Boosting investment where it is needed

How risk affects private investment in renewable energy in developing countries — and how to deal with it

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Preface

This thesis marks the end of my years at the University of Oslo. First, I want to thank my supervisor, Halvor Mehlum, for his guidance and support throughout the writing process. Second, I want to thank my colleagues at ZERO, especially Per Kristian and Ingrid, for their professional input on the subject of renewable energy in developing countries and Norwegian incentive schemes. Third, I want to thank Mark at Norfund, Jan at Scatec Solar and Terje at Empower New Energy for inspiration in the early stages of this thesis.

Thank you, Melissa, for proofreading my thesis and for making sure my language in on point. Thank you, Milla, for helping me with the final read through and quality check. And thank you, Anita and Vilde, for helping me with Latex whenever I got stuck.

To my mum and dad, thank you for calming me whenever I got stressed, and for believing in me and my thesis, even when I did not. To all my fellow students at Blindern, thank you for all the laughs throughout the years. And last, to all my friends, thank you for your continued cheering and support.

All remaining errors and mistakes are solely my own.

Alexandra Paltschik Rønneberg
May 2018
Abstract

Increasing the share of renewable energy in the global energy mix is essential for achieving the goal of the Paris Agreement and for ensuring universal access to energy. Hitherto, governments have not managed to establish the necessary frameworks to catalyze private investment in renewable energy in developing countries. Due to capital intensiveness, investors are more vulnerable to risk when investing in renewable energy and thus require high risk premiums. This increases the fixed investment costs for the energy production company and can make the project less profitable. In this thesis, I will develop a simple model to analyze how political, regulatory, and counterparty risk affect private investment incentives. A higher level of risk will increase the company’s required price for non-negative profits because the investor will require a higher return, which increases the fixed investment costs. I will then show how governments in developing countries have limited possibilities for increasing investment due to the effects of policies being hampered by investors’ risk perception. Following this, I will explain how policies work more efficiently when implemented by other agents as in the case of the Norwegian government. Finally, I will review current Norwegian incentive schemes and explain how these fail to target the relevant risks sufficiently. The thesis will conclude by proposing different policies the Norwegian government can implement in order to create the necessary catalyst for private investment in renewable energy in developing countries.
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Abbreviations

BNEF  Bloomberg New Energy Finance
EIA  U.S. Energy Information Administration
GIEK  The Norwegian Export Credit Guarantee Agency
GPFG  The Global Pension Fund Global [Statens Pensjonsfond Utland]
HLCCP  The High-Level Commission on Carbon Prices
IEA  International Energy Agency
IRENA  International Renewable Energy Agency
NBIM  Norges Bank Investment Management
NHO  Confederation of Norwegian Enterprise [Næringslivets Hovedorganisasjon]
Norad  The Norwegian Agency for Development Cooperation
Norfund  The Norwegian Investment Fund for Developing Countries
NORWEA  The Norwegian Wind Energy Association
OECD  Organisation for Economic Co-operation and Development
REN21  Renewable Energy Policy Network for the 21st Century
UN  United Nations
UNFCCC  United Nations Framework Convention for Climate Change

FDI  Foreign direct investment
GDP  Gross domestic product
LCOE  Levelized cost of electricity
PPA  Power Purchase Agreement
SDG  Sustainable Development Goal
1 Introduction

Ladies and gentlemen, no matter what country you live in, the cost of investing in clean energy now is far cheaper than paying for the consequences of climate change later. (...) And as we work together to achieve our targets, those betting on renewable energy are going to win big.

John Kerry, former U.S. Secretary of State

Increasing the share of renewable energy in the global energy mix is of paramount importance. First, this is essential for reaching the overall goal of the Paris Agreement of limiting the increase in global average temperatures to 2 degrees Celsius (UNFCCC, 2015). To achieve this goal, the world needs to drastically decrease the emission of greenhouse gases. For this to occur, an increase in the use of renewable energy resources is required. Furthermore, when working towards universal access to sustainable energy, it is necessary to turn the expansion of energy generation in developing countries towards renewable energy. Public finance has contributed to the transition towards greener energy, but this contribution is not sufficient. To reach our global goals, we need to activate private capital and create incentives for private investment in green energy, especially in developing countries, where public finance is not adequate.

It would appear that governments are not able to create the necessary frameworks and incentives to catalyze private investment. One reason for this is that policymakers are not sufficiently able to mitigate the risks faced by investors. Renewable energy, compared to fossil energy, is very capital-intensive and requires substantial up-front investments. When capital intensiveness is combined with political, regulatory and counterparty risk, which is prominent in developing countries, investors may find the investments very risky. Thus, investors require high risk premiums to be willing to invest, which limits the amount of affordable capital. Furthermore, since renewable energy is capital-intensive, the high risk premiums increase the cost of capital and may reduce the number of profitable projects.

Increasing private investment in renewable energy requires both environmental policy and economic incentives, so the fundamental question is: How can we use economic...
policy to create the necessary economic incentives and how should this policy be designed? When designing policy, and in an effort to better understand how investors may react to different policies, it is important to recognize what kinds of risk the investor faces and how these risks are incorporated into their profitability analysis. The lack of private investment in green energy suggests that this is an area of improvement for policymakers and that managing to accurately incorporate risks when designing policies could create the necessary catalyst for private investment.

This thesis will look at how political risk, policy risk, and counterparty risk have an adverse effect on investment in renewable energy in developing countries. First, an overview will be given of the current status of renewable energy investment and an explanation will be provided to show what makes these investments different from other energy investments. As will be explained, profitability of a renewable project largely depends on the cost of capital because this technology is capital-intensive. I will then use risk theory to explain how political, regulatory, and counterparty risk in particular play an important role in determining the level of investment in renewable energy in developing countries. Capital intensiveness make the investor more vulnerable to risk, as she faces a potentially larger loss if the entire value of the investment is lost. Thus, she requires higher risk premiums to be willing to invest, and this in turn increases the fixed costs for the company. Drawing on this, I will develop a simple model to analyze how:

i The expected price of energy and the required return from the investor affects expected profits for the company, and how this determines investment

ii Different policies, including subsidies, price guarantees, emissions taxes and risk insurances affect the investment decision, and how political and regulatory risk may hamper their effect

iii The effect of these policies is improved when implemented by other agents like the Norwegian government

The analysis shows that due to instability and inconsistency, an investor does not necessarily trust the implementation of policy. Therefore, she may increase her required return, which will hamper the effect of the policy. Using the results from the analysis, I will explain how current Norwegian incentive schemes, namely GIEK, Norad and
Norfund, fail to target the relevant investment risks sufficiently. If the Norwegian government wishes to increase private investment in renewable energy in developing countries, it could develop an explicit strategy for Norwegian capital export, expand GIEK’s mandate such that it can include capital export and cover commercial risk, establish a new guarantee scheme tailored to this kind of investment, introduce a permanent funding scheme for renewable energy, increase the transfers to Norfund, allow the GPFG to invest in unlisted infrastructure, encourage the recycling of venture capital, and establish a climate investment fund or a challenge fund.

The remaining of this thesis is structured as follows. Chapter 2 gives an overview of current investment and explains how renewable energy investments differ from other energy investments. Chapter 3 presents risk theory. Chapter 4 develops the model. Chapter 5 analyses the effect of different policies when implemented by the host government, and then when implemented by the Norwegian government. Chapter 6 reviews current Norwegian incentives schemes and provides suggestions of alternative policies. Chapter 7 concludes.

2 Background

Renewable energy is essential for achieving the main goal of the Paris Agreement, which is to limit the increase in average global temperature to below 2 degrees Celsius above pre-industrial levels. This will not be possible unless we substantially increase the share of renewable energy in the global energy mix. Recognizing that developing countries are less responsible for climate change, and have less resources to tackle it, the Paris Agreement states that developed economies are to provide financial support to assist developing economies in mitigating and adapting to climate change (UNFCCC nd).

Furthermore, renewable energy is necessary for reaching Sustainable Development Goal (SDG) number 7, which is to “Ensure access to affordable, reliable, sustainable and modern energy for all” (UN GA70/1, 2015, p. 15), with a specific target of substantially increasing the share of renewable energy in the global energy mix by 2030. The number of people without access to electricity has declined from 1.7 billion in 2000 to 1.1 billion in 2016, but this still counts for around 14 percent of the world’s population - of which the majority live in developing countries in Asia and Sub-Saharan Africa (OECD/IEA 2017a, p. 39-40). Most of those who gained access to electricity
between 2000 and 2016 did so through fossil fuels, and renewable sources of energy only accounted for around 34 percent of the increase (OECD/IEA, 2017a, p. 39-40). According to the IEA, around 675 million people will remain without access to electricity in 2030, and 2.3 billion will continue to rely on biomass, coal or kerosene (OECD/IEA, 2017b, p. 28).

For developing countries, the lack of sustainable and reliable energy poses a barrier to development and growth. Increasing the availability of renewable energy would not only help limit climate change, but it could also lead to development and growth. Furthermore, the private sector is essential for sustainable growth, and increasing private investment could help strengthen local businesses.

In 2016, global investments in renewable power and fuels totaled at USD 241.6 billion. This represents a decrease of 23 percent compared to investments in 2015 (REN21, 2017, p. 24), but investment in new renewable power capacity was roughly double that in fossil fuel generating capacity for the fifth consecutive year (FS-UNEP Collaborating Centre, 2017, p. 5). It is, however, interesting and somewhat concerning to note that only USD 21.9 billion, or roughly 9 percent of total investments, was invested in developing countries (FS-UNEP Collaborating Centre, 2017, p. 20).

Expanding energy capacity, regardless of whether it is renewable or not, requires large amounts of capital, but, compared to fossil energy, renewable energy is more capital-intensive and requires higher up-front capital investments (Multiconsult and Menon Business Economics, 2015, p. 13). Fossil energy has high variable costs related to energy input and production, but requires lower capital investment, mostly because the technology is cheaper and more mature. Renewable energy, on the other hand, has low variable production costs because the input is free and the maintenance costs are low. However, it requires large up-front investment because the technology is costly. Due to this capital intensiveness, the investor is more vulnerable to risks and thus requires a higher return to be willing to invest. As a result, the investment and capital costs make up a greater share of the total cost of electricity production for renewable energy. This difference in costs between renewable and fossil energy is summarized in

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2Not including China, India and Brazil. These countries combined stood for USD 94.7 billion in investment (FS-UNEP Collaborating Centre, 2017).

3In this paper, renewable energy refers to energy generated from solar-, wind-, and hydropower. Biomass is not considered as a part of renewable energy.

4Here, investment costs relate to the capital investment and capital costs refer to required interest or return.
Figure 1, which illustrates the breakdown of investment, capital and operational costs within the levelized cost of electricity (LCOE).  

Figure 1: The levelized cost of electricity

Note: The numbers are estimates based on the Figure 11 in Multiconsult and Menon Business Economics (2015) and should not be taken literally. It should also be noted that the operations costs for oil varies considerably with the oil price. In this figure, the operational costs for oil have been reduced by 45.2 percent in contrast to the figure in the report from Multiconsult and Menon Business Economics (2015), in order to account for the decline in the average oil price from 2014 to 2017. Sources: Figure 11 in Multiconsult and Menon Business Economics (2015). Data on the average Brent Crude oil price available at https://www.statista.com/statistics

As Figure 1 shows, investment and capital costs are higher for all renewable energy sources. Except for energy from oil, renewable energy has a higher (LCOE) than all the fossil sources. For wind, solar and hydropower, capital costs make up the biggest share of the LCOE. As a result, the capital cost (as a share of total investment cost) is very vulnerable to changes in the interest or return rate. This implies that if one was able to reduce the cost of capital sufficiently, either by reducing the interest rate, the required return, or by reducing the investment cost, the LCOE of renewables could reach the level of fossil energy and hence be cost competitive (Multiconsult and Menon Business Economics, 2015, p. 14).

Capital intensiveness alone can make an investor less willing to invest in renewable energy, but this could be worsened by a “less friendly” investment environment. The World Bank has developed the ‘Ease of doing business index’, which ranks countries

\[5\] LCOE is a measure of the average lifetime cost of electricity. See appendix for calculation
according to how easy it is to do business in a country. A low ranking implies that the regulatory environment is more conducive to starting and operating a local business, whereas a high ranking implies the opposite.

Figure 2: Ease of doing business index 2017

Figure 2 shows the index for 2017, where the columns in dark grey represent developing countries in Africa. As the figure shows, the majority of developing countries in Africa have high rankings, implying that these countries have less business-friendly policies. An unfriendly business environment will not only affect the countries’ abilities to attract foreign investment, but also the level of national business development.

The effect of a less-friendly business environment may be worsened by the fact that a lot of these countries also suffer from high political instability. Figure 3 on the next page shows the indicator of political stability and absence of violence and terrorism, which measures the perceptions of the likelihood of political instability and politically motivated violence, including terrorism. The estimates range from around −2.5 to 2.5, with a higher score indicating greater political stability.

Again, the darker columns represent African developing countries. Most of these countries have high negative scores, indicating a higher level of political instability and a lower absence of violence and terrorism. Because of capital intensity, investments in

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See appendix for a list of the included countries

See appendix for a list of the included countries
renewable energy can be be particularly vulnerable to this instability as the investor risks losing more capital in the event of a government collapse, sudden changes in policy or frameworks, the outbreak of war or fluctuations with regard to prices and markets.

Poor policies and instability affect how an investor perceives profitability. If an investment is perceived as risky, an investor will require risk premiums to be willing to invest in a project. When investing in developing countries, where the risks are more prominent, the premiums are typically higher than in other countries. Hence, the business environment and political stability will affect an investor’s investment decision and can have a significant impact on the required rate of return.

3 Risk theory

To analyze the effect of risks on renewable energy investment, it is first necessary to define the different investment risks. In this chapter, an overview of some key investment risks will be provided. This will be followed by an explanation of how political, regulatory and counterparty risk has an adverse effect on private investment.

One of the central teachings of economic theory is that, when deciding between different options, economic agents choose the option that maximizes their utility. For
an investor, this implies choosing the investment that yields the highest return. An investment may have a predicted high return, but, if this investment is perceived as risky, it will reduce the expected return for the investor, leading it to require compensation to be willing to invest.

In recent years, the return on investments in the energy market in Africa has been higher than the average return for investments in OECD countries (Multiconsult and Menon Business Economics 2015, p. 2), but despite the seemingly high return, private investors seem unwilling to invest in renewable energy in developing countries. One explanation for the lacking investment could be that these investments are perceived as so risky that the investor requires unrealistically high risk premiums to compensate. The result is that, even though the actual return has been high, it has often been lower than the return required by the investor. The immediate effect is that there is less investment as fewer projects get financed. However, the high required return also affects the profitability of renewable energy. Since this technology is capital-intensive, a higher required return severely impacts the costs for the production company, increasing the necessary price for the company to earn non-negative profits. Thus, the high risk premiums also make renewable energy less competitive relative to fossil energy.

Risks arise because there is uncertainty regarding the outcome or result of an action or decision. For an investor, this means that there is uncertainty regarding the future return of an investment. Because the investment period for renewable energy is long (typically between 15 and 25 years) and the capital requirement is high, uncertainty about the future can severely impact how an investor perceives profitability of an investment.

The risks associated with different investments are not necessarily the same, but for renewable energy investment in developing countries, there are some risks that are more prominent. Table 1 on the next page briefly explains some of the key investment risks faced by financial actors when investing in renewable energy in developing countries.

The different risks materialize in different project phases, but they are all considered and evaluated before an investment is made. However, due to the particular features of developing countries mentioned in Chapter 2, political, regulatory and counterparty risk may be of particular importance in determining the level of investment in renewable energy in these countries. These risks are not unrelated to the other types of risk, but for the problem at hand, price, technology, currency, and resource risk are deemed as
Table 1: Key investment risks

<table>
<thead>
<tr>
<th>Risk Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>Political risk</td>
<td>Risks associated with political events that adversely impact the value of an investment, i.e. (civil) war, rebellion or terrorism</td>
</tr>
<tr>
<td>Policy or regulatory risk</td>
<td>Risks associated with changes in legal or regulatory policies that affect project development or implementation, i.e., expropriation, breach of contract or discriminatory policies</td>
</tr>
<tr>
<td>Counterparty risk</td>
<td>Risks of payment default by the power off-taker, e.g., the electricity utility or households</td>
</tr>
<tr>
<td>Price risk</td>
<td>Risks associated with uncertainty regarding the future price of energy</td>
</tr>
<tr>
<td>Technology risk</td>
<td>Risks associated with the use of emerging technology or inexperienced and unskilled labor deploying it</td>
</tr>
<tr>
<td>Currency risk</td>
<td>Risks associated with currency fluctuations that impact the value of an investment</td>
</tr>
<tr>
<td>Resource risk</td>
<td>Risks associated with uncertainty around the availability, future price and supply of the renewable energy resource</td>
</tr>
</tbody>
</table>

*Source:* Based on Table 2 in [IRENA (2016)]

less relevant and will not be given more attention (for further information, see [IRENA (2016)]).

### 3.1 Political risk

Political risk can be hard to define because it incorporates all risks that have to do with political actions or events that affect the return from an investment. In the related literature, there has generally been a divide between those who define political risk as an unwanted consequence of political activity and those who define it in terms of political events or actions ([Kobrin (1979)]). With regard to the first definition, political risk is seen as “government interference with business operations,” which may include interference with or prevention of business operations, changes in the terms of an agreement, or fully or partial expropriation of private property ([Kobrin (1979)]). According to the second definition, which focuses on events, political risk arises due to environmental factors such as political instability, violence, or terrorism ([Kobrin (1979)]).

The literature provides other definitions of political risk as well (see for example [Jensen (2008)] or [Jakobsen (2010)]), and there is not always a clear distinction in the

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*Price risk will not be discussed further, but it will be included in the analysis when looking at different policies.*
literature between what this paper refers to as political and regulatory risk. In this paper, political risk will refer to risks that arise from unintended political events, thus conforming to the second definition put forward by Kobrin (1979). Regulatory risk will refer to all risks that arise due to uncertainty regarding government action, which is in line with the first definition.

As seen in Figure 3 on page 7, many developing countries in Africa have a high level of instability and violence. This will have a negative effect on the level of investment. In the event of a war, production will likely be reduced or even stopped. The company relies on revenue to cover the required return from the investor, so such an event may reduce the return to an investor. Furthermore, the plant might get damaged or be expropriated by the government or rebel groups. In this case, the investor loses the entire value of the investment. Because renewable energy is more capital-intensive than fossil energy, the investor is thus more vulnerable to political risk. Therefore, it seems reasonable that an investor is more concerned with political risk when investing in renewable energy, and thus requires a higher risk premium than when investing in fossil energy.

The literature provides some empirical analyses of the relationship between political risk and private investment. Schneider & Frey (1985) compare four different models explaining foreign investment in 80 developing countries and find that political instability significantly reduces the inflow of investment. More recently, Busse & Hefeker (2007) use panel data for 84 developing countries to investigate the relationship between political risk, institutions, and foreign direct investments inflows. They find a significant relationship between many variables, amongst others, government stability, internal and external conflict and corruption, and the level of foreign direct investment. Even though the aforementioned research does not examine private investment in renewable energy, it is likely that the results mentioned could be applied to private investment in renewable energy. If anything, the effect might be greater because of capital intensiveness.

3.2 Regulatory risk

Policy or regulatory risk arises when there is uncertainty regarding future policies or policy consistency. Following the distinction made in the introduction to this chapter
between political and regulatory risk, regulatory risk is seen as the risk of “government interference with business operations,” which may include interference with or prevention of business operations, changes in the terms of an agreement or fully or partial expropriation of private property (Kobrin, 1979).

Weak political institutions can make it more challenging to attract foreign direct investment (FDI) because it lowers the credibility of the government when it promises to protect private property from expropriation. This can be expropriation by non-governmental actors, but most notably expropriation by the government itself (Jakobsen, 2010). The government usually has an interest in keeping its promise to protect private property, as this makes it more likely to attract FDIs in the future. However, many developing countries struggle with low solvency and many competing political interests, making it difficult to prioritize public spending. If expropriation of private property can lead to short-term gains, it might be preferable for the government to break their promise or breach a contract. As this can cause the investor to lose an entire investment, this uncertainty can make an investor less willing to invest.

The problem with government inconsistency may be more significant in countries with weak institutions and limited resources because possible short-term gains may outweigh long-term growth. Additionally, political institutions in developing countries may be less advanced and have fewer checks and balances, so it may be easier for a small minority to overthrow adopted policy in favor of policies that secure short-term gains.

Furthermore, renewable energy may be more dependent on policy support than conventional energy because the technology is less mature. Due to the high up-front investment costs, renewable energy requires a higher energy price to be able to cover fixed investments costs. Thus, the profitability of a project is very vulnerable to changes in a government’s regulatory framework or policies.

The probability of expropriation may not be higher with renewable energy than with fossil energy. However, the fact that renewable energy is more capital-intensive makes the effect of expropriation worse when investing in renewable energy. Since an investment is made before construction starts, an act of expropriation by the government would lead to a more significant loss when investing in renewable energy compared to fossil energy. As a result, it is likely that an investor will require a higher risk premium when investing in renewable energy.
There is some empirical research on the relationship between regulatory risk and foreign direct investment. Kirkpatrick et al. (2006) use panel data from lower and middle-income countries to investigate the relationship between foreign direct investment in infrastructure and the quality of the regulatory framework. They find that investment responds positively to an effective regulatory framework, implying that investors may be less willing to make large infrastructure investments in countries where there is regulatory uncertainty. Asiedu (2006) limits her analysis to developing countries in Africa and look at the effect of natural resources, market size, government policy, institutions and political stability on investment. Amongst her results is that large local markets and natural resource endowments have a positive effect on attracting FDI, whereas corruption and political instability have the opposite effect. This suggests that countries can increase FDI by improving institutions and the policy environment (Asiedu, 2006). However, if the government is perceived as inconsistent, policies aimed at improving institutions and the policy environment may have limited effect.

### 3.3 Counterparty risk

With financial agreements, counterparty risk is the risk that one of the parties will not uphold its part of the agreement. In the case of renewable energy investments, it is the risk associated with the possibility that the off-taker will fail to pay for the energy (IRENA, 2016). If the off-taker defaults on its payment obligation, the producer loses its source of revenue and could have difficulties with covering costs. Renewable energy producers mainly face fixed investment costs and do not have the possibility of reducing costs by stopping production. Thus, if there is no revenue, the producer is unable to repay project debt and pay interest to lenders.

The off-taker often consists of, but does not necessarily have to be, an electricity utility. This depends on the structuring of the plant and on the type of grid structure. The type of grid structure has implications for who is the off-taker, which again can influence the level of counterparty risk. Even though grid connection can be an impor-
tant barrier to investment, it will not be further investigated in this paper (see BNEF (2017) for further discussion). Due to low incomes and low solvency, most private off-takers in developing countries might be seen as unreliable. Thus, investors sometimes require payment guarantees from a host government. However, since government budgets are often constrained, a government may not be able to guarantee for an off-taker if it defaults. Thus, all the different off-takers may be seen as unreliable, leading to counterparty risk for an investor.

Furthermore, in the case where the off-taker is a government utility, it can be difficult to distinguish between regulatory and counterparty risk. Since the government enters into the purchase agreement, a payment default will constitute a breach of contract from the government. Furthermore, the government may indirectly expropriate revenue from the production company by not paying for the energy. Thus, when entering a contract with a government utility, one might say that counterparty risk decreases at the expense of increased regulatory risk.

4 Model of investment

In this chapter, a simple model will be developed to analyze how political, regulatory and counterparty risk affects private renewable energy investment in developing countries. The model will first show how the required return rate from the investor determines the break-even price for the company, and how this price is higher for renewable energy compared to fossil energy. Then, the model will be used to analyze how the host government can implement different policies, including subsidies, price guarantees, and taxes, to increase the expected price of energy, or implement risk insurances to reduce the perceived risks. The isolated effect of the policies designed to increase the expected price is to reduce the break-even price for the company, but as the analysis will show, the policies may also affect the perceived risks of the investor. If an investor increases its risk premiums as a response to the policy, the total effect of the policy could be reduced.

The model will draw on basic microeconomic theory and is based on expected profit for a energy production company. Since the focus of this paper is on the investment decision of private actors, the investor will be modeled as a shareholder who becomes an owner through buying shares in the production company. In reality, most private
actors go in as shareholders, whereas loans are more commonly extended by larger corporations, banks or government agencies. When modeling the investor as a shareholder, an important concept is the risk-adjusted opportunity cost. Since the shareholder has alternative uses of capital, she will only choose to invest in a renewable project if the expected return is at least as high as the risk-adjusted opportunity cost. Hence, the investor has an ex ante determined required return to be willing to buy shares in the company. To simplify, we assume that the investor supplies the necessary capital by buying all the shares in the company. This makes her the only owner, and thus there is only one agent in the model.\textsuperscript{10}

As the only owner, the investor has a right to all profits. The profit depends on the fixed investment costs and the variable production costs, which are known to the investor, and the market price of energy $p$. The market price of energy is unknown ex ante, but we assume that the investor knows the minimum and maximum value the price can take. To simplify, we assume that the price is uniformly distributed, implying that the expected price is given by the average between the minimum and maximum price. The profit for the company is given by

$$\pi(p) = pK - (1 + r)Kq - DK$$

where $pK$ is the revenue from selling $K$ units of energy at the market price $p$, $DK$ represents the variable production costs and $(1 + r)Kq$ is the fixed investment cost. Thus, the profit is the company’s remaining surplus after covering variable production costs and the investor’s required return.

We assume that the project has a fixed capacity $K$, which is given exogenously. If there were no maximum capacity, the company would produce infinitely much once the price was high enough for a non-negative cash-flow, i.e. $pK - DK \geq 0$.\textsuperscript{11}

The fixed investment cost depends on the cost of capacity $q$ and the required return from the investor $r$. Because of different risks, the investor demands a risk premium

\textsuperscript{10}If there were multiple owners, it would be more difficult to determine the investment decision because the required return would not necessarily equal the actual payoff. However, the model is easily extended to a situation where the investor becomes either a majority or minority shareholder.

\textsuperscript{11}Furthermore, by assuming that the capacity is the same, it is easier to compare profit for the renewable and fossil projects later on, because the difference mainly depends on the required return from the investor and the capital requirement.
to be willing to enter the project. The ex ante required return is given by

$$r = i + e_p + e_r + e_c + e_x$$

(2)

where $i$ is the bank deposit interest rate and $e_p$, $e_r$, $e_c$ and $e_x$ are the risk premiums related to political, regulatory, counterparty and price risk.\(^\text{12}\)

Since the investor has alternative uses of capital, she will only buy shares in the project if she expects a return that is at least as high as the return from alternative investments. Thus, the required return is a risk-adjusted opportunity cost. We interpret $i$ as the bank deposit interest rate, which we assume the investor gets with certainty. Because of risk, the investor will require a risk premium related to the different risks in addition to the bank deposit interest rate. The risk premiums are meant to outweigh the disadvantages of risk by giving additional returns and will increase if there is an increase in the investor’s perceived risks. This will increase the required return and thus the company’s fixed investment costs.

To simplify the analysis, we assume that there are only two periods of definite length. In the first period, the price is still unknown, and the investor decides whether or not to invest based on expected profit for the company. In this period, the production facility is constructed, and there is still no production.

In the second period, the energy price is revealed, and production starts. Beyond this, what happens in the second period is not relevant for the analysis. The analysis is based on the ex ante belief of the investor, i.e. what the investor believes will happen in the second period before making the investment. The different risks affect the ex ante belief of the investor, and since the investor cannot unmake the investment, it is irrelevant what happens in the second period. Nor is it relevant what return the investor gets.

The investor can choose between two different projects: a renewable or a fossil project. As discussed in chapter 2, there are large up-front costs for renewable energy. After the facility is constructed, production and maintenance costs are low, and the energy input is free. Hence, the investment cost for the company makes up a large

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\(^{12}\)Since the focus of this paper is on political, regulatory and counterparty risk, the remaining risks listed in Table 1 on page 9 will not be included in the model. Even though price risk is not the main focus, it is included because subsidies and price guarantees will have an effect on the perceived variation in price, and will, therefore, have an effect on expected profitability.
fraction of total production costs, as previously illustrated in Figure 1 on page 5. To simplify, we assume that the renewable company pays a cost $Q$ for the capacity $K$, such that $Q$ is the capital requirement supplied by the investor, and that there are no other costs related to production. Thus, the renewable company is a special case where $DK = 0$, so it only faces fixed investment costs. Profit for the renewable company is given by

$$\pi^{RE}(p) = pK - (1 + r^{RE})KQ$$  \hspace{1cm} (3)$$

where $r^{RE}$ is the ex ante required return from the investor for her to be willing to enter the renewable project. As seen from Equation 3, the profit function is linear. Following Jensen’s inequality, this implies that $E(\pi^{RE}(p)) = \pi^{RE}(E(p))$, i.e. that expected profit is equal to profit from the expected price.

The investment decision is based on expected profit for the company. As seen from the first period, when the true price of energy is not yet revealed, expected profit for the renewable company is given by

$$E(\pi^{RE}(p)) = E(p)K - (1 + r^{RE})KQ$$  \hspace{1cm} (4)$$

where the first term on the right-hand side is expected revenue, and the last term represents the ex ante return requirement from the investor.

Given that the investor has complete information about the expected price of energy and her required return, she can now determine whether or not the company is expected to earn positive profits. The question for the investor is: Given my required rate of return, is the company expected to earn a positive profit? If expected profit is positive, the company is expected to be able to cover at least $(1 + r^{RE})KQ$. Thus, the investor can expect to get at least the required return and is willing to invest. When profit is negative, the investor cannot expect to get the required return and so is not willing to invest. If expected profit is exactly zero, the investor is indifferent. However, since this implies that the company can exactly cover the required return, we will assume that the investor is willing to invest. This gives the following decision rule for renewable energy:

$$\begin{cases} \text{Invest if } & E(\pi^{RE}(p)) \geq 0 \\ \text{Do not invest if } & E(\pi^{RE}(p)) < 0 \end{cases}$$  \hspace{1cm} (5)$$

The fossil production company must buy input to produce energy, and has total
input costs $D$ for the capacity $K^{13}$ Whereas the investment must be made before the price of energy is revealed, we assume that the fossil company decides whether to produce or not, and hence how much input to buy, after the price is revealed. This implies that the company can reduce costs by deciding not to produce if the price is too low to ensure a non-negative cash-flow. This is not possible for the renewable company, as it only faces fixed investment costs. We further assume that the fossil company pays a cost $q$ for the capacity $K$, where $Q > q$ to capture the capital intensiveness of renewable energy. The profit function for the fossil company is given by

$$\pi^{FE}(p) = pK - (1 + r^{FE})Kq - DK \tag{6}$$

where $r^{FE}$ is the ex ante required return from the investor for her to be willing to enter the fossil project. Unlike the renewable company, the fossil company does not have a linear profit function. Because it can save $DK$ by deciding not to produce, the profit function is flat until the price is high enough for a positive cash-flow, i.e., when $pK \geq DK$. This means that the profit function is convex, so $E(\pi^{RE}(p)) \geq \pi^{RE}(E(p))$ according to Jensen’s inequality.

Figure 4 on the next page shows the relationship between the price of energy and profit for each company. The horizontal axis shows the market price of energy and the vertical axis shows the profit as a function of the price. Both profit functions are increasing in the price $p$ and have the same slope equal to $K$. As shown in the figure, the renewable company has a larger negative profit than the fossil company when the price is zero. This is due to two factors. First, we assume that $(1 + r^{RE})KQ > (1 + r^{FE})Kq - DK$, i.e. that the higher cost of capacity for renewable energy outweighs the variable production costs for fossil energy. This implies that the profit function is lower for the renewable company for any given price. Second, because the fossil company can decide not to produce if the price is too low to have a non-negative cash-flow, the minimum point on the profit function jumps up from $-(1 + r^{FE})Kq - DK$ to $-(1 + r^{FE})Kq$ because they save $DK$ when not producing.

The possibility of deciding not to produce works as insurance against severe losses

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13 The focus of this thesis is on the uncertainty of the cost of electricity, so for simplicity we assume that there is no uncertainty regarding the input costs. In reality, however, the price of energy input in fossil power is uncertain. Using the same logic, the model can easily be extended to also cover the case of uncertain energy input prices.
for the fossil company. Because the renewable company only faces fixed investment costs, it does not have this insurance. This further increases the distance between the minimum points of the profit functions and is alone enough to make the investor require a higher return when investing in renewable energy. Furthermore, this makes the renewable company more vulnerable to regulatory risk and changes in the price regime. Because the renewable company cannot reduce costs by stopping production, they cannot make a credible threat of stopping production as a response to changes in policy. Thus, the insurance caused by variable production costs both reduce economic risk and vulnerability to policy changes for the fossil company.

The larger fixed investment costs also imply that the renewable company requires a higher price than the fossil company to earn non-negative profits, given by $p^*$. Since the profit function for the fossil company is convex, the price for expected non-negative profit does not correspond to the intersection between the profit function and the horizontal axis, which is marked by $p'$. Following from $E(\pi RE(p)) \geq \pi RE(E(p))$, the break-even price is lower than $p'$ and defined as $\bar{p}$, which is not shown in the figure. As seen from period 1, this implies that the investor is unwilling to invest in the respective projects if the expected price is below $\bar{p}$ for the fossil project and $p^*$ for the renewable project.

As illustrated in Figure 4, the expected price determines which project the investor
will choose. If the expected price is below $\bar{p}$, both companies are expected to earn negative profits. Thus, the investor will choose not to invest in any project. If the expected price is between the two break-even prices, i.e. $\bar{p} \leq E(\bar{p}) < p^*$, the fossil company is expected to earn at least non-negative profits, whereas the renewable company still has expected negative profits. Thus, the investor will choose to invest in the fossil company. However, once the expected price is equal to or greater than $p^*$, i.e., $p^* \leq E(p)$, both companies are expected to earn non-negative profits, and the investor is willing to invest in both projects. However, given that the renewable project is perceived as riskier, we will assume that the investor prefers the fossil project whenever it is expected to be profitable, even when the renewable project is also expected to be profitable. Thus, renewable energy has two barriers to overcome: i) it must become profitable, and ii) it must become more profitable than fossil energy. Hence, if the government wants investment in renewable energy, it must always intervene by implementing policy that makes renewable energy more profitable than fossil energy. This can complicate the analysis of different policy instruments. Thus, to simplify, we assume that the investor does not have the opportunity to switch between investment alternatives. Whenever the investor is considering the renewable project, she either chooses to invest in that project or deposits her capital in the bank, but she cannot choose to invest in the fossil project instead. Thus, we can concentrate on policies that increase the price or reduce risks such that renewable energy is profitable. This also allows us to focus solely on renewable energy in the remaining parts of this thesis.

Whether or not the investor chooses to invest in the renewable project is determined by the expected price of energy. Figure 5 on the next page shows the profit function in two different cases: one where the expected price is below the break-even price, and one where it is above. As mentioned, we assume that the price is uniformly distributed, such that the expected price is the average between the lowest possible price $p^{\text{min}}$ and the highest possible price $p^{\text{max}}$.

As seen in Figure 5a, the company expects negative profits when the expected price is below the break-even price. For the investor, this expected price implies that she cannot expect to receive the ex ante required return, so she is not willing to invest. Figure 5b, on the contrary, shows a situation where the investor is willing to invest. Since the expected price is above the break-even price, the company expects positive profits, so the investor can expect to get her required return.
Figure 5: The expected price of energy

Figure 5 shows that there are mainly two barriers stopping the investor from investing in the renewable energy project: that the expected price of energy is too low for the company to expect non-negative profits, and that the level of risk leads to such a high required return that renewable energy is not profitable. Thus, to increase investment in renewable energy, the government must create greater incentives. This can be done either by increasing the expected price of energy or by mitigating the risks associated with the investment. Such intervention, through different policies, will be discussed in the next chapter.
5 Policy instruments

The previous chapters have explained how risk in developing countries make an investor require high risk premiums. Because the renewable company in this model only faces fixed investments costs, this increases the break-even price, making it more difficult for the company to become profitable. Thus, the government must implement economic policies that create incentives for investing in renewable energy. The government can go about this in two different ways: it can either implement policy that increases the price such that the company is expected to earn non-negative profits thereby making it more attractive, or it can implement policy that mitigates the perceived risks such that the investor requires a lower risk premium, which reduces the break-even price.

We assume that the implementation of policy happens in two steps. The first step is in the first period before the investment is made when the government announces that it will implement some kind of policy in the second period. We assume that the investor has complete information regarding the intended policy, but, because of risk, cannot know with certainty whether or not the policy will be implemented in the second period or if the government will change the policy upon implementation. Thus, even though the policy has a positive effect ex ante, it may lead the investor to increase the risk premiums because of uncertainty regarding the future. The second step is in the second period when the government either implements the policy or not. Since the investor makes a decision based on her ex ante belief about the policy, the actual action of the government is irrelevant for the analysis.

5.1 Increasing the price of energy

As discussed in chapter 4, the decision of the investor depends on the expected profit for the company. Expected profit is determined by the expected price of energy, so implementing some sort of policy that increases the expected price could make renewable energy more profitable. The following sections look at three different policies designed to increase expected price and how these policies affect expected profit. The policies addressed are a price subsidy, a price guarantee, and a tax on emissions. As the subsequent analysis will show, these policies might affect the investor’s perceived risks, so the effect of the policy could be significantly reduced.
5.1.1 Price subsidy

To make it more attractive for the investor to choose renewable energy, the host government can introduce a price subsidy $s > 0$ such that the company receives the subsidy $s$ in addition to the market price $p$. The off-taker still pays the market price $p$. The profit function is now given by

$$\pi^{RE}(p) = (p + s)K - (1 + r^{RE})KQ$$  \hspace{1cm} (7)

where the upward shift in the profit function is given by

$$\Delta \pi^{RE}(p) = sK > 0$$  \hspace{1cm} (7a)

The subsidy implies that the company has a higher profit for each given price, which shifts the profit function up. This is illustrated in Figure 6a on the next page. However, the subsidy may have adverse effects on the level of perceived political and regulatory risk if the government is not seen as credible. First, the government may be overthrown, or some other event may occur that prevents the government from implementing the subsidy. Second, the investor may fear that the government is inconsistent and decides to reduce the size of the subsidy or completely remove it. If this is the case, perceived political and regulatory risk will increase, which leads the investor to require higher risk premiums. This increases the required rate of return as given by

$$\Delta r^{RE} = \Delta e_p + \Delta e_r > 0$$  \hspace{1cm} (8)

The increase in the required return leads to an increase in the company’s fixed investment costs. This reduces the profit for any given price, leading to a downward shift in the profit function. Thus, there are two opposing shifts in the profit function. It is unlikely that the investor’s perceived risks will increase sufficiently to offset the effect of the subsidy entirely, but it will reduce its effect. Hence, the overall effect on expected profit is positive, but the size of the effect depends on how much the investor changes her risk premiums. The total effect is shown in Figure 6b on the next page, which is drawn on the assumption that perceived risk increases sufficiently such that expected profit remains negative. In this case, the investor remains unwilling to invest.
In this framework, we have modeled the renewable company such that there are no variable production costs. Since the fixed investment costs become sunk once the investment is made, and there are no marginal costs, the timing of the subsidy does not matter for expected profit. Instead of implementing a price subsidy $s$, the government can subsidize the capital requirement $Q$. If the size of the capital subsidy is the same as the price subsidy, the capital subsidy will lead to the same upward shift in the profit function. Thus, both subsidies have the same effect on incentives: because the company cannot reduce costs by stopping production, it will always have an incentive to produce, even if the subsidy is disbursed before production starts. However, since the capital subsidy is disbursed before the investment is made, this kind of subsidy will
not have the same effect on perceived regulatory risk.

This is not the case with fossil energy. Because the fossil company can reduce costs by $DK$ when deciding not to produce, it may choose not to produce even when it receives a capital subsidy before production starts. Thus, a capital subsidy will increase the willingness to invest, but it will not change the incentives to produce. This is illustrated in Figure 7.

Figure 7: Subsidies to the fossil company

(a) The effect of a price subsidy

(b) The effect of a capital subsidy

The effect of a price subsidy is shown in Figure 7a, where there is an upward shift in the profit function for positive levels of production. The price subsidy increases the price received by the company, so the required market price for a non-negative

\footnote{Here, we only look at the isolated effect from the subsidy and do not include the opposing effect from increased perceived risk.}
cash-flow decreases. This implies that the price required for the investor to be willing to produce is lower, so the price subsidy increases incentives to produce.

As opposed to the price subsidy, the capital subsidy decreases incentives to produce. As seen in Figure 7b which shows the effect of a capital subsidy, the subsidy only leads to an upward shift of the profit function when there is no production. Thus, since the capital subsidy reduces the amount of capital the investor must supply, the company now has a smaller negative profit when not producing. This increases the price that the company requires to be willing to produce. Hence, the capital subsidy increases incentives to invest by lowering the capital requirement, but it reduces incentives to produce.

The government introduces the subsidy to the renewable company because it wants to increase investment in renewable energy. However, if it sees that the company earns a positive profit, it might decide to expropriate parts of the profit by introducing a tax on profits. If this is the case, the profit function will get a “kink” and shift down for all positive profits, implying that the company gets lower profits for each given price. Furthermore, the profit function will become concave. Following Jensen’s inequality, this implies that $\pi(E(p)) \geq E(\pi(p))$.

**Figure 8: Tax on profits**

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15This is the case in Figure 7b. However, depending on the size of the capital subsidy and the following shift in the profit function, the company can make negative, zero or positive profits when not producing.
Figure 8 is drawn under the assumption that the company knows with certainty that they must pay a fixed tax to the government. However, if there is some uncertainty regarding the tax, for example, the company does not trust that the government will commit to the stated tax rate but rather increase it, there will be an increase in regulatory risk, which causes the profit function to shift down.

Because the profit function becomes concave, expected profit no longer corresponds to profit from the expected price. Expected profit is now lower for any given price, implying that the company requires an even higher price to be able to cover the investor’s required return.

5.1.2 Price guarantee

Instead of implementing a subsidy, the government can issue a price guarantee. This is a special case of the subsidy where the government guarantees a certain price of energy. To ensure that the company expects non-negative profits, the government guarantees the price $p^*$. This implies that there is no subsidy whenever the market price is above the break-even price. Thus, the price received by the company is given by $\max(p^*, p)$, which gives the following profit function:

$$\pi^{RE}(p) = \begin{cases} 
p^*K - (1 + r^{RE})KQ & \text{when } p^* > p 
pK - (1 + r^{RE})KQ & \text{when } p^* \leq p 
\end{cases}$$

where the subsidy is such that $p + s = p^*$. Since the company is guaranteed the break-even price, the company is expected to earn at least zero profit. As shown in Figure 9a on the next page, the profit function becomes convex, which implies that $E(\pi(p)) \geq \pi(E(p))$, as with the fossil company.

The subsidy removes the variance in the price, so the investor’s risk premium related to price risk is reduced. However, the government’s promise of guaranteeing $p^*$ may not seem credible to the investor. As with the subsidy discussed in chapter 5.1.1, the investor may think that the government is inconsistent or that it will be prevented from issuing the guarantee. Thus, the guarantee may at the same time increase perceived regulatory and political risk. The effect on the interest rate is not clear because $e_x$
decreases whereas $e_p$ and $e_r$ increase, as given by

$$\Delta r^{RE} = \Delta e_p + \Delta e_r + \Delta e_x$$  \hspace{1cm} (10)$$

The effect on the return rate depends on the relative change in price risk compared to political and regulatory risk. It seems reasonable that the negative effect of both increased political and regulatory risk will outweigh the positive effect of lower price risk, so we assume that the return rate will increase. If this is the case, expected profit will shift down because the company has a lower profit for each given price. Since the required return increases, the break-even price increases, so $p^*$ is no longer enough to
ensure non-negative profits. This is shown in Figure 9b.

5.1.3 Tax on emissions

Another way to make renewable energy more attractive is by making fossil energy less attractive. Instead of increasing the expected energy price, the government can introduce a tax $t$ for each unit of emissions. For simplicity, we assume that each unit produced by the fossil company leads to one unit of emissions, whereas the renewable company causes no emissions. Hence, the tax will make renewable energy cheaper compared to fossil energy. For the fossil company, profit is now given by

$$\pi^{FE}(p) = (p - t)K - (1 + r^{FE})Kq - DK$$

where the isolated effect on the profit function is given by

$$\Delta\pi^{FE}(p) = -tK < 0$$

(11a)

The fossil company now has a lower profit for each given price, so the profit function shifts down. The tax will not cause a shift in the profit function for the renewable company, so the distance between the threshold prices $p'$ and $p^*$ decreases. This is shown in Figure 10a on the next page.

The tax raises revenue to the government which can in turn be used to subsidize renewable energy, as discussed in chapter 5.1.1. This leads to an upward shift in the profit function for the renewable company. If the tax is large enough, it may increase $p'$ so much that $p^* < p'$, in which case renewable energy becomes cost competitive. This is illustrated in Figure 10b on the next page.

Like the subsidy, it is likely that the introduction of the tax will affect political and regulatory risk. However, as discussed in chapter 3, the perceived risks are probably lower for fossil energy. Thus, we assume that the required return from the fossil project increases less than for the renewable project, as given by

$$\Delta r^{FE} = \Delta e_p + \Delta e_r > 0$$

(12)

$$\Delta r^{RE} = \Delta e_p + \Delta e_r > \Delta r^{FE}$$

(13)
Figure 10: Tax on emissions

(a) The isolated effect

(b) The effect with a subsidy

(c) The total effect
Since the required return increases for both projects, both profit functions will shift down. However, the shift will be greater for the renewable company. This is shown in Figure [10c] where the dotted line is the profit function for the fossil company, and the dashed line is the profit function for the renewable company. Following the discussion in previous chapters, we assume that the increase in perceived risk is not large enough to outweigh the effect of the subsidy, but it significantly reduces it.

5.2 Risk mitigation

For renewable energy, the break-even price is determined by the rate of return required by the investor and the capital requirement. As was shown in chapter [5.1] policies that are designed to increase the expected price of energy have a limited effect due to risk. Thus, policies designed to mitigate the perceived risks may be more efficient because they target the actual problem: the high risks associated with these investments. Furthermore, risk mitigation policies may prove more cost-efficient for the government because they do not necessarily entail a cost. The policy is only in effect if there is an actual event that causes the company to lose all revenue, which does not necessarily happen.

5.2.1 Mitigating counterparty risk with a payment guarantee

As discussed in chapter 3, counterparty risk is of great concern when investing in developing countries. Reducing this risk will lead to a lower risk premium, which can increase private investment. One way to reduce counterparty risk is by letting the government guarantee that the company will get paid for the energy that it delivers. This will decrease perceived counterparty risk, leading the investor to require a smaller risk premium. This implies that $e_c$ decreases, so the fixed investment costs are reduced. The effect on profits is given by

$$\Delta \pi^{RE} = -\Delta r^{RE} K Q > 0 \quad (14)$$

If the guarantor is credible, the guarantee will lead to an upward shift in the profit function as the return rate decreases. This is illustrated in Figure [11a] on the next page. However, it is not necessarily the case that the government is seen as a more reliable off-
taker. Many governments in developing countries have limited resources and may not be able to save the off-taker from default. In this case, the decrease in counterparty risk will be accompanied by an increase in perceived political risk. Furthermore, regulatory risk may also increase if the investor fears that the government may alter the guarantee scheme. The effect on the return rate is then

\[ \Delta r^{RE} = \Delta e_p + \Delta e_r + \Delta e_c \]  \hspace{1cm} (15)

Because there are opposing effects on the return rate, there is uncertainty as to whether it will increase or decrease. If we assume that the government is seen as a very
unreliable off-taker, the required return will increase, leading to a downward shift of the profit function. This is illustrated in Figure 11b. Thus, there are opposing effects on the profit function, and the total effect depends on the relative changes in risk.

5.2.2 Mitigating political risk with a political risk insurance

An increasing amount of institutions are now offering political risk guarantees for financial agents investing in countries with a high level of political instability. The providers of the guarantees are often international insurance agencies or multilateral organizations like the World Bank or other national or multinational development organizations or banks. For simplicity, we assume that there is no cost related to the guarantee and that it covers the entire investment.\(^{16}\) If these agents are seen reliable, the guarantee should have no other effect other than to lower the perceived political risk. This implies that the effect on the return rate is negative, as the investor reduces the risk premium related to political risk, as given by

\[
\Delta r^{RE} = \Delta e_p < 0 \tag{16}
\]

which leads to an upward shift in the profit function given by

\[
\Delta \pi^{RE}(p) = -\Delta r^{RE} > 0 \tag{16a}
\]

The lower required return reduces the fixed investment costs, so the profit function shifts up. Since there is no uncertainty regarding the credibility of the insurance, there is no off-setting negative effect on perceived risk. The effect of the insurance is shown in Figure 12 on the next page.

As the figure shows, the company now expects a positive profit, so the investor is willing to invest. However, such an insurance can be costly and difficult to obtain. The price of the insurance is often increasing in the level of risk, so it may be too costly for the riskiest investments. Furthermore, the insurance often requires a counter-guarantee from the host government. Following the discussion in 5.2.1, this can be difficult to obtain or, if obtained, is unreliable.

\(^{16}\)This is not typically the case in reality, but this will be discussed further in Chapter 6.
5.3 Comparing the policies

The previous chapter has analyzed the effect of different policies the host government can implement to increase investment in renewable energy. Table 2 on the next page summarizes some of the main conclusions.

As the table shows, the policies have a limited effect because they increase perceived risks. Even though the price policies increase the expected price, which in isolation yields expected positive profit, the investor cannot trust the policy. As a consequence, the investor requires a higher return to compensate for the risks. As a result, the government may end up spending public revenue to support a policy with very limited effect.

The risk mitigation policies are more efficient because they are targeted at reducing the required return. However, a payment guarantee may have a limited effect because the investor does not trust that the government will honor it, which leads to an opposing increase in the political and regulatory risk premiums. The total effect of the political risk insurance on the required return is positive, but as discussed, it can be costly and difficult to obtain. Furthermore, it does not reduce the other risks for the investor, so she will still require a risk premium to compensate for the other risks.

To conclude, political and regulatory risk makes it difficult for the host government to implement effective policies. Because of instability and inconsistency, the investor
Table 2: Comparing the effect of different policies

<table>
<thead>
<tr>
<th>Policy</th>
<th>Political risk</th>
<th>Regulatory risk</th>
<th>Price risk</th>
<th>Required return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price subsidy</td>
<td>Increases</td>
<td>Increases</td>
<td>No effect</td>
<td>Increases</td>
</tr>
<tr>
<td>Price guarantee $\max(p, p^*)$</td>
<td>Increases</td>
<td>Increases</td>
<td>Decreases</td>
<td>Increases</td>
</tr>
<tr>
<td>Tax on emissions</td>
<td>Increases</td>
<td>Increases</td>
<td>No effect</td>
<td>Increases</td>
</tr>
<tr>
<td>Payment guarantee</td>
<td>Increases</td>
<td>Increases</td>
<td>No effect</td>
<td>Increases</td>
</tr>
<tr>
<td>Political risk insurance</td>
<td>Decreases</td>
<td>No effect</td>
<td>No effect</td>
<td>Decreases</td>
</tr>
</tbody>
</table>

may respond to the policies by increasing the risk premiums, thus reducing the effect of the policy. Furthermore, it should be noted that governments in developing countries have limited resources, and may not be able to introduce policies at all. Thus, increasing investment in renewable energy requires policy action from other agents. More precisely, governments in developed economies have to implement some kind of policy that creates incentives for national private actors to invest in developing countries.

5.3.1 Subsidy from the Norwegian government

The reason that the price subsidy has a limited effect is due to political and regulatory risk. If the subsidy was supported by the Norwegian government instead, it might be more efficient. The isolated effect will be the same, but the negative effect on the required return will likely be smaller because the Norwegian government is perceived as a more reliable and consistent agent. To simplify, we assume that the subsidy will not affect perceived levels of political and regulatory risk when it is implemented by the Norwegian government. This does not mean that political and regulatory risk disappear altogether, but the introduction of the subsidy will not increase these risks. In this case, the total effect on profit is

$$\Delta \pi^{RE} = sK > 0$$

As is illustrated in Figure 13 on the next page, the profit function will shift upwards. The size of the subsidy determines how much the profit function shifts up. With complete information, the Norwegian government can determine $s$ such that the
Figure 13: Price subsidy from the Norwegian government

Figure 14: Price guarantee from the Norwegian government

Figure 15: Capital subsidy from the Norwegian government
company is expected to earn positive profits.

As with the subsidy, the effect of a price guarantee may be greater when implemented by the Norwegian government because one avoids the off-setting negative effect from increased risk. The effect is shown in Figure 14.

Even though both the price subsidy and the price guarantee have a positive effect on investment, it may be difficult to gain national political support for such a policy. None of the policies yields direct benefits to the Norwegian government, so it may prove difficult to draw from the aid budget to subsidize the price of energy in developing countries. However, it may be easier to gain acceptance for a capital subsidy. Because the effect of a capital subsidy is the same as the effect of a price subsidy, the Norwegian government can implement a capital subsidy $Q - \alpha$ instead. Then, the investor is left to finance $\alpha < Q$. This reduces the fixed investment cost for the company and leads to an upward shift in the profit function. This is shown in Figure 15. If the subsidy is disbursed to the investor before the investment is made, there is no effect on perceived risks. Thus, the Norwegian government can achieve the same result by issuing a capital subsidy. Because this is a scheme aimed at supporting Norwegian companies and not foreign production companies, it may be easier to gain political support for a capital subsidy.

The capital subsidy reduces risks in two ways. First, it reduces vulnerability to political risk because the investor supplies a smaller amount of capital, so she loses less if the investment fails. Second, because the subsidy is disbursed before the investment is made, it reduces regulatory risk as the Norwegian government cannot withdraw the subsidy. Furthermore, it works as if the price received by the company is higher for every unit sold.

5.3.2 Global tax on emissions

The main problem with a national carbon tax is that the investor cannot know for certain if the tax will be maintained over time. However, if the tax were global, it would increase the likelihood of policy consistency. The tax does not affect the profit function for the renewable company, and since the tax is global, it is likely that there will be a smaller effect on risk. To simplify, we assume that the global tax on emissions has no effect on perceived risks, so it will only lead to a downward shift in the profit function for the fossil company. This is shown in Figure 16 on the next page,
The High-Level Commission on Carbon Prices (HLCCP) estimates that, to reach the goal of the Paris Agreement, the explicit carbon-price level is at least USD 50-80/tCO2 by 2020 and USD 50-100/tCO2 by 2030 [HLCCP, 2017]. The HLCCP claims that this carbon price should be implemented on a global scale, although it is probable that some developing countries would charge a lower price initially since there is currently a lack of renewable options.

The carbon price takes into account the externalities and damages from emissions and would create the necessary incentives to change investment, production, and consumption patterns. However, the implementation of this tax on a global scale has proven problematic. First, many developing countries resent the tax because it will make energy more expensive. The effect will be worst for low-income groups who spend a greater share of income on energy. Second, there are strong interest groups within different industry sectors, particularly within the fossil sector, who oppose the tax because it will affect their profits. These interest groups may have a strong influence on politicians, making it more difficult to gain national support for committing to a global tax.
5.3.3 Payment guarantee from the Norwegian government

The payment guarantee issued by the host government leads to an increase in political and regulatory risk. To avoid this increase, the Norwegian government could be the guarantor instead. In this case, it is reasonable to assume that perceived political risk will not be affected, so the effect on the required rate of return is negative:

\[ \Delta r_{RE} = \Delta e_c < 0 \]  

The company now has a higher profit for any given price, so there is an upward shift in the profit function. This reduces the break-even price, as shown in Figure 17.

Figure 17: Payment guarantee from the Norwegian government

6 Review of Norwegian incentive schemes

As discussed in chapter 5, political and regulatory risk limits the host government’s ability to increase investment. Due to instability and weak institutions in the host country, the investor does not necessarily trust in the implementation of policy and may respond by increasing her required return. Thus, governments in developing countries have few effective instruments to increase investment in renewable energy. This implies that other agents, most notably foreign governments, must take responsibility
by implementing the required policies. Because there is limited public finance available, governments should focus on risk mitigation and enabling frameworks, which increases incentives for investment.

The Norwegian government has acknowledged the importance of engaging private actors in fighting climate change and incentivizing development (see Utenriksdepartementet (2017)), and as an oil nation, Norway has a long tradition of establishing frameworks that enable capital-intensive investments. With the reimbursement system for exploration costs \( \text{leretrefusjonsordningen} \), which was introduced by the government in 2005, and investment based deductions, oil companies are compensated for losses and the large up-front investment costs (Norsk petroleum, nd). These have been important instruments for creating incentives for investing on the Norwegian continental shelf, and the petroleum tax system has led to considerable revenue for the Norwegian government. By utilizing the competence and knowledge accumulated from the oil industry, the government could establish a similar enabling framework for renewable energy investment in developing countries. However, Norway does not have a clear “ambition” or “vision” for renewable energy in developing countries, which may hamper the implementation of such a framework (NORWEA, 2018). If one were able to define an explicit strategy, the framework and incentive schemes could follow more easily.

Today, there are different incentive schemes in place in Norway to help private investors who want to engage in developing countries. These include GIEK (The Norwegian Export Credit Guarantee Agency), Norad’s "Enterprise Development for Jobs" \( \text{Bedriftsstøtte for næringsutvikling} \) and Norfund. These schemes are different in scope and design, and handle different challenges faced by investors. However, as illuminated by a recent report written by NORWEA, these schemes do not target the specific risks investors face when investing in renewable energy in developing countries. The NORWEA report is based on contributions from Norwegian exporters, interviews with Norwegian and international financial actors, and reports from different consultancies. The main conclusion is that today’s schemes are not doing enough to catalyze private investment, and the report suggests several changes that can make the incentive schemes more efficient (NORWEA, 2018).

Two agents handle the government-backed export finance systems in Norway; GIEK, which issues guarantees, and Export Credit Norway, which provides loans. Both agen-
cies are administered by the Ministry of Trade, Industry and Fisheries and support Norwegian export companies and help them to reach markets abroad.

GIEK offers investment guarantees to agents operating in countries with a high level of political risk. The guarantees can cover either equity or loans and are available to investors wanting to invest in subsidiary companies abroad or to lenders who lend for the same investment. The guarantee only covers political risk and can cover a maximum of 90 percent of the investment for a maximum period of 20 years. GIEK charges a premium for the guarantee, which is calculated based on the repayment period of the loan and the level of political risk in the country where the investment is made (GIEK, nd).

As several interviewees point out, GIEK’s mandate does include instruments that could help increase capital investments in developing countries. However, the relevant risks are so high that the guarantee becomes too costly or does not cover the entire risk (NORWEA, 2018). As an example, the premium for a 24 month guarantee for a NOK 50 million investment in Mali is almost NOK 2.78 million, or 5.56 percent of the investment. Hence, the premium can be very costly for investments in countries with high levels of risk, making it less attractive for investors.

As an alternative, risk guarantees can be obtained from the World Bank or other multilateral organizations. These guarantees are better suited for the specific risks related to energy investments in developing countries, but they are difficult to obtain for mainly two reasons. First, there are many documentation requirements and a complicated application system, making it time-consuming and costly. This is also true for GIEK’s application system. The complicated application systems lead to high transaction costs for the companies, which can be crucial for the attractiveness of the guarantee, in particular for smaller companies with less human and financial resources. Second, and maybe more importantly, they require a counter-guarantee (“mot-garanti”) from the host government, which is not always available and is far less credible. The result is that this guarantee, which could protect against relevant risks at a reasonable price, becomes too costly or is not available (NORWEA, 2018).

For GIEK to be able to increase private investment in developing countries, it

\[17\] The premium is calculated via GIEK’s premium calculator, based on a guarantee period of 24 months and a drawdown period of 12 months. The calculator is available at https://www.giek.no/calculator/
has to address the relevant risks more efficiently. As of now, GIEK does not have a mandate to cover commercial risk, including counterparty risk. Due to the capital intensity of renewable energy, this is of great concern to investors. If GIEK’s mandate were expanded such that it could cover commercial risk, it would be better suited to target relevant risks. This has been done in Germany, where KfW (the German Development Bank) has entered into a partnership agreement with the African Trade Insurance Agency (ATI) to establish a liquidity guarantee on behalf of off-takers in Sub-Saharan Africa. A similar arrangement in Norway could help release private capital to investments in renewable energy in developing countries (NORWEA, 2018).

Furthermore, the GIEK mandate should be changed such that the investment does not have to increase Norwegian export directly. GIEK was initially established to help with the export of goods produced in Norway, but for renewable energy investment, the export is capital and does not necessarily increase Norwegian export of goods. By allowing the guarantee to cover the export of capital, ”Norwegian export interests” are expanded to include investments that increase the availability of renewable energy, which could be part of a new, clear strategy for renewable energy investment in developing countries. This has been done in the Netherlands, where the government credit organization is no longer limited to supplying credit to only renewable investment that directly increases Dutch exports. This decision was made based on the understanding that all investments that help reduce climate change are of Dutch interest (NORWEA, 2018). Also in Sweden, the government export guarantee institute (EKN) is allowed to cover all export of “Swedish interest,” not only the financing of products produced in Sweden (NORWEA, 2018).

Instead of altering GIEK’s mandate, one could establish a new guarantee mechanism administered by the Ministry of Foreign Affairs (Utenriksdepartementet). This guarantee could be tailored to renewable energy investment in developing countries. Unlike other agents, the Norwegian government would not have to set aside the guaranteed amount because it has high liquidity. If the investment entails a loss, the guaranteed amount could be provisioned for over the aid budget as a part of the 1 percent of GDP that are to finance aid.

Norad is responsible for handling Norwegian aid, and as a part of this, they manage the ”Enterprise Development for Jobs” grant scheme. The goal is to trigger sustainable, private investments that contribute to job creation in developing countries or that
contributes to increasing the availability of renewable energy in developing countries (Norad, 2016). The scheme is organized as an international competition, where companies can apply for a grant related to different "advertisements," where the winner receives a project development grant (Norad, 2016).

There are several requirements that must be fulfilled to qualify for a grant, but the most relevant requirements for this paper are that the project is commercially profitable in the long run, that the project would not be completed without the grant, and that the project is catalytic and would trigger more private capital. Many renewable investments seem to fulfill these requirements, so the grant scheme could work as a reimbursement system for renewable energy as the reimbursement system for exploration costs works for the oil industry (NORWEA, 2018). However, seeing that the "Enterprise Development for Jobs" grant scheme is a competition, few projects receive funding even if they qualify. Therefore, the grant scheme should become a permanent funding scheme. By supplying funding in the early stages of project development, some of the risks are moved from the investor to other agents. This allows companies to expand and diversify their portfolios by including several projects. This will get more projects in the pipeline, which means that investors can choose between different projects.

Another problem with the grant scheme is that the application process is complicated and can be difficult to comprehend. This results in high transaction costs, in particular for companies that are new to the application process, or for smaller companies with less resources. If an approved application could make the basis for a framework agreement, companies would not have to apply for funding for each project, which would reduce the transaction costs.

Norfund is a commercial investment instrument for Norwegian aid with a mandate “to fight poverty and to create sustainable development by investing in profitable businesses in developing countries.” Even though Norfund is a government agency, it operates as a commercial actor. Norfund is active in some of the poorest countries in the world, providing equity directly to companies or indirectly through various funds, and it also provides loans to companies willing to undertake investment in these countries (Norad, 2011). Additionally, Norfund enters into partnerships and joint ventures with private companies where they supply a share of the capital requirement. This relieves private investors from providing all the equity for the project. Thus, Norfund
is an important risk mitigating tool, but it also possesses important knowledge about investment in developing countries. By increasing transfers to Norfund, Norfund, as a result, could expand its portfolio and enter into more projects and joint ventures, which could help catalyze additional private investment.

In November 2017, Norges Bank announced its recommendation of removing oil and gas stocks from the benchmark index of the Government Pension Fund Global (GPFG). The recommendation was based on the analysis that this would make the GPFG less vulnerable to a permanent drop in oil and gas prices (NBIM, 2017). Furthermore, Norges Bank has previously recommended that the Ministry of Finance allow the GPFG to invest in unlisted infrastructure (NBIM, 2015), though not specified to renewable energy. Norges Bank recommends that the GPFG starts by investing in mature markets, thus building competence and expertise, such that it can eventually expand to less mature markets. The Norwegian Parliament (Stortinget) has previously rejected such a proposal, but in April 2018, the National Congress of the Conservative Party of Norway (Høyres landsmøte) voted in favor of allowing the GPFG to invest in unlisted renewable energy infrastructure (Nysveen, 2018). If the GPFG were to replace the portfolio of oil and gas stocks with unlisted renewable energy infrastructure investment, this would release NOK 300 billion to renewable energy investment. In addition, this could reduce how other investors perceive risk by sending a signal that these investments are profitable.

In addition to allowing the GPFG to invest in unlisted infrastructure, one could establish a mechanism for the recycling of venture capital. Since renewable energy projects in developing countries entail risks, some are opposed to the idea that the GPFG should go in as owners in these projects. However, once the project is completed and the plant is operational, the project is less risky. If the GPFG were to buy out Norfund once the plant is operational, this would release Norfund’s venture capital, allowing Norfund to reinvest in new, riskier projects instead of operating completed projects.

Furthermore, a climate investment fund could be established with partial public funding. Some of the capital could be obtained from the aid budget, but it should also encourage participation from other sovereign wealth funds and private pension funds. The fund could be administered by Norfund, thus letting it draw on Norfund’s knowledge about risk and risk mitigation in developing countries. By supplying loans
and credit to investors at reasonable interest rates, it would reduce risk by reducing the amount of equity the investor has to supply to a project. If a project is profitable, the loan is paid back with interest, thus yielding a return to the fund. However, if the project entails a loss and the investor fails to repay the loan, the loss accrued to the fund could be provisioned for from the aid budget. Many countries have established such climate investment funds. In the Netherlands, a public fund that supplies “first-loss” capital has been established. In Denmark, public-private cooperation fund has been established, whereby losses accrued to the government can be provisioned for from the aid budget [NORWEA 2018].

Instead of a climate investment fund, one could use so called ”challenge funds”. In this case, private investors compete for a government-issued grant or subsidy that is to be used to solve a pre-defined challenge in a developing country. The disbursement of the grant or subsidy requires additionality, so it is not given where a project to address such a challenge would have been completed regardless. Provision of such a grant would reduce risk and would encourage partnership and innovation.

In summary, if the Norwegian government wishes to promote private investment in renewable energy in developing countries, it could implement the following policies:

i Develop an explicit strategy for Norwegian capital export to be used for renewable energy in developing countries

ii Expand GIEK’s mandate such that the insurance can cover capital export that does not necessarily increase export of Norwegian goods, and such that it can cover commercial risk

iii Establish a new guarantee scheme that is tailored to investment in renewable energy in developing countries, which is administered by the Ministry of Foreign Affairs

iv Introduce a permanent funding scheme similar to the reimbursement system for exploration costs, which will allow private investors to expand their portfolios and get more projects in the pipeline

v Increase the transfers to Norfund so that it can enter into more projects and joint ventures with private investors
vi Allow the GPFG to invest in unlisted infrastructure in mature markets, thus building up knowledge and expertise such that it can later expand to less mature markets

vii Encourage the recycling of venture capital by allowing the GPFG to buy out Norfund once a project is operational, allowing Norfund to reinvest in new projects

viii Establish a climate investment fund, from which losses can be provisioned for via the aid budget, or a challenge fund, which can be administered by Norad

7 Conclusion

In this thesis, a model has been developed to analyze how political, regulatory, and counterparty risk affects private investment in renewable energy in developing countries. Renewable energy requires large up-front investments, so an investor is more vulnerable to risk and requires a higher return in order to be willing to invest in renewable energy. This implies that a renewable energy company requires a higher energy price to earn non-negative profits than a fossil energy company. Thus, if a government wants to expand renewable capacity, it must implement supporting policies.

The model in this thesis was used to analyze the effect of different policies, which included a price subsidy, a price guarantee, a tax on emissions, a payment guarantee, and a political risk insurance. The analysis showed that, due to instability and policy inconsistency, a host government is unable to implement effective policies. If an investor fears that the policy will not be maintained over time, she may respond by increasing her required return. This reduces the effect of the policy, rendering it less efficient.

Because a host government is inefficient in promoting renewable energy investment, increasing the share of renewable energy requires that foreign governments take responsibility for implementing the policies deemed necessary. The model was used to analyze the effect of the different policies when implemented by the Norwegian government. Not surprisingly, the policies were seen to be more efficient because there was no increase in perceived risk. However, it may be difficult to gain national political support for the policies aimed at increasing the energy price, as this yields no direct benefit to the Norwegian government, but rather entails a cost. Thus, the Norwegian government
should focus on policies that relieve the investor of some of the required capital, or that reduce risk.

Finally, current Norwegian incentive schemes were reviewed. The analysis showed that none of the schemes are optimal because the relevant risks are not targeted sufficiently. Thus, to increase private incentives for investment in renewable energy in developing countries, this thesis suggested different policies that could be implemented. These policies include developing an explicit strategy for Norwegian capital export, expanding GIEK’s mandate such that it can include capital export and cover commercial risk, establishing a new guarantee scheme tailored to this kind of investment, introducing a permanent funding scheme for renewable energy, increasing the transfers to Norfund, allowing the GPFG to invest in unlisted infrastructure, encouraging the recycling of venture capital, and establishing a climate investment fund or a challenge fund.

By introducing these alternatives to existing incentive schemes, the Norwegian government could encourage more private investment in developing countries, which may create the hitherto lacking catalyzt for renewable energy investment in these countries.
References


Appendix

A. The formula for LCOE

The formula for calculating the LCOE of renewable energy technologies is

\[ LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \]

where

- \( LCOE \) = the average lifetime levelised cost of electricity generation
- \( I_t \) = investment expenditures in year \( t \)
- \( M_t \) = operations and maintenance expenditures in year \( t \)
- \( F_t \) = fuel expenditures in year \( t \)
- \( E_t \) = electricity generation in year \( t \)
- \( r \) = the discount rate
- \( n \) = the lifetime of the system

Source: IRENA (2012)

B. Developing countries in Africa

The list of countries classified as developing countries in Africa in Figure 2 and 3:

- Algeria
- Angola
- Benin
- Botswana
- Burkina Faso
- Burundi
- Cabo Verde
- Cameroon
- Central African Republic
- Chad
- Comoros
- Congo, Rep.
- Cote d’Ivoire
- Egypt, Arab Rep.
- Equatorial Guinea
- Eritrea
- Ethiopia
- Gabon
- Gambia, The
- Ghana
- Guinea-Bissau
- Kenya
- Lesotho
- Liberia
- Libya
- Madagascar
- Malawi
- Mali
- Mauritania
- Mauritius
- Morocco
- Mozambique
- Namibia
- Niger
- Nigeria
- Rwanda
- Senegal
- Seychelles
- Sierra Leone
- Somalia
- South Africa
- South Sudan
- Swaziland
- Tanzania
- Togo
- Tunisia
- Uganda
- Zambia
- Zimbabwe