Title: Tackeling the barriers to Climate Friendly Investment - guidelines for policy design

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Summary: This paper develops a better understanding of what may be understood as a barrier to climate friendly investment and suggests to tool that could be used in appropriate policy design. In addition to an overview of the broader conceptual definitions of a barrier, the paper develops a definition of a barrier to adaptation and mitigation investment according to economic mechanisms that lead to the decreased attractiveness of the investment (relative to the hypothetical case of functioning markets) leading to the market imperfections as well as the impact on the risk and return profile. This illustrates that in general barriers may be addressed to correct the market imperfection or compensating the investor. The decomposition of the barriers along the market imperfection and investor's perception enable to suggests a tool to suggest the design for the require policy change.

1. Introduction

The science of climate change is working on global-scale climate to analyses the trade-off between mitigation costs, on the one hand, and adaptation costs and residual damages on the other.[1] Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term and contribute to climate-resilient pathways for sustainable development. At the Paris climate conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally binding global climate deal. The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C.

Reducing emissions is the main objective, as past and future emissions of GHGs will cause further warming and ongoing changes in all components of the climate system. From an economic point of view a carbon price would be an adequate instrument to internalize this emission externality. The real world, however, is more complex and faced with a multicriteria optimisation problem. Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. In other words, the less we achieve the emission reduction, the higher the resulting climate impacts and required adaptation measure. This corresponds to a trade-off between resources expended on mitigation versus adaptation.

In order to achieve aggressive emission reduction targets, all CO2 emitting sectors have to make significant improvements and will have to shift from primary, carbon-containing fuels to electric power. This structural change towards low-carbon and climate-resilient development appears to be possible, not only technically but also economically, but it requires political will and coordinated action to facilitate investments in adaptation and mitigation. Carbon-intensive sectors need to continue transitioning their business models to low-carbon and resilient models. This implies a shift of the capital stock towards low-carbon emission sectors and/or technologies over time. Given the constraints on the availability of public resources, significant private sector financing will be required to play a role towards a transformation. Investors providing capital will form expectation about the different risks of investment alternatives against the background of a structural change e.g. balance risks and return of investment in renewable vs fossil fuel energy. This puts an emphasis on the decisions of investment or allocation of capital resources.

In 2015, a record of $329 billion of new clean energy investment[2] including $286 billion in new renewable energy investments (excl. investments in large hydro of $ 43 billion) has been achieved.[3] Fears remain, however, that delivered investment are of insufficient scale as this is much less than the required annual average investment of USD 840 billion estimated by the IEA for realizing the 2° target.[4] Understanding the reasons for the lack of investment is essential for identifying desirable projects that have not yet taken place.

[1] IPPC (2013), Climate Change 2013: The Physical Science Basis. Intergovernmental Panel on Climate Change 5th Assessment Report.

[2] Bloomberg New Energy Finance (2016), “Clean energy defies fossil fuel price crash to attract record $329bn global investment in 2015”, January 14th 2016, available at: http://about.bnef.com/press-releases/clean-energy-defies-fossil-fuel-price-crash-to-attract-record-329bn-global-investment-in-2015/

[3] Frankfurt School – UNEP/Bloomberg New Energy Finance (2016), Global Trends in renewable Energy finance.

[4] The IEA estimates that for realizing the 2° target the energy sector has to invest USD 13.5 trillion in energy efficiency and low-carbon technologies from 2015 to 2030, an annual average of USD 840 billion. OECD/International Energy Agency (2015), Energy Climate and Change - World Energy Outlook Special Report.

The literature has consistently demonstrated that many mitigation related projects face obstacles. Discussions in the climate community about the type and volume of investment in renewable energy and energy efficiency that would be required in order to avoid dangerous levels of anthropogenic climate change often refer to "barriers" to investment which need to be "overcome" through policies. Common examples for this are the cases in which the level of an investment subsidy is only justified by the fact that this subsidy level is needed in order to make the project commercially attractive. From an economic perspective this way of "using" of the term barriers increases the risk of inefficient and overly costly promotion of renewable energy and energy efficiency. In some cases a rather broad understanding of what constitutes a barrier might be used to justify policy measures in order to overcome them.

A good understanding of barriers is needed for efficient private investment mobilization to support the structural change towards a low-carbon and climate-resilient development. The paper develops a definition of a barrier to investment in mitigation according to economic mechanisms that lead to the decreased attractiveness of the investment (relative to the hypothetical case of functioning markets) leading to the market imperfections. The existing investment barriers are decomposed along their fundamental relation to a given market imperfection and also indicate their impact on the risk return profile of an investor. This illustrates that in general barriers may be addressed through correcting the market imperfection or compensating the investor. In doing so, we develop a tool to inform policy design targeted at mobilizing commercial climate friendly investment to facilitate the structural change.

2. What is a barrier - definitions across different fields?

The literature provides an overview of many barriers mitigation related projects face for their implementation. This raises the question whether all private sector renewable-related activities which are desirable from a societal point of view of a whole economy are implemented.

The term „barrier" (synonyms: obstacles, hindrances, impediments, frictions) is used in different contexts in finance and economics. The extensive literature on trade barriers in the field of political science and economics includes technical barriers to trade "Technical barriers to trade and investment are unnecessary obstacles to international trade"[5] and reasons for government intervention are amongst other aimed at increasing national welfare "[…] to correct market failures and to exploit a country's or a firm's market power (by manipulating the terms of trade and shifting profits)". Barriers to capital flow in the capital market literature as "factors that constrain the efficient the capital flow movements across national boundaries and hinder move to the location with the highest return" where the "removal of barriers to trade in capital may improve overall welfare"[6] These traditional understandings of "barriers" in the literature have in common, that barriers prevent the markets from functioning efficiently.

Over the recent years the term barriers has increasingly been used in relation to climate and environment and appears to have adopted versions of a broad and descriptive definition of barriers to implementing low-carbon technologies are found to signify factors that "hinder the wished-for development"[7] or that "operate in between actual and potential RE development"[8]. Sometimes barriers

[5] World Trade Organisation (2012), World Trade Report 2012.
[6] See e.g. Espinosa, Bruce & Yip (2000), "Mezziani (2003), National Institute of Economic & Social Research (2006) and Lal (1998).
[7] Ahlborg and Hammar (2014).
[8] Verbruggen et al. (2013).

are considered "anything that [reduces the] implementation of low carbon technologies"[9]. This tendency remains in the understanding of barriers in the (renewable) policy context, where "barriers put renewable energy at an economic, regulatory, or institutional disadvantage relative to other forms of energy supply"[10] Various frictions in the energy sector, government regulations, and financial markets may lead to under-investment, the level of investment being lower than the economically efficient level. At least for the field of implementing low carbon technologies, however, it appears obvious that the term barrier is used rather descriptive as opposed to its normative powers in the trade and capital market literature.

As identifying barriers is frequently used for policy design and sometimes the definitions explicitly refer to policies, we argue that a descriptive understanding of the term is not sufficient. Overcoming a barrier in this sense might imply more renewable energy and energy efficiency-related investment, but might not appropriately reflect the costs to overcome the barrier and whether there are other options to improve the market functioning. Furthermore, the common used definitions do not reflect that in reality, barriers can prevent socially optimal resource allocation on various level, e.g. at national level (macro) and investment (micro) level. For an appropriate policy design, the barriers on the different levels need to be assed separately. For instant, the common used definitions around barriers and how to overcome them does not help the investors regarding taking his investment decision nor the regulator how to design appropriate climate policies to facilitate private sector investments.

To analyse whether barriers may lead to under-investment – the level of investment being lower than the economically efficient level – a better understanding of the term "barrier" in the climate context from an economic perspective and its impact on the different stakeholder is needed. Therefore we suggest – leaning towards Ekholm et al. (2013) – going back to the original use of the term barriers that defining barriers requires at least implicit reference to the social optimum – and adds the investor's perspective:

"A barrier to investment in renewable energy or energy efficiency is a friction that prevents renewable and energy efficiency at a socially optimal level."

One simple consequence of such a definition would be: If barriers prevent the social optimum from materializing then – obviously – overcoming all barriers means to advance the situation closer to the social optimum. The major differences between the way barriers are used in relation to climate and environment compared to the traditional understanding is the reference to the social optimum. While this reference might appear rather hypothetical in our applied context, it has one major consequence: Overcoming a barrier in our sense automatically implies a welfare improvement compared to the situation in which all barriers are removed. In other words: anything that qualifies as a barrier under this definition deserves to be removed in order to move the situation closer to the social optimum.

2.1. Renewable energy and energy efficiency barriers in the literature

There is plenty of reference to renewable energy and energy efficiency investment barriers in the literature. Most would acknowledge a broad range of categories and focus on a few specific barrier types, while others would cluster and aggregate barriers in typological themes. Although there are some overlaps, the five most frequently discussed typological in renewable and are policy, regulation & economic, financial market, and institutional barriers within a finance institution, technological

[9] Gillingham and Sweeny (2012) Barriers to Implementing Low Carbon Technologies
[10] Beck, F. and E. Martinot (2004).

barriers and psychological and behavioural barriers. Subsequently, Table 1 aggregates the barriers to investments renewable energy and energy efficiency as they are discussed in the literature in typological themes.[11] However, two issues are worthwhile to keep in mind: First, other categorisations than the one we have used here are equally possible. Second, most barriers are not limited to investments in RE/EE but may exist for other types of investments as well. Therefore, the last column indicates if the literature mentions this barrier in the context of RE, EE or as general barrier to infrastructure investment (GE).

[11] The table is based on the following sources: Source: Black (1974), Eun & Janakiramanan (1986), Rodrik (1991), Sutherland (1991), De Canio (1998), Martinot (1998), Tamirisa (1999), Aherne, Griever & Warnock (2000), Painuly (2001), Banz & Clough(2002), Mezziani (2003), Beck & Martinot (2004), Mackin (2006), Margolis. & Zuboy (2006), National Institute of Economic & Social Research (2006), Azzimonti & Sarte (2007), Blynth et al. (2007), EIB, (2007), EIB, (2007b), Fischer (2008), Sardianou (2008), Schleich & Gruber (2008), Mirza (2009), Sovacool (2009), Cagno et al. (2010), Crotti, Cavol & Wilson (2010), Deutsche Bank (DB) Climate Change Advisory Services (2010), Verbruggen (2010), del Rio (2011), Kolev et al. (2012), Kotsios (2010), West (2010), IFC (2011), Ohls & Moslener (2011), EIB (2012b), Richards (2012), Richards & Noble (2012), Martin & Rice (2012), Masini (2012), UNEP FI (2012), Micheli et al. (2012), Leete (2013), Leete & Xu (2013), del Rio (2011), Byrnes et al. (2013), CPI (2013g), EIB (2013a), Kostka et al. (2013), Masini (2013),UNDP (2013), The World Bank Group (2013), Xuegong et al.(2013), Venmans (2014), Jones (2015). A more detailed table is provided in the Annex. For a literature review about barriers in adaptation see Connell, R., Druce, L., Grüning, C., Pauw, P. and U. Moslener (2016), Demystifying private adaptation finance, working paper, forthcoming.

Table 1: Barriers to renewable energy and energy efficiency investment in the Literature

	Description	Barrier
POLICY, REGULATORY & ECONOMIC BARRIERS	Policy, Regulatory & Economic barriers are typically either created by or result from a lack of government action. Policy and regulatory barriers include laws and regulations as well as the state policy.	Lack of regulatory structure/factors e.g. no independent regulatory authority, non-transparent or inconsistent guidelines and regulatory principles
		Grid access and integration risk (e.g. existence of state-run monopolies of energy supplier and/or distributor, controlled transmission and distribution; lack of grid policies, long- term contracts betw the government and the established market actors)
		Lack of public infrastructure (e.g. lack of institutional coordination and cooperation within and between various ministries, agencies, institutes and other; knowledge gap of governmental instituti inadequately equipped governmental agency)
		Lack of coherent policies to promote RE/EE (e.g. uncertainty in policies, red tape, lack of policies to provide incentive to invest in RET like missing climate change strategy; explicit goals for RE/EE
		Fiscal barriers e.g. subsidies for conventional energy, tariff and non-tariff barriers on import/export of RETs.
		Discriminatory Taxation e.g. foreign investors are more heavily taxed than domestic investors.
		Lack of political stability e.g. corruption., balance of payment problems, uncertain economic growth, Expropriation of Assets (The government of the country where funds are invested confiscates capital investment), Repatriation of profits (e.g. investors are unable to convert earnings into dollars for the repatriation of pro fit because se of the host government's rigid currency rules)
		Foreign Exchange Risk; High inflation rate
		Government procurement
		Intellectual property rights
CAPITAL MARKET BARRIER	All the limitations that reduce the range of financial contracts that agents can sign and/or that prevent them to be honoured appropriate.	Imperfect capital market (e.g. under-developed capital markets, restricted entry to capital markets) and Insufficient liquidity of financial markets
		Capital controls significantly reduce exports into developing and transition economies and not into industrial countries.
		Liquidity Risk (e.g. in a shallow overseas market with insufficient demand, attempts to liquidate assets on a large scale reduce the market value of the assets) and managing liquidity issues
		Limitations on investing in illiquid assets
		Transaction costs for the placing order and screening (e.g. custodial fees, management fees etc. can be higher for international investments).
INSTITUTION AL BARRIERS	General shortcomings in institutional arrangements and governance. Institutional competition, layered bureaucracy and entrenched rules can limit organizations' ability to change behaviour.	High initial capital costs/investments for RE projects
		Lack of appropriate financial products and lending policies e.g. mismatch of the economic lifetime of many clean energy projects and bank's expectation and ability regarding the loan maturity
		Lack of strategy, operational procedures and management of an financial institution or projects/programmes (e.g. missing sustainability aspects in the vision, strategy and business plans, lack resource knowledge combining financial and technical expertise, lack of loan cycle and risk management, lack of standardized energy audits)
		Limited availability of appropriate public-private partnerships
		Diversification and limiting exposure to an industry or investment theme: Sector limits required to manage overall portfolio risk
		Investment practices of institutional investors: Practices that affect how institutions make investment decisions e.g. require certain investment volume
TECHNOLOGICAL BARRIERS	Technological barriers usually refer to the lack of advanced technologies, tools and structures related to scale up deployment of RE/EE technologies	Maturity level of the RES technologies
		Restricted access to RE technology (e.g. technology, equipment for construction and replacement is imported)
		Positive technological externality not internalized (e.g. Technology innovators are not guaranteed a share of the profits, while investment is capital intensive and design decisions are difficult to revers
		Environmental and social aspects e.g. water requirements for biomass production, local pollution like. noise, visual impact in the case of wind energy, resettlement of village for dams
		Lack of compatibility of RES components with existing infrastructure e.g. lack of transmission infrastructure, low reliability of electricity grids (e.g. non-availability of physical infrastructure, a transmission and distribution networks in potential sites of renewable energy)
		Lack of skills for operation and maintenance at the project site
		High transaction costs independent of the project size e.g. the outlay in time and money to obtain agreements, get approvals, make decisions, arrange financing, select site and other similar activit required to move a project from idea to reality.
		Lack of standards for renewable energy products
		Knowledge gap of end-users, developers and utilities
		Lack of awareness and information (e.g. lack of climate change risk and data, lack of technical skills and experience to identify risks and opportunities of cleaner technology and sustainable ene systems like access to energy, energy security).
		Lack of fuel-price risk assessment
PSYCHOLOGI CAL AND BEHAVIORAL	Psychological and behavioural barriers include factors which influence the actor's decision e.g. like social, behavioural and cultural factors.	Social, behavioural and cultural factors (e.g. Lack of consumer acceptance towards RET products)
		Technology prejudice/negative risk perception associated with RE/EE projects
		Language barriers: investors can find it particularly difficult to conduct business in a market that uses a language with which they are unfamiliar.
		Lack of information and uniform accounting rules e.g. lack of availability and dependability of comparable information on individual companies and industries.
		Information asymmetry e.g. inadequate disclosure of economic and financial data as for those considering investing in foreign markets
		Principal-Agent Problem (e.g. If the energy performance of equipment installed by a subcontractor is unobservable or difficult to enforce legally, this creates an incentive for the subcontractor to bu cheaper equipment with poorer energy performance)

[12] RE= Renewable Energy; EE = Energy efficiency and GE=general barrier to investments

2.2. Decomposition of the Barriers: Barriers, Market Imperfections and the Risk-Return Profile

It is obvious from a first look that those barriers mentioned in the renewable energy and energy efficiency as they are used and formulated are a heterogeneous mix of normative and descriptive definitions and reflect the investor and economic perspective. The liquidity risk (e.g. in a shallow overseas market with insufficient demand, attempts to liquidate assets on a large scale reduce the market value of the assets) and managing liquidity issues (e.g. limitations on investing in illiquid assets) reflect the investor perspective, while positive technological externality which are not internalized (e.g. Technology innovators are not guaranteed a share of the profits, while investment is capital intensive and design decisions are difficult to reverse) others refer to deeper market mechanics or market imperfections directly.

After having established our definition, anything that qualifies as a barrier under this definition deserves to be removed in order to move the situation closer to the social optimum. Therefore, the barriers to renewable energy and energy efficiency investment already mentioned in the literature will be filtered with respect to the two questions: i) *Economic perspective*: What is the underlying market imperfection of the observable "barrier"? And ii) *Investor perspective*: What is the consequence for risk and/or return of the corresponding investment for the investor?

Economic perspective

Ekholm et al. (2013) state that "In an ideal environment in which markets are complete[13] and competitive, all positive and negative externalities are priced,[14] and no information asymmetry exists,[15] investments will be at a socially optimal level." This directly implies that market imperfection results where markets, are not able to deliver the most efficient allocation of resources (not welfare maximizing/optimal to society. The absence of any precise typological groupings in the literature the market imperfections are classified in: emission externalities, technological spill-over, imperfect financial market, asymmetric information and other potential unjustified market distortions.

In a simplified way, externality exist as soon as the maximization of the own utility has a uncompensated positive or negative impact on the utility on another actor. Typically, for RE/EE investments externalities result through emission externalities and technology spill-over. Emission externalities refer to negative or positive uncompensated effect of economic activity on an uninvolved party. These external effects are not included in the economic calculations of market agents. Emission externalities include all negative external effects of economic activity on the environment, including e.g. pollution in the form of carbon emissions or abatement activities. Technology spill-over describes a positive externality that is not reflected in the economic calculations of agents. Technology spill-over – such as Research and Development or the deployment of new technologies – generates knowledge that is publicly available, if the idea or development cannot be (patent-) protected. Imperfect financial markets do not allocate capital such that it is used most productively from a social

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[13] Market completeness means that there are traded contracts for every possible contingency in future and there is a price for them. This allows having a unique price for any risky production technology. Obviously, reality is far from this assumption.

[14] Externalities exist when the negative or positive effects of an activity affects other agents in the economy without being reflected in its private price. As an example of positive externality, one can refer to climate effects of renewable technologies. If positive externalities are not included in the price, agents will under-invest in that technology.

[15] There are two main types of informational asymmetries in the financing practice. Adverse-selection refers to a situation in which a financier cannot distinguish between high quality and low quality investment projects. Moral- hazard happens when the entrepreneurs who has received some external financing behaves in a way to maximize her benefits and not necessarily the benefits of the financier. In aggregate level, both types results in lower provision of funds to investment projects.

point of view.[16] Three types of capital market imperfections that typically occur in relation to RE/EE financing decisions are (i) the lack of a (liquid) market for long-term debt, as many RE/EE investments face substantial payback periods due to their lifetime. This is an issue for larger scale infrastructure, (ii) imperfect credit markets, and (iii) the monitoring externalities.[17] For instance known technologies will find financing more easily compared to relatively new ones even if they are tested, just not yet established. On top of this, (iii) all risks that are impossible to insure like the exploration risk for geothermal projects are also some form of capital market imperfection. Information asymmetry need to be distinguished between i) actors using the asymmetric information strategically, and ii) if some market actors have simply access to more information than others for decisions in transactions. The perhaps most famous example for using asymmetric information strategically is illustrated George Akerlof's (1970) analysis of the market for lemons.[18] Similarly, all cases of the principal-agent problems for energy efficiency investment are an example for strategic use of asymmetric information. Capital market imperfection is often one consequence of such asymmetric information. If commercial banks are not familiar with RE/EE projects due to lack of information then this may lead to inefficient credit decisions. Market distortions on other markets subsume all factors which distort the decision of market actors and yield towards a sub-optimal level from a social point of view.

Investor perspective

Barriers may lead to under-investment – the level of investment being lower than the economically efficient level. Investors make their investment and financing decisions based on their expectations about the future, subject to the usual business risks (e.g. development, construction, operation risks).[19] As investments generally take place where the risks are balanced by projected return these are crucial decision factor from the investor's perspective for any investment finance decision as well as other institutional issues like investment practices of institutions or traditional restricted investment and lending policies that hinder the investor from the investment (path dependency). The return category is differentiated in barriers reducing the return of RE/EE projects, barriers that provide fossil fuel projects a comparative advantage (but do not actually reduce the return of the RE/EE) and finally barriers that reduce the return of foreign investors compared to national once. For all type of investment, the investors face various risks. It represents only a barrier in case the investor can't hedge or avoid the risk through contracts. The higher the (perceived) risks are, the higher the expectations of the investor on the return will be. In this context, it is important to keep in mind that risks can be perceived differently on the macro-level than from the investor's perspective, depending on their ability to influence the risk. Each investor, however, has not only an individual risk perception, but as well an individual risk-return profile which is acceptable for him. The high (perceived) risk can burden the financial viability of projects. To attract private sector investments, RE/EE projects need to provide an at least equally attractive risk-return profile– from their perspective.

Based on our definition the barriers in Table 1 are filtered and characterised in terms of the economic mechanisms that lead to the decreased attractiveness of the investment (relative to the hypothetical

[16] J. E. Stieglitz (1974).
[17] Ohl, U. and U. Moslener (2011).
[18] Akerlof, G. A. 1970.
[19] See Pauw (2014) for direct or indirect risks to daily business activities or reduced (potential) returns for investment in changing climate

case of functioning markets) as well as the impact on the risk and return profile, while keeping the classification for barriers in RE/EE, barriers for infrastructure which exist similarly for infrastructure investments in general and barriers which are characteristic for all kind of infrastructure investments in new technologies.

Decomposing the fiscal barriers illustrates that all examples previously mentioned like subsidies for conventional energy, tariff and non-tariff barriers on import/export of RET or lack of CO2 price represent limits to reach the social optimum. From an investor's point of view, however, they represent different obstacles. Subsidies for conventional energy do not reduce the return of a RE/EE project but put them in a comparative disadvantage compared to conventional energy. The market distortion is from the RE/EE market point of view not justified and occurs on the market for conventional energy. The lack of CO2 price reduces the return of RE/EE compared to conventional energy as well. The underlying reason, however, is the missing internalization of the emissions (emission externality). Tariff and non-tariff barriers on import and export reduce the return from increasing costs but this distortion on a different market is of general nature of all imports and export.

Another example is the grid access and integration risk which corresponds for investors to the volume risk whether the power can be sold or not. The volume risk exists as well for other infrastructure projects and goes hand-in-hand with an illiquid electricity market which is a sub-optimal situation.

Following our definition several obstacles mentioned in the literature are not classified as a barrier according to our definition. Transactions costs, for example, represent true costs which reduce the return of a project RE/EE and may therefore affect the financial and economic viability of the project. However, when a RE/EE project is "too expensive", it is not social optimal to implement it. Another example is environmental and social aspects of RE/EE which are actually no barrier to RE/EE infrastructure investment. In contrary, these are negative externalities from RE/EE projects which are not internalized in the investment decision and put them in a comparative advantage compared to infrastructure project in convention. Table 2 provides a synthesis and decomposition of all barriers that are identified in the literature and satisfy our definition of a barrier.

Table 2: Synthesis and decomposition on barriers relevant to financing RE/EE projects

			Economic perspective				
		Barrier	**Emission externality**	**Technological spill-over**	**Imperfect capital market**	**Asymmetric information**	**Other potential unjustified market distortion**
Investor perspective	**Return**	Reduced relative return of RE/EE compared to fossil fuel	no internalisation of emissions due to missing CO_2 price				Comparable disadvantage for RE/EE due t fossil fuel subsidies
		Reduced returns of RE/EE		Lower (but rising) maturity of RE/EE technology; Technology specific learning curve	increased capital cost (e.g. higher interest due to lack of access to the capital market)	Principal-Agent Problem: different interests/information level of Principal and Agent	Import taxes/quotas Principal-Agent Problem (investor might hav reduced benefit of EE investments)
		Reduced return for foreign compared to national investors					Discriminatory taxation of foreign investors
	Risk	Volume risk e.g. can the product like power or service be sold					Illiquid electricity market: Long-term contrac state monopoly, grid connection; controlle transmission and distribution; lack o purchase-power agreements Network externality: Inappropriate gri infrastructure
		Regulatory and policy risk				Non-transparent guidelines unpredictable decision process for the permission	Special interest driven decision making corruption
		legal risk			Expropriation of assets repatriation of profits		
		Currency risk			Illiquid foreign exchange market		
		Inflation risk			No hedging against inflations		
		Liquidity risk e.g. exit risk			lack of liquid asset market		
		Increased planning & operational risk due to lack of experience in a new environment		Lower than expected output or higher than expected operating expenses shorter than planned lifetime of equipment (learning about the technology, operation and maintenance)			
	Institutional barriers	Different levels of lack of information (of the investor)				Lack of knowledge combining financial and economic expertise lack of uniform accounting rules	
		Traditionally restricted lending and investment policies			Restriction to lending for collaterals		
		Traditional indices (low share of RE/EE) used as investment "benchmark"			Distorted price signal		
		Investment practices of institutional investors			Minimum and scale issues of institutional investors		

Legend: green = RE/EE specific barriers; grey = Barriers for new technologies; without colour = Barriers for all infrastructure investments

It is obvious from a first look that the majority of the barriers are of general nature for all infrastructure investments. This includes reduced return for foreign compared to national investors or currency risk or liquidity risk like the exit risk. Moreover, RE/EE investments face additional barriers typical for new technologies in general, e.g. lower (but rising) maturity of technology or increased planning & operational risk due to lack of experience. Finally, there are also barriers which are specific to RE/EE investments like reduced relative return of RE/EE compared to fossil fuel due to a lack of CO2 price or fossil fuel subsidies or traditional indices (low share of RE/EE) used as investment "benchmark".

As a consequence, barriers for RE/EE infrastructure investment tend to be more complex, i.e. composed of more "elementary barriers". Shifting private investments towards low-carbon emissions therefore requires addressing a variety of barriers but and not only reducing the RE/EE specific barriers.

3. Policy implication

The barriers analyzed above correspond to factors limiting investments in RE/EE which are rational given the private sectors' circumstances. Given certain circumstances or the manner in which certain private actors operate, due to these barriers it may be rational for them not to invest as long the barriers exist. One consequence of our definition is that if barriers prevent the social optimum from materializing then – obviously – overcoming all barriers means to advance the situation closer to the social optimum. Decomposing the barriers according to the economic and investor perspective provides a better understanding of the complexity of the existing market imperfections for RE/EE investments and their implication for the investor.

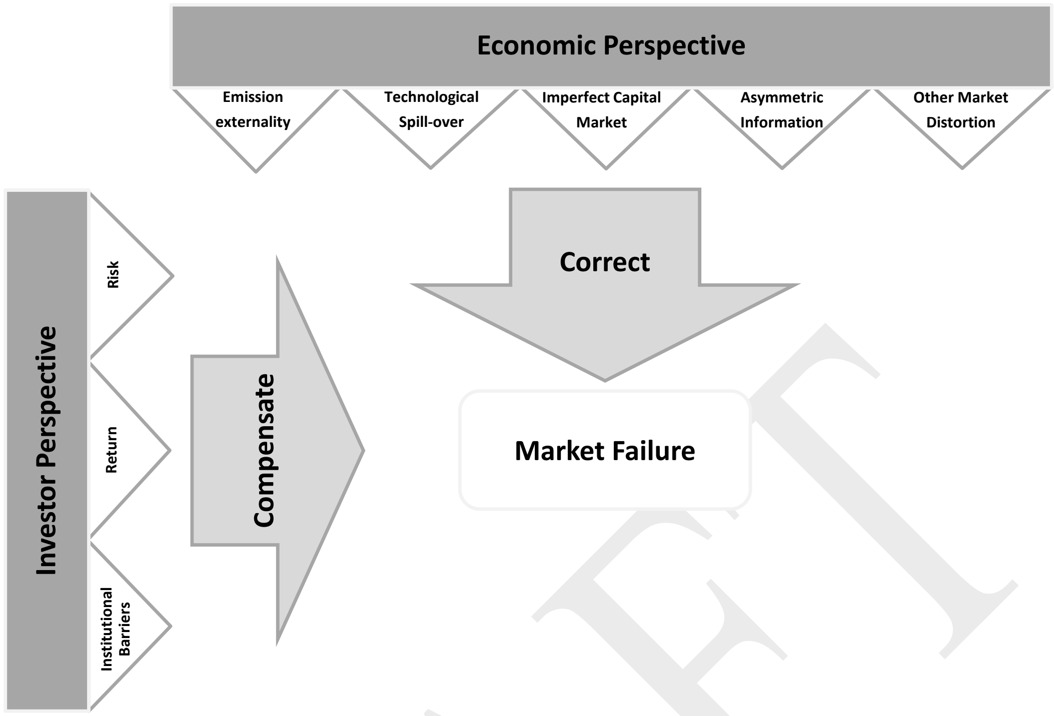
Table 2 can server as starting point to map the status quo and to design policy. A policy maker could go through the lines of the table one by one and identify the barriers according to the investment environment in his country or for a given sector or technology. This mapping can then be linked to the debate about which policy actions can be implemented to get to the "efficient" situation. Basically, there exist two approaches (see

Figure 1):

i) *correcting the market failure:* by altering market institutions or regulation e.g. through markets based or command and control instruments. Potential policy instruments are different kind of emission standards, emission taxes and tradable emission permits.

ii) *compensating the investor for the impact of the barrier*: without correcting the market imperfection e.g. through monetary compensation or risk mitigation measures. For example, grants and subsidized loans increase the return; and guarantees improve risk profiles, or feed-in tariff reduce the output risk of utilities. While the strategy of compensation has less structural implications on the market imperfection, it might use the fact that, e.g., return impacts are typically additive.

Figure 1: Investors and the economic perspective on barriers



A comment seems appropriate regarding the potential use of this approach of this so far rather theoretical concept. Although based on fundamental economic principles related to efficiency, the results are not meant to serve as fundamentalist principles to prescribe policy interventions to remove the barriers. This study argues not for aiming to strictly try to remove all market imperfections and to leave it all to the market. In fact, that would neither be politically, nor practically possible. Often it will be difficult to quantify the market imperfections. Furthermore, the real world, however, is faced with a multicriteria optimization problem, as adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. The analysis is rather meant to provide some kind of a compass with respect to one among many dimensions of policy design.

The focus on market imperfections is meant to provide orientation with respect to a costs-minimal use of public instruments and funds with respect to facilitating a structural change towards a low-carbon economy. It is more than simply looking at how to mobilise large investments with a small public budget in the sense that it includes the change perspective. However, at the same time it is limited to the costs-minimising perspective in the sense that it is blind to distributional effects. Nevertheless, this paper argues that the focus on barriers related to market imperfection is helpful in a secondary priority sense, namely when it comes to the question, which type of support/distribution instrument will have which effect on the structural change. For distributional reason refining policy targets related to compensation and fairness are important, but these policies should be designed in a transparent and explicit manner, and realizing the potential risk of slowing down or delaying the structural change. Even if the barriers are simply used to provide orientation for a cost efficient structural change, the mapping to risk and return from the investment perspective provides guidance on whether the public actor should subsidise or rather take risk and perhaps how to formulate the eligibility criteria which circumstances justify the support.

4. Conclusions

In order to achieve aggressive emission reduction targets to achieve the 2° target, all CO2 emitting sectors have to make significant improvements and will have to shift from primary, carbon-containing fuels to electric power. Consequently, capital stock has over time to shift towards low-carbon investments, which puts an emphasis on the investment decision and/or allocation of capital. Understanding the reasons for the lack of climate friendly investment not only from the economic perspective but as well from the investors' perspective is essential for identifying desirable projects that have not yet taken place.

The barriers mentioned in the literature are a heterogeneous mix of normative and descriptive definitions and sometimes reflect the investor perspective, but sometimes refer to deeper market mechanics or market imperfections directly. Defining barriers with a reference to the social optimum aims to provide some kind of a compass with respect to one among many dimensions of policy design.

Annex - Table 3: Barriers to renewable energy and energy efficiency investment in the Literature

	Barrier	Source	Climate specific[20]
POLICY, REGULATORY & ECONOMIC BARRIERS	Lack of regulatory structure/factors e.g. no independent regulatory authority, non-transparent or inconsistent guidelines and regulatory principles	Rodrik (1991), Painuly (2001), Fischer (2008), Mirza (2009), Ohls & Moslener (2011), IFC (2011), Richards (2012), EIB (2012b), Martin & Rice (2012), Xuegong et al. (2013), Leete (2013), del Rio (2011), Xuegong et al.(2013), EIB (2013a), Jones (2015)	RE, EE, GEI
	Grid access and integration risk (e.g. existence of state-run monopolies of energy supplier and/or distributor, controlled transmission and distribution; lack of grid policies, long- term contracts between the government and the established market actors)	Painuly (2001), IFC (2011), del Rio (2011), Martin & Rice (2012), EIB (2012b),UNDP (2013), Byrnes et al. (2013), Xuegong et al. (2013)	RE, GEI
	Lack of public infrastructure (e.g. lack of institutional coordination and cooperation within and between various ministries, agencies, institutes and other; knowledge gap of governmental institution; inadequately equipped governmental agency)	Sutherland (1991), Martinot (1998), Painuly (2001), Mirza (2009), Martin & Rice (2012), EIB (2013a)	RE, EE, GEI
	Lack of coherent policies to promote RE/EE (e.g. uncertainty in policies, red tape, lack of policies to provide incentive to invest in RET like missing climate change strategy; explicit goals for RE or EE).	Painuly (2001), Margolis. & Zuboy (2006), Blynth et al. (2007), Fischer, C., (2008), Byrnes et al. (2013),	RE, EE
	Fiscal barriers e.g. subsidies for conventional energy, tariff and non-tariff barriers on import/export of RETs.	Painuly (2001), Mezziani (2003), Beck & Martinot (2004), National Institute of Economic & Social Research (2006), Fischer, C., (2008), Mirza (2009), IFC (2011), Kostka et al. (2013)	RE, EE
	Discriminatory Taxation e.g. foreign investors are more heavily taxed than domestic investors.	Black (1974), National Institute of Economic & Social Research (2006)	GEI
	Lack of political stability e.g. corruption., balance of payment problems, uncertain economic growth, Expropriation of Assets (The government of the country where funds are invested confiscates the capital investment), Repatriation of profits (e.g. investors are unable to convert earnings into dollars for the repatriation of pro fit because se of the host government's rigid currency rules)	Painuly (2001), Mezziani (2003), Azzimonti & Sarte (2007), Deutsche Bank (DB) Climate Change Advisory Services (2010), IFC (2011), EIB (2013a), Jones (2015)	RE, EE, GEI

[20] RE= Renewable Energy; EE = Energy efficiency and GEI=general barrier to investments

	Foreign Exchange Risk High inflation rate Government procurement Intellectual property rights	Eun & Janakiramanan (1986), Tamirisa (1999), Painuly (2001), National Institute of Economic & Social Research (2006), Deutsche Bank Climate Change Advisory Services (2010) Ohls & Moslener (2011), IFC (2011), Jones (2015) Kotsios (2010)	RE, EE, GEI GEI
CAPITAL MARKET BARRIERS	Imperfect capital market e.g. under-developed capital markets, restricted entry to capital markets	Sutherland (1991), Painuly (2001), Beck & Martinot (2004), EIB, (2007b), Schleich & Gruber (2008), EIB (2013a), IFC (2011), Martin & Rice (2012), EIB (2012b), The World Bank Group (2013), Xuegong et al. (2013)	RE, EE, GEI
	Insufficient liquidity of financial markets	Sutherland (1991), Painuly (2001), IFC (2011)	RE, EE, GEI
	Managing liquidity issues: Limitations on investing in illiquid assets	Martinot, (1998), CPI (2013g)	RE; EE, GEI
	Capital controls significantly reduce exports into developing and transition economies and not into industrial countries.	Tamirisa (1999), Aherne, Griever & Warnock (2000)	GEI
	Liquidity Risk: In a shallow overseas market with insufficient demand, attempts to liquidate assets on a large scale reduce the market value of the assets.	Mezziani (2003)	RE, EE; GEI
	Transaction costs for the placing order and screening (e.g. custodial fees, management fees etc. can be higher for international investments).	Mezziani (2003), EIB, (2007), Crotti, Cavol & Wilson (2010)	GEI
INSTITUTIONAL BARRIERS	High initial capital costs/investments for RE projects	Sutherland (1991), Beck & Martinot (2004), Margolis & Zuboy (2006), Mirza (2009), del Río (2011), Martin & Rice (2012), Leete & Xu (2013)	RE, EE, GEI
	Lack of appropriate financial products and lending policies e.g. mismatch of the economic lifetime of many clean energy projects and bank's expectation and ability regarding the loan maturity	Martinot (1998), EIB, (2007), Mirza (2009), Cagno et al. (2010), IFC (2011), EIB (2013a), The World Bank Group, (2013), Jones (2015)	RE, EE, GEI
	Lack of strategy, operational procedures and management of an financial institution or projects/programmes (e.g. missing sustainability aspects in the vision, strategy and business plans, lack of resource knowledge combining financial and technical expertise, lack of loan cycle and risk management, lack of standardized energy audits)	De Canio (1998), Martinot (2001), Beck & Martinot (2004), Sardianou (2008), Kostka et al. (2013), Venmans (2014)	RE, EE
	Limited availability of appropriate public-private partnerships	Mackin (2006), UNEP FI (2012)	RE; EE
	Diversification and limiting exposure to an industry or investment	CPI (2013g)	RE, EE, GEI

	theme: Sector limits required to manage overall portfolio risk		
	Investment practices of institutional investors: Practices that affect how institutions make investment decisions e.g. require certain investment volume	Ohls & Moslener (2011), CPI (2013g)	RE, EE, GEI
TECHNOLOGICAL BARRIERS	Maturity level of the RES technologies	Deutsche Bank Climate Change Advisory Services (2010), Del Rio (2011), Jones (2015)	RE, EE
	Restricted access to RE technology (e.g. technology, equipment for construction and replacement is imported)	Painuly (2001), Mirza (2009), Martin & Rice (2012)	RE, EE
	Positive technological externality not internalized (e.g. Technology innovators are not guaranteed a share of the profits, while investment is capital intensive and design decisions are difficult to reverse)	Leete (2013)	Re, EE
	Environmental and social aspects e.g. water requirements for biomass production, local pollution like. noise, visual impact in the case of wind energy, resettlement of village for dams	Painuly (2001), Mirza (2009)	RE
	Lack of compatibility of RES components with existing infrastructure e.g. lack of transmission infrastructure, low reliability of electricity grids (e.g. non-availability of physical infrastructure, and transmission and distribution networks in potential sites of renewable energy)	Martinot (1998), Painuly (2001), Mirza (2009)	RE
	Lack of skills for operation and maintenance at the project site	Martinot (1998), Mirza (2009), Martin & Rice (2012)	RE
	High transaction costs independent of the project size e.g. the outlay in time and money to obtain agreements, get approvals, make decisions, arrange financing, select site and other similar activities required to move a project from idea to reality.	Sutherland (1991), Martinot (1998), Painuly (2001), Beck & Martinot (2004), Margolis & Zuboy (2006), Schleich & Gruber (2008), Mirza (2009), Ohls & Moslener (2011), EIB, (2007b), Deutsche Bank Climate Change Advisory Services (2010), IFC (2011), CPI (2013g)	RE, EE, GEI
	Lack of standards for renewable energy products	Painuly (2001), Mirza (2009)	RE, EE
	Knowledge gap of end-users, developers and utilities Lack of awareness and information (e.g. lack of climate change risk and data, lack of technical skills and experience to identify risks and opportunities of cleaner technology and sustainable energy systems like access to energy, energy security).	Sutherland (1991), Painuly (2001), Margolis & Zuboy (2006), Schleich & Gruber (2008), Sardianou (2008), Mirza (2009), Verbruggen (2010), Richards & Noble (2012), Leete (2013), EIB (2012b), Kostka et al. (2013), Venmans (2014)	RE, EE
	Lack of fuel-price risk assessment	Sutherland (1991), Beck & Martinot (2004), Sardianou, (2008), Mirza (2009), Xuegong et al. (2013), IFC (2011)	RE, EE

PSYCHOLOGICAL AND BEHAVIORAL BARRIERS	Social, behavioural and cultural factors (e.g. Lack of consumer acceptance towards RET products)	Martinot (1998), Painuly (2001), Margolis. & Zuboy (2006), EIB, (2007), Sovacool (2009), Cagno et al. (2010), Verbruggen (2010), Masini (2012), Martin & Rice (2012), Kolev et al. (2012), Venmans (2014)	RE, EE
	Technology prejudice/negative risk perception associated with RE/EE projects	Margolis, & Zuboy (2006), West (2010), Martin & Rice (2012), Leete (2013), Masini (2013)	RE, EE
	Language barriers: investors can find it particularly difficult to conduct business in a market that uses a language with which they are unfamiliar.	Mezziani (2003)	GEI
	Lack of information and uniform accounting rules e.g. lack of availability and dependability of comparable information on individual companies and industries.	Mezziani (2003), Margolis & Zuboy (2006), Micheli et al. (2012)	GEI
	Information asymmetry e.g. inadequate disclosure of economic and financial data as for those considering investing in foreign markets	Martinot (1998), Aherne, Griever, & Warnock. (2000), Banz & Clough(2002), EIB, (2007), EIB (2012b) Micheli et al. (2012)	GEI
	Principal-Agent Problem (e.g. If the energy performance of equipment installed by a subcontractor is unobservable or difficult to enforce legally, this creates an incentive for the subcontractor to build cheaper equipment with poorer energy performance)	Venmans (2014)	EE

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