCOE concept is that it does not take into account the individual load profile of a power plant.

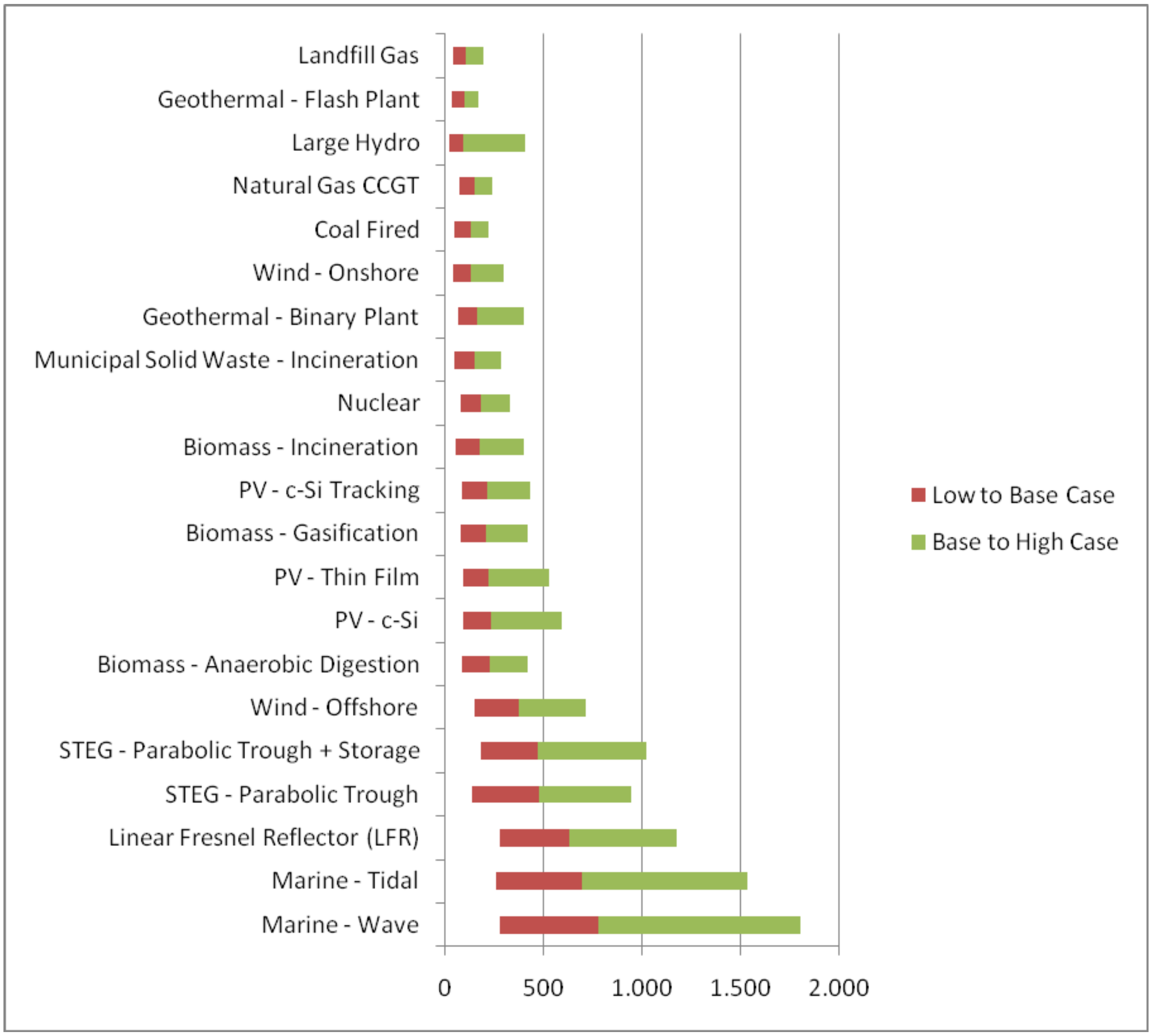

Figure 1: LCOE of different generation technologies[14]

The Bloomberg model includes the cost of carbon in the calculation of LCOEs for fossil fuel-fired power plants by applying BNEF's proprietary European carbon price forecast

[13] Bloomberg New Energy Finance: LCOE model, underlying data retrieved from Bloomberg June 22, 2013

[14] Bloomberg New Energy Finance: LCOE model, underlying data retrieved from Bloomberg June 22, 2013

to each metric ton of emitted CO2. To illustrate, an LCOE of $100/MWh for a wind farm indicates that, after factoring in the costs of development, construction, turbines, balance of plant, short and long-term financing and operating the project, signing a power purchase agreement at $100/MWh would return the owner of the project exactly their hurdle rate or the minimum expected equity return required to allow the project to proceed. The LCOE model is based on a pro-forma project finance schedule which runs through the entire accounting of the project, based on a set of project inputs. This allows the model to capture the impact on costs of the timing of cashflows, development and construction costs, multiple stages of financing, interest and tax implications of long-term debt instruments and depreciation, among other drivers. The outputs of the model include sponsor equity cashflows, allowing calculation of the resulting internal rate of return.

LCOE is frequently used in arguing the case for or against renewables. It is critically important that the assumptions behind these data are understood and properly taken into account. For the purpose of demonstration, what level of detail should lie behind these data, an example for one data series, i.e. the one on crystalline silicon PV is covered below.

Base case assumptions for crystalline silicon PV LCOE:

Technology: PV - c-Si: Crystalline silicon photovoltaic modules mounted on stationary racks on the ground.

Period: 2013 Q1

Plant:

- Capacity: 50 MW
- Capacity factor: 17%
- Operating life: 25 years

Development:

- Time: 1 year
- Cost: US$ 70,000/MW

Construction:

- Time: 1 year

- Cost: US$ 408,261/MW
- Capital Cost: $1,145,239/MW
- % Debt: 75%
- Debt spread above LIBOR: 500bps

Term Loan:

- % Debt: 75%
- Debt spread above LIBOR: 275 bps
- Tenor: 10 years

Operating & Maintenance:

- Fixed: US$ 40,000/MW/year
- Variable: US$ 0/MWh
- Financial depreciation: 20 years

The general conclusion from this cost comparison is that (i) different renewable generation technologies vary widely among each other in terms of generation cost. Therefore, detailed scrutiny and expert level experience is required when assessing the economics of individual technologies and projects. (ii) most renewable technologies in most circumstances are not yet economically competitive with incumbent technologies. While this disadvantage is compensated in many cases with government subsidies or other forms of governmental support, it is exactly this type of support that exposes the sector to political risk, as will be discussed further in section 6.

4.3. GEOGRAPHY

Renewable energy is closely related to the environment and therefore the physical location and topography of a place influences the attractiveness of various energy sources. Geography is a highly relevant criterion for determining the attractiveness of renewable energy investments. The physical parameters (wind parameters, solar irradiation parameters) change with geography, as do the existing power generation installed base, nationally defined power generation strategies and resulting policy frameworks.

For instance solar power can only be effective in areas where the sun is available for a significant number of days of the year. This is particularly true for areas in the low latitudes and with regionally beneficial irradiation parameters. By virtue of geography most of the Middle Eastern countries have a high potential to develop their solar power capacity to meet their entire energy needs.

In geography also we consider the political organization countries. There are countries that have adapted green energy initiative and therefore are more likely to invest and enact policies that would encourage green energy within their borders. Specific example could be the European Union which has publicly advocated for legislation of green regulations and directives among its members.

Another factor related to geography that affects the attractiveness of renewable energy is the proximity to research facilities and other industrial centers.

From an investor perspective, further criteria, which are not directly related to renewables but hold true in every investment setting, are to be applied, such as tax regime, double taxation agreements for foreign investors, restrictions on repatriation of profits, local content requirements, or FDI (foreign direct investments) incentives.

The attractiveness of individual countries for renewable energy investment can be analyzed using the Country Attractiveness Index published by Ernst & Young. This index is published on an annual basis and tracks and ranks 40 countries' renewable energy markets across a selection of technologies each quarter.

The most recent ranking of countries across the different renewable generation technologies is listed below:[15]

Rank[1]		Country	All renewables	Wind index	Onshore wind	Offshore wind	Solar index	Solar PV	Solar CSP	Biomass/ other	Geo-thermal	Infra-structure[2]
1	(1)	China	70	76	78	70	61	66	47	58	51	75
2	(2)	USA[3]	66	66	69	55	72	71	74	61	67	61
3	(3)	Germany	65	69	65	78	51	70	0	65	57	70
4	(4)	India	63	63	71	42	64	69	53	59	45	66
5	(5)	Italy	58	59	62	51	58	63	42	53	62	59
6	(5)	UK	57	64	60	78	34	48	0	57	36	65
7	(7)	France	55	58	59	55	48	55	29	57	33	55
8	(8)	Canada	53	60	65	46	32	45	0	49	35	63
9	(9)	Spain	51	50	54	39	58	56	63	46	30	47
10	(11)	Brazil	50	53	57	40	42	46	32	51	23	49
10	(10)	Sweden	50	54	54	53	30	42	0	56	35	55
12	(12)	Australia	47	47	50	37	53	52	54	42	56	45
13	(16)	Romania	46	51	55	38	33	45	0	44	41	45
13	(12)	Poland	46	52	56	41	30	42	0	42	22	47
15	(14)	Ireland	45	53	53	52	22	30	0	44	24	49
15	(19)	Japan	45	45	47	39	51	61	26	37	46	52
15	(14)	Belgium	45	51	49	57	30	42	0	38	27	50
15	(16)	South Korea	45	47	45	52	43	49	28	40	35	41
19	(16)	Portugal	44	46	50	34	45	49	35	39	25	38
19	(21)	Denmark	44	48	44	58	29	40	0	45	33	52
21	(19)	Netherlands	43	48	48	49	30	42	0	36	21	41
21	(21)	Greece	43	44	48	33	46	51	33	34	25	32
23	(26)	South Africa	42	44	47	35	42	39	47	36	33	46
23	(23)	Norway	42	48	48	46	21	29	0	45	30	51
23	(23)	Mexico	42	42	43	39	42	43	40	38	54	38
26	(23)	Finland	41	45	48	39	20	28	0	52	26	47
27	(26)	New Zealand	40	46	49	36	22	31	0	34	51	46
27	(26)	Egypt	40	41	45	32	41	39	45	35	25	34
27	(31)	Taiwan	40	43	45	38	31	44	0	35	38	42
30	(29)	Turkey	39	41	43	32	37	40	28	34	41	37
30	(29)	Morocco	39	38	42	25	48	47	52	35	21	42
32	na	Ukraine	37	37	41	27	33	46	0	43	32	41
33	(32)	Austria[4]	35	32	39	0	36	50	0	48	33	49
34	na	Tunisia	34	35	38	27	45	44	48	19	27	41
34	(33)	Bulgaria	34	35	39	24	31	42	0	33	34	39
34	na	Argentina	34	35	40	22	30	35	17	31	27	34
37	na	Israel	33	31	37	14	45	48	38	25	28	38
38	na	Hungary[4]	32	31	39	0	26	37	0	41	40	40
39	(34)	Chile	31	33	36	23	30	34	19	27	36	39
40	(35)	Czech[4]	30	31	38	0	26	36	0	30	23	46

Source: Ernst & Young analysis

Notes:

1. *Ranking in Issue 30 is shown in brackets.*
2. *Combines with each set of technology factors to produce the individual technology indices.*
3. *This indicates US states with renewable portfolio standard (RPS) and favorable renewable energy regimes.*
4. *Technology weightings have been adjusted for landlocked countries to reflect the lack of offshore potential.*

Table 1: Country attractiveness Index by Ernst & Young[16]

[15] http://www.ey.com/GL/en/Industries/Power---Utilities/RECAI---All-renewables-index

According to Ernst & Young, China has succeeded the US as the most attractive location in which to invest in renewable energy projects. China entered the Country Attractiveness Indices table in December 2004 and, since then, has progressed steadily to the top of the All Renewables Index.[17] The US dropped in the indices, to fall behind China, after a federal Renewable Energy Standard was not enacted in 2012. Other markets, most notably Spain, are also showing signs of wavering support largely due to 'tariff deficits' and the underlying affordability of support mechanisms. This may remain a feature for some time, and points to the need for governments to continue to make the case for renewable energy and how it can add value to their economies. The outcome that the most attractive country is China is challenging from the perspective of an international investor, since the country maintains a complex inbound foreign investment scheme and particularly in the context of renewables, pursues a political objectives of establishing its own renewables technology industry with significant public support, both financially and with non-financial means. While it thus may be attractive from a general renewables perspective, it appears to be a more challenging country from a foreign investor into renewables perspective.

[16] http://www.ey.com/GL/en/Industries/Power---Utilities/RECAI---All-renewables-index

[17] Ernst & Young: Country Attractiveness Indices. http://www.renewableenergyworld.com/rea/news/article/2010/09/china-is-the-most-attractive-country-for-renewables-investment; retrieved on June 10, 2013

5. PERFORMANCE AND RISK

5.1. PERFORMANCE

The ability to obtain empirical data on the performance of investments varies significantly depending on the asset class. While it is generally easy to track the performance of investments in listed stocks, the performance of unlisted assets of funds is more difficult to gauge. We will therefore limit the quantitative analysis to listed equities and indices of listed equities.

5.1.1. RENEWABLE ENERGY INDICES

Various indices have been created to track the performance of listed renewable energy securities, some examples are quoted below.

WilderHill New Energy Global Innovation Index:
[Bloomberg Ticker: BBGID BBG000VNNY40]

The WilderHill New Energy Global Innovation Index is a "modified dollar weighted index of publicly traded companies active in renewable and low-carbon energy, and which stand to benefit from responses to climate change and energy security concerns. Majority of index members are quoted outside the US. Benchmark value of 100 as of 12/30/02. The index has been created by WilderHill New Energy Finance, LLC."[18]

FTSE ET50 Index:
[Bloomberg Ticker: BBGID BBG000WSLMD6]

The FTSE ET50 Index measures the performance of the "largest 50 companies globally whose core business is in the development and deployment of environmental technologies. This includes alternative energy, water treatment, pollution control and

[18] Bloomberg Ticker NEX, retrieved on November 14, 2012

waste management companies."[19] At least 50% of their business must be derived from ET. Originally designed by Impax in 1999, it has been relaunched as the FTSE ET50 Index. FTSE has set up an independent committee of clean technology and investment professionals to govern the research and management of the FTSE ET50 Index. The Chair is Winston Hickox, former Secretary of the State of California Environmental Protection Agency who also designed and implemented the environmental investment mandates for the California public employees retirement fund, CalPERS.[20]

Credit Suisse Global Alternative Energy Index

Bloomberg Ticker: [BBGID BBG000W48TP6]

The Credit Suisse Alternative Energy Index comprises the 30 largest and most liquid companies from the alternative energy universe worldwide. It comprises 5 sectors: Natural gas; Wind; Solar; Bio-energy/Bio-mass and Geothermal/Hydropower/Fuel cells/Batteries[21]. At the inception date and then at each Rebalancing Date, all five sectors will be capped to 20% to prevent individual sectors from dominating the Index. Stocks selected are major players in their Alternative Energy sectors and/or Alternative Energy activity represents at least 20% of the company's annual sales.[22]

RENIXX World Renewable Energy Industrial Index

The RENIXX World Renewable Energy Industrial Index was established in May 2006 and is the first global stock index, which comprises the performance of the world's 30 largest companies of the renewable energy industry whose weighting in the index is based on the market capitalization. Companies must achieve at least 50 percent of their revenue in the renewable energy industry coming from the wind energy, solar power, biomass,

[19] Bloomberg Ticker ET50, retrieved on November 15, 2012

[20] http://en.wikipedia.org/wiki/Alternative_energy_indexes; retrieved on November 15, 2012

[21] Bloomberg Ticker CSAETRUS, retrieved on November 15, 2012

[22] http://en.wikipedia.org/wiki/Alternative_energy_indexes; retrieved on November 15, 2012

geothermal energy, hydropower or fuel cell sector to be included in the index. It is run by International Economic Platform for Renewable Energies (IWR).[23]

5.1.2. Capital gain

In the following analysis we will focus on the WilderHill New Energy Global Innovation Index, since it provides a transparent description on composition and methodology. The following table includes the names, tickers and percentage weighting of all the assets included in the WilderHill New Energy Global Innovation Index. The composition is as follows:[24]

Ticker	Name	% Weight in the Index
AONE UQ Equity	A123 Systems Inc	0.259925
ABG SQ Equity	Abengoa SA	1.168514
ANA SQ Equity	Acciona SA	1.415698
AYI UN Equity	Acuity Brands Inc	1.483402
AVAV UW Equity	Aerovironment Inc	0.33274
AMRC UN Equity	Ameresco Inc	0.378402
AMSC UW Equity	American Superconductor Corp	0.504331
AMRS UQ Equity	Amyris Inc	0.222558
AOS UN Equity	AO Smith Corp	1.469825
566 HK Equity	Apollo Solar Energy Technology Holdings	0.429364
AYEN TI Equity	Ayen Enerji AS	0.613679
BEP-U CT Equity	Brookfield Renewable Energy Partners LP/	1.761128
1211 HK Equity	Byd Co Ltd	1.1158
CTN GR Equity	Centrotherm Photovoltaics AG	0.613689
1798 HK Equity	China Datang Corp Renewable Power Co Ltd	1.60515
257 HK Equity	China Everbright International Ltd	1.611479

[23] http://en.wikipedia.org/wiki/Alternative_energy_indexes; retrieved on November 15, 2012

[24] Bloomberg Ticker NEX , retrieved on November 16, 2012

658 HK Equity	China High Speed Transmission Equipment	2.28518
916 HK Equity	China Longyuan Power Group Corp	1.711131
956 HK Equity	China Suntien Green Energy Corp Ltd	0.568076
CEN NZ Equity	Contact Energy Ltd	1.726434
CSAN3 BS Equity	Cosan SA Industria e Comercio	1.570554
CVA UN Equity	Covanta Holding Corp	1.618752
CREE UW Equity	Cree Inc	1.71559
300125 CS Equity	Dalian East New Energy Development Co Lt	0.319407
ELON UQ Equity	Echelon Corp	0.393412
EDPR PL Equity	EDP Renovaveis SA	1.424941
ELT UN Equity	Elster Group SE	1.446393
EGPW IM Equity	Enel Green Power SpA	1.581845
EDC PM Equity	Energy Development Corp	1.573312
ENOC UQ Equity	EnerNOC Inc	0.349326
2448 TT Equity	Epistar Corp	1.442662
FKR IM Equity	Falck Renewables SpA	0.423362
FSLR UW Equity	First Solar Inc	1.688008
FUM1V FH Equity	Fortum OYJ	1.425634
FSYS UW Equity	Fuel Systems Solutions Inc	0.248014
FCEL UQ Equity	FuelCell Energy Inc	0.217406
GAM SM Equity	Gamesa Corp Tecnologica SA	1.433487
3800 HK Equity	GCL-Poly Energy Holdings Ltd	1.923276
GEVO UQ Equity	Gevo Inc	0.663151
6674 JT Equity	GS Yuasa Corp	0.779811
GTAT UW Equity	GT Advanced Technologies Inc	1.850885
INE CT Equity	Innergex Renewable Energy Inc	0.488163
IRF UN Equity	International Rectifier Corp	1.472336
ITRI UW Equity	Itron Inc	1.471858
JASO UW Equity	JA Solar Holdings Co Ltd	0.583556
JCI UN Equity	Johnson Controls Inc	1.407715
KSP ID Equity	Kingspan Group PLC	0.417146
KIOR UW Equity	KiOR Inc	0.431407
LXU UN Equity	LSB Industries Inc	2.150903
LYC AT Equity	Lynas Corp Ltd	0.602321
MXWL UQ Equity	Maxwell Technologies Inc	0.28464
6508 JT Equity	Meidensha Corp	1.412844
WFR UN Equity	MEMC Electronic Materials Inc	1.742045
MBTN SE Equity	Meyer Burger Technology AG	1.68013
MCP UN Equity	Molycorp Inc	0.496434
6244 TT Equity	Motech Industries Inc	0.51974
3576 TT Equity	Neo Solar Power Corp	0.717188

1868 HK Equity	Neo-Neon Holdings Ltd	0.490309
110570 KP Equity	Nexolon Co Ltd	0.671118
NIBEB SS Equity	Nibe Industrier AB	1.419275
NDX1 GY Equity	Nordex SE	0.539642
NZYMB DC Equity	Novozymes A/S	1.261187
6255 JT Equity	NPC Inc/Japan	0.302346
ORA UN Equity	Ormat Technologies Inc	1.660913
PPO UN Equity	Polypore International Inc	0.668932
POWI UW Equity	Power Integrations Inc	1.487896
PWER UQ Equity	Power-One Inc	0.478552
PRJ IS Equity	Praj Industries Ltd	0.472526
QCE GY Equity	Q-Cells SE	0.252192
REC NO Equity	Renewable Energy Corp ASA	2.134703
ROCKB DC Equity	Rockwool International A/S	1.580108
RBCN UQ Equity	Rubicon Technology Inc	0.459749
SAFT FP Equity	Saft Groupe SA	0.752882
SMTO3 BS Equity	Sao Martinho SA	0.48225
SECH FP Equity	Sechilienne-Sidec	0.462787
046890 KQ Equity	Seoul Semiconductor Co Ltd	1.649787
S92 GY Equity	SMA Solar Technology AG	1.622735
SWV GY Equity	Solarworld AG	0.491579
SZYM UW Equity	Solazyme Inc	0.387442
STRI UN Equity	STR Holdings Inc	0.409383
SPWR UW Equity	SunPower Corp	1.830708
STP UN Equity	Suntech Power Holdings Co Ltd	0.641302
044490 KQ Equity	Taewoong Co Ltd	0.560802
6013 JT Equity	Takuma Co Ltd	0.457191
TSLA UW Equity	Tesla Motors Inc	1.580763
TSL UN Equity	Trina Solar Ltd	0.522917
2468 HK Equity	Trony Solar Holdings Co Ltd	0.464558
PANL UQ Equity	Universal Display Corp	1.61114
VAGR3 BS Equity	Vanguarda Agro SA	1.587824
VECO UW Equity	Veeco Instruments Inc	1.701699
VER AV Equity	Verbund AG	1.872088
VWS DC Equity	Vestas Wind Systems A/S	1.328714
3393 HK Equity	Wasion Group Holdings Ltd	0.557227
103130 KP Equity	Woongjin Energy Co Ltd	0.781615
2208 HK Equity	Xinjiang Goldwind Science & Technology C	1.944838
YGE UN Equity	Yingli Green Energy Holding Co Ltd	0.499692
ZOLT UW Equity	Zoltek Cos Inc	0.674475

Table 2: Composition of Wilderhill New Energy Global Innovation Index[25]

In the following, the performance of the WilderHill New Energy Global Innovation Index will be analyzed. It opened on December 29, 2000 at 166.05, twelve years later, on November 14, 2012 the index holds at 108.89. In terms of performance since inception, this reflects a loss of 34% of the initial capital and translates to a CAGR (compound annual growth rate) of -4.1% per year).

The following graph shows the performance since inception to November 15, 2012.[26]

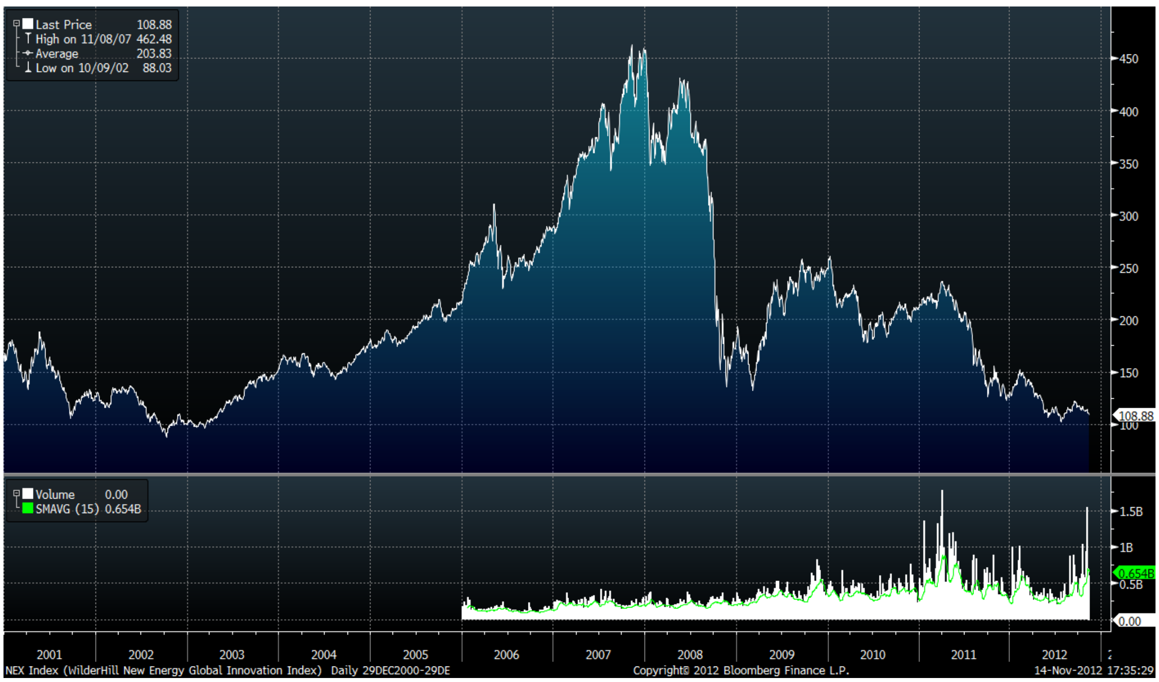

Figure 2: Price and volume performance of Wilderhill New Energy Global Innovation Index[27]

It is necessary to compare this performance to the development of the broader equity market in order to be able to draw conclusions. In order to capture the performance of

[25] Bloomberg Ticker NEX , retrieved on November 16, 2012

[26] Bloomberg Ticker NEX , retrieved on February 16, 2012

[27] Bloomberg Ticker NEX , retrieved on February 16, 2012

global equities, a global index has been chosen. The S&P Global 1200 Index is a composite index, comprised of seven regional and country indices - S&P 500, S&P Europe 350, S&P/TOPIX 150 (Japan), S&P TSX 60 (Canada), S&P/ASX 50 (Australia), S&P Asia 50 and S&P Latin America 40. The S&P Global 1200 is calculated in US dollars. The index is market-cap weighted, free float adjusted outside US. It has been introduced in 1999.[28] The following graph shows its performance for a similar time frame to the one quoted for the WilderHill index above. Both indices are price return indices only, i.e. do not take into account any dividends distributed.

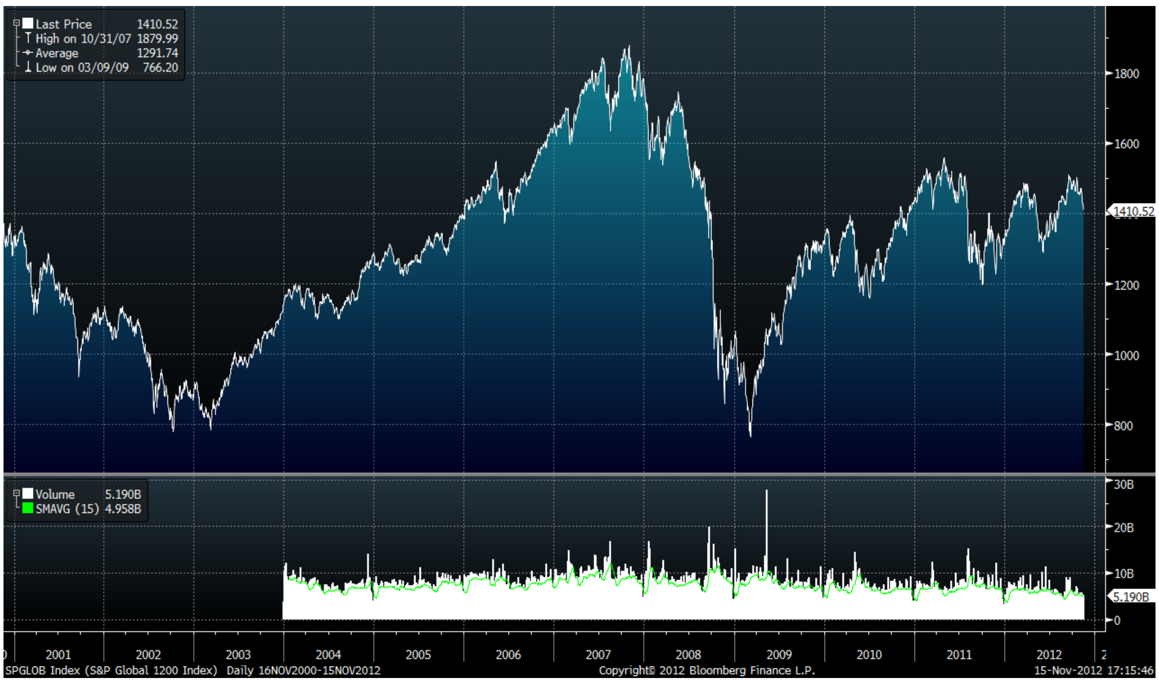

Figure 3: S&P Global 1200[29]

At first sight, the graphs appear to be similar, both show an initial decrease triggered by the general drop in equities following the burst of the Internet bubble in 1999/2000, the positive economic development of the years 2003 to 2007 and the sharp drop triggered by the global financial crisis 2008.

When indexing both graphs to the inception date of the WilderHill index, it becomes apparent how significantly the WilderHill index outperforms the S&P Global 1200 in the

[28] Bloomberg Ticker SPGLOBAL , retrieved on November 17, 2012

[29] Bloomberg Ticker SPGLOBAL , retrieved on November 17, 2012

years 2003 – 2007, followed by a much more pronounced reaction triggered by the financial crisis.

Figure 4: WilderHill New Energy Global Innovation Index versus S&P Global 1200

Also, since the WilderHill index has further dropped significantly since the summer of 2011, its overall performance is now with a CAGR of -4.1% p.a. significantly worse than the S&P Global 1200 which averages an annual growth rate of 0.6% from the end of 2000 to November 15, 2012.

5.1.3. Dividend yield

As both indices are price return indices only, ignoring distributed dividends, dividend yields should be analyzed separately.

The WilderHill Index reports dividend yields as follows:

	CY 2013	CY 2012	CY 2011	CY 2010	CY 2009	CY 2008
Dividend Yield	1.69	1.51	1.72	0.93	0.83	1.51

These compare to dividend yields reported by the S&P Global 1200 index as follows:

	CY 2013	CY 2012	CY 2011	CY 2010	CY 2009	CY 2008
Dividend Yield	3.21	2.99	2.99	2.47	2.58	4.07

Therefore, also in terms of dividend yield, the WilderHill Index significantly underperformed the broader market. In this context it should be mentioned that most SWFs are in a status of capital accumulation without the need to immediately generate cash flows to serve the countries' budgets. Therefore current dividend yield are typically not of the same central importance as e.g. for pension funds that need to meet current cash outflow patterns.

5.1.4. Individual company performance

In order to better understand the individual drivers behind the broader development captured by the indices, it is helpful to examine individual companies. Solarworld AG is an integrated solar PV system manufacturer heavily impacted by the distortions the PV market has faced and hence an example for a broader development that has negatively impacted almost all solar PV companies in the recent years.

Solarworld AG

Solarworld AG had its IPO in 1999 at a price of 0.56 EUR. At its peak in 2007, the shares traded at EUR 47, the market capitalization of Solarworld at the time was EUR 5.2bln. In May 2013, the shares traded again around EUR 0.5 per share. The entire company was then worth c EUR 80mln. What had happened?

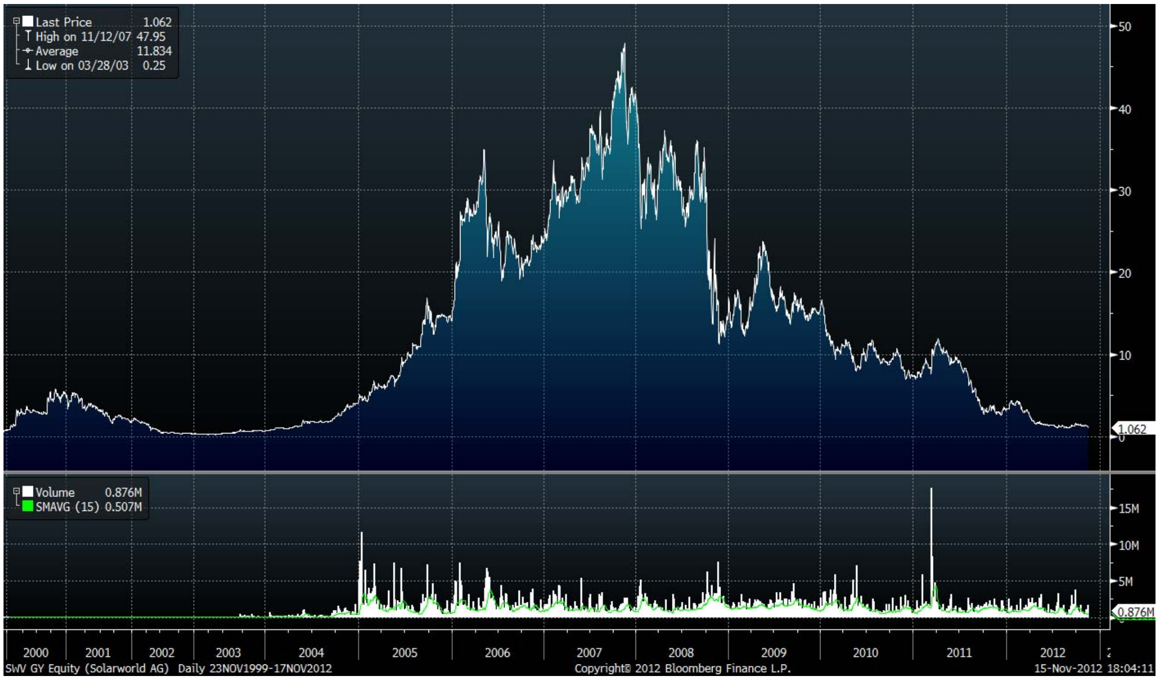

Figure 5: Price and volume performance of SolarWorld AG[30]

SolarWorld is an integrated solar manufacturing company producing wafers, cells, modules and systems from its facilities in the US and Germany.[31]

The significant competition by Chinese manufacturers as well as the over-capacity in the market has led to dramatically shrinking margins for integrated manufacturers. Between September 2009 and May 2013 spot prices for PV grade polysilicon dropped from 70 USD to 17 USD/kg according to the Bloomberg New Energy Finance Survey (Polycrystalline hyper pure silicon with minimal purity 6N. The values are from the Bloomberg New Energy Finance Solar Spot Price Index. Industry manufacturers submit pricing data which is used to create weekly average prices for the component. The Index provides overall average prices as well as China and International prices.)[32]

[30] CitiBank Research Report, SolarWorld (SWVG.DE) 16 August 2012
[31] CitiBank Research Report, SolarWorld (SWVG.DE) 16 August 2012

[32] Bloomberg New Energy Finance, BNEF Survey Spot Polysilicon, Bloomberg Reference SSPFPSNO

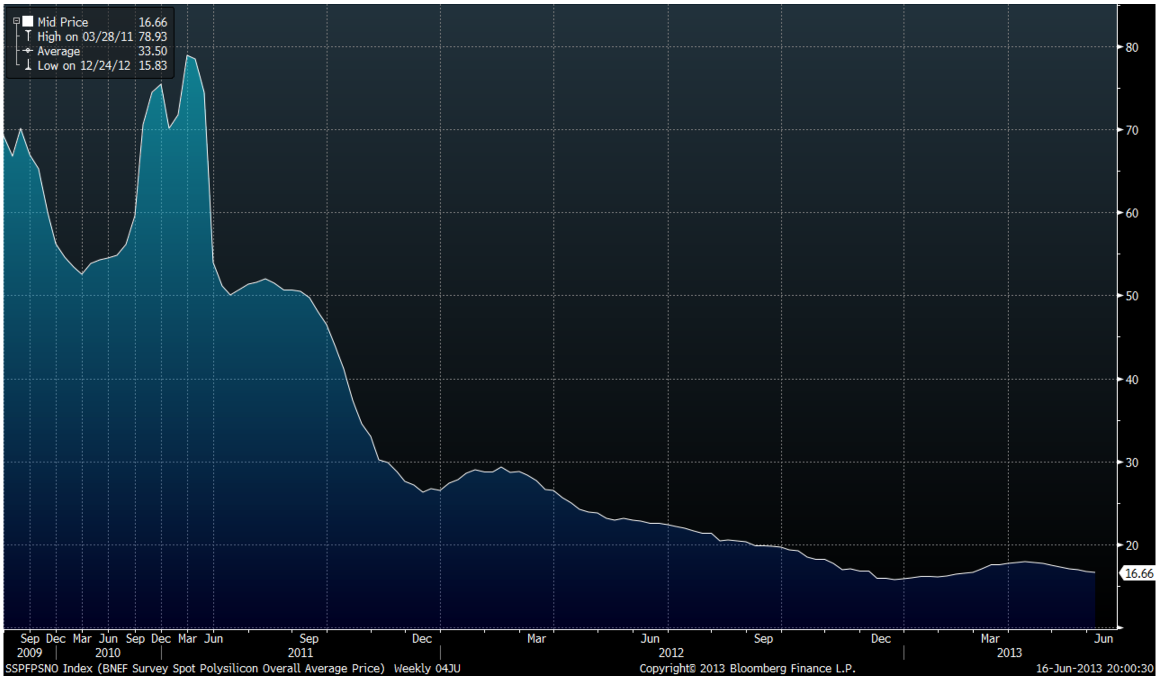

Figure 6: Bloomberg New Energy Finance Solar Spot Price Index[33]

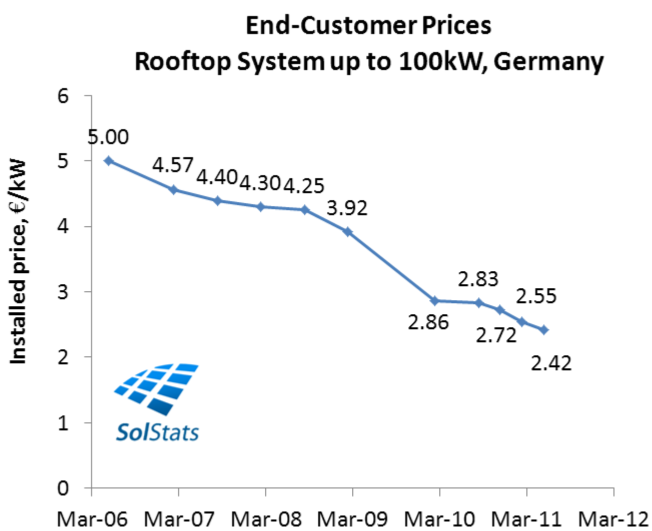

Figure 7: End consumer prices Rooftop systems, Germany[34]

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[33] Bloomberg New Energy Finance, BNEF Survey Spot Polysilicon, Bloomberg Reference SSPFPSNO

[34] SolStats http://www.solstats.com/blog/solar-energy/solar-panel-prices-drop-by-half-over-the-last-5-years/ retrieved on June 16, 2013

This development has had positive impact on the end-consumer prices. In the 5 year period March 2006 to March 2012, end customer prices for rooftop systems in Germany have dropped by more than 50% according to SolStats, an independent website covering solar statistics[35] from EUR 5.00/kW to EUR 2.42/kW.

While the positive effect of the price decline on demand could have supported module sales, SolarWorld was negatively impacted. The key issue for SolarWorld is that its manufacturing facilities remain in higher cost regions (Germany and the US, i.e. not Asia) combined with the fact that the facilities are not particularly new, and hence are not using lowest-cost equipment.

These factors (combined with the company's views on the financial support of and dumping by Chinese companies) mean that it is hard for the company to compete against lower cost Asian manufacturers.

At the time of writing the strong supply/demand imbalance for polysilicon seems to ease [36], it is still unclear though what impact if any this development could have on Solarworld. The realized losses incurred by investors since 2007 are obviously unaffected by any potential turnaround of the underlying market.

5.2. Risk

5.2.1. Quantitative assessment of risk

Risk is generally defined as uncertainty of future outcomes. Various measures are available which will briefly described in the following.

Variance/Standard Deviation of expected returns: The variance of expected returns measures the dispersion of returns around the expected value. Standard Deviation is the square root of variance.

[35] SolStats http://www.solstats.com/blog/solar-energy/solar-panel-prices-drop-by-half-over-the-last-5-years/ retrieved on June 16, 2013

[36] Macquarie Equities Research: Solar polysilicon: Calling the Inflection Point, 7 June 2013

Alternative measures include the range of returns, i.e. the range from smallest to largest return, or semi variance, which only reflects negative outcomes, i.e. returns below the expected value under the assumption that investors are less concerned with positive deviations from the expected value. The measure most widely used in finance theory is variance or standard deviation.[37]

In the following, we will examine the risk of a Renewable Energy Portfolio versus the risk in a broader market portfolio. For these purposes we will return to the WilderHill New Energy Global Innovation Index.

The returns on the WilderHill Index in the years 2009 to 2012 have been as follows (total returns assuming reinvestment of dividends)[38]

	Actual Returns (Ri)
2009	40.86%
2010	21.56%
2011	-24.82%
2012	-27.96%

The variance is measured as: $\sigma^2 = \sum_{i=1}^{n} [R_i - E(R_i)]^2 P_i$

The standard deviation is measured as: $\sigma = \sqrt{\sum_{i=1}^{n} [R_i - E(R_i)]^2 P_i}$

Variance and standard deviation of the returns of the WilderHill Index referred to above, therefore are:

[37] F. Reilly, C. Brown: Investment Analysis and Portfolio Management, 9th edition

[38] Bloomberg NEX Index retrieved June 17, 2013

	Actual Returns (R_i)	Probability P_i	Expected return $E(R_i)$	$R_i - E(R_i)$	$(R_i - E(R_i))^2$	$(R_i - E(R_i))^2 P_i$
2009	40.86%	0.1	4.1%	36.77%	0.135206	0.013521
2010	-13.70%	0.3	-4.1%	-9.59%	0.009198	0.002759
2011	-38.15%	0.3	-11.4%	-26.71%	0.071331	0.021399
2012	-4.17%	0.3	-1.3%	-2.92%	0.000852	0.000256
			-12.7%			0.037935

Variance = 0.03793

Standard deviation = 0.19477

This standard deviation should be compared to the standard deviation of market return as measured by the S&P Global 1200 (the same index that has been used above in measuring market performance). The actual returns in the same period 2009 to 2012 are:[39]

	Actual Returns (Ri)
2009	31.06%
2010	11.83%
2011	-4.77%
2012	16.87%

The variance and standard deviation derived in the same manner as above are:

[39] Bloomberg SPGLOB Index retrieved June 18, 2013

	Actual Returns (R_i)	Probability P_i	Expected return $E(R_i)$	$R_i - E(R_i)$	$[R_i - E(R_i)]^2$	$[R_i - E(R_i)]^2 P_i$
2009	31.06%	0.1	3.1%	27.95%	0.078143	0.007814
2010	11.83%	0.3	3.5%	8.28%	0.006857	0.002057
2011	-4.77%	0.3	-1.4%	-3.34%	0.001115	0.000334
2012	16.87%	0.3	5.1%	11.81%	0.013945	0.004184
			10.3%			0.014390

Variance = 0.01439

Standard deviation = 0.11996

The above (simplified) calculation provides a quantitative validation of the generally perceived higher level of risk of investments in renewable energy companies.

Technical measures of risk however, have in the author’s view significant shortcomings when it comes to describe the underlying risk factors. These risk factors which need to be very well understood are quite different in renewable energy compared to other asset classes. It is therefore worth to examine them further.

5.2.2. Underlying Risk factors

5.2.2.1. Political risk

Most renewable energy projects are economically dependent on government guaranteed support mechanisms as the cost of generation is (so far) typically not competitive with electricity pool prices paid in the open market. Different countries have adopted different mechanisms, ranging from Feed in Tariffs to renewable quotas (obligations on the utilities to procure a given fraction of the electricity they sell to customers to come from renewable sources) to Carbon credits to Capex subsidies.

The various subsidy forms have different features that carry different levels of risk. The most relevant one relates to the setting of Feed in Tariffs. Feed in Tariffs are set in advance and need to take the development of technology cost (i.e. typically decreases in technology cost) as well as power price developments into account. In a rapidly changing environment, suboptimal pricing of Feed In Tariffs will likely occur. The example of the Spanish solar feed in tariff illustrates the risk that can be associated with this type of support mechanism.

Case example: Spanish tariff deficit

The electricity system in Spain has accumulated a staggering deficit of over EUR 30 billion by the end of 2012. The flawed incentive system thus constitutes an issue that has significant impact for the overall public household for Spain. Per 2013, a part of the tariff deficit has been recovered but the outstanding debt still amounts at EUR 22 billion, this relates to over 2% of the Spanish Gross Domestic Product (GDP).[40]

How could a country whose utilities have combined revenues (including gas) of c EUR 50bln have accumulated a system loss of EUR 30bln? This debt derives from the financing of the difference between costs and revenues from regulated activities, accumulated in the years 2002 - 2012. An important component of the electricity costs is the support to renewable energy. Subsidies in the form of feed-in tariffs (FIT) for different types of technologies have been successful in fostering investment in clean energy and have produced a large increase in renewable capacity. To illustrate the growth in the Spanish installed base the following numbers should be considered: In 2005, renewable energy stood at 15% of all generation capacity; in 2011, 33% and it is expected to reach 41% by 2020.[41] This is a remarkable increase and from a pure GHG perspective desirable. However it came at significant cost to the system. This increase was larger than expected, as it was not considered at the time the feed-in tariffs were established that the cost of some of these technologies would decrease so rapidly, hence rendering these projects hugely attractive. In addition, the number of hours of

[40] María Paz Espinosa: Understanding Tariff Deficit and Its Challenges *DFAE-II WP Series* Department of Foundations of Economic Analysis II ; University of the Basque Country UPV/EHU

[41] International Energy Agency (IEA), *World Energy Outlook 2012*

production was also underestimated. The photovoltaic target was 400 MW, and 500 MW for thermo solar. Actual capacity development however resulted in 4,047 MW and 1,049 MW for thermo solar energy by the end of 2011.[42] In 2009, the Spanish parliament passed legislation to eliminate the tariff deficit accumulation. It also set up a securitization vehicle - Fondo de Amortización del Déficit Eléctrico (FADE) - to finance the accumulated deficit. The role of FADE is to act as an intermediary with the capital markets allowing the government to securitize (part of) the tariff deficit and to compensate the utilities. Currently, the utilities are carrying the risk and cost of the tariff deficit as it constitutes accounts receivable on their balance sheets. The tariff deficit receivables recognized by law and transferable to FADE totaled €16.69 billion as of the end of 2010 (including the government's 2011 tariff deficit target of €3 billion).[43] One of several measures to reduce the tariff deficit has been to decrease the feed in tariff, also retroactively for existing projects. The Spanish government announced in 2013 that feed in tariffs for solar PV installations commissioned in 2010 will be cut to EUR 0.349/kWh for integrated systems.[44]

A further example illustrates another area of risk associated with governmental subsidies. The US Department of Energy is providing funding for renewable energy and clean technology companies and projects. It is inevitable that significant support mechanisms will become contentious issues in the political debate, as has been illustrated in the presidential campaign 2012 in the US. Governmental loans, e.g. Solyndra Inc., Tesla Motors Inc., Fisker Automotive Inc., and loan guarantees have come under fire from lawmakers since solar panel company Solyndra filed for bankruptcy in September after receiving a US$535 million government loan in 2009. Republican presidential candidate Mitt Romney accused President Barack Obama for having "shoveled $1 billion out the door" to Fisker and Tesla Motors. He called on Congress to investigate how taxpayer money was spent so poorly. "You think there'd be a few bumps in the road. And then you get entangled in a political campaign in America,"

[42] María Paz Espinosa: Understanding Tariff Deficit and Its Challenges *DFAE-II WP Series* Department of Foundations of Economic Analysis II ; University of the Basque Country UPV/EHU

[43] Standard & Poors: How The Spanish Electricity Tariff Deficit And Political Uncertainties May Affect The Ratings On Spanish Utilities, January 12, 2012

[44] http://www.pv-tech.org/news/spain_announces_retroactive_fit_cuts, retrieved on June 23, 2013

Henrik Fisker, founder and CEO of Fisker Automotive said [45]. Negative public press, additional workload to satisfy public scrutiny and less predictable financing decisions by governmental decision makers are the consequence which particularly early stage companies can have significant negative impact.

5.2.2.2. SINGLE ASSET RISK

In an industry that is still nascent, but which requires projects of significant size, it can happen that a single project has a material impact on the success or failure of the entire company. To illustrate this issue, a case example on a formerly leading German solar company will be introduced.

Case example: Solar Millenium AG

The company was founded in 1986 and conducted an IPO in July 2005. Its share price development is shown below.[46]

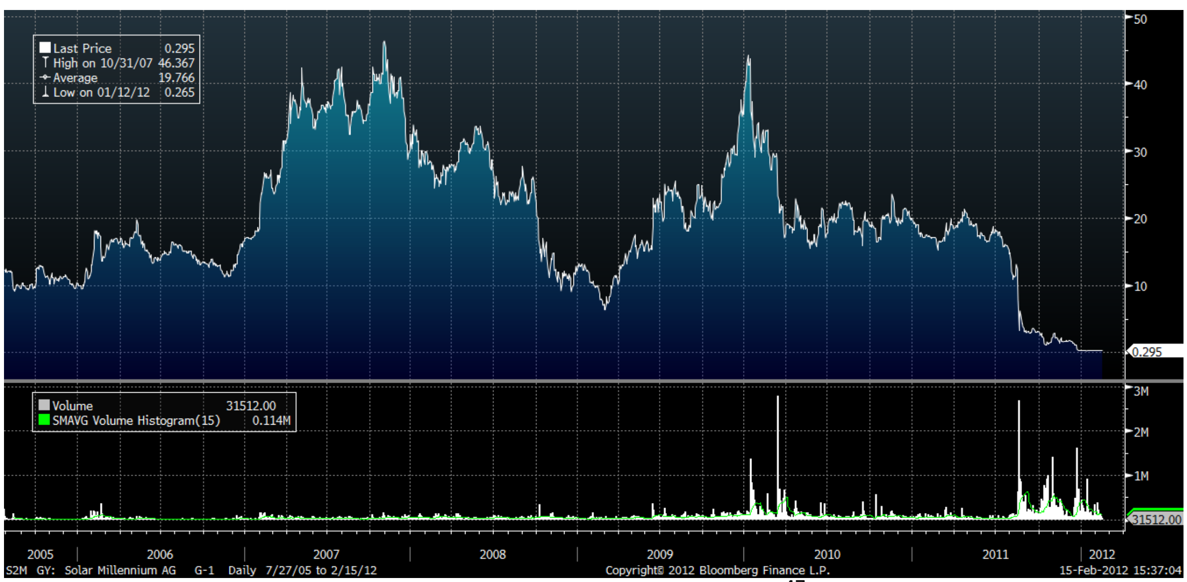


Figure 8: Price and volume performance Solar Millenium AG[47]

[45] Reuters, February 15, 2012 (Reporting By Edwin Chan in Los Angeles and Ben Klayman in Detroit. Editing by Jane Merriman)

[46] Bloomberg Ticker S2M GY, retrieved on February 15, 2012

[47] Bloomberg Ticker S2M GY, retrieved on February 15, 2012

In autumn 2010, the US administration approved a plan to build a large scale solar power plant in Blythe, California. Solar Millennium was selected to realize four solar power plants with a total capacity of 1,000 MW, at the time the the largest solar energy facility in the world. In April 2011, US Secretary of Energy, Dr. Steven Chu, offered Solar Millennium a conditional commitment for a US$ 2.1 billion loan guarantee. In June 2011, a foundation laying ceremony was conducted. The project was designed as a 1,000 MW CSP project using parabolic trough technology, a technology Solar Millennium is experienced with. However, subsequently the fiscal support system in California was changed rendering the project more attractive as a PV rather than a CSP project. Solar Millennium however is a CSP company and changing to PV would have meant at least to take a significant PV player into the consortium. In the end, the Solar Millennium was unable to successfully sell the project and in December 2011 filed for bankruptcy protection.

5.2.2.3. TECHNOLOGY RISK

While the performance in established industries, such as on shore wind, can typically be insured through vendor guarantees or similar instruments, thus reducing the risk exposure of investors, this is not necessarily the case for more nascent technologies such as off shore wind or newer generation PV installations. If considered more broadly an element of technology risk is also the fact that in some countries renewables have become a significant factor in the generation pool and further additions require significant transformation to the power transmission networks and concepts. This is particularly the case in off shore wind, where in addition to technological issues (corrosion under sea water conditions etc.), grid connection issues are a critical topic for investors.

5.2.3. COVARIANCE

Markowitz Portfolio Theory stipulates that the return of a portfolio of assets can be described by the individual returns of its constituent assets whereas the risk can be described by the standard deviation of the individual assets and, importantly, by the covariance between the rates of returns for the individual assets. [48] Adding assets with

[48] F. Reilly, C. Brown: Investment Analysis and Portfolio Management, 9th edition

negative or low positive covariance of the returns to a portfolio can result in lower levels of portfolio risk at given levels of return. Therefore it is interesting to analyze the covariance between the returns of renewable energy assets and a broader market portfolio, essentially to identify if there is a 'diversification benefit' of adding renewables to a given equities portfolio.

The covariance of returns of two assets is measured as:

$$Cov_{ij} = E\{[R_i - E(R_i)][R_j - E(R_j)]\}$$

As above, in practice the average of actually observed returns is used as the expected value of returns.

In order to standardize the outcome, the covariance is divided by the product of the standard deviations of the two distributions, the outcome is the correlation coefficient r_{ij}. It is defined as:

$$r_{ij} = \frac{Cov_{ij}}{\sigma_i \sigma_j}$$

In order to arrive at a more reliable data set the returns for the WilderHill and the S&P Global 1200 indices will be taken on a monthly rather than on the yearly basis as applied above.

The monthly total returns of the two indices are listed in the table below.[49] When the covariance formula is applied to this data series, it becomes

$$Cov_{ij} = 1/47 \sum_{i=1}^{48} [R_i - E(R_i)][R_j - E(R_j)]$$

	WilderHill New Energy Global Innovation		S&P Global 1200	
	Actual Monthly Returns (Ri)	(Ri - E(Ri))	Actual Monthly Returns (Rj)	(Rj - E(Rj))
1/1/2009	0	0.1983	0	-1.38346
2/1/2009	-12.5818	-12.3835	-10.2081	-11.59156
3/1/2009	11.2959	11.4942	8.0069	6.62344
4/1/2009	21.6877	21.8860	11.3705	9.98704
5/1/2009	16.608	16.8063	9.5899	8.20644
6/1/2009	-3.6062	-3.4079	-0.627	-2.01046

[49] Bloomberg NEX Index and SPGLOB Index retrieved June 18, 2013

7/1/2009	6.3881	6.5864	9.0532	7.66974
8/1/2009	-1.3047	-1.1064	3.7306	2.34714
9/1/2009	7.3301	7.5284	4.3203	2.93684
10/1/2009	-6.6335	-6.4352	-1.7084	-3.09186
11/1/2009	3.0063	3.2046	4.482	3.09854
12/1/2009	4.391	4.5893	1.8534	0.46994
1/1/2010	-10.5288	-10.3305	-4.4775	-5.86096
2/1/2010	-4.3716	-4.1733	1.4843	0.10084
3/1/2010	4.9401	5.1384	6.311	4.92754
4/1/2010	-0.5638	-0.3655	0.118	-1.26546
5/1/2010	-14.4842	-14.2859	-9.3709	-10.75436
6/1/2010	-3.888	-3.6897	-3.441	-4.82446
7/1/2010	10.6206	10.8189	8.4853	7.10184
8/1/2010	-6.8098	-6.6115	-3.8891	-5.27256
9/1/2010	11.5312	11.7295	9.3208	7.93734
10/1/2010	0.9991	1.1974	3.8474	2.46394
11/1/2010	-5.9023	-5.7040	-2.286	-3.66946
12/1/2010	7.6793	7.8776	7.4189	6.03544
1/1/2011	1.1055	1.3038	2.2945	0.91104
2/1/2011	2.1763	2.3746	3.4439	2.06044
3/1/2011	7.7991	7.9974	-0.7042	-2.08766
4/1/2011	-1.1756	-0.9773	4.2886	2.90514
5/1/2011	-6.0761	-5.8778	-2.0216	-3.40506
6/1/2011	-5.9745	-5.7762	-1.55	-2.93346
7/1/2011	-5.5042	-5.3059	-1.9855	-3.36896
8/1/2011	-10.6854	-10.4871	-7.1658	-8.54926
9/1/2011	-21.5648	-21.3665	-8.6434	-10.02686
10/1/2011	11.6939	11.8922	10.5294	9.14594
11/1/2011	-8.7447	-8.5464	-2.2046	-3.58806
12/1/2011	-6.7688	-6.5705	0.0864	-1.29706
1/1/2012	9.2131	9.4114	5.1895	3.80604
2/1/2012	4.0173	4.2156	4.8025	3.41904
3/1/2012	-5.3941	-5.1958	1.4095	0.02604
4/1/2012	-6.6318	-6.4335	-1.0818	-2.46526
5/1/2012	-12.035	-11.8367	-8.46	-9.84346
6/1/2012	3.9032	4.1015	5.0764	3.69294
7/1/2012	-7.7622	-7.5639	1.4902	0.10674
8/1/2012	6.4848	6.6831	2.4151	1.03164
9/1/2012	3.3704	3.5687	2.8466	1.46314
10/1/2012	-3.7194	-3.5211	-0.5271	-1.91056
11/1/2012	-0.3176	-0.1193	1.3021	-0.08136

12/1/2012	7.2677	7.4660	2.1908	0.80734
Mean	-0.1983		1.3835	

$$Cov_{ij} = 1/47 \quad \sum_{t=1}^{48} [R_{it} - E(R_{it})][R_{jt} - E(R_{jt})] = 1/47 \quad 1{,}933 = 41.13$$

The correlation coefficient is:

$$r_{ij} = \frac{Cov_{ij}}{\sigma_i \sigma_j} = \frac{41.13}{8.63 \times 5.28} = 0.90$$

The correlation coefficient is always a number between -1 and +1, -1 for a perfect negative relationship and +1 for a perfect positive relationship. A coefficient of 0.9 therefore is an indicator for a strong positive relationship in the development of returns between the two indices.

This result also makes intuitive sense. All renewable energy companies are listed equities and face the same degree of equity market risk as the broader market index. Individual risk factors have exacerbated the negative outcomes, i.e. depressed returns below the average market returns. When a broader equities market movement has occurred though, it typically also affects listed renewable energy stocks.

6. INVESTMENT CRITERIA OF SWF INSTITUTIONS

6.1. DESCRIPTION OF SWFS

Generally speaking, SWFs are investment funds, directly or indirectly state owned, that invest national budget surpluses. The Sovereign Wealth Fund Institute defines SWF as: "[…] a state-owned investment fund or entity that is commonly established from balance of payments surpluses, official foreign currency operations, the proceeds of privatizations, governmental transfer payments, fiscal surpluses, and/or receipts resulting from resource exports. The definition of sovereign wealth fund exclude, among other things, foreign currency reserve assets held by monetary authorities for the traditional balance of payments or monetary policy purposes, state-owned enterprises (SOEs) in the traditional sense, government-employee pension funds (funded by employee/employer contributions), or assets managed for the benefit of individuals".[50]

The Sovereign Wealth Fund Institute has published a list of SWFs including an estimate of the respective fund sizes. The list is reproduced below: [51]

Country	Sovereign Wealth Fund Name	Assets $Billion	Inception	Origin
Norway	Government Pension Fund – Global	$656.2	1990	Oil
UAE – Abu Dhabi	Abu Dhabi Investment Authority	$627	1976	Oil
China	SAFE Investment Company	$567.9**	1997	Non-Commodity
Saudi Arabia	SAMA Foreign Holdings	$532.8	n/a	Oil

[50] Sovereign Wealth Fund Institute, http://www.swfinstitute.org/what-is-a-swf/; retrieved on November 12, 2012

[51] Sovereign Wealth Fund Institute http://www.swfinstitute.org/fund-rankings/; retrieved on November 12, 2012

China	China Investment Corporation	$482	2007	Non-Commodity
Kuwait	Kuwait Investment Authority	$296	1953	Oil
China Hong Kong	Hong Kong Monetary Authority Investment Portfolio	$293.3	1993	Non-Commodity
Singapore	Government of Singapore Investment Corporation	$247.5	1981	Non-Commodity
Singapore	Temasek Holdings	$157.5	1974	Non-Commodity
Russia	National Welfare Fund	$149.7*	2008	Oil
China	National Social Security Fund	$134.5	2000	Non-Commodity
Qatar	Qatar Investment Authority	$115	2005	Oil
Australia	Australian Future Fund	$78.2	2006	Non-Commodity
UAE – Dubai	Investment Corporation of Dubai	$70	2006	Oil
UAE – Abu Dhabi	International Petroleum Investment Company	$65.3	1984	Oil
Libya	Libyan Investment Authority	$65	2006	Oil
Kazakhstan	Kazakhstan National Fund	$61.8	2000	Oil
Algeria	Revenue Regulation Fund	$56.7	2000	Oil
UAE – Abu Dhabi	Mubadala Development Company	$53.1	2002	Oil
South Korea	Korea Investment Corporation	$43	2005	Non-Commodity
US – Alaska	Alaska Permanent Fund	$42.3	1976	Oil

Iran	National Development Fund of Iran	$40	2011	Oil & Gas
Malaysia	Khazanah Nasional	$34	1993	Non-Commodity
Azerbaijan	State Oil Fund	$32.7	1999	Oil
Brunei	Brunei Investment Agency	$30	1983	Oil
France	Strategic Investment Fund	$28	2008	Non-Commodity
US – Texas	Texas Permanent School Fund	$25.5	1854	Oil & Other
Ireland	National Pensions Reserve Fund	$17.5	2001	Non-Commodity
Canada	Alberta's Heritage Fund	$15.9	1976	Oil
New Zealand	New Zealand Superannuation Fund	$15.5	2003	Non-Commodity
Chile	Social and Economic Stabilization Fund	$14.7	2007	Copper
US – New Mexico	New Mexico State Investment Council	$14.3	1958	Non-Commodity
Brazil	Sovereign Fund of Brazil	$11.3	2008	Non-Commodity
East Timor	Timor-Leste Petroleum Fund	$11.1	2005	Oil & Gas

Table 3: Sovereign Wealth Funds by size of Assets under Management[52]

Partly driven by the high commodity price environment, the fund sizes have increased considerably over the last years. The quarterly tracking of total SWF Assets by the SWF Institute shows an aggregate of between US$ 3.5tln to US$ 4tln before the financial crisis 2008, which reduced assets US$0.4tln. Since then, aggregate fund size has

[52] Sovereign Wealth Fund Institute http://www.swfinstitute.org/fund-rankings/; retrieved on November 12, 2012

increased to US$ 4.8tln at the end of 2011. During 2012, the amount has further increased to US$ 5.1tln (September 2012).[53]

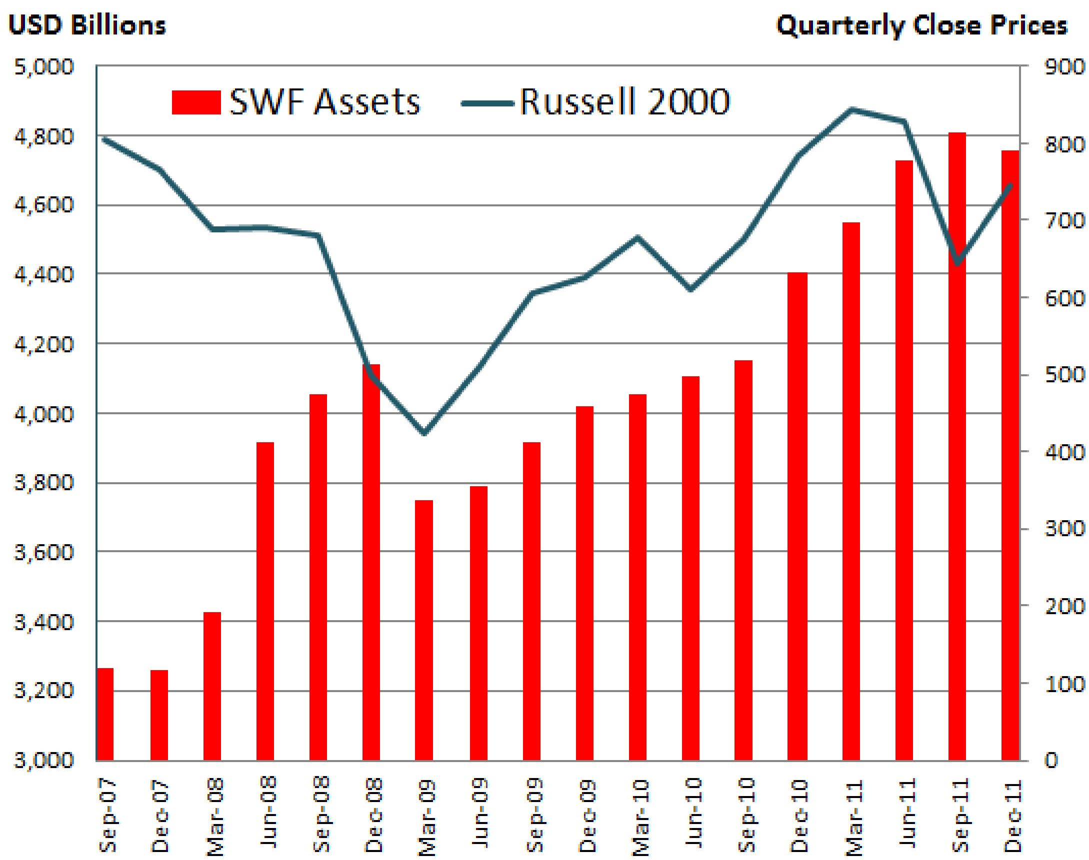


Figure 9: Aggregate Fund size vs. Russell 2000[54]

Clearly therefore, it terms of volume, SWFs have become a very relevant player on the international principal investment landscape. It is the total size of available funds that makes them stand out but also the particular investment criteria, which we shall turn to in the following section.

[53] Sovereign Wealth Fund Institute http://www.swfinstitute.org/fund-rankings/; retrieved on November 12, 2012

[54] Sovereign Wealth Fund Institute http://www.swfinstitute.org/fund-rankings/; retrieved on November 12, 2012

6.2. STRATEGY AND ASSET ALLOCATION

Unsurprisingly, Sovereign Wealth Funds have a varying degree of disclosure about their investment strategy, objectives, asset allocation or governance. Various institutions are surveying SWFs, e.g. the Sovereign Investment Lab, a group of researchers at the Universita Commerciale Luigi Bocconi. The Lab tracks trends of sovereign investment fund activity and conducts research on the rise of states in the global investment arena. The Sovereign Wealth Fund Institute is publishing a transparency index and other forms of research on SWF activity. Various scholarly articles have examined the relationship between political relations and SWF decision making, e.g. Knill, Bong-Soo, Mauk.[55]

Generally, it can be differentiated between passive investment strategies that are focused on achieving an optimal risk weighted financial return and 'activist' or 'strategic' investment strategies that follow a broader set of objectives, such as increasing the political influence of the country, supporting the development of the national industry or facilitating trade in sectors that are critical to the host country.

The Sovereign Wealth Fund Institute has published the following graph, ranking SWFs according to the observed level of transparency and investment strategy.[56]

[55] Knill, April, Bong-Soo Lee, Nathan Mauck: Bilaterial political relations and sovereign wealth fund investment. In: Journal of Corporate Finance 18(1): 108-123.

[56] Sovereign Wealth Fund Institute: SWF Strategy and Transparency; http://www.swfinstitute.org/swf-research/sovereign-wealth-funds-strategy-and-transparency-jan-2011-update/. Retrieved on June 19, 2013

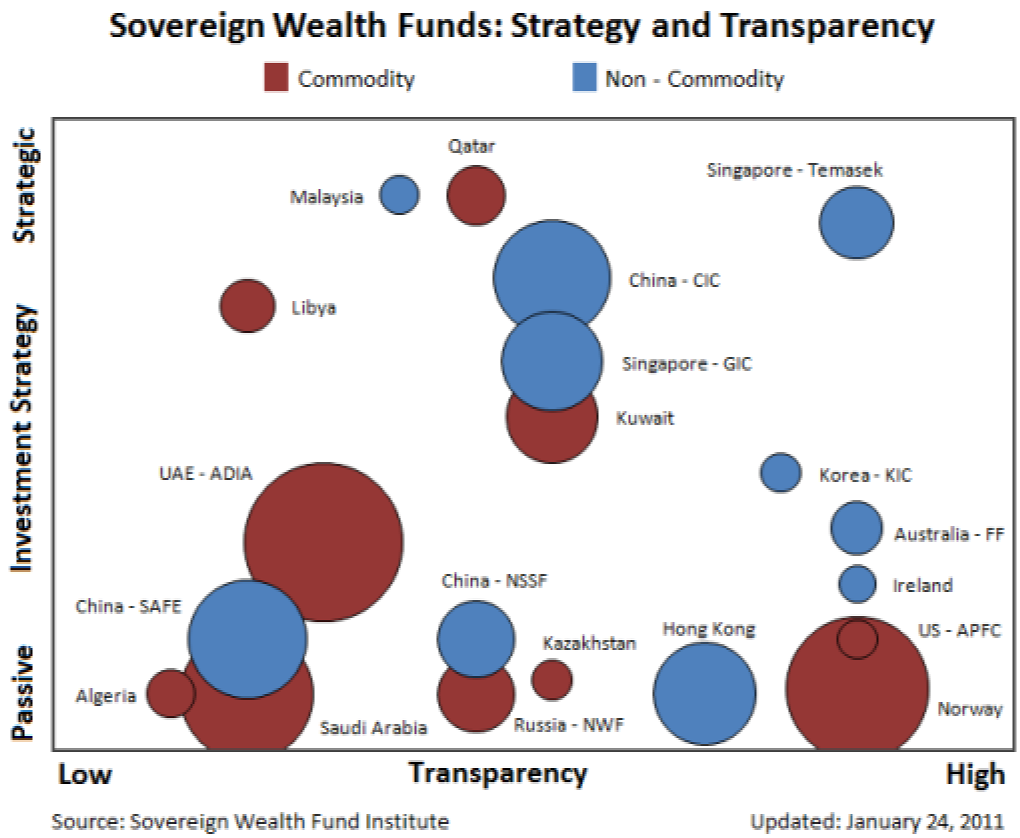


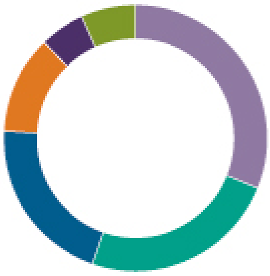
Figure 10: Transparency vs. Investment Strategy of SWFs[57]

Regarding SWFs with relatively high levels of transparency, Temasek is typically an example of a strategically acting fund whereas the Government Pension Fund of Norway is a transparent institution prototypical for a passive investor.

Temasek Holding is the SWF of Singapore. It is publishing the following statistic on asset allocation across sectors and asset classes.[58]

[57] Sovereign Wealth Fund Institute: SWF Strategy and Transparency; http://www.swfinstitute.org/swf-research/sovereign-wealth-funds-strategy-and-transparency-jan-2011-update/. Retrieved on June 19, 2013

[58] http://www.temasek.com.sg/portfolio; retrieved on June 12, 2013



Sector[1] (%)	2012	2011
Financial Services	**31**	36
Telecommunications, Media & Technology	**24**	22
Transportation & Industrials	**21**	23
Life Sciences, Consumer & Real Estate	**12**	11
Energy & Resources	**6**	3
Others	**6**	5

Liquidity (%)	2012	2011
Listed large blocs (≥20% share)	**37**	39
Liquid & sub-20% listed assets	**36**	39
Unlisted assets	**27**	22

Figure 11: Temasek Asset Allocation Statistic[59]

From a sector perspective, Financial Services, TMT (Telecommunications, Media & Technology) and Transport & Industrials account for more than 75% of total exposure. Energy & Resources is represented only with 6%. One reason behind the low sector weighting for energy could be that the exposure consists primarily of utilities, which are facing low growth rates and high cash yields. This could be taken as a sign that Temasek is more interested in growth at the expense of current cash yields, which as a strategy would appear sensible for a long term oriented fund. From an asset class perspective, the fund is heavily focused on long equity exposure, i.e. building its return expectations around the long term appreciation of stocks. Historical evidence also suggests that over the long term , stocks have outperformed all other asset classes and therefore this strategy appears to be sensible as well. There is a 27% allocation to unlisted assets, which comprise private equity investments but also infrastructure project exposure. Following from this individual example and other observations, we shall draw inferences on the investment criteria of Sovereign Wealth Funds more generally below.

[59] http://www.temasek.com.sg/portfolio; retrieved on June 12, 2013

6.3. Investment criteria

As we have seen above, investment strategies between Sovereign Wealth Funds can vary. Following the categorization introduced above and applied by the Sovereign Wealth Fund Institute we shall differentiate between purely return driven vs. strategically oriented funds. This of course is a simplification and the author is proposing a slightly more granular description

The following dimensions appear relevant when defining investment criteria and each of them will be commented on in the following:

- Risk / return
- Dividend yield
- Target Holding period
- Investment size
- Oil/gas counter-cyclicality
- Industrial development

Risk / return:

- Returns are clearly a very relevant measure that very often is also reflected in the incentive systems of fund management. The question (and divergence between the more professionally managed funds and others) are in the (i) risk adjustment of returns, (ii) the time horizon, and (iii) the measurement of returns against benchmarks.

Dividend yield:

- The life of the asset that is typically underlying the income stream feeding Sovereign Wealth Funds varies significantly. Oil and gas reserve life is a difficult measure, as it is influenced by production rates which can be changed, future discoveries and uncertainty about the credibility of existing reservoir and recoverability data. They range between 10 and 200 years from country to country. Clearly, a country that is facing a depletion of its resources within a decade has to worry about cash contribution of its SWF to the state's budget in a more immediate way compared to a state whose resources have another century to go. This in turn will influence the cash yield component of the return and countries with shorter life and/or lower absolute levels of SWF size vs state budgets will typically require higher cash yields than others.

Target holding period

- A similar logic applies to the target holding period which might range from a few weeks (or even shorter for funds with active capital market trading desks) to 10 – 15 years. Some funds also adopt the famous motto of Berkshire Hathaway's CEO Warren Buffet: ("Our favorite holding period is forever")[60]. Funds with a strategic agenda will in theory have a longer orientation, commensurate with the time it requires to build infrastructure and industries in the respective countries.

Investment size

- Investment size should be a function of the total fund size, the annual incoming flow of new funds, portfolio turnover, the size of the organization managing investments and the type of involvement the management has, in particular the extent of direct versus indirect, i.e. to third party managers, exposure. Therefore it can already be seen that it is influenced by many variables. In practice, the organizations behind SWFs tend to be relatively small. In many cases, decision making is central and close to the political leadership of countries. Therefore the number of investments to be entered into must remain small and consequently if the volume of funds to be deployed remains constant, the size of individual investments must be large. There are examples of investments worth EUR 10,000,000,000 in one single investment. This is an important dimension with respect to renewable energy since some sub sectors and project types in renewable are relatively small and require only moderate equity funding.

[60] Berkshire Hathaway, Inc.: Chairman's Letter - 1988

Oil/gas counter-cyclicality

- For SWFs that are funded through income generated by the sale of hydrocarbons, the investment objectives include a hedging dimension to the risk in the expected revenue stream from oil and gas sales. This can be achieved on various levels, i.e. exposure to Oil & Gas with contrarian risk profile to own revenue stream. An example would be an exposure sought by countries producing in the Persian Gulf and dependent upon oil/gas sea exports using the Strait of Hormuz, where one central risk lies in the fragile political situation around the Strait. The risk could be hedged by investing into oil and gas companies with significant reserves outside the Persian Gulf. In the event of a closure of the Strait, it can be expected that the value of companies being able to deliver oil and gas despite the closure, will significantly rise. Another level, where this can be achieved is through investing in sectors that have low positive of negative correlation with oil and gas prices, i.e. defensive industries such as retail, consumer staples, or utilities.

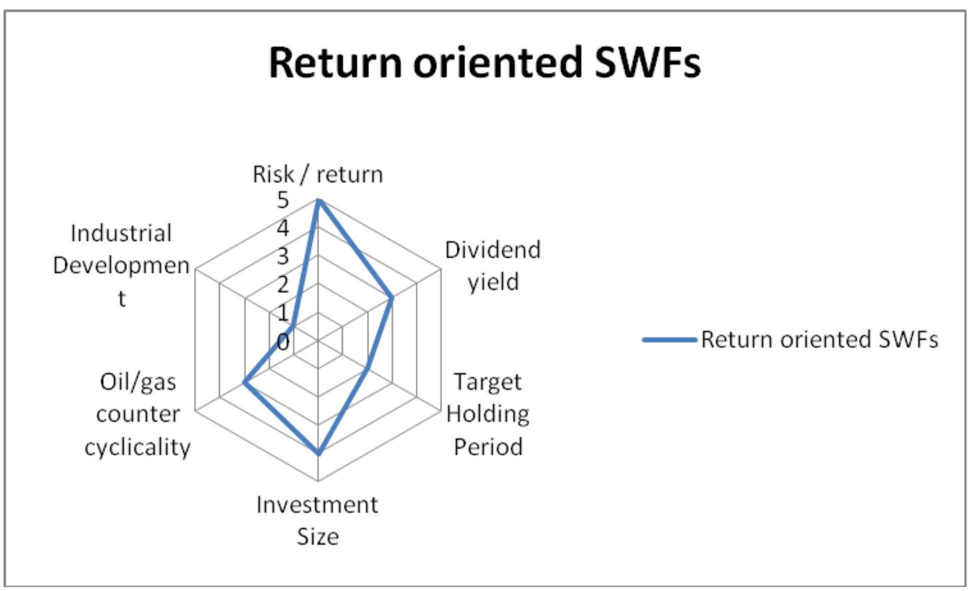
Industrial development

- Most SWFs are interested in selecting assets based on risk-adjusted investment returns. The purely financial sovereign fund investor ignores strategic development as a factor. The Sovereign Wealth Funds Institutes concludes “after examining transactions through the Sovereign Wealth Fund Direct Transaction Database […] that Middle Eastern and some Asian sovereign wealth funds use a form of strategic development as a factor when allocating funds to major investments. Portfolio investor objectives tend to play a major role, even in national strategic investments.”[61] States can effectively utilize sovereign funds to achieve macroeconomic objectives and planning goals. Examples include The Mubadala Development Co. who considers itself as a “catalyst for economic diversification in Abu Dhabi. The Abu Dhabi government-owned entity has purchased large positions in foreign companies and established joint ventures in several sectors to draw industrial and social development in Abu Dhabi. Take for instance, Mubadala’s investment in General Electric. General Electric in turn

[61] Sovereign Wealth Fund Institute: SWF Strategy and Transparency; http://www.swfinstitute.org/swf-research/sovereign-wealth-funds-strategy-and-transparency-jan-2011-update/. Retrieved on June 21, 2013

partnered with Mubadala in a financing business and created employment opportunities within the Gulf region. Recently, [the Sovereign Wealth Fund Institute] witnessed Singapore's Temasek Holdings take stakes in several major Chinese banks, while Temasek Holdings itself has large holdings through various subsidiaries of financial companies and institutions based throughout Asia."[62] The desire is often to kick start a new industry supporting the diversification of the local economy. Investments in technology providers or other corporates are conducted with the intention for these companies or Joint ventures with them to set up local activities. Advanced Micro Devices, Inc. (AMD) received investment from a governmental authority in the United Arab Emirates which was followed by a foundry being built in the Middle East. Qatar has hinted that it is willing to invest in fund managers, if they relocate or bring operations to Doha.

An attempt by the author to categorize the two groups of SWFs, more return oriented ones and more strategically oriented ones, along the importance of these dimensions could yield the following result:



[62] Sovereign Wealth Fund Institute: SWF Strategy and Transparency; http://www.swfinstitute.org/swf-research/sovereign-wealth-funds-strategy-and-transparency-jan-2011-update/. Retrieved on June 21, 2013

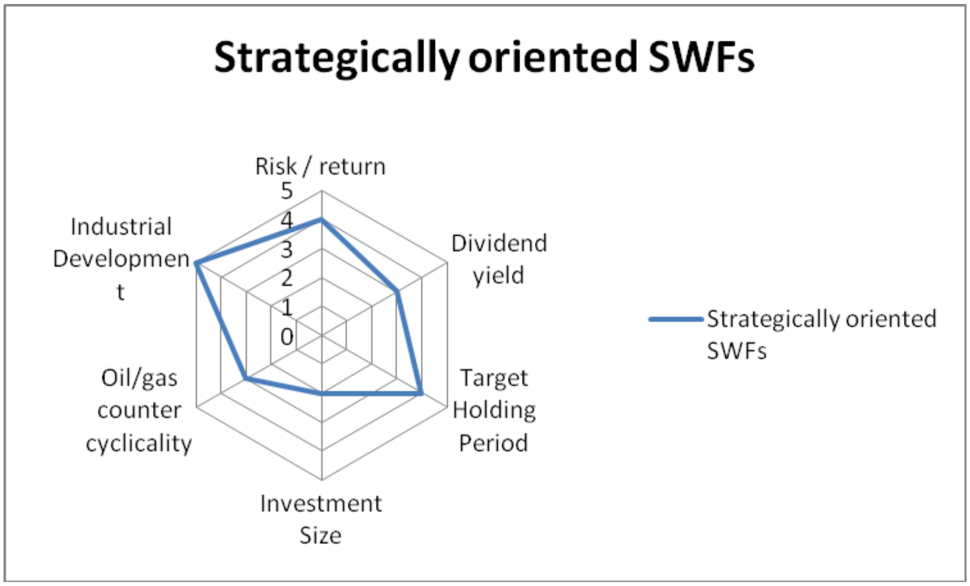


Figure 12: Return oriented vs strategically oriented SWFs (own categorization)

It shows that both groups have a high ranking on risk/return. All funds will have (high) return expectations. Some might provide a certain allocation to a segregated vehicle dedicated to strategic investments (e.g. Korea) while maintaining the majority of assets in a purely risk adjusted return oriented entity. Cash yield expectations should not be an area of systematic differences between the types. In terms of investment sizes, it can be observed that SWFs with strategic orientation are capable of committing moderate sums, i.e. 10 million USD, to projects that have potential to support the national development. A large return oriented fund will have difficulties justifying a USD 10 million individual exposure.

Against the background of this categorization, we shall now proceed to compare the characteristics of renewable energy investments with investment requirements by SWFs.

7. FIT OF INVESTMENT CRITERIA WITH ASSET CLASS AND POTENTIAL FOCUS AREAS

In this chapter, will compare the investment criteria and requirements described in chapter 7 with the characteristics of renewable energy assets as described in chapter 6.

- **Risk / return**

As has been described, achievement of a certain level of risk adjusted returns is relevant for any type of SWF, both strategically or purely return oriented ones. Many SWFs have acquired capabilities to invest the entire range of asset classes. Given the long term orientation, most SWFs have significant weighting of equities. A comparison of expected returns on renewable investments with a broader equity market return is therefore relevant. As has been shown in chapter 6, the performance of the selected renewables index (WilderHill New Energy Global Innovation Index) against the broader equity market has turned out to be significantly worse. Over the 12 year time span 2000 – 2012, Wilderhill returned a CAGR of -4.1% p.a., which is significantly worse than the S&P Global 1200 which averaged an annual growth rate of 0.6% for the same period.

In certain countries, market imperfections, mistakes in the introduction of support systems etc. have resulted in significant outperformance for initial equity investors in certain renewable projects, leading to the perception of a ‘gold rush’ in certain cases. However, these type of projects are typically not accessible to SWFs and the above norm returns are not sustainable. Therefore the conclusion is that on the most important criterion, economic return, renewable energy is less attractive than other sectors.

Regarding the higher level of risk identified in chapter 6, the question typically is who the party most appropriate to hold risk. Regarding technology and the asset selection risk, SWFs are typically less qualified given their lean structure and (generally) lack of specialized staff to analyze technology risk. Regarding political risk, it might be a more balanced situation. Whereas in most countries SWFs would be seen as foreign investors, which – in the event that retroactive disadvantageous changes are carried out – will probably not be regarded as institutions particularly worth of protection. If the scope of activities and influence become big enough though, it is possible that the political ties between the host country of an SWF and the government are strong and political risk can be better managed by an SWF than a 'regular' private investor.

Finally, we also evaluated the diversification impact that the addition of renewable energy assets could have to a standard global equities portfolio. And the finding that the asset classes are still heavily correlated suggests, that little or no diversification benefit is achievable.

The conclusion from all three major parameters, return / risk / correlation, is that investment in renewables has in the past not generated positive outcomes above market in any of the dimensions.

- **Dividend yield**

With SWFs being increasingly prone to demonstrate cash yields on their portfolio, dividend yield is also a relevant criterion. In a low interest rate environment and faced with the desire to support government budgets in the medium term actual cash yield is becoming an equally relevant indicator then IRRs.

As the discussion in chapter 6 has shown, the WilderHill Index has shown consistently lower dividend yield than the S&P Global 1200.

WilderHill:

	CY 2013	CY 2012	CY 2011	CY 2010	CY 2009	CY 2008
Dividend Yield	1.69	1.51	1.72	0.93	0.83	1.51

S&P Global 1200:

	CY 2013	CY 2012	CY 2011	CY 2010	CY 2009	CY 2008
Dividend Yield	3.21	2.99	2.99	2.47	2.58	4.07

For some SWFs, this outcome is likely to reduce the appetite for investment in listed renewables assets. A complicating factor in this context can be, that the allocation for renewables can potentially reduce the available allocation to utilities. Since utilities is typically a sector with significantly higher dividend yields, typically between 5% and 7%, allocation to a sector that leading on average between 1% and 1.5% can impact the overall construction of the portfolio from a yield perspective.

- **Target Holding period**

Target holding period does not appear to be an issue that can be decided on a general basis. Investments in liquid listed assets have potentially very short holding periods, equity investments in unlisted development projects are potentially illiquid and have to be held for several years before a competitive secondary market becomes available.

- **Investment size**

A similar argument applies to investment size. If anything, then the companies and investment opportunities are on the smaller end of what SWFs consider their sweet spot. As of December 2012, the total market capitalization of the WilderHill Index stood at US$ 185 billion, the average market cap per constituent was around US$ 2bln. For SWFs that seek individual ticket sizes of several hundred million US$, companies below that average will typically be too small. Regarding individual projects, only very large solar or off shore wind projects with capex exceeding US$ 1 billion appear attractive. This estimated number results from the fact that such projects will be around 20-30% equity financed, and an SWF will not typically want to take a majority position in the equity but still might seek to deploy in excess of US$ 100 million. Small scale PV projects, individual on shore wind plants or biomass, biogas, or CHP plants will typically be too small to be considered.

- **Oil/gas counter-cyclicality**

As described above, for a significant number of SWFs the source of cash inflow derives from the sale of hydrocarbons, oil or natural gas. These funds would typically use the allocation of their SWF to hedge against significant drops in the price of their commodity or prepare for the possibility of involuntary production shortfalls.

At the most basic level, the performance of renewables and hydrocarbons seems to be directly positively related. The case for renewables in these areas where they can directly or indirectly replace hydrocarbons will improve when oil prices go up. Conversely, as oil prices and therefore revenues to oil exporting countries drop, the case for renewables generally becomes more difficult and the value of companies in the area will tend to drop.

The following graph shows the development of oil price (WTI active contract) against the WilderHill New Energy Global Innovation Index used above over a one year period. The positive relationship is clearly visible, e.g. during the months of July and August when oil prices were rising, the WilderHill Index increased as well, both indices then dropped the following three months.[63]

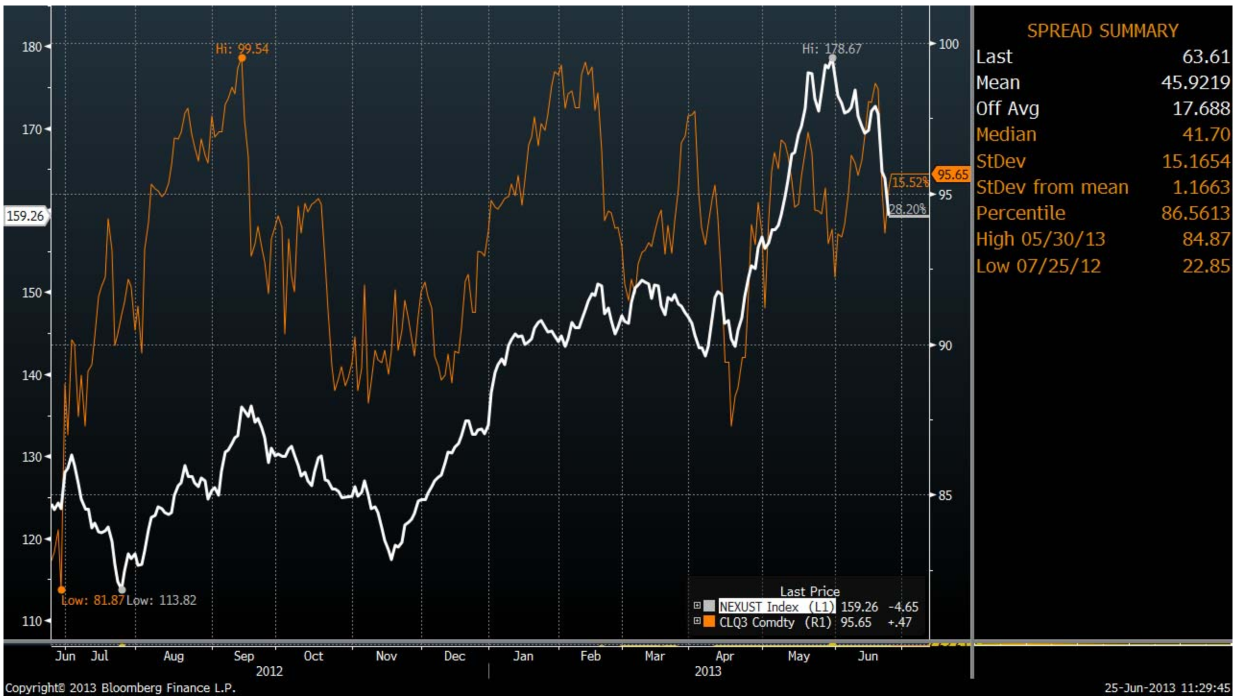


Figure 13: Oil price (WTI active contract) against the WilderHill New Energy Global Innovation Index[64]

The general conclusion therefore is that renewables are not considered attractive for the purpose of diversifying or hedging the risk in the underlying hydrocarbon revenues.

A case in point is the development of the relationship between natural gas prices and renewables. Many of the countries with SWFs are exporters of natural gas. Gas is increasingly becoming the price setting fuel for power production in the US as well as in Europe. Absent non-market subsidy schemes, new renewable installations will therefore

[63] Bloomberg NEXUST Index vs. CLA Commodity, retrieved June 25, 2013
[64] Bloomberg NEXUST Index vs. CLA Commodity, retrieved June 25, 2013

in many circumstances have to be measured against the background of gas based power generation cost. Therefore, looking beyond short term market volatility, the economics of renewables, solar and wind, installations in particular, will be driven by natural gas prices. This trend is particularly discernible in the United States rather than Europe due to the significant difference between gas cost in the US and Europe. In the US, in 2011, natural gas prices are in decline i.e. in 6 months in Q4 2011 and Q1 2012 gas prices have come down in the US from US$ 4/mmbtu to US$ 3/mmbtu. [65] European prices are around double to triple the US level (US$ 8 – 9/mmbtu). The most significant trend underlying the drop in US gas prices are the expected new supply volumes from domestically produced shale gas. Demand side impacts have also weighed on pricing.

- Industrial development

Finally, the question remains if the development of renewable energy can contribute to the industrial development of the host countries of SWF. Focusing on the countries in the Gulf, the following situation can be described.

In all of the GCC countries, industrial and residential power prices are kept at a very low level. Eg. the residential power price in Qatar is 8 Dirhams/kWh, which translates into US$ 0.02/kWh. Citizens of Qatar are entirely exempted and are provided with power and water for free. Therefore there is currently no incentive for commercial or residential users to consider renewable replacements of conventional power supply.

In the case of Qatar, economic activities around renewables have been approached from a different perspective. While there is no immediate need or economic case for renewable power generation, the cheap and abundant gas resources are contributing to an economic case for manufacturing energy intensive parts in the value chain of renewables equipment. In this context, Qatar Solar Technologies, a Joint Venture between the philanthropic arm of the Emirate and the German solar company SolarWorld has embarked on building a major polysilicon production facility in the country.

More recently, the link between the energy and (particularly) water demands and self-sustainability ambitions for food production have triggered new plans in the deployment of renewable energy assets, particularly solar power plants used to

[65] Goldman Sachs: Global Clean Energy Monthly, January 2012

desalinate water. These programs are considered critical to the future development of the country and significant resources are dedicated to it.[66]

In the case of the Kingdom of Saudi Arabia, the issue is even more critical. The Kingdom is the world's largest exporter of crude oil. The Kingdom is pumping around 10mln barrels per day. It supplies roughly 12% of total global oil demand. However, the country is using approximately one fifth of its oil production for domestic use, most of it fired in un-efficient oil power plants. Fuel for combined cycle gas plants is at times imported due to local shortages. The Ministry of Petroleum and Saudi Aramco are very aware of the economic consequences of this development as well as the related greenhouse gas emissions. Mr. Naimi, the minister for petroleum and mineral resources said: "Societal expectations on climate change are real, and our industry is expected to take a leadership role. We are addressing this topic with significant resources in Saudi Arabia."[67]

[66] Mari Luomi: The Gulf Monarchies and Climate Change, Georgetown University, Doha 2013

[67] The New York Times, 'An Oil Minister, plugging renewables?', January 30, 2012, http://green.blogs.nytimes.com/2012/01/30/an-oil-minister-plugging-renewables/ retrieved on December 19, 2012

8. EMPIRICAL EXAMPLES ABU DHABI AND QATAR

Abu Dhabi and Qatar have been selected as empirical examples for the following reasons. Both emirates are locally close to each other, the geographic proximity also results in very comparable natural determinants, i.e. climate, environments, solar irradiation and wind parameters or natural resources. They are both almost ‘city states’ with the overwhelming share of public revenue generated from the sale of hydrocarbons in the form of crude oil exports and natural gas exports. Both countries are ruled by hereditary monarchs. Yet, both countries appear to have adopted different strategies. The following map shows the location of both emirates in relation to the broader Middle East.

Figure 14: Map of Middle East[68]

[68] Wikipedia: http://en.wikipedia.org/wiki/Middle_East Middle East, retrieved June 22, 2013

Both emirates possess abundant hydrocarbon resources. Qatar accounts for 1.3% of total global oil reserves and 13.5% of total global gas reserves. In terms of current production it accounts for 1.7% (oil), respectively 3.7% (gas) of global production. Abu Dhabi can claim reserve numbers of 6.7% of total global oil reserves and 3% of global gas reserves.[69] Given the small size of these countries, these reserve and production numbers are clearly very high.

The revenues from the sale of hydrocarbons have resulted in the accumulation of significant public resources invested in the respective Sovereign Wealth Funds. In the case of Qatar, it is the Qatar Investment Authority (QIA), with, according to the Sovereign Wealth Fund Institute[70], holds assets of US$ 115mln. Abu Dhabi, with a longer history of crude oil exports has concentrated most of its assets in the Abu Dhabi Investment Authority (ADIA), the Sovereign Wealth Fund Institute quotes its assets at US$ 627mln. In addition, several other investment entities have been set up, most notably IPIC, the International Petroleum Investment Company, with the objective to invest in hydro carbon related assets on a global level with assets of US$ 65m and the Mubadala Development Company with the objective of conducting strategic investments that will foster the development of the country. According to the Sovereign Wealth Fund Institute, it holds assets of US$ 53mln.

In terms of local energy consumption, both countries show similar characteristics, in particular very high summer peak load levels when widely deployed air conditioning appliances are operational. Summer peak load can be up to 50% - 60% higher than average levels during the rest of the year. Abu Dhabi expects its power capacity demand to rise to 20 GW by 2020.[71] Abu Dhabi expects to cover 50% of this demand with natural gas based power generation. Despite its significant gas reserves, Abu Dhabi is facing a production shortage which is also due to the very high gas demand for reinjection to enhance recovery from oil fields. This leads to a situation where Abu Dhabi is currently importing gas via pipeline from Qatar. Therefore the pressure to

[69] BP Statistical Review of World Energy, 2011

[70] Sovereign Wealth Fund Institute http://www.swfinstitute.org/fund-rankings/; retrieved on November 12, 2012

[71] The National (Abu Dhabi newspaper), 18 April 2011

develop alternative power supply options are more pressing in Abu Dhabi than in Qatar. Consequently, Abu Dhabi has announced and is currently pursuing the development of 4 nuclear reactors with an expected capacity of 1.4 GW each. Renewables are expected to contribute 7% of total demand. This would translate into 1.33 GW.

The implementation of renewables faces several difficulties however. The very high levels of subsidies have made it economically unattractive to substitute gas based production with renewables. While 1kWh power costs around 7.5 UScts to produce, the industrial tariffs are around 4 UScts and residential tariffs to locals are around 1 USct.[72] Similar levels apply to Qatar, where power consumption for residential locals is entirely free of charge. It is apparent that under these conditions, consumer driven strategies for implementing renewables or energy efficiency investments are inoperative. Energy subsidies are however an ingrained part of the set of expectations by the locals to their leadership and it is therefore unlikely that these subsidies will be phased out in the foreseeable future.

Nevertheless, given the constraints in its domestic gas supply, which became particularly apparent during acute power and gas shortages in the second half of the last decade, Abu Dhabi has been investing significantly in the development of renewable energy. Its key initiative is Masdar, a set of projects around the development, education and implementation in the realm of renewable energy. The project is held by the Mubadala Development Company, which as described above, is responsible for developing and investing into projects of relevance to the strategic development of the country. It comprises 5 pillars: Masdar City, Masdar Capital, Masdar Institute, Masdar Power and Masdar Carbon. The allocated resources were quite significant, in 2008, Abu Dhabi announced an investment of US$ 15bln into the project.

The project faced a significant crisis in 2009 when it became apparent that the investment requirements would exceed plans by far, and technologies were not available or scalable as planned. At the same time, a significant drop in oil prices (driven by the global financial crisis) reduced state revenues significantly and the asset values of the Sovereign Wealth Funds dropped. Reasons for the crisis were also attributed to the overly rapid implementation of renewable energy technologies. Photovoltaic panels installed at the Masdar City allegedly operated at significantly lower efficiencies (up to 40% below name plate capacity) due to miscalculation in irradiation and dust levels.

[72] Abu Dhabi Regulation and Supervision Bureau, Annual Report 2010

No public recollection of decisions is available to analyze the Abu Dhabi government's response to the crisis. It is clear though that certain projects have been de-prioritized and the claim of Masdar City as a 'zero emission' city has been changed to a 'low carbon' city. Masdar's investment arm, Masdar Capital, though has continued to invest in renewable energy projects, most importantly, in the largest British off shore wind park Thames Array, where Masdar took over a stake sold by Shell B.V.[73] This can be taken as a sign that Masdar is also contemplating investments internationally in projects that do not have direct impact on its national agenda. Public statements also express the interest to keep investing in stable regulatory and favorable investment regimes, such as the one in the UK.

In terms of domestic investment, the most notable is the US$ 600mln investment in Shams 1, a 100 MW concentrated solar plant. It is built by a consortium of Abengoa and Total and has been commissioned in early 2013.

In comparison to Abu Dhabi, Qatar is even more affluent, with a GDP per capita between US$ 90,000 and US$ 150,000, depending on the source, the richest country on a per capita basis in the world. The development of hydrocarbon infrastructure has started later than the Emirates, in particular the dramatic build out of natural gas liquefaction infrastructure, which propelled Qatar to the position of the world's largest LNG exporter. Qatar has initiated a number of mega-projects, including a multi billion education initiative, which includes the construction of campuses for international universities such as Georgetown, Texas A&M, Weill Cornell and HEC, several multi billion real estate projects and a rail project with estimated cost in excess of US$ 20bln.[74] In

[73] The National (Abu Dhabi newspaper), 4 July 2013

[74] Mari Luomi: The Gulf Monarchies and Climate Change, Georgetown University, Doha 2013

contrast to Abu Dhabi, renewable energy has not been included as one of the mega projects as is the case with Masdar in Abu Dhabi. A more prudent approach has been adopted. This approach also might have been influenced by the difficulties faced by the neighboring project in 2009. One sign of a more prudent approach for instance is the focus on extensive testing of solar equipment before installation. In December 2012, a solar panel testing facility has been inaugurated by Qatar Foundation, the non profit foundation through with many of the national development projects are channeled. During the first half of 2013 however, several new announcements have been made with regards to new solar energy projects, in particular in connection with a national 'Food security program', which has the ambition to reduce significantly the dependence of the small emirate on international food imports. Therefore, it remains to be seen if the difference in development of renewable energies between the two emirates is of a more principal nature or merely a difference in timing, with Qatar catching up in terms of deployment and investment over the next couple of years.

10. CONCLUSION

With a view to the past performance of renewable energy assets, it is not possible to recommend large exposure to listed equities in the renewable space. The assets have clearly underperformed the market. The related risk is higher and SWFs are probably not best positioned to adopt some of the risks. Also a positive diversification effect could not be empirically demonstrated.

However, there are a couple of factors that make this asset class still potentially attractive.

The increasing professionalism and cumulative experience have increased the reliability of renewable energy projects, thus decreasing the risk.

The decreasing cost of renewable power generation has and still is decreasing the dependence on government support mechanisms which carry political risk as described above. Therefore allocations to mature, operating projects, ideally in areas and countries with little or no excess cost of generation above pool prices, are indeed likely to become an important constituent of an infrastructure portfolio.

Given the inherent (and increasing) volatility of equity markets, the interest of SWFs to build exposure to unlisted vehicles is increasing, particularly since the short term liquidity provided by stock exchanges should not be a relevant criterion for a long term oriented fund.

In addition to these low risk, low return infrastructure type exposures, selected technology exposure could be achieved through risk investments in new technology developers. The rationale for these investments would typically be in line with the host countries' desires to establish a proprietary technology basis and to control technologies that could be used to develop their respective renewable industries.

In the end, there is also a moral element to the topic. Most SWFs are funded by hydro carbon revenues of their host countries. The revenues are derived from hydrocarbons that directly contribute to global warming. The mitigation of which forms a key reason for migrating the power generation systems of the world to a more renewable basis. The countries would do well to use investment in renewables to demonstrate their concern and willingness to participate in the global fight against global warming.

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