Financing the Transition to Sustainable Energy

seo economisch onderzoek

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Financing the Transition to Sustainable Energy

Literature Overview

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SEO Economic Research carries out independent applied economic research on behalf of the government and the private sector. The research of SEO contributes importantly to the decision-making processes of its clients. SEO Economic Research is connected with the Universiteit van Amsterdam, which provides the organization with invaluable insight into the newest scientific methods. Operating on a not-for-profit basis, SEO continually invests in the intellectual capital of its staff by encouraging active career planning, publication of scientific work, and participation in scientific networks and in international conferences.

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Preface

At Duisenberg school of finance, we are committed to providing excellent financial education in order to create the next generation of responsible financial leaders. To achieve this, leading industry practitioners and world-class academics have joined to develop a set of forward-looking financial programmes. These programmes integrate theory and practice, and encourage critical thinking and continuous reflection on the dynamic financial landscape.

The existing set of programmes at Duisenberg school of finance will soon be expanded. With the support of Holland Financial Centre, specifically the Centre for Climate & Sustainability, Duisenberg School is currently developing a Programme on Finance & Sustainability. As part of the Programme, Duisenberg School and Holland Financial Centre intend to offer top-notch education and conduct cutting edge research in the area of finance & sustainability.

While industry practitioners and policymakers around the world are facing the topic of finance & sustainability on a daily basis, academic interest in the topic is relatively recent. In designing a curriculum and a research agenda, therefore, we feel it is important to take into account not only the insights yielded by academic research but also by industry practitioners and policymakers. Accordingly, as a preliminary step, we have asked SEO Economic Research to conduct a broad, high-level literature overview on finance & sustainability.

The survey has resulted in four reports, each providing a literature overview on one aspect of finance & sustainability: (i) financing the transition to sustainable energy; (ii) carbon trading; (iii) innovations in financing environmental and social sustainability; and (iv) sustainable investment. The report you have before you describes the review on ‘financing the transition to sustainable energy’.

The survey has been conducted by SEO Economic Research; Duisenberg School has offered suggestions throughout the process. The result should be of use not only to Duisenberg in designing its curriculum and research agenda, but also, we hope, to anyone interested in the increasingly relevant subject of finance & sustainability.

Amsterdam, August 19, 2010

Prof. Noreena Hertz
Chair of Globalisation, Sustainability and Finance

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Dean, Duisenberg school of finance

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Executive Summary and Further Research

Investments in Sustainable Energy are essential

The world is facing an enormous challenge in the transition towards a more substantial role for sustainable energy (SE) as compared to traditional energy sources.[1] Demand for energy is continuously increasing due to economic and population growth, a demand which in the long turn cannot be met by conventional energy alone. At the same time climate change, and also the need for energy security, is putting significant pressure on finding alternatives for fossil fuels. This challenge has a strong financial element to it: the transition to SE is only possible if sufficient investments flows are directed towards the SE sector. Calculations of required investments vary considerably depending on operational definitions and the reduction targets underlying the calculation – stronger reduction targets evidently require higher investments. Notwithstanding differences, calculations from various trustworthy sources – like the Stern Review, UNFCCC, IPCC and IEA – point to a (massive) lack of investment flows compared to requirements. As a reference, the Stern Review calculated required investments of US$ 540 billion per year starting in 2005, while global investments amounted to circa US$ 145 billion in 2009 and are expected to reach an annual US$ 500 billion only in 2030. Stern presses for immediate investment, in order to avoid adaptation costs.

…but face specific risks

The lack of investments merits the question what drives, or prevents, funding of SE projects. As in other sectors, obtaining funding primarily depends on the risk-return profile of investments. Although risk of SE investments is generally assessed high, it seems that it is above all the *combination* of relevant risk that poses a barrier. Risks of specific importance to the SE sector are:

- policy and regulatory risk: the development of SE projects is regulated and supported by governments in many ways, making financial attractiveness depending on clear, stable and predictable public policy;
- technological risk: SE projects are often characterized by technological and innovative solutions, with uncertainty on R&D costs, term-to-maturity, lack of capacity storage options, and whether solutions will prove fit for the intended use;
- market uptake: the success of SE projects is often uncertain due to development of fossil fuel prices (i.e., low price of fossil fuels decreases attractiveness of SE), the innovative and technological character of many SE products and a lack of individual willingness to pay for end-products or advantages (‘externalities’); and
- resource risk (like the availability of wind).

…and inconclusive financial attractiveness

In order to gain full insight in financial attractiveness of SE investments, risks must be analyzed in perspective of (expected) returns. At first sight, the most logical way to do this is to focus on the actual risk adjusted return of SE companies, by comparing financial (valuation) multiples between traditional and SE firms and analyzing the background of differences. (Academic) literature, however, has not thoroughly tackled this subject as yet. The lack of publicly quoted

1 *Sustainable Energy* (SE) is defined as: the provision of energy such that it meets the needs of the present without compromising the ability of future generations to meet their own needs.

companies in the SE sector could be one reason for this. The diversity within the sector and the lack of experience-based financial data in many parts of the industry are other possible reasons. Research that has been done, points to potential attractive returns but most of all to the need for further research.

As an alternative, a method often used to assess financial attractiveness of SE technologies is the levelized cost approach. Levelized costs are determined as the annualized present value of discounted costs – including a return to investors – which would facilitate a fixed return for all technologies. The lower the levelized costs, the more attractive a technology is for investors. For instance, Lazard (2008) shows that several SE technologies are already cost-competitive with conventional energy sources. The levelized cost approach, however, does not fully reflect the elements taken into account by investors. For one, the levelized cost approach fails to recognize potential savings of alternative energy sources. This is tackled by another method often used to determine financial attractiveness: the net cost approach. In this approach an 'abatement cost curve' depicts the abatement potential and net costs of all Greenhouse Gas (GHG) abatement opportunities beyond business as usual. The use of 'net costs' indeed implies that the potential for monetized energy savings of SE technologies is taken into the equation. McKinsey (2009) provides such an abatement curve, showing that all energy efficiency measures have a net positive business case – i.e., discounted net cash flows are positive. Although providing good insights in financial attractiveness, an important drawback remains – a drawback the methodology shares with the levelized cost approach. That is, differences in risk between technologies are not taken into account. As risk is an important variable in investor decisions, neither approach fully reflects the investment case faced by decision makers. Additional research could therefore be focused on the potential to incorporate risk considerations in the net cost approach and/or on expanding insight into actual risk adjusted return of SE companies.

Investment barriers prevent funding

Although none without flaws, all of the discussed methodologies to assess financial attractiveness point to potentially viable SE investments. At the same time, investment flows are deemed insufficient. Literature defines sector characteristics posing barriers to SE investments. Of main importance in this regard are the sectors innovative and technical character – often resulting in complexity in the eyes of investors – its relatively young history, its capital intensity which is often combined with long time to maturity, its lack of competitiveness and lack of scale compared to fossil fuel investments, and its high dependency on regulation. These sector characteristics result in barriers – which are summarized as informational, scale, market, and regulatory barriers in this report – that adversely impact risk and return. In finding solutions for funding barriers, it must be recognized that these differ between the various stages of the (technical) life cycle. In addition, the well-known funding gaps 'valley of death' – going from the R&D phase towards demonstration and deployment – and 'debt-equity gap' – in the phases towards maturity – are more pronounced for SE investments.

…but solutions are found in risk management

Decreasing barriers can be done in many ways, and can be spurred by private and/or public initiatives. A first option is to focus on managing risks. The specific risk challenges that SE investors face, provide ample commercial opportunities to private insurers. In fact, numerous insurance products focused on SE risks have been introduced in recent years, like performance risk insurance through wind power derivatives, energy savings insurance and Energy Savings Contracts. But, as argued by some authors, these products are often little more than bundling or repackaging of existing insurance offerings, and real innovative solutions to cover specific SE risks are lacking. More research is needed in this field, e.g., on the extent to which SE risks are covered by the private sector, the potential of (innovative) SE risk insurance products and experience-based impact of insurance of risks. In case the private sector is unable (or unwilling) to insure certain risks which are regarded as important barriers by SE investors, the public sector might insure risks instead. Examples where public offerings could be considered are country risk and currency risk cover, both focused on projects in developing countries. Another example is low-carbon policy risk cover, which would insure the risk of government failure to adhere to announced policy.

… and in existing policy instruments

Starting from the broader concept of financial attractiveness, it is generally accepted that investment barriers imply that public policy is essential in addressing climate change and increasing funding of SE investments. Carbon taxes and carbon emission trading are the two primary market-based policy instruments. In addition, a multitude of non-market based instruments, like Renewable Portfolio Standards, investment subsidies, loan guarantees and direct public investments, is at the disposal of policy makers. Deciding which instruments to apply depends on many variables. The stage of the (technical) life cycle is generally seen as one of the key variables, as each stage is confronted with specific risks and barriers. Another way of analyzing policy instrument choice is to determine their impact on financial variables, and thus on investment decisions. For example, the extent to which specific policy instruments influence levelized costs could be a good proxy for the final impact on investment volume. More research is needed in this area.

An interesting alternative is to research investors' *perceptions* of the influence of policy instruments on financial attractiveness, which constitutes a research field relatively untouched as yet. But choosing between policy instruments requires more than insight in impact on financial attractiveness. In the end, one of the primary underlying goals is to address climate change. That means the 'sustainability return' on public investment should be taken into account as well. The abatement cost curve, combining abatement potential with net costs, provides a good starting point to assess possible trade-offs between financial and sustainability attractiveness.

Based on the many possible ways to select and prioritize public solutions as well as the difference in requirements between SE investments, various policy recommendations can be drawn. Often quoted recommendations include:

- Combine emission trading markets with ambitious and coherent national reduction targets;
- Implement or raise energy (efficiency) standards;
- Consistency and reliability of policy regime and instruments is key;
- Implement regulation on governance and transparency on climate risks;
- Provide direct government support to R&D investments, with a specific focus on Carbon Capture and Storage;
- Phase out subsidies to fossil fuels.

Focus should also be on innovative financial instruments

Focusing on traditional funding sources and risk management as well as existing public policy instruments alone will not suffice. The enormous challenge ahead asks for innovative ways to increase funding, both by the private (financial) sector and by governmental institutions. Examples include specific climate change funds, index-linked carbon bonds and (supra)national green banks. The latter has been proposed in the UK recently, and could facilitate centralizing the many dispersed government initiatives to boost SE funding as well as increase independency of public support from the political arena. Many innovative ideas are suggested, and future research should focus on success factors – both in terms of the process from idea to realization as in terms of impact on funding of SE investments.

…and on specific solutions for developing countries

Future energy use will be greatly affected by the development of non-industrialized countries. Required climate funding needs in developing countries are immense, and a prerequisite for successful global climate change. At the same time, developing countries face specific risk and barriers – in addition to those also encountered in developed countries. Examples include instable and immature political, legal and tax systems, a small-scale, a lack of (technical) knowledge, and poorly developed financial markets. As Official Development Assistance (ODA) by governments from developed countries is insufficient – and is expected to remain so – success is depending on increased funding from the private sector. The Clean Development Mechanism, which is part of the Kyoto Protocol and facilitates companies in developed countries to fulfill carbon emission reduction targets by investing in projects in developing countries, contributes to catalyzing investments but is not expected to cover total funding needs. Many point to Public Finance Mechanism (PFM) – financial commitments by the public sector – as alternative to catalyze private sector investments. In particular, PFMs should be focused on catalyzing investments by institutional investors, by far the largest potential source of private funding. Recent discussions focus on specific funds to attract institutional investors, like challenge funds and cornerstone funds. Further research is necessary in this field.

Room for further research

This report will be used by Duisenberg school of finance which is currently designing a research agenda for its Programme on Finance & Sustainability. Box 1 hopes to contribute to the efforts of Duisenberg school of finance in this area, by summarizing blind spots in the research areas encountered during the course of writing this report. Some subjects have not been discussed in (academic) literature but are found to merit further research or updating.

Box 1 Subjects for future research

Included in this box are areas for further research that were encountered when composing this literature overview. Within each area potential research questions have been defined. The list of research areas and questions is by no means comprehensive, but should offer an interesting starting point to define further research.

- The background of the assumed gap between required funding and estimated investment flows. Does this reflect
  - a gap between the funding needs to meet government commitments (e.g., EU agreements) and available finance? and/or
  - a gap between available finance and the funding needs of existing SE projects? and/or
  - a gap between available finance and the number of SE projects? I.e., are there enough creative

  inventors and courageous entrepreneurs in energy, compared to other sectors?
- The optimal length of regulation certainty: the longer investors are provided with certainty on government support and regulation, the lower related risk will be. There are, however, limits to the time period governments can *reliably* provide this certainty.
  - Is there a trade-off between the length and the reliability of regulation certainty in the SE-sector?
- Cost of capital of SE investments
  - What is the impact of the (perceived) main risks of SE-projects on the cost of capital?
  - As risks differ between technologies, discount rates should also differ. This element is often not taken into account when comparing financial attractiveness. What is he impact of different discount rates per technology on their financial attractiveness?
  - How can risk considerations be incorporated in the net cost approach (i.e. the 'abatement cost curve')?
- (Comparative) analysis of financial performance/valuation ratios of SE companies;
- Innovative financial solutions
  - What is the potential role of innovative financial solutions – as compared to the focus on the role of regulation – to reap the fruits of investment potential by focusing on the specific barriers faced by SE investment (per stage in the life cycle)? Energy efficiency opportunities merit specific attention because these often offer financially attractive NPV.
  - What are success factors of innovative financial instruments – both in terms of the process from idea to realization as in terms of impact on funding of SE investments?
- Analysis of other sectors with comparable characteristics as the SE sector (like innovative and technological character, high upfront investments and dependency on public policy)
  - How do these other sectors deal with risks and barriers? What are the lessons for the SE sector?
- Insurance of SE risks
  - To what extent are SE risks covered (resulting in an overview of (potential) coverage of SE risks, in terms of insurers, insurance products, blind spots et cetera)?
  - What is the actual impact of SE insurance products on (perceived and actual) risks and on cost of capital?
  - What type of innovative insurance products is needed – as compared to bundling/repackaging of existing products?
- Impact of public policy (instruments) on SE funding
  - How should the impact of policy instruments on financial variables like cost of capital and levelized costs be calculated? Can standardized tools be designed?
  - What is the actual impact of policy instruments on SE funding, e.g., in the development of technologies towards maturity?
  - What is investors' perception of the impact on financial attractiveness variables?
-
- Developing countries
  - How can Public Finance Mechanisms (PFM) be used in innovative ways to leverage private investment towards developing countries?
  - How can PFM-funds be designed (or ideas for funds, like the Challenge fund and the Cornerstone fund be improved) in order to attract institutional investors and maximize leverage potential of PFM?

Source: SEO Economic Research

1 Introduction

As recognized today by leading CEOs and leading thinkers, 'sustainability' is a key issue for business leaders to understand and manage. Whilst the term 'sustainability' is being used to mean different things by different parties, this paper will follow the extended WCED definition of sustainability incorporating both environmental and human rights objectives, based on the Three-Dimension Concept of the 'Declaration of Rio on Environment and Development'. The World Commission on Environment and Development (1987) defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The 'Declaration of Rio on Environment and Development' recognized that sustainable development is a balance of three dimensions: environmental protection, economic growth and social development (United Nations Conference on Environment and Development, 1992).[2] Research on finance & sustainability is still very much an emergent field. At the request of Duisenberg school of finance, SEO Economic Research has surveyed the literature on finance & sustainability. This has resulted in four reports, each providing a literature overview of one aspect of finance & sustainability:

- Financing the transition to sustainable energy;
- Carbon trading;
- Innovations in financing environmental and social sustainability; and
- Sustainable investment and reporting.

Each report provides comprehensive insights on a major topic within the field of finance & sustainability. Based on our findings from (academic) literature and relevant policy discussions, key topics per subject are identified and discussed. Moreover, areas where it is felt that the literature is underdeveloped have been identified in order to contribute to Duisenberg school of finance's overall thinking about research objectives for its Programme on Finance & Sustainability. The topics as well as the broader scope and focus points of each topic, have been defined in close cooperation with Duisenberg school of finance.

This report highlights leading literature and empirical research on 'financing the transition to sustainable energy'. Given the extensive body of literature in the field it is not meant to be all-encompassing, but is meant to provide the reader with a strong base from which to carry out further research and investigation. Chapter 1 describes the environmental and corresponding investment challenge and provides an overview of the current funding flows towards Sustainable Energy (SE) investments. Chapter 2 discusses the attractiveness of SE investments, defining risks and barriers standing in the way of the required magnitude of funding. Acknowledging that the current level of funding is highly insufficient to meet the challenge of climate change, chapter 3 provides insight in the instruments - both private and public - to increase funding. Chapter 4 focuses on developing countries, whose role is essential but most challenging in fighting climate change. Conclusions and room for further research are included in the Executive summary.

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2 In practical terms, the UN Global Compact – a framework for the development, implementation, and disclosure of sustainability policies and practices – has translated this into ten principles in the areas of human rights, labour, the environment and anti-corruption. These principles enjoy universal consensus (www.unglobalcompact.org).

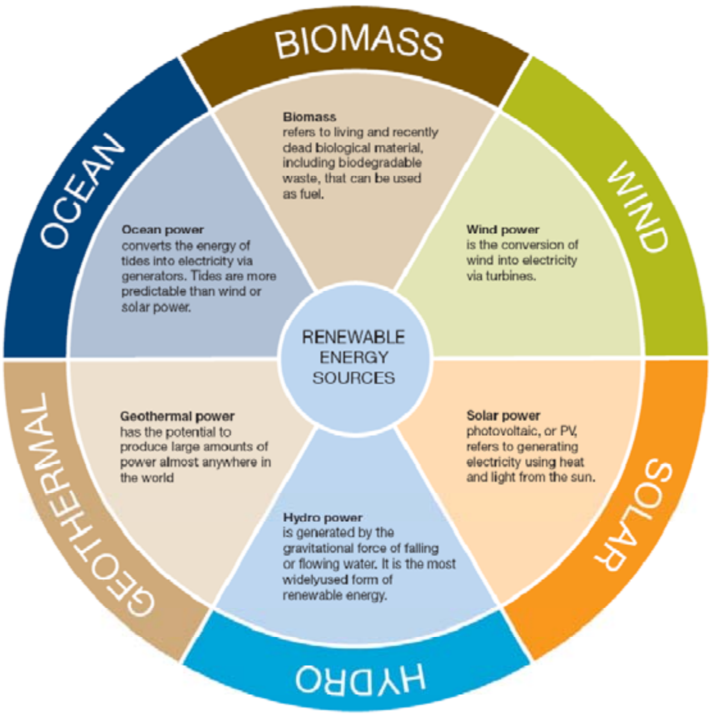
2 Sustainable energy

2.1 Sustainable energy: saving the future

2.1.1 Defining sustainable energy

Sustainable Energy (SE) is the provision of energy such that it meets the needs of the present without compromising the ability of future generations to meet their own needs.[3] It has two key components: renewable energy technology (RET or RE) and energy efficiency (EE).[4] Power-generating RETs include wind power (onshore and offshore), solar power (photovoltaic and thermal electricity generation), geothermal power, small-scale hydropower, ocean/tidal power, municipal solid waste-to-energy and biomass (Figure 1). Liquid biofuels include first-generation (sugar-based) and second-generation (cellulosic, algal, etc.). Although nuclear energy and large-scale hydropower meet the aforementioned definition of SE, they are generally not regarded as such.[5]

Figure 1 Renewable Energy Technologies



Source: (PwC, 2009, p. 15)

3 Renewable Energy & Energy Efficiency Partnership (REEEP) and Tester (2005, p. xix).

4 Sustainable energy overlaps with the term 'clean technology' or 'cleantech', which was popularized in large part through the work of the Cleantech Group. It is a broader concept and consists of 11 segments. Cleantech includes, among others, energy storage, energy infrastructure, transportation, (waste) water, materials, recycling and agriculture.

5 Large hydro can have severe negative environmental consequences (WEF, 2010, p. 56). Nuclear power in its current form has many concerns regarding costs, safety, waste disposal and proliferation (WEF, 2010, p. 26).

Improving energy efficiency represents the largest, most cost-effective and immediately available way to mitigate green house gas emissions (WEF, 2009b, p. 8). The International Energy Agency (IEA, 2009) reckons that energy efficiency gains account for more than half of the abatement potential in its "450 Scenario".[6] Other research hints at comparable potential (Efiong, 2007; Project Catalyst, 2009). With total investments of US$ 170 billion in existing technologies (water heating, heating and cooling, lighting and appliances) , total annual energy savings of roughly US$ 900 billion a year could be achieved (Farrell & Remes, 2008, p. 1).

2.1.2 The energy and climate challenge ahead

Global population has grown from 2.5 billion in 1950 to 6.5 billion in 2005 and is expected to expand a further 2.5 billion to over 9 billion people in 2050. This is the equivalent to two Chinas, with its current population of 1.3 billion. Already there has been a strong surge of resource/energy prices in line with GDP growth in emerging economies (e.g., Brazil, Russia, India and China), indicating that population growth without corresponding additions to energy supply will result in considerable cost increases. Some projections indicate that by 2030, total energy consumption could reach almost twice its 1980 level. Accommodating demand for this with 'traditional' energy supply seems impossible. In other words, renewable energy sources are first and foremost essential to provide the minimum requirements for sustaining human life (Mizuguchi & Monoe, 2009, pp. 4-7; PwC, 2009, p. 10).

Next to economic growth, and corresponding consumption and production requirements, the second major factor contributing to the need for sustainable energy is climate change. The Intergovernmental Panel on Climate Change (IPCC) argues that "most of the observed increase in global average temperatures since the mid-20th century is likely due to the observed increase in anthropogenic GHG concentrations" (IPCC, 2007, p. 10). To prevent detrimental climate change, the IPCC reasons that deep emission cuts are required. Many scientists and policy makers, including the United Nations Framework Convention on Climate Change (UNFCCC) and the European Union, believe that holding the rise in global mean temperatures below two degrees Celsius compared to pre-industrial times is essential (Enkvist, Nauclér, & Rosander, 2007; McKinsey&Company, 2009; Müller, 2008).

A third driver behind RETs is security of energy supply, i.e., increasing fuel independence (M. Thompson, Elford, Glover, Prouty, & Quealy, 2007). Energy supply is "secure" if it is adequate, affordable and reliable. Security risks include the incapacity of an electricity infrastructure system to meet growing load demand; the threat of an attack on centralized production, transmission and distribution grids or pipelines; or global oil and gas supply restrictions due to political actions, or even just volatile prices. For example, the EU's dependency on foreign supply of fossil fuels is likely to increase over time.[7] Increasing shares of RETs could reduce temporary interruption of fossil fuels, such as played out in the recent dispute between Russia and Ukraine (PwC, 2009, p. 12).

Energy use will continue to rise (progressively) with global economic and population growth. To keep up with energy demand and simultaneously stabilize the atmospheric concentrations of CO_2

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6 The number 450 refers to stabilizing the atmospheric concentration of CO_2e at 450 parts per million.

7 Currently 85 % of EU's oil is imported. Almost all oil will be imported by 2030, by which time 85 % of gas and 60 % of coal will also be imported.

equivalents[8] at levels the scientific community deems safe, sustainable energy sources are vital. This requires immediate action. From an environmental point of view, a single year of delaying abatement could cause 1.8 $GtCO_2e$ of additional emissions globally.[9] In case of delay, emissions would grow according to the business-as-usual scenario. During this year of delay, high-carbon infrastructure with long lifetimes (e.g., coal fired power plants) would be built in order to meet economic growth requirements and to replace depreciated assets. In addition to forgone abatement of 1.8 $GtCO_2e$, the new high-carbon infrastructure causes a lock-in effect and commits the world to 25 $GtCO_2e$ of cumulative emissions over the following 14 years.[10] Based on these calculations, delaying abatement with 10 years, from 2010 to 2020, causes a reduction of 40 percent of the potential abatement, results in a cumulative lost abatement opportunity of 280 $GtCO_2e$ by 2030 (comparable to 25 times the combined emission of the US and China in 2005), and a massive lock-in effect (McKinsey&Company, 2009, p. 46).

2.2 Funding sustainable energy

2.2.1 The investment challenge

To meet energy demand and prevent climate change, investment in sustainable energy is of critical importance. Numerous institutions and authors have calculated the investments required for abatement:

- Sir Nicholas Stern estimated that the annual global investment needed to avoid the worst impacts of climate change to be around 1 percent of global GDP each year provided that action would start immediately. At the time, global GDP was circa US$ 54 trillion. Therefore, the global investment estimates in the *Stern Review* amount to circa US$ 540 billion annually (Cameron & Blood, 2009, p. 6; Stern et al., 2006). Four pathways to lower GHG emissions are set out in the *Stern Review*: reducing demand for emissions-intensive goods and services, increasing energy efficiency, action on non-energy emissions (e.g., avoiding deforestation) and switching to lower-carbon technologies for power, heat and transport. Stern admits that a portfolio of technologies will be required, since "[i]t is highly unlikely that any single technology will deliver all the necessary emission savings, because all technologies are subject to constraints of some kind, and because of the wide range of activities and sectors that generate greenhouse-gas emissions" (Stern et al., 2006, p. xiv) ;
- The UN estimated that US$ 200 to 210 billion worth of additional investment and financial flows would be necessary in 2030 to return global greenhouse gas (GHG) emissions to current levels. This figure is divided between 7 sectors – energy supply, industry, buildings, transportation, waste, agriculture and forestry – and technology R&D[11] (UNFCCC, 2007);

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8 The global warming impact of other greenhouse gases is measured in terms of equivalency to the impact of carbon dioxide (CO2) via global warming potentials.

9 The figures and conclusions on delaying abatement, discussed in the remainder of this paragraph are based on McKinsey&Company, 2009).

10 14 years is the average effective lifetime of high-carbon infrastructure, however, the range is broad: coal fired power plants have a lifespan of 40 to 50 years, many industrial plants 20 to 30 years, and vehicles typically 10 to 20 years (McKinsey&Company, 2009, p. 47)

11 Detailed information on (additional) financial requirement per sector can be found in chapter four of UNFCCC (2007, pp. 35-95).

- To realize the abatement potential as calculated by McKinsey&Company, global incremental investments (i.e., investments above and beyond business-as-usual) of € 320 billion annually for the period 2011-2015 would be required, increasing to € 810 billion for the period 2026-2030, of which roughly 60 % is needed in the Transport and Buildings sectors.[12] These figures correspond to 5 to 6 percent of projected global investments in fixed assets in the business-as-usual scenario in respective periods (McKinsey&Company, 2009, pp. 40-41);
- The International Energy Agency (IEA), in its "450 Scenario", describes another way of meeting the world's energy needs while restricting emissions to a level consistent with a 2°C temperature increase. It estimates that this scenario would require a total investment of US$ 38 trillion between now and 2030, equivalent to 2 percent of global gross domestic product (GDP). This is US$ 10.5 trillion more than required under the business-as-usual scenario. The largest chunk of additional investment, around 45 % (US$ 4.7 trillion), is needed in transport, followed by buildings (US$ 2.5 trillion), power plants (US$ 1.7 trillion), industry (US$ 1.1 trillion) and (second-generation) biofuels production (IEA, 2009; WEF, 2010);[13]
- The Intergovernmental Panel on Climate Change (IPCC) reckons that the costs of cutting GHG emissions by 50 percent by 2050 could be in the range of 1 to 3 percent of global GDP (IPCC, 2007; The World Bank, 2010).

Clearly, the calculations of investments required for abatement differ substantially. These differences in outcomes partly result from operational definitions used by the respective institutions. For example, some source look at mitigation (some institutions calculate the funds needed to cover the incremental costs of a low-carbon project over its lifetime (mitigation costs), while others calculate the additional financing requirement created as a result of the project (incremental investment needs). The latter can be up to 3 times higher than the former.[14] In addition, mitigation costs increase steeply with the stringency of emission reduction targets and with the certainty of reaching it. The (policy) choices assumed by the institutions highly influence the outcome of their calculations.

Although sources differ in their calculation methods and results, it is evident that current investment flows are insufficient to meet funding requirements. Total global annual investment in sustainable energy amounted to US$ 145 billion in 2009. It looks set to rise to US$ 200 billion in 2010, and to continue growing beyond that, to US$ 500 billion per 2030 (WEF, 2010). This leaves, regardless which model or source is used for funding requirements, a gap between the funding flowing into sustainable energy and what is needed to reach global climate goals.

An important elaboration of this assertion, is the question where this gap originates. Merely identifying the discrepancy between current investment flows and the funding requirements to meet global climate goals leaves this question unanswered. There are various options:

- a gap between the funding needs to meet government commitments (e.g., EU agreements) and available finance;

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12 See Exhibit 4.2.1 in McKinsey&Company (2009, p. 42) for a detailed breakdown of both figures.

13 In this business-as-usual or "Reference Scenario", a global mean temperature increase of 6°C per 2030 is estimated.

14 Many clean investments have high up-front capital costs, followed later by savings in operating costs. Therefore, the incremental financing requirements tend to be higher than the lifetime costs reported in mitigation models (The World Bank, 2010).

- a gap between available finance and the funding needs of existing SE projects;
- a gap between available finance and the number of SE projects? I.e., are there enough creative inventors and courageous entrepreneurs in energy, compared to other sectors.

This question is underexposed in current (policy) reports and academic literature.[15] It seems that the general assumption is that available finance (i.e., capital supply) is insufficient compared to funding needs (i.e., capital demand). Whether this concerns a discrepancy between climate ambitions and funding (the first gap) or a discrepancy between the funding needs of existing projects and available finance (the second gap), is often left an open question.

2.2.2 Funding sources

SE investments can be funded by either equity or debt.[16] *Equity* means selling a stake in the project or company, providing (partial) right of ownership, control and a stake in residual earnings. Typical equity providers for SE investments are Venture Capital firms (VCs), Private Equity firms (PEs), Infrastructure funds[17] and Pension funds. Alternatively, companies or project developers might make an Initial Public Offering (IPO) or issue additional shares, raising capital on the stock market from a wide range of investors.

With *debt finance*, funds are borrowed for a specified period at certain terms and conditions including interest rate and loan repayment schedule. Mezzanine finance is a hybrid type of lending with a risk-return profile between equity and loans. Repayments are scheduled behind (senior) debt, resulting in higher risk. Providers of mezzanine therefore demand a higher interest rate compared to senior debt. Still, risk and return are lower than that of equity capital. Typical providers of debt to SE investments are banks.

The various providers of funds have different risk-return profiles, resulting in focus on different types of investment projects in different parts of the technology life cycle. VCs for example, accept relatively high risks but demand high returns. They are therefore an important funding source for start-ups which usually have a high-risk profile. Table 1 summarizes the various funding sources, the type of investment they typically focus on in view of risks and an indication of levels of return.

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15 Some of the few examples include (Wustenhagen & Teppo, 2006, pp. 9-10), who hint at a possible shortage of entrepreneurs in the SE sector, and UNEP (2009, p.14), who point to a "shortage of deal flow" as constraint for institutional investors to be active in low-carbon investments. UNEP (2009, p.19), however, further defines this as "a shortage of sufficiently commercially attractive, easily executable deals" with one of the prime reasons being that projects are too small. In view of the writers of this report, this underlines the importance of one of the barriers for funding (lack of scale), and does not constitute a lack of projects.

16 A third option is internal funding. Focus here is on external funding.

17 Funds drawn from a range of institutional investors and pension funds, targeting infrastructural projects like roads and power generating utilities (long duration, steady and low risk cash flows).

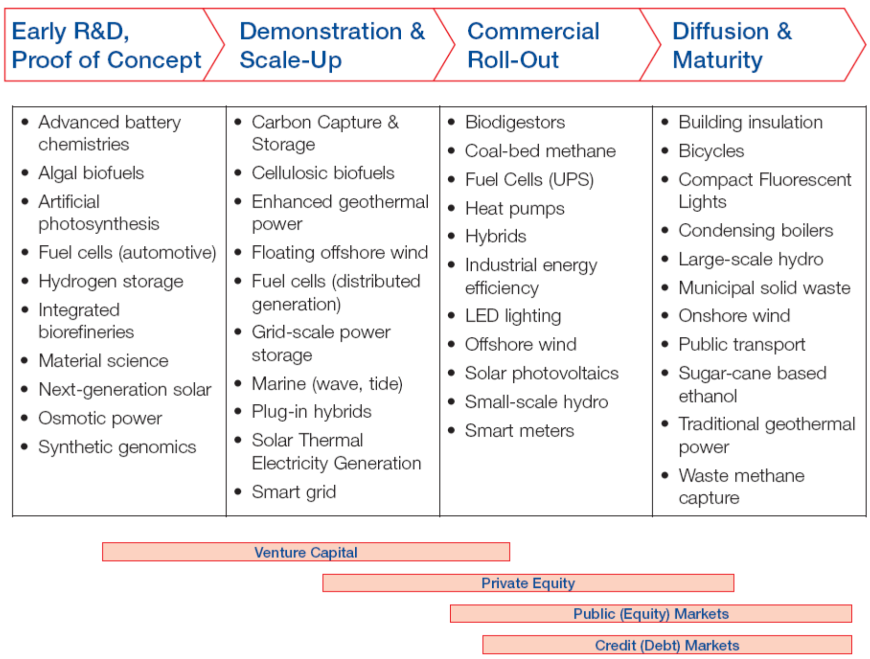
Table 1 Typical funding sources of SE investments

Source	Equity				Equity/debt	Debt
	Venture Capital	Private Equity	Infrastructure funds	Pension funds	Banks - mezzanine	Banks – senior debt
Typical investment characteristics	Start-ups, new technology, prototypes	Pre-IPO companies, demonstrator technology	Proven technology, private companies	Proven technology	Demonstrator/ proven technology, new companies	Proven technology, established companies
Expected Return*	IRR: > 50%	IRR: 35%	IRR: 15%	IRR: 15%	LIBOR+700 bps	LIBOR+300 bps

Source: adapted from (UNEP, SEFI, NEF, & Chatman House, 2009); * returns are purely indicative and reflect market conditions per June 2009; IRR = Internal Rate of Return; LIBOR = London Interbank Offered Rate

Figure 2 gives examples of different types of SE, categorized according to the stage of development of the technology, and the type of financing that private capital markets typically commit in each stage.

Figure 2 Sustainable energy by stage of maturity and private funding sources



Source: (WEF, 2010, p. 35)

Funding can be based on a specific project (project finance) or on the company starting the project (corporate finance or on-balance sheet finance). Available funds for project finance deals depend on the cash flow the project is expected to generate and the specific risk-profile of the project. With corporate finance, the company receiving the funds decides which part is used for which projects. In that case there is no link between availability of funding and the project characteristics; investors provide the company with funding based on the risk-return profile of the company. Not all SE investments will have the luxury to choose between the two financing models, mainly depending on the scale of the project or company. For investments "ranging from several tens to hundreds of million euros, the project initiator often has not enough capital available to finance the project on its balance sheet and therefore project finance is used" (de Jager et al., 2008). Especially larger companies investing in SE can choose between the two models and will do so based on the model which provides the cheapest funding.[18]

2.2.3 Current investment landscape

Box 2 provides a snapshot of the current investment landscape. A more elaborate overview of available figures is provided in Appendix A. In chapter 3.5 the (background of) financial attractiveness per energy technology is discussed in more detail.

Box 2 Literature snapshot on current investment landscape

Investments by ***sector***:

- **Wind** is the most mature clean energy technology and accounted for more than a third of capacity investment (roughly US$ 35 billion, see Figure 3) in 2008 (WEF, 2009a, p. 16)[19]
- **Solar energy** is the fastest-growing sector. The development of large-scale solar projects propelled the sector into the limelight in 2007, when it attracted US$ 17.7 billion in project financing, nearly a quarter of all new investment. Solar is also the leading sector for venture capital investment, as investors back such emerging technologies as thin film and Solar Thermal Electricity Generation.[20] Total solar investment in 2008 is estimated at US$ 26 billion, a 10% increase on 2007[21] (WEF, 2009a, pp. 16-17)
- **Solar** accounted for 39% of global Venture Capital in cleantech sectors in 2008, followed by **biofuels** (11%) and **transportation** (9%) (Cleantech Group, 2008)
- 80% of European VC investment is targeted at **wind** and **solar energy** (Cleantech Group, 2008)
- The fact that solar energy is the fastest-growing sector, is underlined by the amount of new money raised on global main markets (IPO, Secondary or Convertible/Other): in the 3rd quarter of 2008, US$ 2,2 billion (11 transactions) was raised for **solar**, US$ 419 million for **wind energy** (Newsletter New Energy Finance, October 2008)
  In 2008 total public markets new investment in **solar** was US$ 6.4 billion (UNEP, SEFI, & New Energy Finance, 2009, p. 18).
- About 50 percent of new asset finance concerns **wind energy** ($ 47.9 billion), followed by US$ 22.1 billion in **solar** and US$ 14.9 billion in **biofuels** (UNEP, SEFI, & New Energy Finance, 2009, p. 19).
- Expected developments:
  - Renewable energy technologies are expected to absorb cumulative investment of US 7.5 trillion between now and 2030. According to New Energy Finance (NEF), investments in **solar technologies** will increase exponentially until 2030 (see Figure 34 in Appendix A).
  - Investments in **wind energy** increase gradually until 2020, and will fall thereafter (WEF, 2010, p. 12).
  - **Solar and wind energy** have a combined potential capacity of 2,000 gigawatt (GW) by 2030, with **solar PV** (1,000GW in grid scale and residential) and **onshore wind** (800 GW) as the major contributors (WEF, 2010, pp. 24-25)

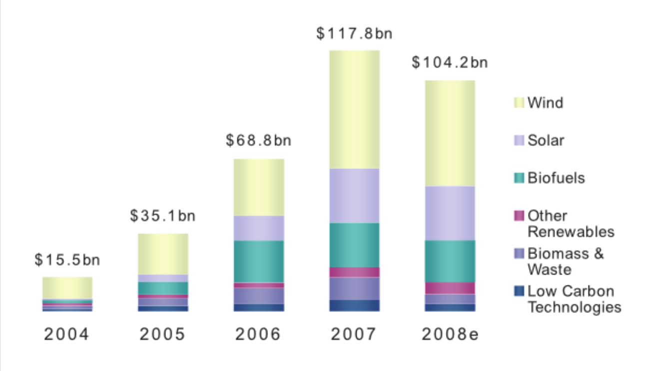
[18] Attractiveness also depends on fiscal regimes and public support schemes.

[19] Sector estimates are extrapolated values based on disclosed deals from the New Energy Finance Industry Intelligence Database. They exclude R&D and Small Projects (WEF, 2009a).

[20] PV has also flourished because of "generous incentive regimes" (feed-in tariffs and/or tax credits) in Germany and Spain, encouraging high profile IPOs from silicon, wafer, cell and module manufacturers (WEF, 2009a).

[21] UNEP reports a 49 percent increase in financial new investment in 2008 (UNEP, SEFI, & New Energy Finance, 2009, p. 18).

Figure 3 Global cleantech investments by energy source (billion US$)[22]



New Energy Finance in (WEF, 2009a, p. 16)

Investments by ***region/part(s) of the world***:

- In terms of asset finance: as recently as five years ago, clean energy meant wind, mostly in Denmark, Germany and Spain. Since then renewable capacity rollout has shifted away from Europe and towards **China and the US**. Developing (non-OECD) countries attracted 23% (US$ 26 billion) of asset financing in 2007, compared to just 13% (US$ 1.8 billion) in 2004, although the bulk of this went to the fast growing economies of China, India and Brazil. **India and China** in particular are determined to become clean energy powerhouses. By 2007, investment in clean generation capacity in China – excluding large hydro projects such as the Three Gorges dam – had soared to US$ 10.8 billion (WEF, 2009a, p. 17)
- In terms of Venture Capital (VC): **North American companies** raised US$5.9 billion in cleantech VC investment in 2008, as a result of closing 300 financing deals. Companies in the Silicon Valley/Northern California region accounted for almost 30% of the global VC investment total, but only 20% of the deals. Hence, Valley VCs put more support behind fewer companies. Companies in **Europe and Israel** accounted for one-fifth of the total venture capital raised, or US$1.8 billion (200 VC transactions). **China and India** remain emerging powers in the cleantech space, with companies in those markets raising US$430 million and US$277 million invested, respectively, accounting for a combined 9% of total VC investments (Cleantech Group, 2009, p. 9)[23]
- In terms of power capacity: the top six countries in 2008were **China** (76 GW), the **United States** (40 GW), **Germany** (34 GW), **Spain** (22 GW), **India** (13 GW), and **Japan** (8 GW). The capacity in developing countries grew to 119 GW, or 43 percent of the total, with China (small hydro and wind) and India (wind) leading the increase (Martinot & Sawin, 2009, p. 12)
- In terms of power capacity leaders per technology: **Germany and Spain** are Europe's leaders in terms of **wind** and **solar** (PV) power capacity. **Brazil and the US** produce 61 billion liters of **fuel ethanol**, 91 % of the total global production. **Germany, the US, France, Argentina and Brazil** are global leaders in terms of **biodiesel** production, with a total of 8.2 billion liters in 2008 (Martinot & Sawin, 2009, pp. 23-25)

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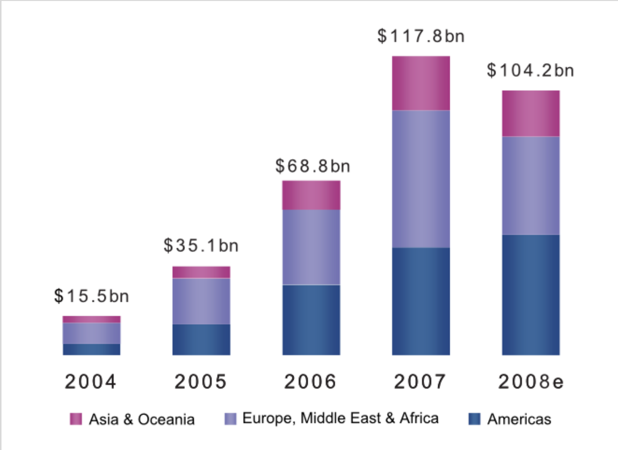
22 To enhance readability, not all of the surveyed figures and tables are included in this box. See Appendix B for more data on the respective investment flows.

23 Cleantech Group does not yet cover Asia beyond China and India (including Japan, Korea, Singapore, Malaysia, Taiwan, and others), South America (including Brazil, which has significant biofuels activity), or Africa. They estimate that these uncovered markets may add up to another 10-15% of the total.

Figure 4 Global cleantech investment (billion US$)[22]

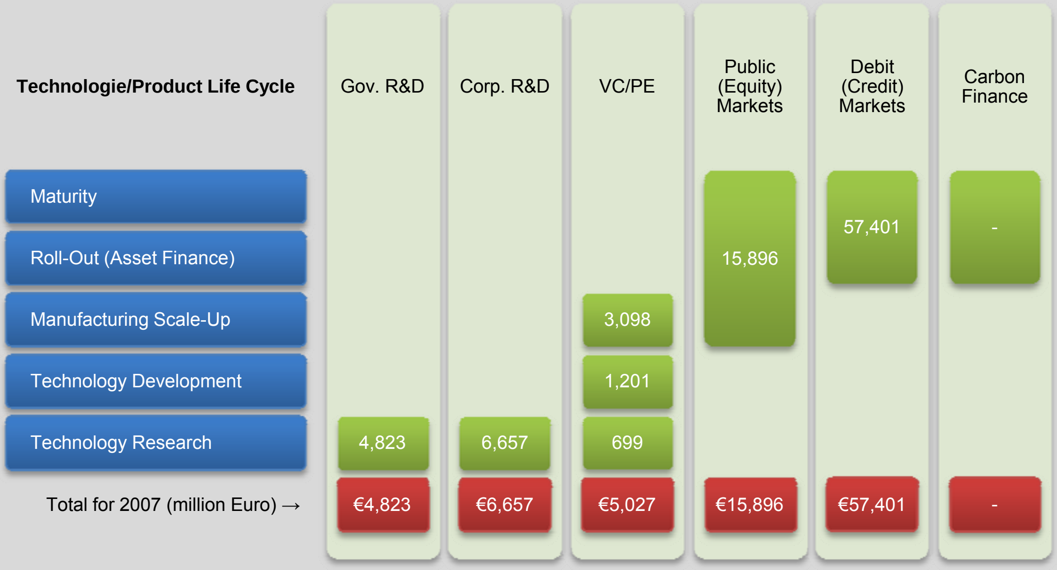


New Energy Finance in (WEF, 2009a, p. 16)

Investments by ***stage in life cycle*** and the link with funding sources:

- 60 % of global VC/PE investment is geared towards **manufacturing scale-up**.
- In 2007 Public (Equity) Markets raised approx. € 16 billion for **scale-up**, **roll-out** and **maturity**.
- Debit (Credit) Markets target **roll-out** and **maturity**, generating € 57.4 billion in 2007. As of 2007,
  - o

Figure 5 Global capital market for renewable projects (2007; million Euro)[22]



(Biermans, Grand, Kerste, & Weda, 2009) after (UNEP, SEFI, & New Energy Finance, 2008, p. 6)

Investments by ***funding source***:

- In 2008, roughly 80 % of global cleantech investments[24] ($ 80.6 billion) concerned **asset finance**, to fund the building of wind farms, geothermal power plants, biofuels refineries and the like. A large number of different financing structures have been used: fairly standard project finance structures may account for the bulk of deals, but utilities have funded much new capacity by means of corporate finance (WEF, 2009a, p. 20)

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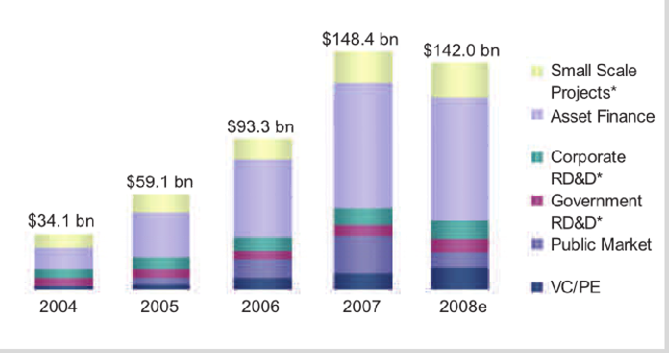
[24] Renewable energy and energy efficiency technology, excluding nuclear power and large hydro.

- **Small-scale projects** accounted for US$ 21.5 billion in 2008, **VC/PE** for US$ 14.2 billion (WEF, 2009a, p. 15)

Figure 6 Global cleantech investments (billion US$)[22]



New Energy Finance in (WEF, 2009a, p. 9)

3 Business Case for funding of SE investments

3.1 Introduction

Understanding capital flows to sustainable energy sectors requires insight in investment decisions. City of London et al. (2009) puts the importance of this point as follows "whilst it is clear that business has a critical role to play in financing, developing and deploying low carbon solutions, it is important to understand that investors (…) need to make returns on this investment". Financial attractiveness being key, a generally accepted way of understanding investment and funding decisions is the Discounted Cash Flow methodology.[25] By discounting all future cash flows (CF) to one moment[26], treating investments as negative cash flows, the Net Present Value (NPV) of an investment is calculated. The cash flows are discounted by means of the Weighted Average Cost of Capital (WACC), reflecting the return demanded by the providers of debt and equity.

$$NPV = \sum_{t=0}^{N} \frac{CF(t)}{(1+WACC)^t}$$

Projects with a NPV greater than zero are economically viable, because return on the investment is then expected to be higher than the required return by investors. Financial attractiveness is therefore determined by expected return (i.e., future cash flows) and required return. The latter is directly linked to risk: investors demand higher return, and thus a higher WACC, for investments with higher risk.

3.2 Risks

Investment decisions require an in-depth analysis of risks potentially impacting success and profitability. Risk assessment typically includes analyzing a number of risk areas, identifying the risks that are of importance for the investment under consideration as well as their expected impact.[27] The following general risk areas are considered:

- Project level risk: risks specific to the selected project, e.g., lead time risk (i.e., estimating time and costs involved in the planning stage), construction risk, technological risk (i.e., will the

25 Biermans et al (2009) conclude that SE investments have to obtain their funding from the same capital markets as any other investment. This implies that financial attractiveness is a key variable in decisions on funding SE investments, as is it is for other investments.

26 This moment is generally the start of the investment life cycle.

27 This assessment is used as input to determine the required return, i.e. the WACC in the NPV formula, with a higher (non-diversifiable) risk profile resulting in a higher WACC. For a more detailed discussion on WACC-calculation see for instance Brealey & Myers (2003).

technology work, be fit for the purpose, etc.), environmental risk and operation and management risk;

- Economic and financial risk: adverse changes in financial/economic factors like interest rates, currency exchange rates and inflation;
- Market risk: market specific risks, like resource risk (referring to availability, quality and price of e.g., raw materials, funding and human resources), competitive environment and market adoption risks (i.e., the demand for a new product);
- Country and political risk: country specific economic and political risks[28], like government (in)stability and status and maturity of the legal system including a solid basis for security over assets, policy and regulatory risk (i.e., adverse changes in policy and regulations);
- Force majeure risk: risk of natural catastrophes.

Building on Justice (UNEP, SEFI, NEF et al., 2009), Ecofys (de Jager et al., 2008), (Sjöö, 2008), (Meijer, Hekkert, & Koppenjan, 2007), (Wustenhagen & Teppo, 2004, 2006) and (SEFI & Marsh, 2005) the following risks are of specific importance for SE investments:

Policy and regulatory risk

Regulatory risk is often assessed as one of the main risks of SE investments. Governments tend to support the deployment of sustainable energy in many ways, while also regulating relevant procedures and impacting the competitive environment (e.g., fossil fuel subsidies). Regulation and policy instruments include licensing procedures, subsidies, tax based incentives, portfolio standards, liberalization of the electricity market, emission regulation - just to name a few. Success and profitability are often heavily, and directly, influenced by public policy, implying that (adverse) deviations from expected policy regimes pose a serious risk.

To get a grip on this risk and assess possible impact, investors will analyze "duration of the regime, its legal basis, its ability to be amended, a country's track record of continually adjusting or replacing legislation, and the impact of a change of political party in government" (UNEP, SEFI, NEF et al., 2009). Another, more direct, instrument, is lobbying for particular forms of regulation.

Unclear, unstable and unpredictable public policy can hamper the development of sustainable energy. Policy makers should take this into account. At the same time, length of regulation certainty cannot be expected to be infinite. Defining the minimum length of regulation required for investors to build a solid business case could prove helpful for policy makers, especially for instruments directly impacting investment return like feed-in tariffs. This will obviously depend on the planning and financing horizon, but also on the dependency of public policy over the lifetime of a project (this will most often decrease). The only source found on this subject is SEFI & Marsh (2005), roughly estimating 10 years would be sufficient for onshore wind, while offshore wind would require 15 years due to longer planning and financing horizon.

Technological risk

Technology is generally an important element in SE investments. Exploiting the potential of renewable energy sources in an economically efficient way, as well as increasing the efficiency of current energy use, often asks for (innovative) technological solutions. The development of these

28 Part of political risks refers to policies on supranational level, e.g., EU legislation.

technologies is risky because it is not certain what R&D costs will turn out to be, how long it will take for the technology to become mature, whether the technology will work, and whether it will prove fit for its intended use.

Resource risk

Resource risk can refer to the availability of the resource as such, like is the case with wind. But also when resources are generally available, SE projects might have to compete over these with others. An interesting (ethical) example is the use of corn as fuel or as food (Sjöö, 2008). Wustenhagen & Teppo (2006) point to human capital as potential resource risk. The SE sector, being relatively young, is highly dependent on entrepreneurial skills. Investors might fear that the sector attracts idealists rather than entrepreneurs, making them vulnerable to bad management of their investment.

Market adoption risk

As with any 'new' industry, SE investments face uncertainties in the market uptake. The innovative and technological character of many SE solutions makes it even harder to predict consumer interest. Market adoption further depends on SE specific regulation (e.g., product standards like energy classes) and the role of utility companies (e.g., connection of small-scale energy projects to the electricity grid).

Prices of fossil fuels influence the competitive environment and impact market uptake. Assumptions on the development of fossil fuels will therefore be part of the business case. In case actual prices are lower than expected, the attractiveness of SE sources will decline potentially resulting in lower return on investment.

Benefits of SE technologies are for a large part not private but societal in nature. Although society at large would be expected to attribute value to these benefits, this is not reflected in individual willingness to pay. Many times, market adoption for SE investments therefore depends on making someone pay for these externalities (e.g., via carbon emission trading).

Table 2 provides an overview the main risks for SE investments per risk area.

Table 2 Main risks of SE investments

Risk area	General description of risk area	Main Sustainable Energy risks
Project level risk	Risks specific to the selected project: • lead time risk (i.e., estimating time and costs involved in the planning stage), • construction risk, • technological risk (i.e., will the technology work, be fit for the purpose et cetera), • environmental risk and • operation and management risk	• Technological risk • Lead time risk
Economic and financial risk	Adverse changes in financial/economic factors, like: • interest rates, • currency exchange rates, • inflation	• Not of specific importance
Market risk	Market specific risks: • resource risk (referring to availability, quality and price of e.g., raw materials, funding and human resources), • competitive environment (i.e., characteristics and actions of competitors, impacting competitive position of the firm/project/product), • market adoption risks (i.e., the demand for a new product)	• Resource risk • Development of fossil fuel prices • Market adoption risk
Country and political risk	Country specific economic and political risks, like: • government (in)stability, • status and maturity of the legal system including a solid basis for security over assets, • policy and regulatory risk (i.e., adverse changes in policy and regulations)	• Policy and regulatory risk
Force majeure risk	Risk of natural catastrophes	• Not of specific importance

Source: SEO Economic Research, based on (de Jager et al., 2008; Meijer et al., 2007; SEFI & Marsh, 2005; Sjöö, 2008; UNEP, SEFI, NEF et al., 2009; Wustenhagen & Teppo, 2006)

3.3 Financial attractiveness

Financial attractiveness is determined by the combination of risk and return. Comparing the financial attractiveness of investment opportunities is usually done based on public stock market figures providing insight in financial ratios on profitability compared to e.g., company market value, shares outstanding or funding obligations. If individual companies are not publicly quoted, experience with other (publicly quoted) companies in the sector is combined with company specific data.[29] The literature on attractiveness of SE investments, however, is not often based on financial ratio-analysis. The next two sections cover the methodologies which are used instead, the third section focuses on the literature on financial ratio-analysis which is available

3.3.1 Levelized cost approach

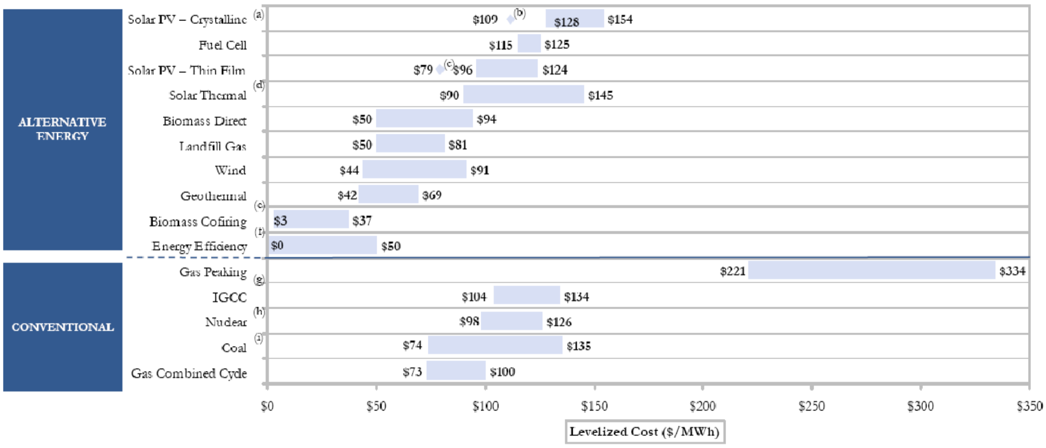
Much of the research on the development of alternatives to fossil fuels has focused on comparative costs (Houghton & Cruden, 2009). Being an important lever in competitiveness and market uptake, (relative) costs would provide a good indication of the financial attractiveness. A

[29] Most often, a Net Present Value calculation approach is underlying analyses.

way to compare cost levels is the concept of *levelized cost*. The levelized cost represents the present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments .[30]

(Lazard, 2008, p. 2) uses the concept of levelized cost to assess comparative financial attractiveness of renewable energy technologies based on U.S. cost figures. The authors conclude certain renewable energy technologies are already cost-competitive with conventional generation technologies, even before factoring in environmental and other externalities (like potential carbon emission costs) or the fast-increasing construction and fuel costs affecting conventional generation technologies.[31] This is illustrated in Figure 7.

Figure 7 Levelized cost of energy comparison (2008 US$)[32]



Source: (Lazard, 2008, p. 2)

Figure 7 classifies levelized costs ($/MWh) per sector, divided in sustainable energy types ("alternative energy") and non-sustainable types ("conventional energy"). Each sector comprises a variety of technologies, therefore ranges of levelized costs are presented.[33]

Lazard's exercise is a good example of an in-depth levelized cost analysis. Other examples include (NEA, IEA, & OECD, 2005), (CUPC, 2008) and (WEF, 2010). Results of levelized cost analyses however significantly vary across existing studies due to underlying assumptions, e.g., fuel price projections and employment of different discount rates (Van Kooten & Timilsina, 2009, p. 11). A general consensus on the most suitable assumptions does not seem to be reached as yet. A general drawback of the levelized cost approach is that externalities are not included, therefore costs do not reflect total costs to society.

30 Definition taken from IEA's 'Energy Glossary'.

31 Costs do not include transmission costs to connect electricity grids, which could be substantial for wind power, especially where wind farms are remotely sited (e.g., offshore or mountainous regions). Costs are levelized in real dollars (i.e., adjusted to remove the impact of inflation).

32 Reflects production tax credit, investment tax credit, and accelerated asset depreciation as applicable. Assumes 2008 dollars, 60% debt at 7% interest rate, 40% equity at 12% cost, 20-year economic life, 40% tax rate, and 5-20 year tax life. Assumes coal price of US$2.50 per MMBtu and natural gas price of US$8.00 per MMBtu.

33 Levelized costs of solar thermal, for example, vary from US$ 90 to US$ 145 per MWh, with 'solar tower' representing the lower boundary and 'solar trough' representing the upper boundary.

The levelized costs are determined as a price level which would facilitate a fixed return for all technologies, net of the costs of the specific technology.[34] As such, it implies that trade-offs between technologies are based on their costs, with low-cost technologies attracting capital flows. Houghton and Cruden (2009) argue such a "cost optimization approach" has important shortcomings, most importantly that it does not reflect all key variables for investment decisions. The authors prefer an "investment-led approach", analyzing development of (commercial) capital flows based on maximization of investor value in which costs is only one of many variables. Indeed, two important variables of great interest to investors are missing in the levelized cost approach: upside opportunity of investments in SE technology – i.e., (energy) savings – and differentiation of risk between technologies.[35] The first issue is tackled within the net cost approach, which takes the upside opportunity into account and is the discussed in the next paragraph. The second issue merits additional explanation.

The type and magnitude of risk differs between technologies. As an example in advocating the 'investment-led' approach, Houghton & Cruden (2009) argue to take price volatility into account when assessing attractiveness. This is important because price volatility, and thus risk, is high for commodities like fossil fuels, but low for manufactured goods like hydrogen. Krohn et al. (2009) raise a similar point. They state that levelized costs calculations normally underestimate the cost of conventional fuels because their dependency on volatile oil and gas prices increases risk and would justify a higher cost of capital. They conclude that applying the same discount rate for all technologies results in favouring conventional fuels.[36]

Additional research is needed to calculate the effect of differentiated discount rates per technology on the financial attractiveness of SE technologies.

3.3.2 Abatement cost curve: net cost approach

An abatement cost curve identifies a global cost curve of GHG abatement opportunities[37] beyond business as usual. One of the key elements underlying the analysis is the focus on net costs, i.e., all costs of an abatement measure, including investment costs, net of monetized (energy) savings. Although the exercise is most importantly intended to show the potential for CO_2 reduction, the abatement cost curve also shows (relative) financial attractiveness: the lower the net costs, the higher the financial attractiveness. McKinsey&Company (2009) provides an update of earlier work on the abatement cost curve (see Figure 8).[38]

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34 In corporate finance terminology, Lazard determined "the levelized cost of energy, on a US$/MWh basis, that would provide an after-tax IRR to equity holders equal to an assumed cost of equity capital".

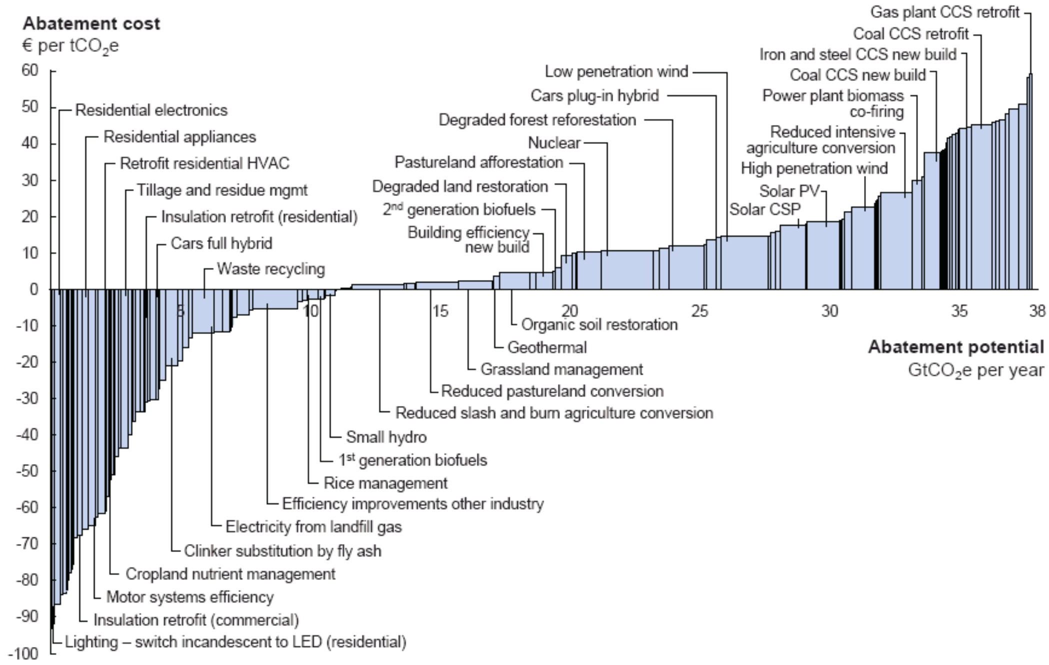
35 By using a uniform cost of capital (WACC) for all technologies, differences in required return in view of differences in risk are not taken into account.

36 The authors refer to Awerbuch as an important source of inspiration. Early 2000, Awerbuch concluded "[t]he divergence between valuation theory and practice is perhaps nowhere greater than in energy planning, where outmoded accounting concepts and engineering approaches, long since discarded in manufacturing and other industries, still provide the sole basis for decision-making (Awerbuch, 2000, p. 1032).

37 "Potential to reduce emissions of GHGs" (McKinsey, 2009)

38 Vattenfall (2007) includes a comparable exercise, identifying a global cost curve of GHG abatement opportunities beyond business as usual.

Figure 8 Global GHG abatement cost curve beyond business-as-usual (2030)



Source: (McKinsey&Company, 2009)

Figure 8 shows that all energy efficiency measures have a net positive financial profile, as do some renewable energy measures like small hydro and first generation biofuels. McKinsey concludes "there are about 11 $GtCO_2e$ per year of abatement opportunities in 2030 (…) where the energy savings actually outweigh the upfront investments, so that these opportunities carry a net economic benefit over their lifetime" . Evidently, one would expect measures with a net positive cash flow profile to result in a vast number of investment activities. This is especially true for energy efficiency. Whereas the investment equation of other energy investments is often less clear, it seems undisputed that many energy efficiency investments opportunities provide positive net cash flow. Investment flows, however, are relatively low (Efiong, 2007). Apparently, the business case for energy efficiency faces other barriers (see chapter 3.4).

Notwithstanding the insights the abatement (net) cost curve provides, some important drawbacks remain. First, as with the levelized net costs approach, differences in risk between technologies are not taken into account.[39] Moreover, costs are *before* taxes, tariffs and subsidies. This approach "serves as useful starting point for policy makers [but] does not reflect the economic investment case faced by those making decisions about whether to capture these opportunities" (McKinsey&Company, 2009, p. 40).

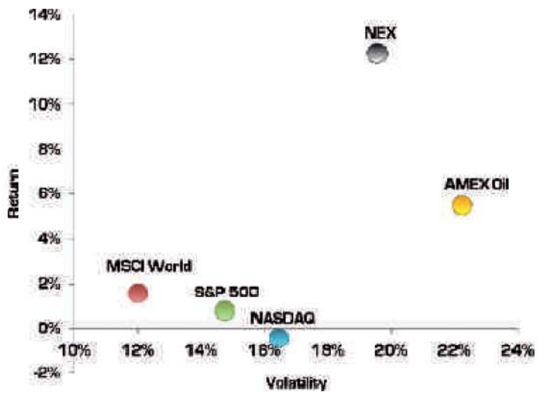
3.3.3 Actual performance of SE investments: market approach

A seemingly logical way of assessing financial attractiveness of SE investments is tracking their actual (risk adjusted) returns based on available market information.

[39] McKinsey uses a uniform interest rate of 4% to calculate capital costs.

WEF (2009a) shows that high volatility (i.e., risk) of publicly quoted Clean Energy companies is combined with consistently high returns, as depicted in Figure 9, "making them an attractive investment proposition on a risk-adjusted basis" (WEF, 2009a, p. 19).[40] We do note the data-sample includes publicly quoted "leading clean energy companies", implying a possible bias towards the more profitable (and large) companies. In a more detailed attempt to shed light on the risk-return profile of publicly quoted SE companies, Houghton & Cruden (2009) compare financial multiples reflecting risk and/or return between fuel cell providers, alternative energy technology providers, traditional utilities and the oil&gas industry. They find valuation differentials that do not match with weak returns of the fuel cell companies and an imperfect relationship between risk and return, implying need for further research.

Figure 9 NEX vs. AMEX Oil, NASDAQ and S&P 500, Sep 2005 – Sep 2008



Note: Returns are over 3 years, annualized so they represent the compound annual return.
Volatility is averaged over the same 3 year period.

Source: (WEF, 2009a); NEX: New Energy Global Innovation Index

Based on research by NEF, WEF (2009a) points to exceptional Internal Rates of Return (IRR) by Venture Capital and Private Equity investments in SE of 60% in the period 1997-2008/H1, but this is based on a relatively low number of exits and primarily caused by a small number of big successes. (Wustenhagen & Teppo, 2006) execute a high-level analysis of VC returns, concluding that there might be attractive returns, but mainly point at ample room for further research. (Kenney, 2009) still regards the Wustenhagen paper as the exception to the lack of academic interest in the field of greentech VC investment. He concludes that notwithstanding recent focus on investment by VC companies in sustainable energy, "…understanding of Greentech VC investment is still limited", pointing to the need for more empirical research on actual returns of energy VCs.

40 Data is based on the WilderHill New Energy Global Innovation Index (NEX), which tracks the performance of some 80 to 90 leading clean energy companies.

Focusing on the differences in risk-return and valuation multiples between traditional and renewable energy firms and the background of these differences – what (Houghton & Cruden, 2009) call the "investment-led approach" – could provide interesting insights in SE investment decisions.[41] Academic research, however, has not thoroughly tackled this subject as yet. The lack of publicly quoted companies in the SE sector could be one reason for this. The diversity within the sector and the lack of experience-based financial data in many parts of the industry are other possible reasons. More research is needed in this field.

3.4 Barriers to funding of SE investments

Both the levelized cost approach and McKinsey's abatement cost curve indicate potential for financially viable investments in SE, triggering the latter to question: "[i]f there are such attractive abatement opportunities, why then have consumers and entrepreneurs not already captured them?".[42] This seems all the more puzzling as both public and politicians' awareness and acknowledgement of the necessity of a transfer to sustainable energy has grown substantially (Stack et al. 2007; PwC, 2009).

Neither the levelized cost approach nor the net cost approach, however, take all relevant investment elements into account. Most importantly, the impact of risk –by means of a differentiated required rate of return– is not accounted for. Although the described risk categories in chapter 3.2 are encountered within other industries as well, SE sector characteristics imply that risk of many SE investments is perceived as high. (Biermans et al., 2009) conclude it is above all the set of risk characteristics combined in this one industry that poses a barrier to investments.[43]

SE investments do not meet funding requirements (see chapter 2.2). Apparently, sector characteristics pose barriers to investments. As explained, risk and return are unmistakably essential in this regard. Below, the potential barriers preventing funding of SE investments as described in the literature are summarized and categorized in informational barriers, scale barriers, market barriers and regulatory barriers. All barriers influence (perceived) risk and return one way or the other, thereby impacting financial attractiveness.

41 Alternatively, actual performance of specific sustainable investment types could be analyzed as long as it is possible to identify a relating 'traditional' alternative. An interesting example is the research on Green Buildings by Eichholtz et al. (for instance (Eichholtz, Kok, & Quigley, 2009) and (Eichholtz, Kok, & Quigley, 2010). They compare the rents on green buildings (i.e. "certified" as such by independent rating agencies) with otherwise identical office buildings and find higher rents for the former category.

42 Reasons that may be relevant but not taken into account by the McKinsey analysis are: sunk costs (some investments might not be made because of high-carbon tech investments still need to pay-pack) and consumer preferences which might not always be in line with low-carbon ideology.

43 The authors have executed a high-level check of various barriers/risk characteristics shared with other industries, like telecom, ICT and pharmacy. None of these sectors share the combination (and magnitude) of risks encountered by SE. It would still be worthwhile to look at those comparable other sectors to see what can be learned. This is hardly done in the research and papers reviewed for this report. One of the few exceptions is (Wustenhagen & Teppo, 2006).

3.4.1 Overview of barriers

Informational barriers

Evidently, investors need to understand what they are investing in and what financial benefits they can expect. This is true for both professional investors as consumers. Due to e.g., regulatory, innovative and technical characteristics, SE investment are often complex in nature (SEFI & Marsh, 2005). (UNEP & MISI, 2009) conclude "[c]onsumers, lenders, developers, utility companies, and planners, both in developed and developing countries, often lack adequate information about clean energy". This is especially true for potential savings offered by energy efficiency alternatives (McKinsey&Company, 2009; Plinke, 2008; WEF, 2010).

In addition, the sector is relatively young, resulting in a lack of experience with and quantitative data on investment results. This makes it hard for investors to build and assess the financial business case. Informational barriers are especially important in the Research and Development phase, where asymmetric information between investors and entrepreneurs/technicians might prevent projects to be funded.[44]

The informational barriers also imply investors, if interested in a deal, face higher transaction costs (negotiating, consulting with experts, monitoring agreements, finding partners). Higher transaction costs evidently reduce returns.

Scale barriers

Attracting funding might be difficult when high investments are needed upfront, especially when combined with long lead times. Uncertainty and the importance of risks grows when the amount at stake is high and it takes long before success is proven. SE solutions are in many cases capital intensive, like is the case with offshore wind and building energy efficiency, and have long lead times.[45] This contradicts with investors' short time horizons (Cameron & Blood, 2009).[46] But also with short required payback periods required by consumers, like is the case with most energy efficiency investments consumers face (McKinsey&Company, 2009).[47] In conclusion, capital intensity combined with long lead times is regarded an important barrier for SE investments (Plinke, 2008; Wustenhagen & Teppo, 2006).

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44 This is one of the reasons why public funding is so important in the R&D phase.

45 Offshore wind farms, for example, have turnkey investment costs of 1,200 to 1,850 Euros per kW, compared to 800-1,100 €/kW for onshore wind farms (Junginger, Faaij, & Turkenburg, 2004, p. 100).

46 Relatively certain profits on the short term will be favoured over reaping (uncertain) long term benefits based on high upfront investments.

47 Specifically for energy efficiency in buildings the time to replace existing building stock (30 to 50 years) is an important barrier as retrofitting building is more expensive than implementing energy efficiency when building in the first place (WEF, 2010).

Table 3 Cost of Engineering, Procurement and Construction (EPC)

Sector/technology	Total Capital Cost[48] (EPC Cost + Owner's Cost)
Alternative Energy	
Solar PV – Crystalline Utility	5,500-6,000 US$/kW
Fuel Cell	3,000 US$/kW
Solar PV – Thin Film Utility	3,500-4,000 US$/kW
Solar Thermal	4,500-6,300 US$/kW
Biomass Direct	2,750-3,500 US$/kW
Landfill Gas	1,500-2,000 US$/kW
Wind	1,900-2,500 US$/kW
Geothermal	3,000-4,000 US$/kW
Biomass Co-firing	50-500 US$/kW
Conventional Energy	
Gas Peaking	650-1,500 US$/kW
IGCC	3,750-5,075 US$/kW
Nuclear	5,750-7,550 US$/kW
Coal	2,550-5,350 US$/kW
Gas Combined Cycle	900-1,100 US$/kW

Source: SEO Economic Research, adapted from (Lazard, 2008)

Although the sector is characterized by high upfront investments and capital intensity, many projects are relatively small compared to investments in fossil fuel power generation plants.[49] This results in high transaction costs – permits, planning costs, assembling finance – relative to e.g., kW capacity (UNEP & MISI, 2009). (SEFI & Marsh, 2005) concludes "[a]ttracting the financial interest of international lenders and insurers generally requires a minimum project size of €10 million [t]ime and time again, the small scale of a potential project has prevented an otherwise viable deal".

Besides size of investments, also relative size of energy savings might pose a barrier.[50] The opportunities of these savings are often overlooked because, in many industries, energy costs only reflect a relatively small part of total costs (Plinke, 2008). In this regard, (McKinsey&Company, 2009) also points to the challenge that many savings opportunities are small on an individual level – the level at which investment decisions are made – while related energy savings are high on aggregated (societal) level, like is the case with low-energy lighting.[51]

48 Includes capitalized interest costs during construction.

49 For all clarity: upfront investments and capital intensity are assessed compared to total investments of a specific project or total cash flow profile. That they are assessed 'high' for SE investments should thus be seen in relative terms and does not imply that investments are high in absolute terms. In addition, especially in case of on-balance funding, investors often look at the company executing the project instead of only at the project itself. It is easier and cheaper to assess financial power of one large corporate than of a number small companies. SE projects are in many cases developed by small companies.

50 This mainly refers to energy efficiency investments.

51 Needless to say there are also examples of substantial savings opportunities on individual level, e.g. within a shipping fleet.

Market barriers

Sustainable energy sources compete with fossil fuels. As such, a relatively low price of fossil fuels might prevent uptake of sustainable energy. (PwC, 2009) expects a continuous rise in fossil fuel prices, because remaining fossil fuel sources are expected to be in more difficult to reach areas. More generally, Pindyck (2007) simply points to depletion as reason for rising fossil fuel prices. At the same time, costs of SE are expected to decline in view of increasing economies of scale. Pindyck (2007) concludes that there is "reason to think" price differences may decline over the next fifty years. For now, demand of SE has however not yet grown to sufficient levels for production to achieve sufficient economies of scale (UNEP & MISI, 2009), preventing SE solutions from being competitive compared to conventional fuels (PwC, 2009; UNEP, SEFI, NEF et al., 2009). The (relatively low) price level and the uncertainty regarding future price development of fossil fuels are therefore still seen as a barrier.[52]

Although reduced in the past decades, fossil fuels are still heavily subsidized (Jefferson, 2008; SEFI & Marsh, 2005). The World Bank and IEA have estimated that global annual subsidies for fossil fuels are in the range of US$100-200 billion (UNEP & MISI, 2009).[53] Subsidizing fossil fuels results in an inequitable market structure, allowing fossil fuels to be sold at artificially low prices, providing non-market incentives in favor of fossil fuels and reducing competitive power of SE solutions.[54]

The road to a society based on sustainable energy instead of fossil fuels is more and more regarded as critical to meet the growing demand for energy and prevent adverse climate change. The latter is largely attributed to greenhouse gas (GHG) emission, caused by the use of fossil fuels. Hence, fossil fuels put a grave cost to society and the solution is to be found in deployment of sustainable energy. At first sight, this would simply cause everybody to stop using fossil fuels and turn to sustainable energy. However, neither costs to society of fossil fuels nor benefits of sustainable energy are included in prices. If costs (benefits) of conventional (sustainable) energy would be factored into prices, return of investments in these technologies would be lower (higher). Because this is not the case, these so-called 'externalities' prevent a level playing field between conventional fuels and SE (Stack, Balbach, Epstein, & Hanggi, 2007; UNEP & MISI, 2009; Wustenhagen & Teppo, 2006).

Market organization can fail to align incentives properly. An important example is the so-called split incentive or agency issue posing a barrier for energy efficiency investments in the building sector (Efiong, 2007; McKinsey&Company, 2009; Owen, 2006). If a building owner invests in energy efficiency, normally the tenant will see his energy bill decrease. The building owner will

52 Work by e.g., (Lazard, 2008; McKinsey&Company, 2009; Vattenfall, 2007) concludes there are seemingly many SE opportunities with competitive cost structures. As explained in chapter 3.3 there are certain drawbacks to these analyses. Still, it seems safe to say relatively high costs alone is not a showstopper for (all) SE investments.

53 For a elaborate discussion of fossil fuel subsidies and an overview of energy subsidies over countries and energy source, see Victor (2009).

54 The same could be said of subsidizing sustainable energy. However, many of the barriers described here result from market imperfections, providing reason for government interference with SE solutions. This seems hardly the case for fossil fuels. Moreover, it seems at the least fair to say that providing competitive edge to fossil fuels is rather out of key with general public policy to promote sustainable energy.

therefore not necessarily benefit from his investment and will thus have limited incentives to invest.[55]

Regulatory barriers

The barriers mentioned above all have considerable impact on the cash flow of SE investments, in many cases preventing an attractive business case. (UNEP, SEFI, NEF et al., 2009) describes the necessity of public policy as follows "[r]enewable energy is most typically attractive in a policy-driven market. This is because it is often only marginally competitive, if at all, compared with conventional power on a standalone basis". Combined with the importance attached to a change to SE by politicians and the public alike, government interference in the sector is high.[56]

As described in chapter 3.2 policy intervention results in policy and regulatory risk. Risk of e.g., termination of subsidies during the lifetime of a project or unexpected changes in industry standards have serious repercussions for financial attractiveness (Kann, 2009; SEFI & Marsh, 2005; Wustenhagen & Teppo, 2006).[57] According to Jefferson (2008), policies are often based on short term and unrealistic targets and exaggerated claims of CO_2 reduction, resulting in misdirected subsidy systems and unnecessary support of mature technologies. Incorrect design of public policy and lack of clarity are potential barriers as well (Holmes & Mabey, 2009; Jefferson, 2008)

Financial crisis

The financial crisis is often seen as an important barrier preventing SE investments in the previous year(s). Although the SE sector was certainly not the only sector reaping the sour fruits of the crisis, it was hit relatively hard. The reason for this lies in its characteristics. The financial crisis caused a decrease in supply of capital. The little capital available was only provided to low-risk investments – especially by banks whose business model turned towards traditional core-business. To obtain finance, investments would have to be small, short term and have predictable returns. As discussed above, SE investments do not fit this profile being more often than not capital intensive, long term and high-risk. In addition, the sharp decrease in oil prices did not do any good to the economics of SE investments (Biermans et al., 2009; PwC, 2009; WEF, 2009a).

Luckily, impact was not as large as expected. Whereas IEA still expected a decrease of 20% over 2009 in November of that year, when the dust cleared Clean Energy investments had only dropped by 6,5% in 2009. The unexpected recovery was caused by rapid growth in China, general recovery of financial markets and the inclusion of green stimulus policy in government reaction to the crisis (WEF, 2010).

55 The same is true for energy efficiency investments by construction companies, resulting in benefits for homeowners instead of the construction companies.

56 Chapter 4.2 deals with the role of public policy in lowering barriers to SE investments.

57 In terms of Net Present Value this means risky cash flows, resulting in a high discount rate and thus a low NPV.

Box 3 Business case: Better Place, successful in obtaining funding

Risks and barriers prevent many SE project from being funded. It is interesting to analyze projects which are funded notwithstanding these challenges. One example in this area is Better Place.

Better Place was started in 2007 by Shai Agassi. He saw electric vehicles (EV) as the solution to decrease oil dependency and had a solution for the major challenge faced by the industry. Although electric vehicles are generally seen as highly promising, the industry had not really found a solution for its biggest frustration: quick recharging. Whereas it is not a problem to have a long recharge time when doing this overnight at home or during work-hours, this is not an option when traveling for longer distances. The best option in the market as yet - the Tesla Roadster - is able to drive 250 miles, after which a recharge of two hours or more is required. Agassi's solution combines the traditional idea of charging spots with a novelty: robotized battery-swap stations that change batteries - not refill them - within minutes. His vision entails a worldwide structure of both options, thereby providing the infrastructure to make electric cars a cheap and accessible alternative to traditional vehicles. Money would be made by buying (green) electricity in bulk and reselling it to customers much the same way as in the mobile phone industry - based on unlimited miles, a maximum number of miles each month, or pay as you go.

In terms of obtaining funding, Better Place has been a success. By April 2009 it had already raised US$400 million worth of venture capital and other private funding. The total initial investment was US$200 million, with the Ofer family - partly via Israel Corp. - having a majority stake. Other investors include VantagePoint Venture Partners, Morgan Stanley, and Esarbee Investments Canada. In 2010 a further US$350 was raised by a consortium led by HSBC, the latter gaining 10% share ownership.

Being a start-up with an innovative/R&D character, venture capital and private funding are the most logical sources of funding. This is also the phase in the life cycle where risks and barriers are most profound. The Better Place business case provides an interesting example as it has clearly been able to overcome these challenges. Some key factors for its success are the following:

- Clear earning model: the concept is clear on how and when money will be made once the infrastructure is implemented. In addition, the earning model - although based on a system unprecedented in the car industry - has proven successful in the mobile phone industry. These elements - clarity and proven success - are important to attract investors at the start-up and R&D phase;
- Immediate consumer advantage: although EV results in a reduction of energy-cost per mile of driving, upfront investment for consumers is high due to battery costs. This is a key-barrier for consumer take-on. Deutsche Bank (2008, p.12) concludes that Better Place provides a "business model in which it will own the battery and sell the consumer "miles" at a lower cost than the equivalent cost of gasoline in each country (this is the only model that we know of in which the consumer can immediately benefit from lower fuel costs, without incremental upfront cost in the vehicle)".
- Alternatives: EV is becoming more interesting compared to its alternatives. Besides the oil price volatility, the limits of further efficiency-gains in traditional energy-use of cars are in sight making it a more compelling alternative for car producers;
- Combining environmental concerns and innovation with industry beliefs and business-logic: starting from a known - though still innovative - technology (EV) which is generally regarded a promise in decreasing oil dependence and focusing on the main element preventing it from becoming practically - and thus financially – interesting.

Source: SEO Economic Research, based on (Deutsche Bank, 2008; Roth, 2008; C. Thompson, 2009)[58]

3.4.2 Barriers and risks per stage of the life cycle

With each stage of the maturity or technology life cycle, an investment will encounter new risks and barriers. Knowing which risks and barriers are relevant during which part of the life cycle, helps to design (policy) solutions to overcome obstacles.[59]

Generally speaking, there are two important finance gaps during the technological life cycle. At the time technologies move out of the R&D-phase towards demonstration and deployment, risks

58 See also: 'Better Place wins $350 m. investment', Israel 21c (26-1-2010), (www.israel21c.org).
'Ofer to invest $30 mln in electric car deal', Reuters (27-12-2007), (www.reuters.com)
'Q&A: Agassi's Better Place idea--brilliant or nuts?', CNET News (23-4-2009), (news.cnet.com)

59 See chapter 2.2.2 for an overview of SE technologies per stage of the life cycle.

are high because of increasing scale - and thus production costs - while demand is still low and uptake uncertain. The increased scale implies requirement of funding beyond internal and public sources usually characterizing R&D investments. Venture Capital would be the most logical next step but Venture Capital firms might still assess risks as too high or scale (although increasing) too small for transaction costs. This 'valley of death' often prevents innovations to get deployed (UNEP et al., 2008).[60]

Going from deployment, via diffusion, to commercial maturity, Venture Capitalists typically exit projects. Project developers need to attract new and/or additional funding for increasing investments. This is often difficult because projects are too small to go to the stock market but are still too risky for banks to step in due to low track record and lack of securing assets. This is called the 'debt-equity gap'. Biermans et al (2009) conclude that both the valley of death and the debt-equity gap is more pronounced for SE investments due to their unattractive risk-return profile.

For effective policymaking, an overview of risks and barriers per stage of the life cycle is required. Table 4 provides such an overview based on UNFCCC (2009).[61]

Table 4 Financing barriers for SE investments per stage of the technical life cycle

Stage of technological maturity	Risks / Funding barriers
Research & Development	• Concept not proven yet, resulting in insufficient rate of return • Spill-over effects, preventing reaping full potential benefits • Lack of good technical information, resulting in high-risk
R&D, Demonstration	• Lack of technological track-record, resulting in high risk
R&D, Demonstration, Deployment	• High costs and lack of policy to overcome these, leading to low return
R&D, Demonstration, Deployment, Diffusion	• Energy prices and subsidies • Lack of, or insufficient carbon prices • High upfront capital costs, including requirement for parallel infrastructure • Lack of (consumer)market • Split incentives • Lack of labour skills • Lack of regulatory framework and international standards
Commercial nature	• Inefficient regulatory environment • Lack of specific risk assessment/management tools • Lack of appropriate financial packages • Lack of awareness and information • Market imperfection

Source: SEO Economic Research, adapted from UNFCCC (2009)

60 For more on the Valley of Death, see for instance (Auerswald & Branscomb, 2003) and (Beard, Ford, Koutsky, & Spiwak, 2009).

61 For a different typology of stages in the life cycle and relevant risk in each stage, see for example (de Jager et al., 2008).

3.5 Attractiveness per energy technology

Opinions on attractiveness of energy technologies - and what will be the 'next best thing' - differ and are constantly updated. Below some general observations on a sample of the major SE energy sources are discussed, primarily based on WEF (2010).[62] This is purely meant as reference, providing a general idea of the latest insight in the rational for investment streams.

Onshore wind is the most mature technology, able to compete with conventional energy sources without subsidy. Development is no doubt spurred by feed-in tariffs and tax credits (e.g., in Germany, Spain and US). **Offshore wind** is a logical step after onshore wind. It provides enormous potential, but is relatively unexploited as yet. Challenges include grid-connection, long lead times, high capital expenditure and low margin on offshore wind turbines compared to onshore turbines. In December 2009, various European countries signed the 'North Seas Countries' Offshore Grid Initiative', planning to develop a European offshore wind grid in the North and Irish seas. Notwithstanding dramatic cost reduction in 2009, **Solar Photovoltaics** (PV) remains one of the most expensive RE technologies. Its potential is not expected to be exploited for several years. The PV market is mainly driven by policy incentives. **Biomass** held up good in 2009. It is based on a range of feedstocks like wood and is driven by public policy, e.g., Renewable Portfolio Standards (RPS) in some US states where other renewable sources are scarce. Main bottlenecks are long term availability and price risk of feedstock. **Geothermal** is interesting due to its predictability and is the lowest cost form of RE. It is hindered by long project duration and high capital costs, partly caused by the required (though risky) exploration drilling. **Small hydro**[63] is a mature and well-established RE technology, though a variable source of power. Together with large hydro it accounts for 16% of global power. It is characterized by relatively low risk and small size. Bottlenecks are grid-access and environmental and social resistance.

Table 5 Key data on attractiveness per energy technology

Energy Technology	Levelized costs	Current and (potential) scale	Project Return
Onshore wind	US$68-109/MWh	140GW (800GW)	10-20%
Offshore wind	US$109-205/MWh	2,4GW (120GW)	Marginal
Solar PV (Grid scale and Residential)	US$170-450/MWh	21GW (1000GW)	incentive based
Solar thermal electricity generation (STEG)	US$190-250/MWh	616MW (80GW)	n/a
Biomass incineration/ gasification/ anaerobic digestion (AD)	US$70-148/MWh US$90-170/MWh US$80-189/MWh	45GW (150GW)	±10%
Municipal Solid Waste-to-Energy	US$38-157/MWh	18GW (50GW)	±12%
Geothermal	US$55-83/MWh	10GW (40GW)	12-37%

62 WEF (2010) discusses a total of 10 clean energy sectors which are assessed promising in terms of abatement and cost competitiveness with conventional energy. For explanation of the technologies, see chapter 2.1. WEF itself adds that the discussed technologies are by no means the only sources. Nor is WEF the only party assessing technologies. Among many others, see for instance Canaccord Adams and the Daiwa Institute of Research.

63 Large hydro is generally not included in SE technologies, see chapter 2.1.1.

Energy Technology	Levelized costs	Current and (potential) scale	Project Return
Small hydro	US$70-120/MWh	92GW (328GW)	8-13%
Sugar-based ethanol	Competitive with oil at around US$45 per barrel	/	8-15%
Next Generation biofuels	Competitive with oil at around US$150 per barrel	/	/
Energy efficiency	Investment potential of US$ 170 billion with an average internal rate of return (IRR) of 17 percent	/	/

Source: (WEF, 2010, pp. 24-25); no information on calculation method of project returns

4 How to increase funding of SE investments

As explained, investment decisions are based on the cash flows they generate and the return investors demand based on the relevant risks (i.e., the cost of capital). Due to the high-risk profile and the barriers described in chapter 3, financial attractiveness of SE investments (or investors' perceptions of the attractiveness) can be too low to attract sufficient funding. In order to increase funding, solutions can be designed to improve cash flows and/or risk-profile. Although most attention is focused on governmental-based solutions (public policy solutions), the private (financial) sector should also be involved in finding solutions to increase attractiveness or a combination of these two (public-private solutions).

4.1 Risk management

Techniques to identify, quantify and manage risk are well-established in the financial community – and many of these can be effectively applied to SE projects. With a risk management analysis framework in place that assesses controllable project intrinsic volatilities (e.g., energy volume risk, asset performance risk and energy baseline uncertainty risk) and hedgeable project extrinsic volatilities (e.g., energy price risk, labor cost risk and currency risk), energy experts and investment decision-makers can exchange the information they need to expand investment in energy projects (Mills, 2003; Mills, Kromer, Weiss, & Mathew, 2006). Important in managing risks is the possibility to decrease risks at a pre-defined price by means of financial instruments. Financial Risk Management Instruments (FRMIs) can be provided by private companies or can be part of Public Finance Mechanisms (PFMs). Figure 10 provides an inventory of potential FRMIs related to risks of large and small scale RE projects and of carbon financed projects.[64]

[64] Further information on instruments and their use can be found in several UNEP/GEF reports (http://www.unep.fr/energy/activities/frm/). Available data on scale of use - necessary to assess to what extent risks in SE investments are insured - is relatively old and focused on specific areas rather than providing a full overview. This information has therefore not been included here.

Figure 10 RE project risks by project phase and related FRM instruments

Renewable Energy Project Risks	Financial Risk Management Instruments
Risks associated with Large Scale Projects	
Project Development/ Pre-construction Phase	
Concept to implementation	Grants, Contingent Grants (GEF)
Construction Phase	
Construction/ Completion Risk	Insurance – Construction All Risks (CAR/EAR)
Counterparty Risk	Surety bonds - Performance guarantees Liquidation damages
Operating Phase	
Performance Risk	Insurance
Counterparty Risk	Surety bonds - Performance guarantees Liquidation damages
Fuel Supply/Weather resources Risk	Weather Insurance/ Derivatives
Credit Risk	Guarantees Credit derivatives
Generic – All Phases	
Financial Risk	Standard derivative products
Political Risk	Political Risk Insurance MFI Guarantees Export Credit guarantees
Force Majeure Risk	Insurance Catastrophe bonds
Risks associated with small scale projects	
Project Developer	
Development (Credit) Risk	Guarantee Funds
End User	
Risks of physical damage including theft	Insurance
Credit Risk	Guarantees Credit lines
Risks associated with Carbon Financed projects	
Market Risk	Standard derivative products to hedge against price
CER delivery Risk	Insurance – carbon delivery guarantee, permit delivery guarantee

Source: (UNEP & GEF, 2008)

4.1.1 Risk insurance by the private sector

In the field of risk insurance, the apparent climate change has double impact. First, insurance companies will have to adapt their internal risk management to the new environment of increased climate and energy risks. The insurance sector faces material liability exposures to both the causes and consequences of climate change, many of which have already begun to materialize (Ross, Mills, & Hecht, 2007). Some insurers have begun to apply their expertise in risk management towards helping their customers avoid liabilities. Proactive approaches are likely to yield a "win-win-win" situation, in which insurers, policyholders, and third parties affected by climate change-related externalities will all benefit from decreased risk (Ross et al., 2007).

Second, the intention to reduce climate change effects, resulting in a vast potential landscape of SE investments, provides commercial opportunities for insurers. The specific risk profile of SE investments poses challenges to companies in covering these risks. Risk insurance instruments could play an important role in diminishing risks of SE investments. This has caused numerous insurance companies to create new business units targeted at sustainable energy projects in recent years (SwissRe, 2009). Examples of commercial opportunities include:

- Energy savings insurance: protecting the installer or owner of an energy efficiency project from under-achievement of predicted energy savings, e.g., by means of energy savings insurance or real options and derivatives for energy efficiency (Mills et al., 2006, p. 198; SEFI & Marsh, 2005);

- Renewable energy project insurance: covering performance risk for renewable energy systems, e.g., through wind power derivatives;
- Coverage extensions to fill gaps in green building projects: green building can involve new risks during construction and operation compared to conventional buildings (SwissRe, 2009).
- Energy Service Contracts: a third party (e.g., Energy Service Companies, ESCOs, and energy suppliers) funds the cost of an efficiency improvement and is paid out of the savings, whereby secondary markets in these contracts could evolve as the market matures (WEF, 2010)[65];

Table 6 gives an overview of insurance providers and the sector in which their SE products can be categorized. Unsurprisingly, wind energy projects are currently best served by the insurance market.

Table 6 Inventory of RE and Carbon[66] insurance providers

Insurance company	Wind	Solar	Geothermal	Biofuels	Comprehensive	Carbon
ACE						*
AIG	*				*	*
Aon				*		
Axa		*	*			
Caron Re					*	
Chubb					*	
Munich Re		*	*			*
Navigator Group	*					
Renewco	*					
RNK Capital LLC						*
RSA					*	
Sompo Japan Insurance	*	*				
Sovereign GIC	*					
Swiss Re	*					*
Tokio Marine & Nichido	*					
Travelers'	*					
Willis Holding	*					
World Bank			*			*
Zurich						*

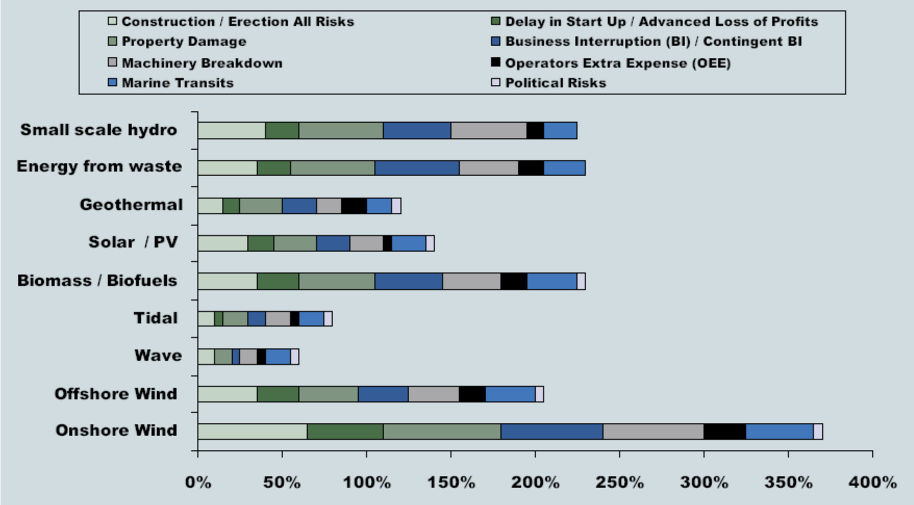
Source: (Mills, 2009)

Figure 11 provides an overview of coverage of specific risks by insurance products, based on an insurance provider survey – the percentages represent respondents providing the insurance products. Availability mirrors the stage in the technology life cycle the respective RETs are in. Insurance products are plentiful for 'mature' technologies (e.g., wind energy and small-scale hydro) – which have a significant operating and loss history – and scarce for new technologies (e.g., tidal and wave power).

65 Already used on a larger scale in e.g. UK, following the implementation of white certificate scheme (documents certifying that a certain reduction of energy consumption has been attained). For more background on the economics of ESC's, see for instance Sorrell (2005).

66 Carbon-credit insurance: CDM and Carbon-Offset Projects.

Figure 11 Availability of Insurance Products for different Renewable Energy Technologies



Source: (Marsh, 2006, p. 9)

In line with opportunities, recent years have indeed seen numerous insurance products targeted at renewable energy projects and their risks (see Box 4 for two examples). Some authors, however, suggest that most of these products are little more than bundling/repackaging of existing offerings (general (energy) project-related insurance products that are given new, 'green' names), rather than pure innovation to fill coverage gaps or carefully tailor coverage to the unique features of these technologies (Mills, 2009, p. 29).

Box 4 Examples of SE insurance schemes

Insurance4Renewables
Munich, RSA Insurance Group (RSA), and CarbonRe – with support from the Global Environment Facility (GEF) and the United Nations Environment Programme (UNEP) – have launched a mechanism for insuring renewable energy projects in developing countries. The global renewable energy insurance facility offers standard and customized insurance solutions for renewable energy projects in developing countries.[67] I4R has special focus on medium and large-scale projects in developing countries and offers, in addition to standard renewable energy insurance, special insurance lines such as Country and Political Risk, Third Party Counter Credit and Credit insurance covers and consultancy services.

CarbonRe, an insurance broker specializing in clean energy projects, is the appointed broker for access to the facility. Expertise is offered on a broad spectrum of technologies such as wind power, photovoltaics, solar thermal and biomass and biogas systems in every phase of construction and operation. Besides the traditional insurance products for construction, operation and transit, the facility offers on a case-by-case basis innovative covers such as carbon counterparty credit risk insurance, carbon all risk insurance, carbon delivery guarantee insurance/Kyoto Multi Risk Policy and lack-of-sun/wind insurance (Global Environment Facility, 2009; UNEP, 2008).

Wind Power Derivative for Large Scale Wind Farm Projects
Paris Re has introduced an index-based weather cover for the wind energy sector. The cover was developed in cooperation with MARSH in the framework of a study commissioned by the United Nations Environment Programme (UNEP) and the Global Environment Facility (GEF). When financing a wind farm project, the index-based product designed by Paris Re and MARSH provides coverage against the most important of all weather risks: the lack of sufficient wind (Paris Re, 2008; UNEP, 2008).

A specific form of SE insurance is *energy-savings insurance* (ESI), which is a formal insurance of predicted energy savings traditionally used to guarantee power reductions at retrofitted buildings. It transfers and spreads risk over a larger pool of energy efficiency projects and reduces barriers to market entry of smaller energy service firms that lack sufficiently strong balance sheets to self-

67 http://www.insurance4renewables.com/

insure the savings. ESI offers an important macro-level benefit of spreading aggregate risk over a larger pool of energy efficiency projects than most individual purveyors are likely to have. This is a natural benefit of establishing financial markets for previously unmonetized externalities. Furthermore, the presence of ESI encourages the parties to go beyond standard, tried-and-true measures (e.g., simple lighting retrofits) and thereby achieve more significant levels of energy savings (Mills, 2003; Schleich & Gruber, 2008; E. Vine, Mills, & Chen, 2000; E. L. Vine, 1992). Governmental agencies have been pioneers in the use of ESI and could continue to play a role (Mills, 2003). Commercial insurance companies, like AIG and Lloyds, also offer ESI. These products appear to be most widely practiced in Canada and the US, with examples also in Brazil and Malaysia (Mills, 2003). It has many potential applications (e.g., for homeowners, offshore property and aviation), but current supply includes only a few of them: industrial/energy property, real estate and crop (Mills, 2009, p. 7)

If properly applied, ESI can potentially reduce the net cost of energy-saving projects by reducing the interest rates charged by lenders, and by increasing the level of savings through quality control. Notwithstanding its potential – as also recognized by policy makers – demand for ESI is low. This is partly due to the fact that performance-based financial products seem to have fallen out of favor, and because there seems to be a profound lack of recognition on the part of customers that predicted energy savings cannot be taken for granted. In many cases, energy-efficiency projects suffer from lack of quality control, and underperformance as a result (Mills, 2009, pp. 29-30).

More works is needed to assess the full potential of ESI and its actual impact in practice. (Mills, 2003, pp. 273, 280) claims that, in 2003, no evidence could be found to evaluate the real-world experience of ESI agreements, or to conduct detailed financial analysis of the added project costs versus savings (e.g., lower financing costs).

4.1.2 Risk insurance by the public sector

(UNEP, 2009) points to country risk and currency risk cover (both supporting the supply of finance) and low-carbon policy risk cover (supporting the demand for finance) as the main insurance instruments governments should provide.

Country Risk Cover
Although there are many low-carbon investment opportunities in the developing world, country risk can prevent these opportunities from being realized. Public bodies writing guarantees which cover this risk have an important role to play in overcoming these problems (UNEP, 2009).

Insurance against country risk is already available at the project level from, among others, the Multilateral Investment Guarantee Agency (MIGA) of the World Bank and national Export Credit Agencies (ECAs), which cover political risks. Furthermore, indirect support (international to national) is provided by WB/IFC Partial Credit and Partial Risk Guarantees (Neuhoff et al., 2010, p. 17).

ECA support usually takes the form of export credit guarantees or insurance (political and/or commercial risk), investment insurance (political risk insurance only), or direct loans. ECAs can help further break down barriers to financing RE projects. However, most RE projects are relatively new and therefore may not meet standard ECA underwriting criteria, e.g., track history of successful trading. Historically, only a small portion of ECA business supports renewable energy projects and/or the sales of renewable energy technology (UNEP & SEFI, 2004).

Currency Risk Cover

Financial instruments to hedge exchange rate risks, currency controls, devaluation, et cetera are already available for commonly traded currencies but the private sector appears unwilling to provide the same instruments for currencies traded less frequently. This suggests that there is a gap in the market that the public sector can fill (UNEP, 2009), which is especially important for SE investments in developing countries.

Low-Carbon Policy Risk Cover

Investors are concerned that policy or regulatory risk will undermine the profitability of low-carbon investments, e.g., the adjustment or removal of a feed-in tariff. One way to mitigate policy risk would be to extend country risk guarantees to cover specific low-carbon policy risks (e.g., insurance could be provided against governments reneging on statutory grandfathering provisions). Alternatively, financial instruments such as put options might allow the policy risk to be hedged.[68] The provision of instruments of this sort could be expected to require no net subsidy (UNEP, 2009, p. 17; UNEP, SEFI, NEF et al., 2009).

4.2 Public policy solutions

There is no question whatsoever to the importance attributed to public policy as a key instrument in addressing climate change. Amongst many others, McKinsey (2009) concludes “the transition to a low-carbon economy might be the first global economic transition of this scale to be driven largely by policy”. Although crucial, the role of public policy in stimulating funding of SE investments is not easy. As stated by WEF (2009a), “there will be no one-size-fits-all solution.

4.2.1 Public policy instruments

There are two principal market-based policy instruments for climate mitigation and the underlying issue of externalities: carbon taxes and carbon emissions trading, also referred to as cape-and-trade or allowance trading.[69] Carbon taxes and cap-and-trade schemes can and are used conjointly (Kolk & Pinkse, 2005; Kossoy & Ambrosi, 2010; Nordhaus, 2007; Pinkse, 2007). In addition, governments can chose from a multitude of non-market based instruments. Table 7 provides an overview of public policy instruments currently used in stimulating the deployment of sustainable energy. Instruments directly focused at mobilizing and leveraging commercial funding are often called Public Finance Mechanisms (PFMs).

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68 E.g., options could be devised to place a floor on a key policy variable that crucially affects the profitability of low-carbon investment, such as the carbon price (UNEP, 2009).

69 For a detailed literature overview on this topic, reference is made to one of the other reports in the Finance&Sustainability literature review series, providing a literature overview on *Carbon Trading*.

Table 7 Policy instruments to promote SE

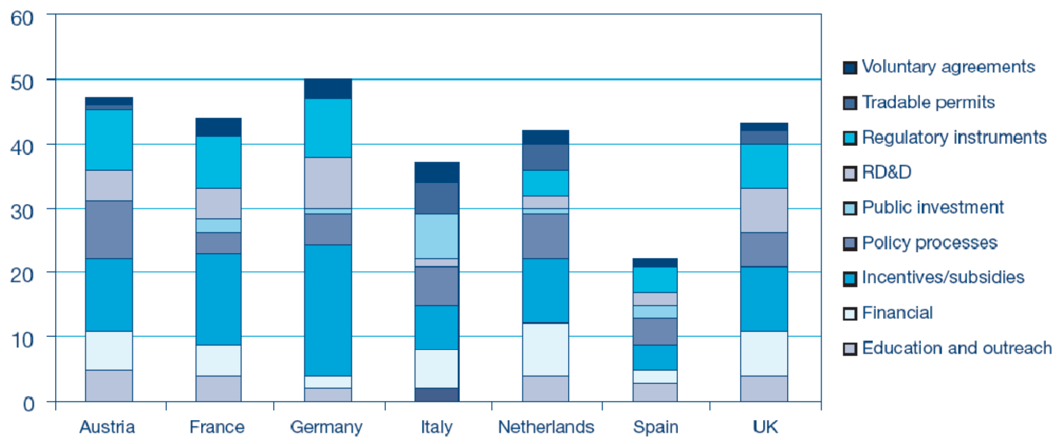
Category	Instrument/description
Voluntary agreements	Agreements among governments and businesses to promote/stimulate SE.
Education	Information about SE for target groups.
Policy processes	Special measures to facilitate SE projects, including emission reduction targets, shorter permitting processes and increased grid capacity/ connection.
Trade arrangements	*Quota obligations/Renewable Portfolio Standards (RPS)*: impose a fixed share of renewable energy in the electricity mix of consumers, suppliers or producers. A party that fails his obligation has to pay a penalty.
	Tendering: a government or institution issuing a tender, asks project developers to prepare a bid for a certain amount of electricity from a certain technology source. The price is determined based on a market mechanism (bid procedure). Tenders usually include long-term purchase contracts. The main disadvantage is the risk that price is set too low, resulting in the project not being materialized. For this reason, tendering has been abolished by several countries actively using this instrument in the past.
	Tradable permits: cap-and-trade systems: participants exceeding their objectives (cap) can sell permits to those not meeting theirs.
Direct financial/price support	*Production subsidies*: provide a financial incentive for each unit of energy produced over a given period.
	Investment subsidies/Capital grants: provide up-front subsidies based on installed capacity, reducing risk and thus capital costs.
Fiscal incentives	*Tax relief*: a tax exemption linked to installed production capacity, with the same result as an investment subsidy.
	Tax credit: a tax exemption linked to the amount of energy production, increasing profits.
	Flexible/accelerated depreciation schemes: allow writing off assets faster (or differently) than usually allowed, resulting in maximized tax benefit of depreciation and thus higher Net Present Value.
	Energy and emission taxes: taxing the use of conventional energy sources and/or directly taxing emissions.
Accessibility of finance	*Loans*: governments provide loans directly to projects or companies producing SE, often at lower interest rates.
	Loan guarantees: governments guarantee debt repayment to the lending bank, decreasing risk and thus interest rates and/or debt conditions.
	Carbon finance: facilities that monetize the advanced sale of emissions reductions to finance project investment costs.
Public investment	Government investments or participation in SE projects.

Source: SEO Economic Research, based on (de Jager et al., 2008; EC, 2008; PwC, 2009; UNEP & SEFI, 2008; WEF, 2010)

Figure 12 provides an overview of the use of policy instrument for a number of European countries.[70]

[70] The policy tools mentioned by PwC do not cover all instruments mentioned in Table 7. This is for al large due to the greater detail provided in the table.

Figure 12 Number of policy tools per country



Source: (PwC, 2009, p. 23)

4.2.2 Selecting public policy solutions to stimulate funding

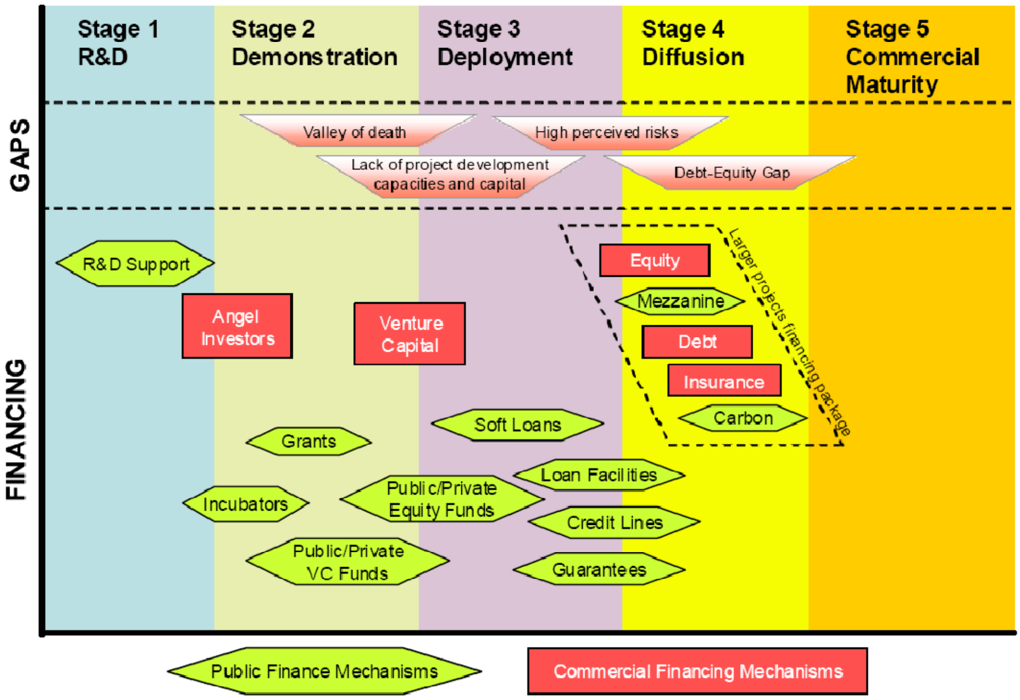
In determining which public solutions should be used for what SE investments, part of literature focuses on general solutions for the barriers impacting risk and/or return the sector is confronted with, while other research focuses on specific countries, funding parties, technologies and/or policy instruments. The latter category provides useful insights in the (proposed) use of public solution for specific cases like wind project finance in Australia (Kann, 2009) or solar cell promotion in Germany (Frondel, Ritter, & Schmidt, 2008). Here, the focus is on the general framework for selecting policy solutions.

A primary element for selecting appropriate policy instruments is the stage of the life cycle of the relevant SE solution (UNEP & SEFI, 2008; WEF, 2010). As discussed in chapter 2.4.2, each stage is confronted with specific risks and barriers. In addition, available funding sources depend on the stage in the life cycle as well.

The R&D phase asks for substantial public involvement in order to encourage innovations and development of new ideas. Before going to the marketplace, projects have to cross the 'valley of death' (see chapter 3.4.2), implying policy instruments should be focused on those risks that capital markets cannot take. Towards commercial rollout SE solutions will have to compete with fossil fuels – a rather challenging battle seen these conventional energy sources are based on years of experience, trustworthy technologies and incomparable investment flows. Public policy will have to provide economic support during this stage, albeit at exactly the right pace and intensity. Towards maturity, competitiveness of SE technologies should increase (and in the end beat fossil fuels). However, policy support will continuously be required in this stage as long as externalities, informational barriers, subsidization of fossil fuels and other barriers remain intact.

Figure 13 summarizes high-level gaps, the typical commercial funding sources and the Public Finance Mechanisms commonly used per stage of the life cycle.

Figure 13 High-level gaps RETs



Source: (UNEP & SEFI, 2008, p. 2)

Table 8 provides a more detailed overview of policy mechanisms, matched to the most appropriate stage of the life cycle.

Table 8 Policy instruments most suitable for each stage in life cycle

Stage / ***Policy mechanism***	**Early R&D**	**Demonstration & Scale-up**	**Commercial roll-out**	**Diffusion & maturity**
Market		• National/local procurement	• Feed-in tariffs • RPS/Green certificates • Renewable fuel standards	• Best available technology requirement • Utility regulation
Equity finance	• Incubators • National laboratories • Prizes • National/state-funded VC • R&D grants	• Project grants		• Technology transfer funds • Infrastructure funds
Debt finance		• Mezzanine/ subordinated debt • Venture loan guarantees	• Green bonds • Loan guarantees • Senior debt funds	• Export trade credit • Microfinance • Policy risks insurance • ESCO funds
Tax-based	• Capital gains tax waiver • R&D tax credits	• Development zones	• Accelerated depreciation • Investment tax credits • Production tax credits	• Carbon tax
Carbon market				• Domestic Carbon Cap and Trade • Project based carbon credits • Carbon funds

Source: SEO Economic Research, based on (WEF, 2010)

(WEF, 2010) includes a detailed assessment of all the instruments in Table 8 based on their scalability, efficiency and multiplier effect[71] as well as their applicability for developed, emerging and/or developing markets.[72]

The above studies focus on instruments fit for removing or lowering barriers in each stage of the life cycle, taking into account the commercial funding instruments that are usually used in each stage. Using a different approach, Ecofys (de Jager et al., 2008) links policy instruments directly to their impact on important financial variables used by investors to determine financial attractiveness. The report defines several renewable energy projects (e.g., in the field of wind energy and solar photovoltaic), which are funded based on a project finance scheme. First, the business case, in terms of e.g., levelized costs[73], is calculated without policy instruments. This default scenario is compared with scenarios including specific policy instruments, thus calculating the effect on levelized costs of government loans and interest reduction, government

71 Does each dollar of public money attract follow-on funds from private investors?

72 Scalability and country conditions are also mentioned by UNEP and SEFI (2008) for the evaluation of Public Finance Mechanisms.

73 The concept of levelized costs was explained in chapter 3.3.1: the levelized cost represents the present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments

participations, fiscal measures and production support.[74] The change in levelized costs, as a result of introducing policy instruments, is a measure of the effect on financial attractiveness Although results are business case specific and some input-assumptions are oversimplified, the analysis certainly shows the importance of proper insight in the effect of policy instruments on risk and project costs. It also draws attention to the vast number of variables to be taken into account when assessing the effect of policy instruments.

A more specific discussion point in academic literature has been on the choice between quantity-based versus price-based systems.[75] Although theoretical reasoning in the 90s pointed towards preference for quantity-based policies, actual experience revealed price-based policies to be more effective. The success of feed-in tariffs was for a large part explained by the lower risks they pose for investors compared to other policy instruments (see for instance (Bürer & Wüstenhagen, 2009; Dinica, 2006)). One example often cited is the success of feed-in tariffs in Germany. Frondel et al. (2008), however, conclude that PV promotion by high feed-in tariffs in Germany has not met climate and employment expectations, while at the same time having led funds away from potentially more beneficial investments. Generalized conclusions on preference for types of policy instruments should be prevented, implying the necessity of case-by-case assessment. Moreover, this example points to the potential problem of government failure. Government intervention creates a pool of economic rents, like subsidies, taxes emission rights et cetera, which economic parties try to capture by influencing politicians (Helm, 2010). As government mostly has less information on the subjects to be decided on than does the private sector (asymmetric information), it turns to private parties for information, providing a window for influencing decisions. The scale of these activities tend to grow with the economic rents. Helm (2010) concludes "because climate change is such a large market failure, the scale of the intervention is likely to be correspondingly large, and that *therefore* the scope for government failure is massive, too".[76]

An interesting alternative approach to assess policy effectiveness is to research investors' *perception* of risks (and opportunities) associated with specific energy and climate policies. This field of research is relatively new. In one of the first broad empirical studies, (Bürer & Wüstenhagen, 2009) questioned 60 private equity investors about which policies they regard as effective. The authors find that although technology-push policies are a prime focus area for many governments, on average market-pull policies are preferred by investors over technology-push policies.[77] Interviews with the investors indicate that a policy mix of both is required to address the different stages of the innovation cycle.

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74 In addition, the effect of reducing regulatory risk by ensuring long-term commitment of policy schemes is monetized, resulting in reduced levelized costs as high as 10 to 30%.

75 Quantity-based policies target the amount of relevant units – like the percentage of RE in energy portfolios or allowed emissions – while price-based mechanisms target the price of relevant units – like carbon taxes and feed-in tariffs.

76 The article provides more information on government failure and examples in view of climate change intervention.

77 Instruments to promote innovations in renewable energy can roughly be divided in 'technology-push' and 'market-pull' policies. Examples of the former are public R&D grants for SMEs and investment subsidies, examples of the latter are feed-in tariffs, reduction of fossil fuel subsidies and technology performance standards. See for instance (Grubb, 2004) and (Bürer & Wüstenhagen, 2009).

4.2.3 Abatement potential and other policy concerns

(Jefferson, 2008) claims that stimulating the development of renewable energy technologies by public policy is often done with insufficient regard for their costs, their contribution to electricity generation, transportation fuels' needs, or carbon emission avoidance. He concludes "[h]igher-cost, less mature renewable energy technologies that have large potential for meeting global energy needs are not getting the support they warrant". The author thus points to an important consideration from a policy perspective: lack of focus on actual abatement potential results in poor energy return on public investment. Besides financial attractiveness, necessary to attract private funding, policy makers should also take impact on climate change ('sustainability return') into account when designing and selecting instruments.

The work of (McKinsey&Company, 2009) and (Vattenfall, 2007) provides excellent insights in the sustainability return of SE investments. By linking the abatement potential to net costs per unit of potential CO_2 reduction, they offer starting points for policy prioritization aimed at both financial and sustainability return. Evidently, policy instruments should be focused on those investments providing the highest abatement potential. In addition, the net cost can be regarded as a rough estimation of the potential (financial) loss/profit of an SE project and therefore as a first indication of the required intensity of policy support in case governments want to stimulate projects: higher net costs imply higher potential losses and therefore higher intensity of policy measures to make investments economically viable and vice versa. Combined with the stage of the life cycle and investment characteristics, specific policy instruments can be selected.

Another element to be taken into account is the possibility of unintended consequences of policy instruments. An example in this regard, having received a lot of attention in the literature and media, is the 'Green Paradox'. The Green Paradox states that subsidizing renewable energy reduces future value of fossil fuels and gives an impetus to exhaust them now, bringing forward the date at which fossil fuels become exhausted with adverse impact on climate change(Kemfert, 2009; Sinn, 2008a, 2008b, 2009; Van der Ploeg & Withagen, 2010).[78] The Green Paradox thus links policy incentives for increasing the long-term share of sustainable energy on the one hand to unintended incentives for increased emissions of CO_2 on the short term on the other hand. For instance, Van der Ploeg & Withagen (2010, p. 29) argue that the Green Paradox is dependent on the type of renewable energy, more specifically its costs and 'cleanness', providing additional insights for the selection of policy instruments. Table 9 gives an overview of their taxonomy, concluding that the Green Paradox applies for expensive alternative energy sources which reduce CO_2 emission to zero, like solar and wind, but not for cheap alternatives like nuclear power.[79]

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78 The argument is as follows: subsidizing renewable energy such as solar or wind energy leads to lower (future) demand for fossil fuels and a (future) decrease in their consumption. Countries which supply fossil fuels, mainly oil, react by flooding the market with oil, because they assume that in the future oil will be a non-starter. This leads to an increase in supply, and thus further pressure on prices, which will then lead to higher demand for and use of oil on the short term. An important assumption underlying the analysis is the absence of a tax on CO_2 emissions.

79 As for now, it is uncertain whether a green paradox arises in the other combinations in their matrix (e.g., tar sands and carbon capture and storage), however, given the recentness of the paper their framework is an interesting guide for further research.

Table 9 Alternative energy sources to conventional oil and gas

Backstop	Expensive	Cheap
Zero CO2 emissions	Solar/wind/advanced nuclear ***Green Paradox applicable***	Nuclear ***Green Paradox not applicable***
Cleaner	CCS coal	-
Bit dirty	-	Coal
Very dirty	Tar sands	-

Source: SEO Economic Research, adapted from (Van der Ploeg & Withagen, 2010, p. 2)

Although there has been fundamental criticism on the theory underlying the Green Paradox (Hoel, 2010; Kemfert, 2009)[80], it does underline the importance of considering potential (short term) adverse effects when designing and selecting policy instruments.

In a broader context, the Forum for the Future (2007, p. 7) describes the tradeoffs between 5 types of capital – natural capital, human capital, social capital, manufactured capital and financial capital – and points out that investments in sustainable energy should be assessed based on their impact on all 5 capitals ("5 capitals maximization"). Currently, there is inadequate identification of issues, difficulties in measuring impacts, challenges in incorporating the value of impacts into decisions (due to lack of appropriate incentives) and into maximizing personal capital at the expense of global capital (i.e., negative externalities). Figure 14 provides an overview of the impact of several renewable energy sources on all five capitals. The first and last columns denote the tension between environmental yield and financial yield. For example, solar energy types have low operating costs but energy intensive manufacturing.

80 Critics doubt a (future) lowering of demand for fossil fuels even in the case of an uptake of SE, e.g., in view of the expected rapid growth of economies like China and India. Moreover, they regard it impossible for oil supply to be adjusted drastically on the short term in order to 'flood the market'.

Figure 14 Impact of RE technologies on five types of capital

	Natural	Human	Social	Manufactured	Financial
Biofuels	- Very high resource use and waste - Negative biodiversity impact	- Limited potential for smallholder farmers	- Inflationary impact on food prices, can undermine food security	- Aligns with existing fuel infrastructure	- Lower upfront investment need but ongoing input costs
Solar	- Some toxic materials in 2nd gen PV - Energy intensive manufacturing	- Installation & maintenance skills	- Potential for robust off-grid rural power solutions	- Complex inputs & manufacturing processes	- Very low operating costs but high initial investment
Nuclear	- Mining, use & disposal of radioactive materials	- Tested technology with strong skills base - But shortage of / ageing skills	- Security risks for many sites - Catastrophic hazard potential	- Long lead times for construction - Planning & location issues	- Very high economic costs - Unlimited potential decommissioning liability
Wind	- Low resource use, some land take - Limited visual, noise & wildlife impacts	- Established skills base	- Some negative impacts on rural communities	- Long grid connections for rural and offshore sites	- Onshore wind competitive installation & operation costs
Carbon Capture & Storage	- Untested long-term impacts of seepage - Reduces fuel efficiency	- Scientific & engineering skills for carbon storage not yet available	- Limited disruption to existing lifestyles	- Can be retrofitted to existing plant - Highly complex technology process	- Cost effective low carbon fossil fuel energy with CCS unproven
Geothermal	- Potentially renewable resource - Limited local pollution - But possible water impacts	- Limited impacts	- Limited disruption to existing lifestyles	- Relatively simple technology, uses existing drilling & turbine knowledge	- Cost effective in appropriate regions
Avoided deforestation	- Maintains ecosystem services	- Enable continued livelihoods - Or lack of livelihood skills for affected individuals	- Could preserve indigenous peoples' way of life - Or could undermine land rights, displace native populations	- Limited impacts	- May need conservation financing vehicles - Some secondary economic impacts
Carbon markets	- Impact dependent on carbon price	- Existing origination & trading skills base	- Markets do not generally effectively work for the poor	- Depends on technologies used, but generally minimal impact	- Fragile markets with unclear pricing, validity & consistency

Key to impacts: very negative | negative | neutral | positive | very positive

Source: (Forum for the Future, 2007, p. 16)

4.2.4 Policy recommendations

Based on the many possible ways to select and prioritize public solutions, different policy recommendations can be drawn. Below an overview of the main lines of reasoning is provided:[81]

- Design emissions trading markets. Combine these with ambitious and coherent national emission reduction targets; they are a prerequisite for broad, deep and liquid global carbon markets (Stack et al., 2007; WEF, 2009b);
- Implement and/or raise energy (efficiency) standards ((Jefferson, 2008; McKinsey&Company, 2009; Stack et al., 2007; WEF, 2009b)
    - Many energy efficiency investments, though financially attractive and providing high abatement opportunities on aggravated level, do not materialize due to market imperfections. A possible solution would be to align interests of the large number of consumers and companies, who would gain little in absolute terms on an individual basis but much on aggregated level (see chapter 3.4.1 on 'scale barriers'). An effective public policy instrument to achieve this is the use of technical standard and norms (McKinsey&Company, 2009);
    - Regulation of utility companies is now mostly focused on unit cost of supply aimed at preventing adverse effects of market power. As such it does not addresses climate change

81 Choices for specific instruments are not included as this requires case-by-case discussion. The recommendations are shared by many authors. Mentioning authors is purely for sake of back-ground references for the reader.

although it seems logical to include incentives to improve end-use efficiency there where energy-products change hands (WEF, 2010);

- Consistency and reliability of policy regime and instruments is key;
- Implement regulation on governance and transparency of climate risks by companies, because more pronounced disclosure regulation will provide investors with clear insights in (hidden) climate risks and opportunities in their portfolios. (Cameron & Blood, 2009; Shepherd, 2009; WEF, 2009b);
- Provide direct government support to R&D: R&D is essential for technology development and decrease of SE-costs. In this stage of the life cycle, risks are high and private funders are hesitant. Direct government support and encouragement instruments should be focused on R&D and technology development, especially of immature technologies with high abatement potential (Jefferson, 2008; McKinsey&Company, 2009; Stack et al., 2007);
    - As coal dependency will remain strong, technologies that capture and store CO_2 emissions are important. Carbon Capture and Storage (CCS) is far from commercially interesting as yet and needs government funding to bridge the 'valley of Death' (WEF, 2009a, 2009b)
- Phase out subsidies to fossil fuels (e.g., (Jefferson, 2008)).

4.3 Innovative funding solutions[82]

So far, focus has been on traditional funding sources and risk management as well as existing public policy instruments. However, the enormous challenge ahead and the lack of success in facing this with current action alone imply the need for innovative ways to increase funding. This is not only true for governmental institutions, but also for the private financial sector. As City of London (2009) puts it, "it is essential that…the financial services sector recognises that reflecting societal concerns is an essential part of its license to operate". Below a number of examples in this area is described, some of which are close to being successful in stimulating funding, while others merit further thought and research:

- Carbon trade: putting a price on CO_2 emissions via cap-and-trade systems provides incentives for abatement investments. Carbon trade is predominantly based on the Kyoto trading mechanism with the EU Emission Trading System (EU ETS) as biggest carbon market to date[83];
- Carbon bank: as a boost to the Clean Development Mechanism, a financial institution would sell carbon credits at their market (marginal) cost to developed countries – countries would be obliged to buy – while using the proceeds to buy credits from developing countries at a price close to incurred (average) costs. The difference would be used to fund mitigation and adaptation projects in developing countries ((Cameron & Blood, 2009), based on the Catalyst Project);
- Global Climate Change Fund: buying emission credits at a floor price, funded by developed countries, supporting the carbon market by increasing investor confidence (Edwards, 2009);

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82 This paragraph provides a snapshot of some promising innovations. For a more comprehensive literature overview on innovative funding solutions, reference is made to one of the other reports in the Finance&Sustainability literature review series, providing a literature overview on *Innovations in financing environmental and social sustainability*.

83 Although the Kyoto Protocol has been in force since 2005, it seems carbon trading has not reached its full potential in terms of catalyzing SE investment. For a literature overview on this subject, see Kerste et al. (2010).

- Green bonds: funds raised specifically for mitigation and adaptation projects. An example of this is the program launched by Swedish Bank SEB and the World Bank, responding to a demand by Scandinavian institutional investors (Cameron & Blood, 2009; Cameron & Holmes, 2009);
- Green Bank: the case for a Green Bank is discussed in detail in Box 5;
- Index-linked carbon bonds: bonds issued by governments, whereby the actual interest payments depend on whether these governments keep environmental promises. E.g., interest payable rises when the verified GHG emissions of the issuing country breach a promised maximum or decrease when feed-in tariffs for SE are higher than a pre-approved level. In this way the bonds provide a hedge instrument against regulatory risk. The idea of index-linked carbon bonds has emerged from discussions with participants in the London Accord community. It has been presented to the World Bank in 2009 and discussed with government debt offices and Treasuries. Further market research on supply and demand is required.[84](City of London et al., 2009);
- Micro-finance: scale is an important barrier to many SE investments. Small projects, most importantly on household and community level, could be financed based on micro-credit (Balachandra, Nathan, Salk, & Reddy, 2010);
- Innovative use of existing financial instruments: existing financial instruments could be used in an innovative way to stimulate SE investments. Examples include mortgaging SE technologies – whereby the SE technology is seen as a valuable asset providing funders with a security base – or leasing RE assets. The latter is a flexible form of finance, focused on assets. It could provide great potential to funding of RE investments as these are mostly asset-based. Public policy could stimulate this by means of fiscal incentives and information sharing (Balachandra et al., 2010)
- Energy-efficiency instruments: energy-efficiency investments are relatively high and outcome is uncertain. On several accounts, parties like banks, non-profits, energy services companies and building owners have cooperated to design solutions to guarantee savings and prevent high initial investments. An example is the Clinton Foundation Climate Change Initiative's Energy Efficiency Building Retrofit Program (Cameron & Blood, 2009).

84 According to Onstwedder et al. (2010) anecdotal evidence indicates there is investor appetite.

Box 5 Business Case - Green Bank

Government intervention to facilitate funding of climate change investments is generally accepted a necessity. As part of public policy, governments use financial instruments - e.g. grants, insurances, loans et cetera. A recent idea to improve institutionalization of these instruments is the establishment of a Green Investment Bank in the UK, as proposed by the Green Investment Bank Commission in June 2010. The idea of a government owned or sponsored financial institution focused on a specific area is not new, nor is this concept new to the SE sector. Examples include the Instituto de Crédito Official in Spain, with funding activities amongst other sectors focused on renewable energy and energy efficiency, and KfW Bankengruppe in Germany, that supports investments in a range of areas amongst which environmental protection and energy efficiency. In addition, ideas of this kind have also been part of legislation proposals in the US during the last two years – although without success as yet.

The recent proposal in the UK is the most explicit in linking a separate financial institution established by the government on the one hand with required investments for the transition to a low carbon economy on the other. The Green Investment Bank (GIB) would be established by an Act of Parliament but not be accountable to ministers or the Parliament for individual decisions in order to build credibility in the market. Its goal would be threefold: (1) increasing the availability of capital for investments in view of mitigating and adapting to climate change (2) better channeling existing government resources in this area (3) bridging to financeable market risk.
The GIB would roughly consist of two interrelated parts: a 'UK Fund for Green Growth', aimed at providing public sector funding and support, and a 'Banking division', aimed at "catalyzing private sector investments to enable Britain's low carbon transition". In terms of funding of activities, three funding types are proposed by the Commission:

- initial bank capitalization to support activities: e.g. via bank bonus taxes, proceeds of sale of government assets and revenues from EU ETS auctions;
- government funding for disbursement of grants: e.g. via incorporating the large number of existing quangos and funds focused on low carbon investments into the GIB;
- financing for ongoing activities and 'commercial' investments: e.g. via green bonds or green investment bank debt fund.

The Commission proposes a broad range of types of products the GIB could offer in view of its activities, from grants and co-investments to insurance products and carbon price underwriting. Support should be focused on those areas with maximum impact and short time to result. It does however underline that crowding out of the private sector should be prevented at all times and returns on public provided funds should be reinvested.

Although still on the political agenda, to be further discussed after the spending review in the autumn, establishment of the GIB is not a certainty. Current discussions focus on funding of the GIB, primarily whether sale of government assets will be part of this.

A Green Bank, as proposed in the UK, would be an important step towards centralizing the many dispersed government initiatives to boost SE funding - as would be favorable in many countries. Moreover, independency of public support from the political arena could reduce policy risk and facilitate a more private sector based approach.

Source: SEO Economic Research, based on (Green Investment Bank Commission, 2010), (Hewett, 2009), (Cameron & Holmes, 2009), (Podesta & Kornbluh, 2009), (Holmes & Mabey, 2009)

5 Developing countries

5.1 Funding requirements

The development of the non-industrialized economies will greatly affect energy use in the future. Wagner et al. (2009) conclude "[t]he stark reality is that, even if emissions from industrialized countries and deforestation were reduced to zero by 2050, the climate goal cannot be met unless emerging economies also reduce their emissions". Kenney (2009, p. 2) point out that, if the economic growth of China, initially, and then India were to follow the historical trajectory of fossil fuel energy usage and resource consumption that Japan, Taiwan, and Korea followed, "the environmental impacts would be nothing short of monumental".

According to the IEA, the majority of energy infrastructure projects needed by 2030 will be in emerging markets like China and India (IEA, 2008). Table 10 summarizes the mitigation costs, financing needs and adaptation costs developing countries face, according to different studies. Although figures differ substantially, they do illustrate the magnitude of requirements.

Table 10 Estimated annual climate funding needed in developing countries (2005 US$ billions)

Source of estimate		
Mitigation costs	*2010–20*	*2030*
McKinsey & Company		175
Pacific Northwest National Laboratory (PNNL)		139
Mitigation financing needs	*2010–20*	*2030*
International Institute for Applied Systems Analysis (IIASA)	63–165	264
International Energy Agency (IEA) Energy Technology Perspectives *	565	
McKinsey & Company	300	563
Potsdam Institute for Climate Impact Research (PIK)		384
Adaptation costs	*2010–15*	*2030*
World Bank	9–41	
Stern Review	4–37	
United Nations Development Programme	83–105	
Oxfam	>50	
United Nations Framework Convention on Climate Change (UNFCCC)		28–67
Project Catalyst		15–37
World Bank (EACC)		75–100

Source: (The World Bank, 2010, p. 260); *IEA figures are annual averages through 2050

5.2 Risks and barriers

Funding of SE investments in non-industrialized economies faces specific risks and barriers, requiring tailored mitigation instruments and mechanisms. Based on (Liming, 2009; Ockwell, Watson, MacKerron, Pal, & Yamin, 2008; SEFI & Marsh, 2005; UNEP, 2009; UNEP & SEFI, 2008; UNEP, SEFI, NEF et al., 2009) the following specific risks and barriers, and related solutions, are identified:

Political system and policy environment
Instable and immature political systems pose additional risks. UNEP, SEFI, NEF et al. (2009) point to political risk insurance as mitigation instrument (e.g., by the Multilateral Insurance Guarantee Agency). Besides an uncertain policy regime in terms of regulations and support for the SE sector, legal and tax systems might provide insufficient comfort to conduct business. As in developed countries, long-term off take contracts and a sound institutional environment is crucial in this regard.

Scale
Projects in developing countries are often even more small-scale compared to those in industrialized countries, aggravating related risks. Developing countries face problems in managing minimum required scale and the relatively high level of technology of RE projects. General training and education, as well as specific technology transfer support is therefore an important part of measures to improve success-rate of investments.[85] In addition, economies of the least developed countries are small and wealth level is low. Foreign direct investments (FDI) and risk mitigation products will therefore not easily find their way to these countries in view of low commercial attractiveness.[86] Public policy and intermediation by multilateral or bilateral agencies is therefore required (SEFI & Marsh, 2005).

Besides project and economy of scale issues, many developing countries have poorly developed financial markets and face comparative liquidity restrictions. Financial institutions have less experience with project finance structures and are relatively risk averse (UNEP & SEFI, 2008).

Economic and financial risk
Macroeconomic conditions are most often less stable. Elements like exchange rate, interest rate and (hyper)inflation risk – not assessed of specific importance for SE investments in industrialized countries – can result in considerable risk exposure in developing countries. Tools generally used in industrialized countries to mitigate these risks, like interest rate swaps, are often not available to the least developed countries (SEFI & Marsh, 2005). Development banks and ECAs are equipped to facilitate in this regard. In addition counterparty risk, e.g., credit worthiness of final off-takers for generated power, might hamper financial attractiveness (UNEP, SEFI, NEF et al., 2009).

Rural areas
Connecting rural areas to energy networks in developing countries will be a challenge in itself.[87] According to (Liming, 2009) costs will be higher than in urban areas (amongst many other factors, due to the need of accompanying infrastructure development). In general, the author assesses these investments as 'high risk and low profit'. On the bright side, sustainable energy is expected to be more cost effective than non-sustainable energy. The main reason is that stand-alone solutions are cheaper in these areas than connections to the central energy grid.

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[85] For more information on technology transfer support, see for instance (UNFCCC, 2008) and (Ockwell et al., 2008).
[86] This is not so much a problem in growth economies like China and India.
[87] And an important one: access would contribute to (economic) development and reduction of poverty.

5.3 How to meet funding requirements of developing countries

Required investments in developing countries are substantial. Delaying investments is not an option in view of serious lock-in consequences. Though justifiable[88], counting on contributions by richer, developed countries will not cover requirements either.[89] This leaves the private sector, which does not seem to favor taking on the additional funding requirements – expected returns do simply not meet risks on a sufficiently widespread basis.

(The World Bank, 2010) points to the Clean Development Mechanism (CDM) as the principal instrument for catalyzing mitigation in developing countries at this moment. They see potential for improvements of CDM in terms of e.g., efficiency, governance and operation and enlarging scope of benefits to low-income countries.[90] London School of Economics (2009) concludes "carbon market finance may, in the longer term, generate sufficient additional investment to meet stringent emission targets".[91] (WEF, 2009b), on the other hand, is of the opinion carbon markets and international offset schemes like CDM will not result in sufficient financial flows in the required time frame. Whether this will hold true or not, at the least for the medium term additional instruments are needed to attract sufficient private funding.

Public Finance Mechanisms are generally seen as a potential tool for closing the funding gap in developing countries. PFMs are financial commitments made by the public sector, which alter the risk-reward profile of private investments and thus catalyze investments.[92] Examples of mechanisms include credit lines, guarantees, first loss equity positions and carbon finance facilities. In choosing the most appropriate government intervention, London School of Economics (2009) underlines the importance of appropriate risk allocation between private and public sector. Public risk intervention should be limited to those risks "associated with market failures, policy credibility and equity consideration. Going beyond this would be inefficient…causing deadweight loss".

In the design of PFMs, both (WEF, 2009b) and (UNEP, 2009) point to the importance of institutional investors, by far the largest potential source of private funding. PFMs to stimulate SE funding in developing countries should therefore be designed to attract pension funds, insurance companies, et cetera. This implies the need for (sufficiently large and) low-risk funds focused on SE in developing countries.[93] At this moment, few large, diversified funds are available and involved risks and uncertainties remain considerable.

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88 Developing countries have contributed little, historically, to the underlying problem.

89 In Copenhagen it was agreed that developing countries would submit Nationally Appropriate Mitigation Actions (NAMAs) to the UNFCCC, which are "voluntary emission reduction measures undertaken by developing countries…They are expected to be the main vehicle for mitigation action in developing countries under a future climate agreement" (Dalkmann et al, 2010). It is intended these countries get the adequate support for implementing these plans, but it is a relatively new concept with success still to be proven. For sake of reference: in 2009, only some 25% of required funding was covered by public sector commitments from developed countries (UNEP, 2009). This figure is pre-Copenhagen but also pre-Greece's liquidity crisis. In general, most OECD countries face enormous public debt as it is, increasing ODA does not seem a public policy priority.

90 Carbon trading is part of one of the other reports in the Finance&Sustainability literature overview series.

91 Assumed investment requirements, however, are substantially lower than those in Table 10.

92 (UNEP & SEFI, 2008) calculates a multiplier of US$3 to US$15 per every US$1 of public investment.

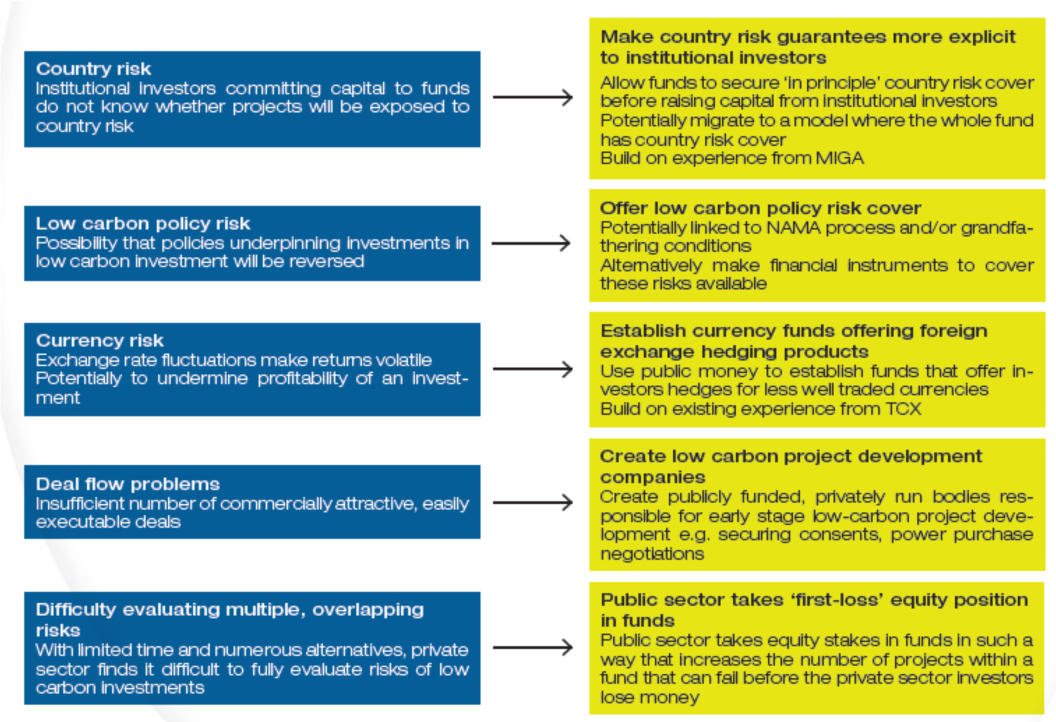
93 Institutional investors typically invest in investment funds (WEF, 2009b).

In specifying solutions to attract institutional investments with PFMs, (WEF, 2009b) focuses on the design of the funds. The report mentions two types of funds potentially catalyzing huge investment flows into developing country regions: challenge funds and regional cornerstone fund.[94] London School of Economics (2009) also mentions these funds as "proposals for a global architecture" to mobilize finance. In the *challenge fund*, fund management firms bid for access to regional packages of PFMs. The PFM packages, offered by Multilateral Development Banks (MDBs), improve the risk-return profile and the fund managers must explain in the bid how they will leverage these mechanisms. In *cornerstone funds*, regional MDBs would raise equity (the 'anchor equity') from major institutional investors and then invite fund management firms to bid on distribution of part of the anchor equity. Based on their part of the anchor equity – and access to preferential risk mitigation instruments from the MDBs – the fund managers would attract additional (secondary) institutional investors. Since most of the funds would be invested in infrastructure-style investment characteristics, project portfolio funding could be further leveraged with debt. The regional cornerstone funds would thus invest in smaller funds that would invest in individual projects (i.e., a fund-of-funds). Further work is necessary as (WEF, 2009b) concludes by stating "[t]he UN or negotiating parties are invited to ask a group of leading investors, financial experts and industry representatives to work with finance ministers and their officials to develop these ideas."

(UNEP, 2009) focuses on design of the PFMs underlying the funds. They identify five key areas preventing institutional investors from engagement in low-carbon investment and propose PFMs for each of these areas. Figure 15 summarizes the result.

94 The regions are ASEAN and Pacific, China, India, Latin America, Middle East/North Africa and Sub-Saharan Africa.

Figure 15 Five constraints on private sector engagement are matched with five operational PFM proposals



Source: (UNEP, 2009, p. 14)

According to London School of Economics (2009) the private sector favours concessional debt as a PFM. Concessional debt refers to lending at terms that are below market terms. Other instruments having high leverage potential are risk mitigation and credit enhancement instruments like full or partial guarantees and insurance, although these instruments are better suited for middle income than for the least developed countries. Furthermore, the report sees an important role for Multilateral Development Banks and advices an enhanced mandate for MDBs to leverage private investments. Important going forward, the report concludes "[the] private-public dialogue on innovative ways of using public funds to leverage private investment could become much stronger…so that private funds can flow at the necessary scale and speed".

References

Auerswald, P. E., & Branscomb, L. M. (2003). Valleys of death and Darwinian seas: Financing the invention to innovation transition in the United States. *The Journal of Technology Transfer, 28*(3), 227-239.

Awerbuch, S. (2000). Investing in photovoltaics: risk, accounting and the value of new technology. *Energy Policy, 28*(14), 1023-1035.

Balachandra, P., Nathan, K., Salk, H., & Reddy, B. S. (2010). Commercialization of sustainable energy technologies. *Renewable Energy*.

Beard, T. R., Ford, G. S., Koutsky, T. M., & Spiwak, L. J. (2009). A Valley of Death in the innovation sequence: an economic investigation. *Research Evaluation, 18*(5), 343-356.

Biermans, M., Grand, H. l., Kerste, M., & Weda, J. (2009). *De kapitaalmarkt voor duurzame projecten: De regels van het spel zijn het zelfde maar het spel verloopt anders*. Amsterdam: SEO Economisch Onderzoek.

Brealey, R. A., & Myers, S. C. (2003). *Principles of corporate finance*. New York, NY: McGraw&Hill.

Bürer, M. J., & Wüstenhagen, R. (2009). Which renewable energy policy is a venture capitalist's best friend? Empirical evidence from a survey of international cleantech investors. *Energy Policy*.

Cameron, J., & Blood, D. (2009). *Catalyzing Capital Towards the Low-Carbon Economy*. Copenhagen: Copenhagen Climate Council.

Cameron, J., & Holmes, I. (2009). *Accelerating green infrastructure investment with green bonds*. London: Green Alliance.

City of London, The London Accord, & CEAG Ltd. (2009). *Delivering Copenhagen: The Role of the City's Financial Services Sector in Supporting Action on Climate Change*. London: CEAG Ltd.

Cleantech Group. (2008). *Cleantech Investment Monitor 2Q08*. San Francisco: Cleantech Group LLC.

Cleantech Group. (2009). *Cleantech Investment Monitor: 2008 Annual Review & 4Q08 Quarterly*. San Francisco: Cleantech Group LLC.

CUPC. (2008). Retrieved 5-20-2010, 2010, from http://www.sourcewatch.org/index.php?title=Comparative_electrical_generation_costs

de Jager, D., Rathmann, M., Klessmann, C., Coenraads, R., Colamonico, C., & Buttazzoni, M. (2008). *Policy instrument design to reduce financing costs in renewable energy technology projects*. Utrecht: Ecofys.

Deutsche Bank. (2008). Electric Cars: Plugged In - Batteries must be included, *Global Autos Research Team*.

Dinica, V. (2006). Support systems for the diffusion of renewable energy technologies -- an investor perspective. *Energy Policy, 34*(4), 461-480.

EC. (2008). *The support of electricity from renewable energy sources*. Brussels: The European Commission.

Edwards, R. (2009). *Carbon finance for developing country greenhouse gas emissions mitigation from 2010 – 2020 and the role of a Global Climate Change Fund*. London: Climate Change Capital.

Efiong, A. (2007). *Energy Efficiency: The potential for selected investment opportunities*. London: Merrill Lynch.

Eichholtz, P., Kok, N., & Quigley, J. M. (2009). Doing Well by Doing Good? Green Office Buildings. *American Economic Review, Forthcoming*

Eichholtz, P., Kok, N., & Quigley, J. M. (2010). *The Economics of Green Building*.

Enkvist, P.-A., Nauclér, T., & Rosander, J. (2007). *A cost curve for greenhouse gas reduction*. New York: McKinsey.

Farrell, D., & Remes, J. K. (2008). *How the world should invest in energy efficiency*. New York: McKinsey&Company.

Forum for the Future. (2007). *Investments to combat climate change – Exploring the sustainable solutions*. London: Z/Yen Group.

Frondel, M., Ritter, N., & Schmidt, C. M. (2008). Germany's solar cell promotion: dark clouds on the horizon. *Energy Policy, 36*(11), 4198-4204.

FUNDETEC. (2007). *Comparison and Assessment of Funding Schemes for the Development of New Activities and Investments in Environmental Technologies*. Brussels: European Partners for the Environment.

Global Environment Facility. (2009). Innovative Renewable Energy Insurance Facility Introduced to Cover Risks in Developing Countries. Retrieved 7-5-2010, from http://www.thegef.org/gef/node/1603

Green Investment Bank Commission. (2010). *Unlocking Investment to Deliver Britain's Low Carbon Future.*

Grubb, M. (2004). Technology Innovation and Climate Change Policy: An overview of issues and options. *Keio economic studies, 41*(2), 103.

Helm, D. (2010). Government failure, rent-seeking, and capture: the design of climate change policy. *Oxford Review of Economic Policy, 26*(2), 182.

Hewett, C. (2009). Establishing a Green Investment Bank for the UK [Electronic Version].

Hoel, M. (2010). Is there a green paradox? University of Oslo, Department of Economics.

Holmes, I., & Mabey, N. (2009). *Accelerating Green Infrastructure Financing: Outline proposals for UK green bonds and infrastructure bank*. London: Climate Change Capital.

Houghton, T., & Cruden, A. (2009). An investment-led approach to analysing the hydrogen energy economy in the UK. *International Journal of Hydrogen Energy, 34*(10), 4454-4462.

IEA. (2008). *World Energy Outlook 2008*: International Energy Agency.

IEA. (2009). *World Energy Outlook 2009*: International Energy Agency.

IPCC. (2007). *Summary for policymakers*. Geneva: Intergovernmental Panel on Climate Change.

Jefferson, M. (2008). Accelerating the transition to sustainable energy systems. *Energy Policy, 36*(11), 4116-4125.

Junginger, M., Faaij, A., & Turkenburg, W. C. (2004). Cost reduction prospects for offshore wind farms. *Wind Engineering, 28*(1), 97-118.

Kann, S. (2009). Overcoming barriers to wind project finance in Australia. *Energy Policy, 37*(8), 3139-3148.

Kemfert, C. (2009). There is no green paradox. *Hürriyet Daily News and Economic Review.*

Kenney, M. (2009). Venture Capital Investment in the Greentech Industries: A Provocative Essay. *BRIE Working Paper 185.*

Kerste, M., Weda, J., & Rosenboom, N. (2010). *Carbon Trading*. Amsterdam: SEO Economic Research.

Kolk, A., & Pinkse, J. (2005). Business responses to climate change: identifying emergent strategies. *California Management Review, 47*(3), 6-20.

Kossoy, A., & Ambrosi, P. (2010). *State and trends of the carbon market 2010*. Washington, DC: The World Bank.

Krohn, S., Morthorst, P. E., & Awerbuch, S. (2009). The economics of wind energy. *preparado para a European Wind Energy Association.*

Lazard, L. (2008). *Levelized Cost of Energy Analysis -- Version 2.0.*

Liming, H. (2009). Financing rural renewable energy: A comparison between China and India. *Renewable and Sustainable Energy Reviews, 13*(5), 1096-1103.

LSE. (2009). *Meeting the Climate Challenge: Using Public Funds to Leverage Private Investment in Developing Countries*. London: London School of Economics and Political Science.

Marsh. (2006). *Survey of Insurance Availability for Renewable Energy Projects: United Nations Environment Programme*. London: Marsh Ltd Marine and Energy Practice.

Martinot, E., & Sawin, J. (2009). Renewables global status report: 2009 update. *Paris, France: REN21 Secretariat.*

McKinsey&Company. (2009). *Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve.*

Meijer, I. S. M., Hekkert, M. P., & Koppenjan, J. F. M. (2007). The influence of perceived uncertainty on entrepreneurial action in emerging renewable energy technology; biomass gasification projects in the Netherlands. *Energy Policy, 35*(11), 5836-5854.

Mills, E. (2003). Risk transfer via energy-savings insurance. *Energy Policy, 31*(3), 273-281.

Mills, E. (2009). *From risk to opportunity 2008: Insurer responses to climate change*. Boston MA: Ceres.

Mills, E., Kromer, S., Weiss, G., & Mathew, P. A. (2006). From volatility to value: analysing and managing financial and performance risk in energy savings projects. *Energy Policy, 34*(2), 188-199.

Mizuguchi, H., & Monoe, Y. (2009). *Green Industrial Revolution Gaining Momentum: Promising industries and players in next-gen eco, energy technologies*. Tokyo: Daiwa Institute of Research Ltd.

Müller, B. (2008). *International adaptation finance: The need for an innovative and strategic approach*: Oxford Institute for Energy Studies.

NEA, IEA, & OECD. (2005). *Projected Costs of Generating Electricity: 2005 Update.*

Neuhoff, K., Fankhauser, S., Guerin, E., Hourcade, J. C., Jackson, H., Rajan, R., et al. (2010). Structuring International Financial Support for Climate Change Mitigation in Developing Countries. *Discussion Papers of DIW Berlin.*

Nordhaus, W. D. (2007). To tax or not to tax: Alternative approaches to slowing global warming. *Review of Environmental Economics and Policy, 1*(1), 26.

Ockwell, D. G., Watson, J., MacKerron, G., Pal, P., & Yamin, F. (2008). Key policy considerations for facilitating low carbon technology transfer to developing countries. *Energy Policy, 36*(11), 4104-4115.

Owen, A. D. (2006). Renewable energy: Externality costs as market barriers. *Energy Policy, 34*(5), 632-642.

Paris Re. (2008). PARIS RE, Marsh and the UNEP/GEF develop innovative renewable energy insurance solutions.

Pindyck, R. S. (2007). Uncertainty in environmental economics. *Review of Environmental Economics and Policy, 1*(1), 45.

Pinkse, J. (2007). Carbon emissions trading: managing climate change through financial markets. *Aenorm, 56*, 17-20.

Plinke, E. (2008). *Energy Efficiency: Hidden Capital - How Investors Can Benefit From The Cheapest Source Of Energy* Basel: Bank Sarasin & Co. Ltd.

Podesta, J. D., & Kornbluh, K. (2009). *The Green Bank.*

Project Catalyst. (2009). *Enabling technologies for low carbon growth.* Brussels: ECF Energy Strategy Centre.

PwC. (2008). *Monitoring publiek gefinancierd Energieonderzoek 2007.* Amsterdam: PricewaterhouseCoopers.

PwC. (2009). *Crisis or not, renewable energy is hot: To reap the rewards, governments and companies should act now.* Amsterdam: PricewaterhouseCoopers.

Ross, C., Mills, E., & Hecht, S. B. (2007). Limiting Liability in the Greenhouse: Insurance Risk-Management Strategies in the Context of Global Climate Change. *Stanford Journal of International Law, 43*, 251.

Roth, D. (2008). Driven: Shai Agassi's Audacious Plan to Put Electric Cars on the Road.

Schleich, J., & Gruber, E. (2008). Beyond case studies: Barriers to energy efficiency in commerce and the services sector. *Energy Economics, 30*(2), 449-464.

SEFI, & Marsh. (2005). *Scoping Study on Financial Risk Management Instruments for Renewable Energy Projects: United Nations Environment Programme*. Paris: SEFI/Marsh.

Shepherd, P. (2009). *Reshaping the capital markets for a sustainable recovery*. London: Green Alliance.

Sinn, H. W. (2008a). Das grüne Paradoxon. *Plädoyer für eine illusionsfreie Klimapolitik. Econ, Berlin.*

Sinn, H. W. (2008b). Public policies against global warming: a supply side approach. *International Tax and Public Finance, 15*(4), 360-394.

Sinn, H. W. (2009). *The Green Paradox*. Paper presented at the CESifo Forum 3/2009.

Sjöö, K. (2008). The Influence of Uncertainty on Venture Capital Investments in Renewable Energy Technology: an exploratory study.

Stack, J., Balbach, J., Epstein, B., & Hanggi, T. (2007). *Cleantech venture capital: How public policy has stimulated private investment.*

Stern, N., Peters, S., Bakhshi, V., Bowen, A., Cameron, C., Catovsky, S., et al. (2006). *Stern Review: The economics of climate change.*

SwissRe. (2009, November 3, 2009). *Climate Change Adaptation and the Role of Insurance Products.* Paper presented at the CC & Insurance Adaptation, Las Vega.

Tester, J. W. (2005). *Sustainable energy: Choosing among options*: The MIT Press.

The World Bank. (2010). *World Development Report 2010: Development and Climate Change*. Washington, DC: The International Bank for Reconstruction and Development / The World Bank.

Thompson, C. (2009). The Green Issue - Batteries Not Included. *The New York Times.*

Thompson, M., Elford, S., Glover, E., Prouty, E., & Quealy, J. (2007). *Sustainability: Investing in renewable energy*. London: Canaccord Adams.

UNEP. (2008, 13-14 October 2008). *Summary of Discussions.* Paper presented at the Roundtable on Financial Risk Management for Renewable Energy Projects in Emerging and Developing Countries, Paris.

UNEP. (2009). *Catalysing low-carbon growth in developing economies: Public Finance Mechanisms to scale up private sector investment in climate solutions*. Paris: UNEP.

UNEP, & GEF. (2008). Financial Risk Management Instruments for Renewable Energy projects, *Project Status Note - March 2008* (pp. 4).

UNEP, & MISI. (2009). *Why Clean Energy Public Investment Makes Economic Sense: The Evidence Base*. Basel: SEF Alliance.

UNEP, & SEFI. (2004). *Executive Briefing: Making it Happen: Renewable Energy Finance and the Role of Export Credit Agencies*. Paris: UNEP.

UNEP, & SEFI. (2008). *Public Finance Mechanisms to Mobilise Investment in Climate Change Mitigation*. Paris: United Nations Environment Programme.

UNEP, SEFI, NEF, & Chatman House. (2009). *Private Financing of Renewable Energy – A Guide for Policymakers*. Paris: UNEP.

UNEP, SEFI, & New Energy Finance. (2008). *Global Trends in Sustainable Energy Investment 2008: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency*. Paris: UNEP.

UNEP, SEFI, & New Energy Finance. (2009). *Global Trends in Sustainable Energy Investment 2009: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency*. Paris: UNEP.

UNFCCC. (2007). *Investment and Financial flows to Address Climate Change*. Bonn.

UNFCCC. (2008). *Identifying, analysing and assessing existing and potential new financing resources and relevant vehicles to support the development, deployment, diffusion and transfer of environmentally sound technologies*. Bonn.

United Nations Conference on Environment and Development. (1992). *Rio Declaration on Environment and Development.* Paper presented at the United Nations Conference on Environment and Development.

Van der Ploeg, R., & Withagen, C. (2010). Is There Really a Green Paradox?

Van Kooten, G. C., & Timilsina, G. R. (2009). *Wind Power Development: Economics and Policies*. Washington, DC: The World Bank.

Vattenfall, A. B. (2007). Global mapping of greenhouse gas abatement opportunities up to 2030. *Web: http://www. vattenfall. com/www/ccc/ccc/Gemeinsame_Inhalte/DOCUMENT/567263vattenfall/ P, 272860.*

Victor, D. (2009). *The Politics of Fossil-Fuel Subsidies*. Winnipeg/Geneva: The Global Subsidies Initiative.

Vine, E., Mills, E., & Chen, A. (2000). Energy-efficiency and renewable energy options for risk management and insurance loss reduction. *Energy, 25*(2), 131-147.

Vine, E. L. (1992). Persistence of Energy Savings: What do we know and how can it be ensured? *Energy, 17*(11), 1073-1084.

Wagner, G., Wang, J., Dudek, D., Haverkamp, J., Keohane, N., & Petsonk, A. (2009). *The CLEAR Path: Rewarding early actions by emerging economies to limit carbon*. Washington, DC: Environmental Defense Fund.

WEF. (2009a). *Green Investing: Towards a Clean Energy Infrastructure*. Cologny/Geneva: World Economic Forum.

WEF. (2009b). *Task force on low-carbon prosperity: Summary of Recommendations*. Cologny/Geneva: World Economic Forum.

WEF. (2010). *Green Investing 2010: Policy Mechanisms to Bridge the Financial Gap*. Cologny/Geneva: World Economic Forum.

World Commission on Environment and Development. (1987). *Our common future*.

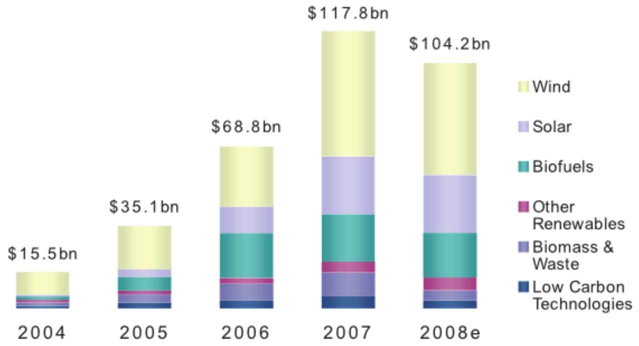
Wustenhagen, R., & Teppo, T. (2004). *What makes a good industry for venture capitalists? Risk, return and time as factors determining the emergence of the European energy VC market*. St. Gallen: University of St. Gallen.

Wustenhagen, R., & Teppo, T. (2006). Do venture capitalists really invest in good industries? Risk-return perceptions and path dependence in the emerging European energy VC market. *International Journal of Technology Management, 34*(1), 63-87.

Appendix A Investment Landscape

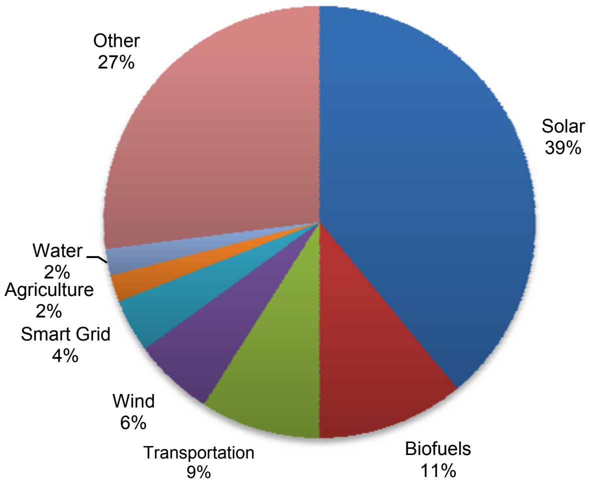
Appendix A.1 By sector

Figure 16 Global cleantech investments by energy source (billion US$)



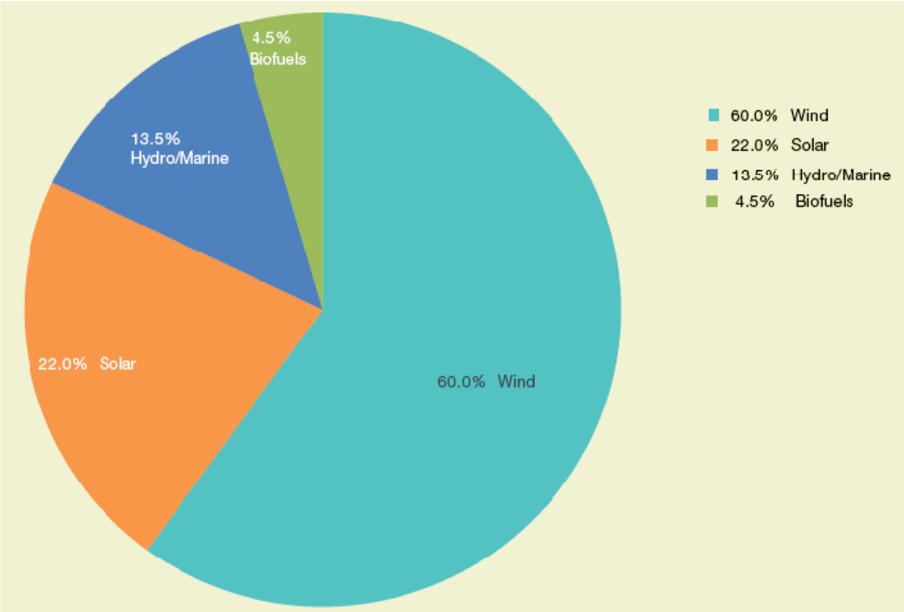
Source: New Energy Finance in (WEF, 2009a, p. 16)

Figure 17 Global Top Venture Capital Clean Technology Sectors in 2008



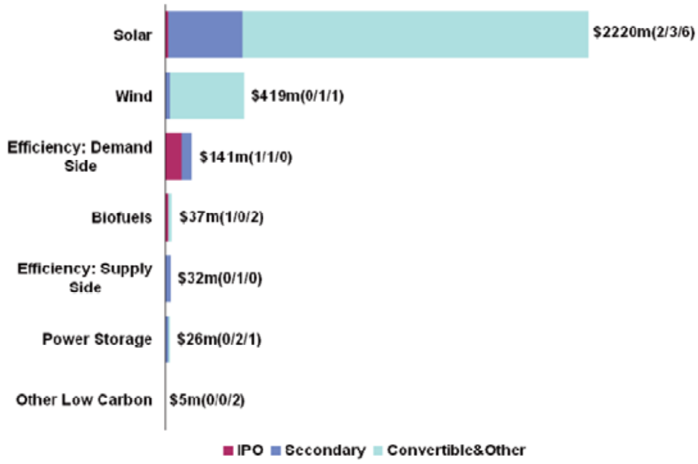
Source: (Cleantech Group, 2008)

Figure 18 Europe 2Q08 Percentage of Energy Generation VC Investment by Amount



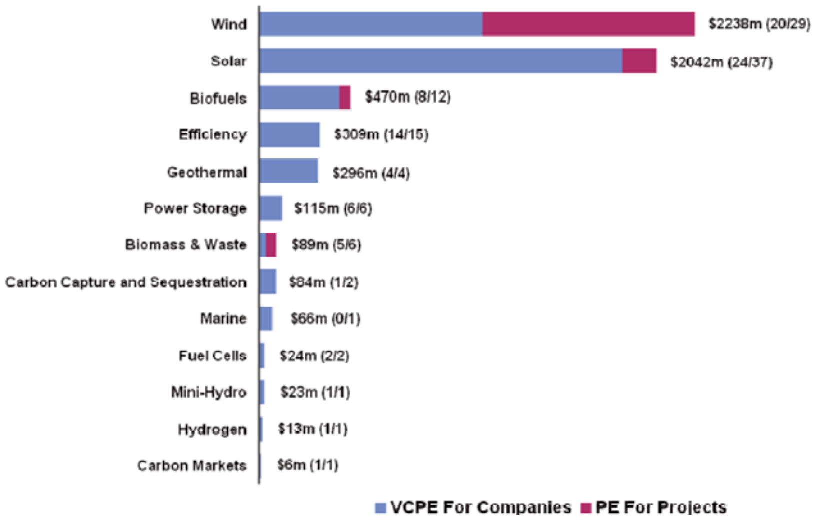
Source: (Cleantech Group, 2008)

Figure 19 New money raised on global main markets by sector in Q3 2008



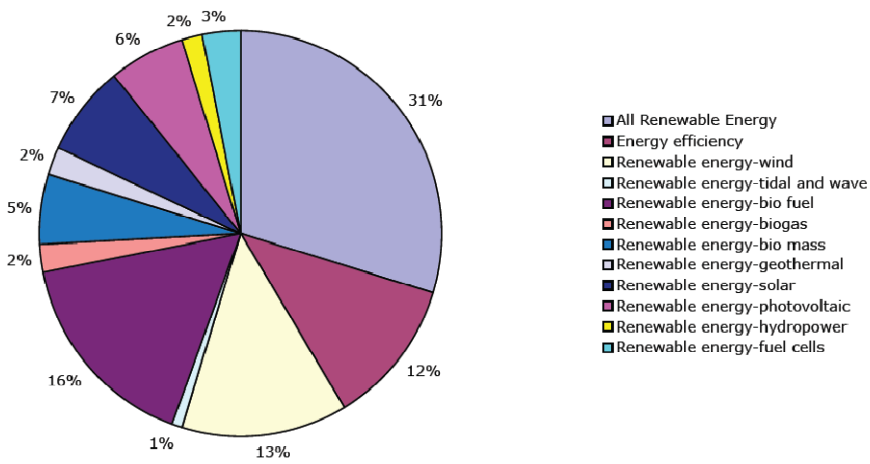
Source: Newsletter New Energy Finance October 2008 (V-18)

Figure 20 Global VC/PE transactions by sector, Q3 2008



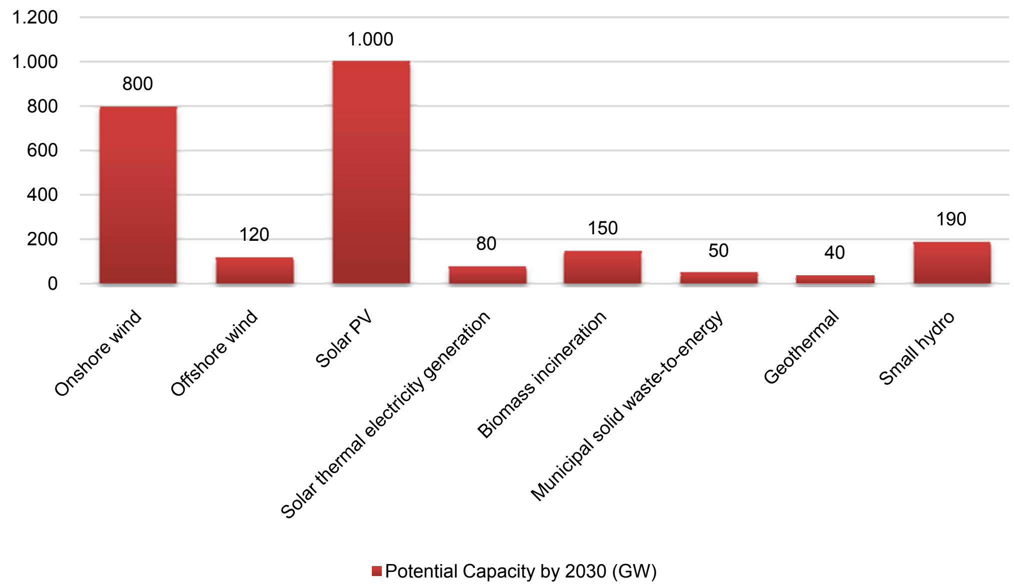
Source: Newsletter New Energy Finance October 2008 (V-18)

Figure 21 Relative Frequency of Reported Renewable Energy Technologies



Source: (FUNDETEC, 2007, p. 28)

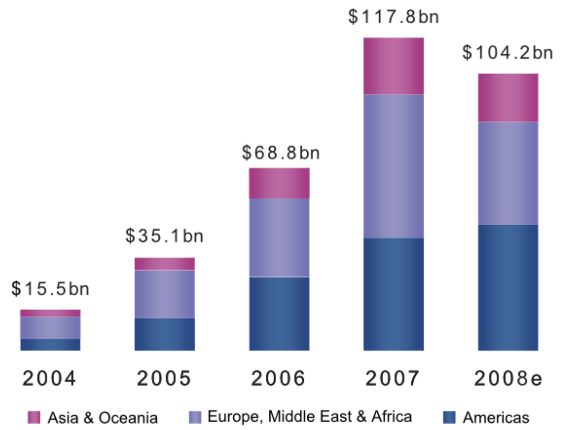
Figure 22 Potential Capacity 2030 by energy source (GW)



Source: (WEF, 2010, pp. 24-25)

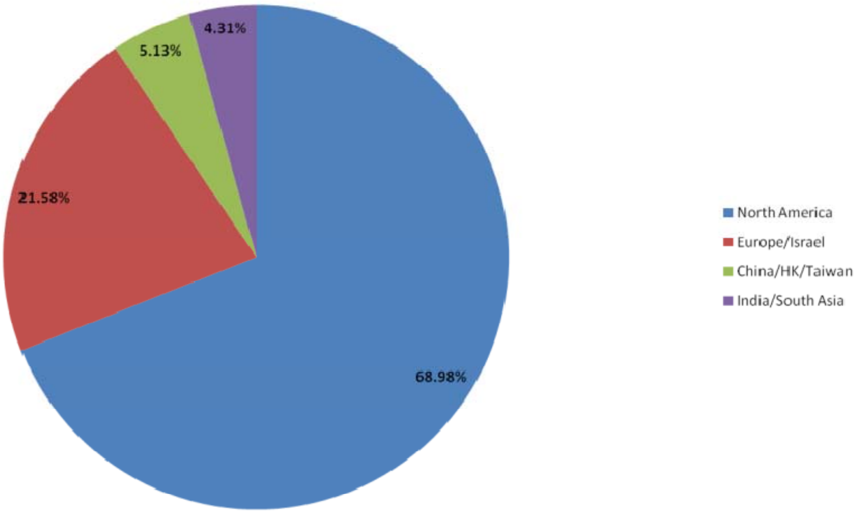
Appendix A.2 By region/part(s) of the world

Figure 23 Global cleantech investment (billion US$)



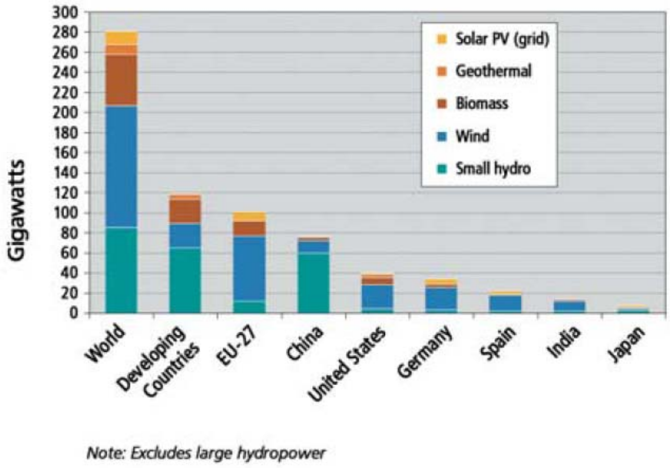
Source: New Energy Finance in (WEF, 2009a, p. 16)

Figure 24 Cleantech VC Investment by World Region (2008)



Source: (Cleantech Group, 2009, p. 9)

Figure 25 Renewable Power Capacities, Developing World, EU and Top Six Countries, 2008



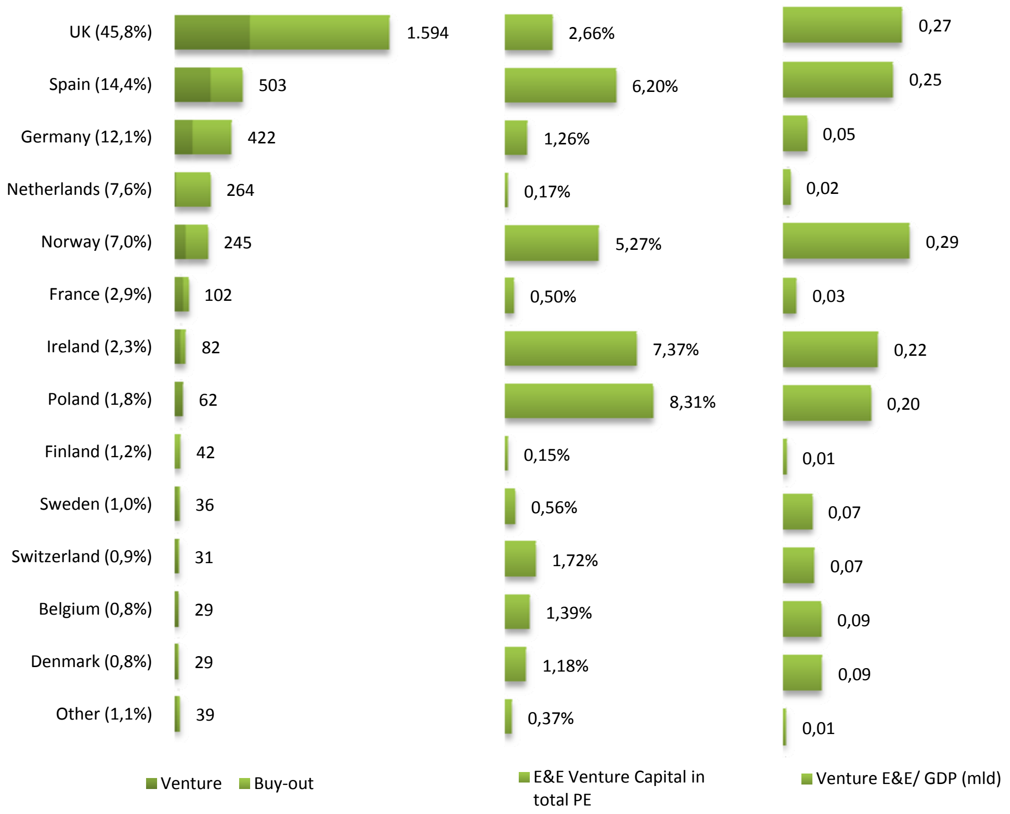
Source: (Martinot & Sawin, 2009, p. 12)

Table 11 Renewable capacity per country

	Wind Power (MW, 2008)	Grid-Connected Solar PV (MW, 2008)	Solar Hot Water Installed (GW, 2007)	Fuel Ethanol (billion liters, 2008)	Biodiesel (billion liters, 2008)
Denmark	3.180	.	.	.	.
France	3.400	.	.	1,2	1,6
Germany	23.900	5.400	.	0,5	2,2
Italy	3.740	.	.	0,13	0,3
Poland	.	.	.	0,12	0,1
Portugal	2.860	.	.	.	.
Spain	16.740	3.300	.	0,4	0,3
Sweden	.	.	.	0,14	0,1
United Kingdom	3.240	.	.	.	0,2
Other EU	.	750	.	.	.
EU Total	**.**	**.**	**15,5**	**2,8**	**8**
Argentina	.	.	.	.	1,2
Australia	.	.	1,2	.	.
Brazil	.	.	2,5	27	1,2
California	.	730	.	.	.
Other USA	.		.	.	.
United States	25.170	.	1,7	34	2
Canada	.	.	.	0,9	0,1
China	12.210	.	84	1,9	0,1
Colombia	.	.	.	0,3	0,2
India	9.650	.	1,5	0,3	0,02
Israel	.	.	3,5	.	.
Japan	.	1.970	4,9	.	.
Jordan	.	.	0,6	.	.
South Korea	.	350	.	.	.
Thailand	.	.	.	0,3	0,4
Turkey	.	.	7,1	.	.
Other World	.	> 450	< 3	.	.
World Total	**.**	**12.950**	**126**	**67**	**12**

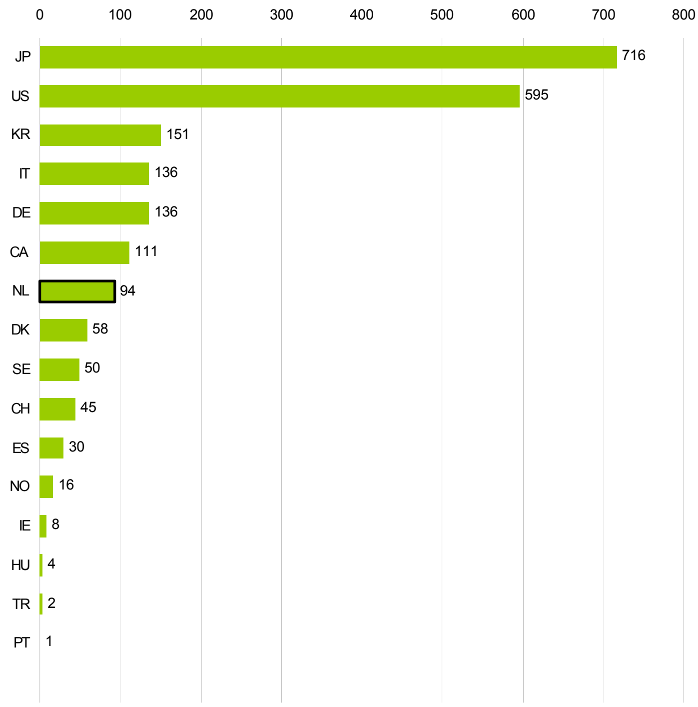
Source: (Martinot & Sawin, 2009, pp. 23-25)

Figure 26 European comparison of VC/PE investment in 'Energy & Environment (2007; from left to right: in million Euro, E&E VC as % of total PE, E&E VC related to GDP)



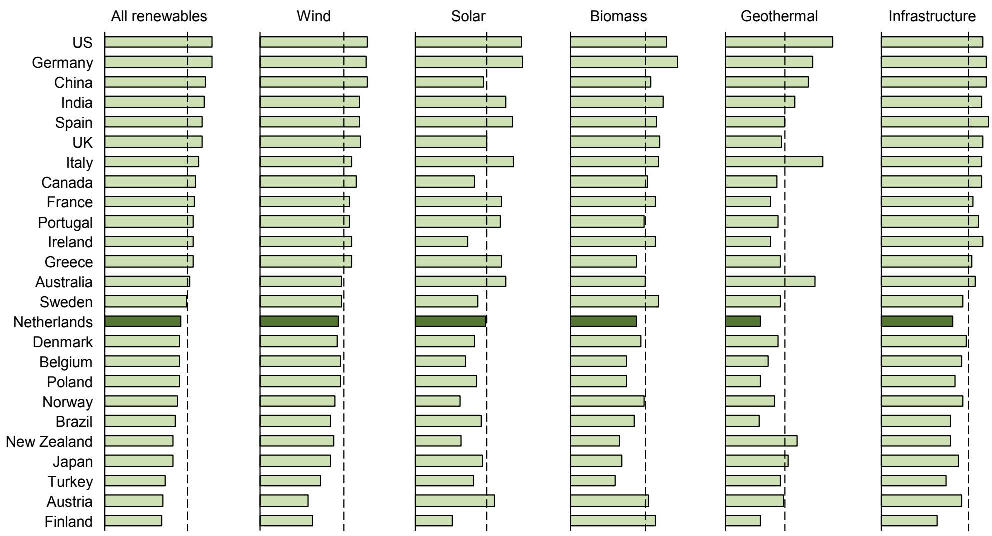
Source: EVCA (2008) & Eurostat (2009)

Figure 27 International renewable energy R&D (million Euro; 2006; excluding CCS)



Source: (PwC, 2008) & IEA Data Services

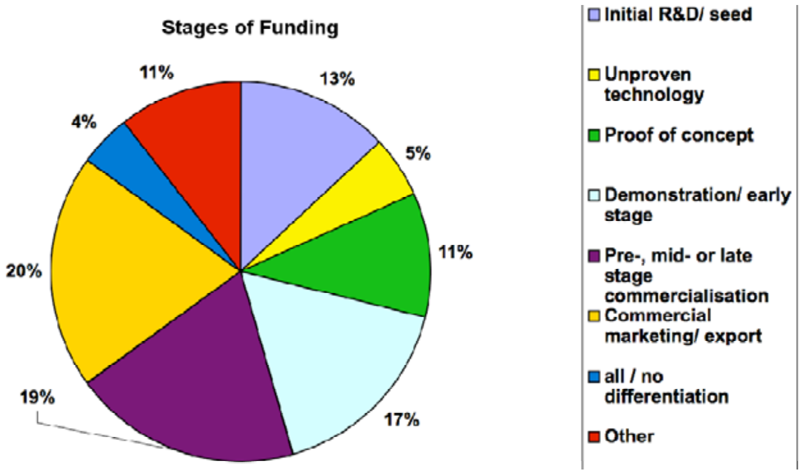
Figure 28 Country Attractiveness Index for renewable energy (2008-Q3)



Source: Ernst & Young (dotted line represents average score per criterion)

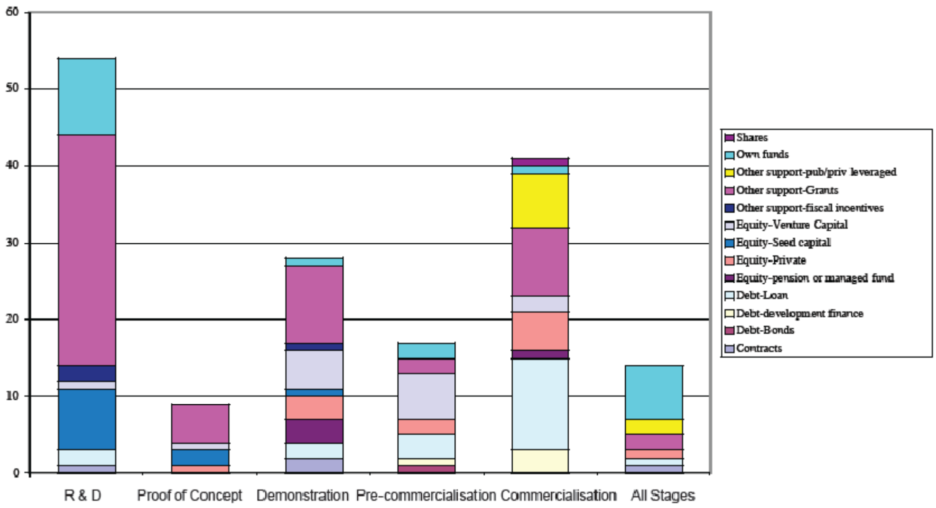
Appendix A.3 By stage in life cycle

Figure 29 Relative frequency of the reported stages of funding



Source: (FUNDETEC, 2007, p. 38)

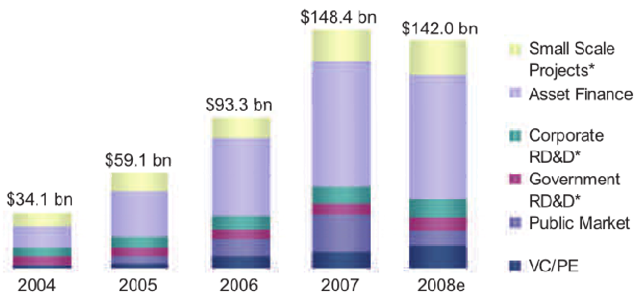
Figure 30 Funding Types by Development Stage



Source: (FUNDETEC, 2007, p. 55)

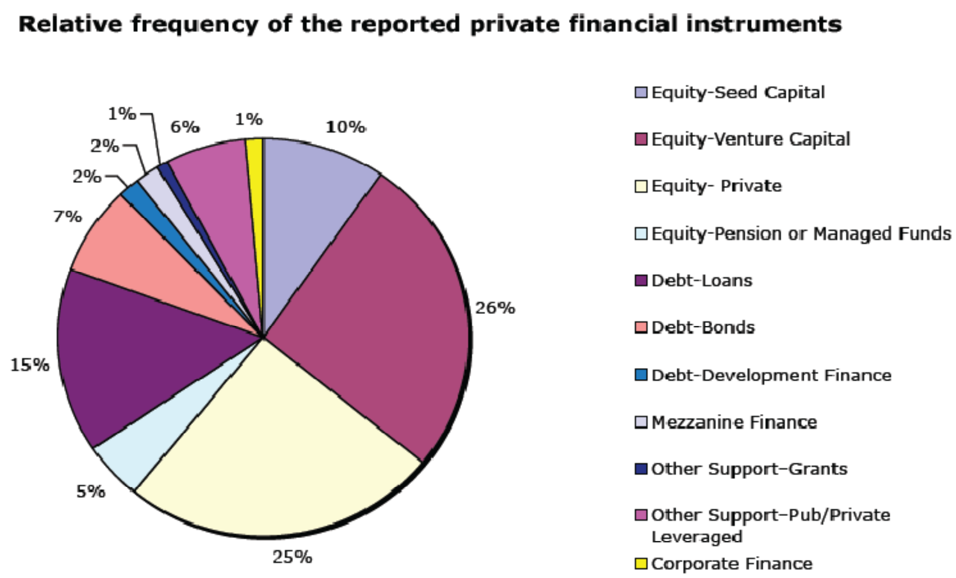
Appendix A.4 By funding source

Figure 31 Global cleantech investments (billion US$)



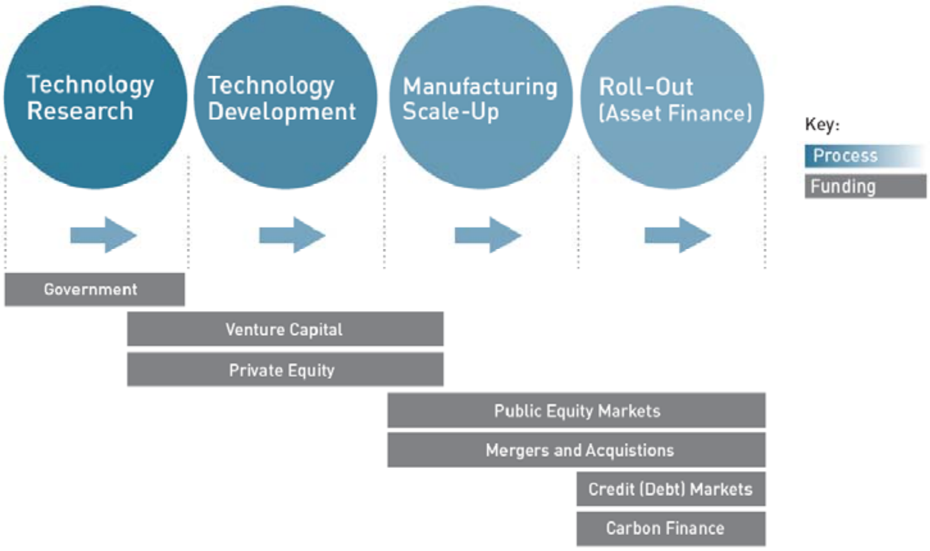
Source: New Energy Finance in (WEF, 2009a, p. 9)

Figure 32 Relative Frequency of Reported Private Financial Instruments



Source: (FUNDETEC, 2007, p. 25)

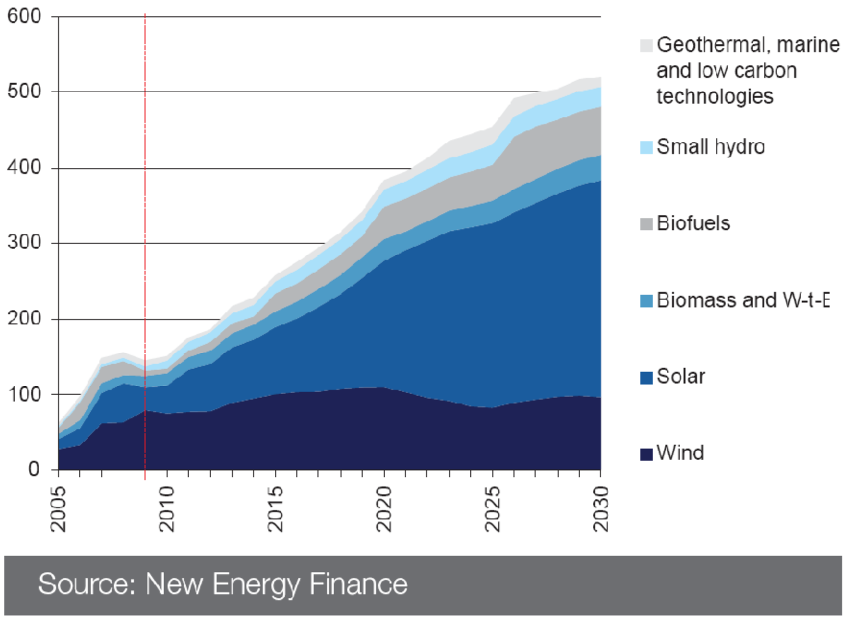
Figure 33 Sustainable Energy Financing Continuum



Source: (UNEP, SEFI, & New Energy Finance, 2009, p. 9)

Appendix A.5 Future developments

Figure 34 Expected Clean Energy Investment per annum 2007 to 2030, US$ billions



Source: (WEF, 2010, p. 11)

Appendix B Insurance Providers

Table 12 Official Export Credits Agencies (ECA) OECD countries

Country	ECA
Australia	Export Finance and Insurance Corporation (EFIC)
Austria	Oesterreichische Kontrollbank AG (OeKB)
Belgium	Office National du Ducroire/Nationale Delcrederedienst (ONDD)
Canada	Export Development Canada (EDC)
Czech Republic	Export Guarantee and Insurance Corporation (EGAP) Czech Export Bank
Denmark	Eksport Kredit Fonden (EKF)
Finland	Finnvera Oyj Finnish Export Credit Ltd (FEC)
France	Compagnie française d'Assurance pour le commerce extérieur (COFACE) Direction des Relations Economiques Extérieures (Ministère de l'Economie) (DREE)
Germany	AuslandsGeschäftsAbsicherung der Bundesrepublik Deutschland Euler Hermes
Greece	Export Credit Insurance Organisation (ECIO)
Hungary	Hungarian Export Credit Insurance Ltd (MEHIB) Hungarian Export-Import Bank
Italy	SACE S.p.A. Servizi Assicurativi del Commercio Estero
Japan	Nippon Export and Investment Insurance (NEXI) Japan Bank for International Cooperation (JBIC)
Korea	Korea Export Insurance Corporation (KEIC) The Export-Import Bank of Korea (KEXIM)
Luxembourg	Office du Ducroire (ODD)
Mexico	Banco National de Comercio Exterior
Netherlands	Atradius
New Zealand	Export Credit Office (ECO)
Norway	The Norwegian Guarantee Institute for Export Credits (GIEK)
Poland	Korporacja Ubezpieczén Kredytów Eksportowych (KUKE)
Portugal	Companhia de Seguro de Créditos
Slovak Republic	Export-Import Bank of the Slovak Republic (Eximbank SR)
Spain	Compañía Española de Seguros de Crédito a la Exportación Secretaría de Estado de Comercio (Ministerio de Economía)
Sweden	Exportkreditnämnden (EKN)
Switzerland	Swiss Export Risk Insurance (SERV)
Turkey	Export Credit Bank of Turkey (Türk Eximbank)
United Kingdom	Export Credits Guarantee Department (ECGD)
United States	Export-Import Bank of the United States (Ex-Im Bank)

Source: OECD Trade and Agriculture Directorate

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