PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE
ESCUELA DE INGENIERIA

CLEAN DEVELOPMENT MECHANISM: PROFITABILITY DRIVERS AND SUSTAINABLE DEVELOPMENT PROFILES

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Thesis submitted to the Office of Research and Graduate Studies in partial requirements for the Degree of Master of Science in Engineering

Advisor:
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A mi familia y amigos por todo su apoyo

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RESUMEN

El mecanismo de desarrollo limpio (MDL) es el único mecanismo de mercado bajo el Protocolo de Kyoto destinado a ayudar a los países en desarrollo a crecer siguiendo un camino más limpio. Los proyectos de energía renovable presentan el mayor potencial dentro del MDL para contribuir al desarrollo sostenible de los países. Sin embargo, ofrecen un menor número de créditos de carbono que otras alternativas de proyectos y presentan mayores riesgos. Hasta el momento, los incentivos del MDL han promovido proyectos que entregan mayores dividendos, dejando las energías renovables y el desarrollo sostenible atrás, exponiendo la necesidad de entender los proyectos de energías renovables y aquellos factores que afectan la rentabilidad para reducir los riesgos y aumentar su rentabilidad.

En esta investigación se analizan proyectos de energía renovable de Latinoamérica. Primero se estudian factores de rentabilidad mediante la réplica de 44 flujos de caja y también las diferencias existentes en supuestos usados en proyectos con características similares en Chile. Luego se estudian beneficios de desarrollo sostenible en una muestra de 180 proyectos de energía renovable. Para la muestra el factor de planta es clave para la rentabilidad, seguido del precio de la electricidad, del costo de la inversión y de un retraso de un año. Los resultados también sugieren que los desarrolladores de proyectos eligen los parámetros que más les convengan para que sus proyectos puedan ser registrados en el MDL. Para el desarrollo sostenible, si bien no existen tendencias entre el país anfitrión, la escala o el tipo de proyecto con la sostenibilidad, todos los proyectos evaluados claman entregar al menos un tipo de beneficio. Sin embargo, la transferencia de tecnología, que ayuda a los países a desarrollar sus propias capacidades, se queda atrás.

El estudio propone que el MDL sea reestructurado para promover las energías renovables y el establecimiento de criterios universales para la evaluación de la adicionalidad de inversión. Así se evitaría la manipulación de datos que busca aumentar los ingresos por MDL. Una de las medidas propuestas es el uso de una lista de categorías de beneficios como un estándar internacional en el MDL para ayudar a los

países más pobres en el desarrollo de capacidades institucionales y a que puedan adaptarse al cambio climático.

Palabras Clave: CDM; Energías Renovables; Adicionalidad de Inversión; Factores de rentabilidad; Desarrollo Sostenible; América Latina; Chile

ABSTRACT

The clean development mechanism (CDM) is the only market-based mechanism under the Kyoto Protocol aimed to help developing countries grow following a cleaner path. Renewable energy projects present the highest potential within the CDM to contribute to countries' sustainable development. However, they deliver fewer carbon credits than other project alternatives and present higher risks. So far, the CDM's incentives have promoted projects delivering higher dividends, leaving renewable energies and sustainable development behind, thereby exposing the need to understand renewable energy projects and their profitability drivers better to reduce their risks and increase their profitability

In this research first the profitability drivers associated with CDM renewable energy projects in Latin America are studied by replicating 44 cash flows. The different assumptions taken by project developers for projects with similar characteristics in Chile are also studied, aiming to expose that no methodologies are used to choose parameters for evaluating projects. Then sustainable development benefits are studied for a sample of 180 renewable energy CDM projects from Latin America. Since these types of projects are associated with the highest sustainability benefits, their analysis aims to portray the best possible scenario for the contribution of CDM towards sustainable development. The results show that for the sample the plant factor is the key driver for profitability, followed by electricity price, investment cost and a one-year delay. It also suggests that project developers may choose the parameters that most accommodate them so that their projects can be registered under the CDM. For sustainable development while no trends exist between host country, scale or type of project with sustainability, all of the evaluated projects claim to deliver at least one type of benefit. Nonetheless, technology transfer, which helps countries to build their own capacities, is left behind.

The study proposes the CDM to be restructured to promote renewable energies and to establish universal criteria for the investment additionality assessment, avoiding data manipulation solely with the goal of increasing CDM revenues. One of the measures proposed is to use of a checklist of categories and subcategories of benefits as an international standard in CDM to aid the poorest countries in the development of institutional capacities in order to help them adapt to climate change.

Keywords: CDM; Renewable Energy; Investment Additionality; Profitability drivers; Sustainable Development; Latin America; Chile

IMPORTANT TERMINOLOGY

CDM: Clean Development Mechanism. It allows developed countries with emission reduction targets to implement a CDM project in developing countries (not obligated to reduce emissions). These projects can earn CERs (Certified Emission Reductions), each equivalent to one tonne of CO_2, which can be counted towards meeting Kyoto targets.

PDD: Project Design Document. Contains all the information about the project, including additionality test, barrier analysis, common practice analysis and sustainable development claims.

Additionality Test: The project developer needs to prove that his project is additional, meaning that it is not the business as usual case and that the reductions are additional to what would otherwise have occurred, in order to be registered into the CDM. It usually includes an investment, barrier and common practice analysis, as well as stated sustainable development contributions.

Investment Analysis: The project developer needs to prove that the project either faces more costs than an alternative or is less profitable than a reference case or a benchmark.

Barrier Analysis: The project developer needs to prove that the project faces more barriers than a reference case or that the CDM allows the project to overcome certain barriers.

Common Practice Analysis: The project developer needs to prove that the project is not the common practice, meaning that if other similar projects are already operating, they should either face a very different economic situation or they should also be receiving incomes from the CDM.

CER: Certified Emission Reduction. Corresponds to an approved metric tonne of CO_2e reduced, attained by investing on projects in non-Annex I countries.

GHG: Greenhouse gases. The main GHG gases considered in the Kyoto Protocol are carbon dioxide, methane, nitrous oxide, hydroflurorocarbons, perfluorocarbons and sulphur hexafluoride.

1 INTRODUCTION OF THE RESEARCH

This section provides an overview of the total work presented on the thesis in the form of two separate papers, which are meant to be read and understood on their own, each one presenting the context of the study, introduction, development and conclusions. The motivation for the research, literature review and methodology for the study, along with the main results and general conclusions are provided.

1.1 Motivation: Climate Change and the Kyoto Protocol

Anthropogenic climate change, primarily due to the increase in greenhouse gases (GHGs) in the atmosphere, is a phenomenon capable of affecting both human life and the planet's ecology. Even though industrialized countries are responsible for the majority of the historic and current stock of GHGs, developing countries growth in emissions have been significant, even considering that their per capita emission levels continue to be lower than developed countries. As a result of this new scenario, climate mitigation became a global issue (Bailis, 2006; Dagoumas et al., 2006; Schneider et al., 2010; Winkelman and Moore, 2010).

Reducing GHG emissions globally is critical to limit the impacts of global warming (Arent et al., 2011), that is why the United Nations Framework Convention on Climate Change (UNFCCC, n.d.) was established as an agreement to address the problem of climate change, taken on the United Nations Conference on Environmental and Development (UNCED) in Rio, Brazil in 1992 (Nautiyal and Varun, 2012). Its main aim is to stabilize atmospheric concentrations of GHGs, while assuring food, security, adaptation of ecosystems to climate change and sustainable development (Ellis et al., 2007).

The Kyoto Protocol is born in 1997 as a response to the UNFCCC's ambition to reverse the increase in GHGs emissions. Its main achievement, beyond creating social awareness, is to create legally binding obligations for industrialized countries (referred as Annex I countries) to reduce their emissions of GHGs to an average of 5% below their 1990 levels over the first commitment period from 2008 to

2012 (UNFCCC, 1997). The developed countries accepted the responsibility of leading the climate change mitigation efforts since their per capita emission levels were more than ten times greater than those of developing countries (Grubb et al., 1999; Banuri and Gupta, 2000; Baranzini et al., 2000; Grubb, 2003).

The Clean Development Mechanism (CDM) is one of the three flexible mechanisms set under the Kyoto Protocol (UNFCCC, 1997). It has two objectives, to lower the compliance costs of developed countries to help them reach their targets and to incorporate developing countries in the mitigation of climate change by providing them with sustainable development so they can grow following a cleaner path. CDM lets developed countries receive credits for certified emission reductions (CERs), corresponding to an approved metric tonne of CO2e reduced, attained by investing on projects in developing countries and is the main effort to include developing countries into the global emissions market by hosting projects (Hamwey and Baranzini, 1999; Dutschke and Michaelowa, 1998; Begg, 2002; Dagoumas et al., 2006; Boyd et al., 2009; Grub et al., 2010).

While CDM has contributed to tackle climate change and offers developing countries an opportunity to participate in the global carbon market by hosting projects, it is considered widely imperfect (Boyd et al., 2009). The main critics surrounding CDM have to do with its high transaction costs (Michaelowa and Jotzo, 2005; Chadwick, 2006), with promoting CDM projects with higher dividends whilst neglecting the pursue of sustainable development (trade-off between CDM's two objectives), with the difficulty of testing a project's additionality[1] and with the fact that CDM projects are unequally distributed across developing countries (Sutter and Parreño, 2007; Nussbaumer, 2009; Schneider et al., 2010).

[1] Additionality is one of the eligibility criteria for CDM projects, meaning that emission reductions from a CDM project should be "additional to any that would occur in the absence of such activities" (UNFCCC, 1997).

This research studies renewable energy projects in the CDM, which have the greatest potential to help decarbonize the energy sector (Schneider et al., 2010) and also create more independence from fossil fuels (Weiss et al., 2008). Renewable energy is the technology most likely to contribute to sustainable development (Ellis et al., 2007; Sutter and Parreño, 2007; Nussbaumer, 2009), however as it is very capital intensive it requires host countries to support and promote it (Xingang et al., 2011). This reveals the need to study the profitability drivers associated to these types of projects, such as investment costs, plant factor, delays and electricity prices, among others, in order to discover the most important ones and to be able to lower the uncertainties associated with renewable energy.

Hence, the first article presents a financial analysis, studying the drivers associated to profitability through the replication of 44 cash flows taken from the 180-project-sample from Latin America. A case study on Chile is done aiming to expose the difference in assumptions taken by project developers in similar projects, such as types of benchmarks considered, electricity prices and costs, among others.

The second article focuses on the sustainable development benefits claimed by each of the projects of the sample, aiming to portray the best possible situation for the contribution of CDM towards sustainable development in the region with the most homogeneous distribution of projects. Sustainable development profiles are provided according to countries, size of projects and types of technology (hydro, wind or biomass). A study on the trends regarding the four main types of benefits: economic, environmental, social and technology transfer is also performed.

1.2 Literature Review and the Contribution of this Research

The main literature for this study has to do with the areas of sustainable development and economic issues in the CDM.

In the context of the first article for the study of profitability drivers among renewable energy projects, there are four main streams of literature in this regard. A first one studies investment additionality as a general term (Shrestha and Timilsina, 2002; Greiner and Michaelowa, 2003; Philibert, 1998; Au Yong, 2009), debating on which option (barriers, IRR, NPV, ∆IRR, payback period, etc.) is the best to prove a project's additionality and most of them agreeing that the IRR benchmark makes the less prone to manipulation alternative. A second stream analyzes the investment additionality related to renewable energies (Schneider et al., 2010; Masini and Menichetti, 2013; Monjas-Barroso, Balibrea-Iniesta, 2013). However none of them focus on a particular region or study the profitability drivers for all of the first commitment period (2008-2012), as it is evaluated in this paper. A third stream focuses on techno-economic performance of determined projects in a particular area (Weiss et al., 2008; Xingang et al., 2011; Yunna and Quanzhi, 2011; Purohit, 2008; Bergqvist et al., 2008; Yang, 2010), emphasizing the need to promote renewable energies to contribute towards sustainable development and to help to reduce the energy crisis by expanding the energy matrix in a clean manner. The final stream studies risk, pricing and how to promote the CDM (Lee et al., 2013; Cormier and Bellassen, 2012; Tang et al., 2012; Bode and Michaelowa, 2003), but most of the evaluation are in regard to CDM specific risks, like high transaction costs and delays in registering the project, but not considering risks associated to the lucrativeness of a project.

Previous studies on economic issues of the CDM have taken their field of research as investment additionality, and in particular about the impact of additionality whether in a certain project or in a type of technology, like renewable energies. However, despite the similar scope of work, in order to compare the financial performance of a project, a range of indicators exist, where the NPV (Net Present Value), IRR (Internal Rate of Return) and ∆IRR (Difference between the IRR with without CDM revenues), seem to be the most used ones. Yang et al. (2010) use both the NPV and IRR for their study of a wind farm investment and find that uncertain CDM benefits significantly affect the project's NPV while at the same time that in order for the project to meet the benchmark, very hard to achieve conditions on CERs and electricity prices have to be met. Bergqvist et al. (2008) also use both indicators to perform a techno-economic assessment of rice husk-based generation and find that for this case operating hours and investment cost are the most critical parameters influencing the lifetime cost of electricity. Others, like Monjas-Barroso and Balibrea-Iniesta (2013) decide upon the NPV to evaluate an investment in a wind-renewable energy project, modeling the main uncertainties that affect this kind of projects, like the cost and production of electricity, investment costs and consumer price index in order to evaluate the regulatory options present in three different countries, still they do not rank the uncertainty, but rather study which countries support wind projects the most. Some revisions focusing on the IRR include Weiss et al. (2008) and Yunna and Quanzhi (2011), who study the impacts of CDM in the Thai electricity sector and the additionality for small-scale hydropower, respectively. The first study finds out that a sectorial approach to the CDM could help financing renewable energy projects, and the second one mainly performs a full additionality assessment for the hydro project, proving that it should be registered under the CDM. Au Yong (2009) on the other hand, decides to use ΔIRR to assess the degree of additionality for a sample of registered CDM projects, and finds out that almost a third of the projects exhibit ΔIRR of less than 2%, indicating that CDM only makes a small contribution and suggesting to set a minimum for the value. Nonetheless the study also shows that the projects with the smaller impact from CDM correspond to renewable energies, which are much more capital intensive than the rest of the technologies, but at the same time receive incomes for electricity or heat, whilst the ones with the highest ΔIRR only obtain gains from CERs. Another study that stands out belongs to Schneider et al. (2010), in which six renewable energy technologies and their drivers for financial and environmental aspects are analyzed. They perform the evaluation using a profitability index (NPV/Invested Capital) and the GHG specific reductions (Total GHG emissions/Invested Capital) and evaluate how project level parameters, regional and global variables impact the financial and environmental performance of a project. The data is not representative of a country, but an average of parameters found in developing countries, not allowing the cash flows to truly represent each country's case or the performance of a particular region, as it is presented in this study. In fact, all parameters are discounted using the same rate, not taking into account a country's specific risk, which in our study will be conducted by setting an IRR benchmark adjusted by each country's own risk. This is the first paper assessing and ranking the drivers for profitability in renewable energy projects by replicating cash flows from Project Design Documents (PDDs), comparing the results against a calculated IRR benchmark taking into account the specific risk factor of each country and attempting to provide concrete ways in which renewable energies may be promoted within the CDM. No other study has evaluated this type of technology for a whole region or focused on the different assumptions made by project developers that end up producing the variety of results observed in PDDs concerning the investment additionality analysis. The investigation is focused in Latin America, and within it, hydro and wind projects in Chile will be examined more closely. In that way, an assessment of Chile's situation should provide one of the most conservative examples regarding different assumptions made for CDM projects.

As for sustainable development, some of the main literature reviewing its benefits includes Ellis et al. (2007) who studied the 12 first registered projects, Sutter and Parreño (2007), who assessed 16 officially registered projects, Nussbaumer (2009) who studied 39 CDM projects with high sustainable development benefits and Boyd et al. (2009) who took a random sample of 10 projects to evaluate them according to qualitative measures of direct and indirect benefits based on sustainable development criteria. So far, Olsen and Fenham's study (2008) is the most complete, analyzing 296 projects of all types, but not including in their evaluation technology transfer benefits. Regarding the latter, a number of assessments have been conducted, including Haites et al., (2006), who analyzed 854 registered and proposed projects regarding only technology transfer benefits, Dechezleprêtre et al., (2008), who take on 644 registered projects and analyze the frequency and nature of technology transfer, including a study on its drivers, Schneider et al., (2008) who focuses on the purchase of technology via trade off and transfer of technology as part of an investment, showing how CDM lowers the barriers for technology transfer and Seres et al., (2009) who provides an update of the situation covering a larger base of projects (3296) and analyzing trends in technology transfer via CDM. However, no study conducted has analyzed all sustainable development benefits including technology transfer for a large volume of renewable energy projects, the ones that should provide the higher benefits, nor is there an evaluation that comprises an up to date evaluation of the situation for the whole first commitment period.

The second article contributes by assessing 180 renewable energy projects in Latin America, the first region where all of its eligible countries (those that both ratified the Kyoto Protocol and have a designated national authority – DNA) hosted a CDM project and where renewable energy projects are distributed in a more homogeneous manner. A study of Asia, the leading region, would only portray the situation of two countries: China and India, since they hold the majority of the projects, while the rest of the countries either have a few or no renewable energy projects. For the analysis we investigate the way in which CDM has contributed to sustainable development through renewable energy projects by analyzing the trends regarding frequency of benefits, types of projects and leading countries associated with different benefits. Some of the existing methodologies to evaluate sustainability can be classified as checklist approaches and multi-criteria assessment. The checklist approaches consist in a qualitative analysis of the PDD and are easily adapted for different interests amongst host countries. In studies conducted (Ellis et al., 2007; Olsen and Fenhann, 2008; Boyd et al., 2009) several pre-defined sustainable development criteria is checked against the selected documents PDDs and the obtained information analyzed for tendencies. The multi-criteria approach on the other hand, consists in combining qualitative and quantitative data and weighting the relative significance of all factors to arrive at a single measure for sustainability. Various of the most commonly used methods include the Multi-Attribute Assessment (MATA-CDM), developed by Sutter (2003), and later on by Sutter and Parreño (2007) in a study of 16 registered projects, which is modified by Nussbaumer (2009) for a study comparing normal CDM projects with those with Gold Standard qualification. The Gold Standard proposes a methodology to develop high-quality emission reduction projects with high environmental integrity and secured sustainable development benefits (Nussbaumer, 2009). Both types of methodologies have their weaknesses as the matters evaluated are subjective and no ex-post verification of sustainable development claims is carried out by the DOE. Also, the fact that no international standard exists for measuring sustainable development benefits can lead to a “race to the bottom” (Kolshus et al., 2001), in which countries lower their requirements to attract more projects. However, the multi-criteria approach also poses the complication of collecting large amounts of data from projects’ stakeholders, and since the focus of this study in through public information from PDDs, a checklist approach is chosen instead.

1.3 Hypothesis

We intend to show that despite renewable energy being associated with the highest amount of sustainable development benefits, their distribution is very uneven across countries and key benefits such as technology transfer are left behind. On the other hand, as for finding drivers of profitability, we expect to find that the investment cost, which is much higher for renewable energy that other technologies, is essential to calculating the internal rate of return (TIR), and that other factors such as the possible one-year delay in a project also influences profitability substantially. Further efforts will be made to show that the IRR benchmark used by project developers is chosen so that the project is not more profitable than such benchmark, to ensure the chances of it being registered under the CDM in order to receive carbon credits.

1.4 Methodology for the Study

This section presents the methodologies used for both articles: the study of profitability drivers and of sustainable development benefits in renewable energy projects.

1.4.1 Methodology for the Study of Profitability Drivers (Article 1)

In order to obtain the sample for the study, a previous analysis on additionality was performed, selecting 180 renewable energy projects from 18 countries in the region, in particular hydro, wind and biomass projects, since other types are not numerically substantial enough as registered CDM projects. From this sample, projects are chosen to study their profitability drivers following a set of rules: they have to perform a benchmark analysis and present the IRR as a financial indicator; they have to provide enough information in order to be able to replicate their cash flows; and for the biomass projects only those generating electricity are considered. 83 projects from the initial sample have a benchmark analysis and of those, 44 meet the rest of the requirements, including 20 hydro, 18 wind and 6 biomass projects, representing in total 24% of the original sample and 14.4% of all registered renewable energy projects in Latin America. The cash flows for these projects are replicated and after that a sensitivity analysis is carried out as a simple method often used in other studies to assess risk (Diakoulaki et al., 2007; Bergqqvist et al., 2008; Yunna and Quanzhi, 2011), in order to rank the profitability drivers. The parameters varied in the sensitivity analysis correspond to the investment cost, total costs, prices on electricity, prices on capacity and plant factor, as well as simulating a one-year delay and studying the inclusion of a residual value. Finally, in order to compare projects, a benchmark IRR is also calculated, as well as CERs prices, which are obtained as an average of historical values, so as to include a comparable measure for ΔIRR between projects. A special case study is done in Chile in order to assess how much parameters can vary in one of the main economies of the region for hydro and wind technologies (no biomass project in Chile met all the requirements).

1.4.2 For the Study of Sustainable Development (Article 2)

The utilized methodology will take on a checklist approach based on the criteria selected by Olsen and Fenhann (2008), and Nussbaumer (2009). The first article includes a detailed set of sub-parameters from which to measure sustainable development as part of the macro parameters of social, environmental and economic benefits used in most studies, however it does not include technology transfer amongst them. The second study on the other hand does include technology transfer as part of the potential economic benefits, but as it was mentioned, it does not use a checklist approach. To complement this analysis, we include the works done by Haites et al., (2006), Dechezleprêtre et al., (2008) and Seres et al., (2009), which analyze exclusively technology transfer, defined as “a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders…” (Metz and Turkson, 2000). The two aspects examined by all papers regarding technology transfer include the use of equipment and/or knowledge not previously available in the country hosting the CDM project.

The sample of projects evaluated is based in 180 CDM renewable energy projects in Latin America. The totality of renewable projects in Latin America was filtered as follows: from 21 countries in the region, only countries with at least one renewable energy project are considered, reducing the total to 18 countries (Bahamas, Cube and Paraguay do not have registered renewable energy projects). For those remaining countries, if they have less than 8 projects, all of them are included in the sample, if they have more than 8 projects, 20% of all the projects in the country are considered randomly. Chile is the only country in which all the renewable energy projects are considered, with a total of 36. This is due to the fact that it is the second country in Latin America with the most projects in this category, but its quantity is still possible to evaluate, whilst Brazil, the country with most renewable energy projects, has 116, so assessing each one of them would have been a biased analysis representing only that country’s reality. The final result leads to a sample of 180 projects registered up until December 8, 2012, belonging to 18 countries: Brazil, Chile, Peru, Mexico, Honduras, Colombia, Ecuador, Guatemala, Panama, Argentina, Costa Rica, Uruguay, Nicaragua, El Salvador, Dominican Republic, Jamaica, Bolivia and Guyana.

1.5 Main Results, General Conclusions and Recommendations

All the projects in the study, large and small, rank their drivers in the same order. The results show that the most important factor affecting the IRR of a project is the plant factor, with a bigger impact done in wind projects, being able to increase the IRR of these projects in over 3 percentage points with a 10% increase. This is mainly due to the fact that these projects present lower performance than hydro and biomass (41% of plant factor for wind projects compared to an average in Latin America of 59% for hydro and 51% for biomass). In second place is the electricity price, affecting biomass projects almost twice as much as the others, particularly small scale projects with a more expensive cost structure. While hydro and wind projects generate large amounts of income for electricity sales, biomass projects only produce low amounts of energy, hence an increase in electricity price has a greater impact on them. In the third place is the investment cost, affecting biomass projects, the ones with the lowest capital requirements (834 US$/kW on average for projects in Latin America vs. 2,307 US$/kW for wind and 2,201 US$/kW for hydro) the most. The one-year delay ranks fourth among drivers, which influences small-scale projects much more than large-scale ones, though presenting similar drops in the projects' IRRs for all three technologies. The total costs follow in order, influencing biomass projects the most and having a similar impact for hydro and wind projects. Finally, capacity price ranks last mainly due to the fact that electricity sells represent approximately 90% of the revenues without CERs, while capacity sells only an approximate of 10%; also most countries in Latin America do not sell capacity, thus decreasing the effect of this factor. Another important parameter to consider is the inclusion of a residual value in the cash flow, and though it is not a common practice in the region, for wind projects it can increase the IRR more than 2 percentage points. In this matter the time frame chosen for the project plays a key role since for projects with an evaluation horizon of 20 years (such as wind projects), the inclusion of a residual value makes an impact, while for horizons of over 30 years the effect is almost negligible.

The lack of criteria within the CDM points to two specific problems within the study: the IRR benchmark used in the PDDs and the consideration of a residual value. We discovered the variety of values used for the IRR benchmark across Latin America, but the case of Chile demonstrated that just in one country more than three different criteria are accepted as an appropriate choice for the benchmark. This incentives project developers to use the benchmark that most suits their project so that they can be registered under the CDM, but which in many cases may not reveal the true situation of the market, hindering renewable energy projects by making them appear as risky and unattractive investments even when CERs are considered. That is why the proposed approach of the IRR benchmark would allow the majority of renewable energy projects to still be registered under the CDM to obtain revenues from it, but would also make them more attractive to investors, and by doing so, would help to promote this type of energy.

The main need is for the CDM to define a universal criterion to calculate the benchmarks to be used in PDDs, in order to increase transparency and ensure that the figures are not being manipulated to gain CDM revenues. On the other hand, the lack of criteria regarding the use of a residual value is also a flaw in the CDM. Although for hydro and biomass projects the impact in profitability is not that punctuated, for wind projects it makes a huge difference, which suggests that formal rules should be set up on this factor, to either limit its use or to include a section explaining why and how it is calculated in order to prevent manipulation.

An option to help the most impoverished countries to participate in renewable energy projects would be to fast-track some proposals according to host country, type and sector so that transaction costs can be minimized, as long as the majority of the countries still prove investment additionality to ensure that non-additional projects are not registered. This is essential since renewable energy projects have barely been developed in the poorest countries, because they lack the institutional frameworks and infrastructure, the policies to plan these technologies and the skilled labor and strategies to promote cleaner energies (Karekezi and Kithyoma, 2003). Other ways to help encourage renewable energies is to provide long-term governmental programs to support them, to set standards for equipment, buildings and cars to limit their amount of emissions. By increasing the performance of the projects, in the future investment requirements should decrease (Brown et al., 2001; Karekezi and Kithyoma, 2003; Geller et al., 2004). However other measures such as establishing a minimum ΔIRR (Au Yong, 2009) would hurt renewable energy projects instead of promoting them. This is due to the fact that these projects usually also sell electricity, so the effect of CERs is not as dramatic as for projects whose only incomes come from carbon credits.

As for the sustainable development research, the sample of projects presents no tendencies between sustainable development and a host country's activeness in CDM, the project's size or a clear leadership of any kind of technology within renewable energies. Nonetheless, benefits are much more heterogeneous when considering host countries or types or technology than with project's size. The likelihood of providing benefits varies greatly across types of technology, with wind projects providing higher sustainable benefits in the economic and technology transfer category and biomass projects providing greater environmental benefits, mainly due to land management. For social benefits hydro and wind projects are fairly similar, with the biggest difference in favor of hydro projects being the delivery of health benefits. Amongst all categories technology transfer is the least developed, with average benefits per project far below the rest of the categories. In fact, the countries presenting no technology transfer in Latin America: Bolivia, El Salvador, Guyana and Jamaica are amongst the poorest in Latin America, and as technology transfer is an essential help for developing countries to grow without polluting as much as developed countries have done so far, if binding emissions are set for developing countries in the future as it has been announced for the successor of the Kyoto Protocol, these countries will be the most unprepared.

Although all renewable energy projects claimed to contribute with at least one type of benefit, these statements are not checked after the project is registered, nor are the stakeholders amongst the poorest population consulted for their opinion. That is why urgent action is needed in order to regulate the sustainable development aspect of the CDM so that it can fulfill its potential and at the same time provide justice for developing countries if emission reduction targets are to be set upon them. The proposed policies consider in the first place the crucial need to help the most impoverished countries to develop institutional capacities so they can attract CDM projects. At the same time DNAs should verify stakeholders' opinions before issuing a letter of approval, and not just limiting their analysis to what project developers present in the PDDs. On the same matter an international standard should be set in spite of the country's sovereignty right to decide upon their own sustainability requirements, since this framework has proved to be inefficient in terms of sustainable development. The definition of the categories and sub-categories used in this article may help in this matter as a checklist, but other incentives such as lowering transaction costs for projects presenting more types or quantities of benefits (which should be previously defined), would encourage project developers to ensure real sustainable development benefits.

As it has been seen, it is fundamental to take more action to promote both CDM and renewable energies. The succeeding document to the Kyoto Protocol is to be presented in 2015, so changes to the structure of the agreement should be made now. The next agreement should also impose short-term goals and not only long-term targets, as stated by Verbruggen (2009), in order to keep a more detailed control of how many reductions are being accomplished, and to be able to take sooner action in case of need. The CDM should be placed directly below the United Nations, and not just as a mechanism within the Kyoto Protocol. Its framework should also be restructured, so that incentives are put in the correct path: to promote renewable energies, to build capacities and give opportunities to develop projects in the poorest countries and most importantly to give the CDM the attention it deserves as the main effort aimed to help developing countries to adapt to climate change.

This study provides a proof to the benefits provided by renewable energy projects and at the same time a warning to realize that without promoting this type of energy, it is very difficult for projects of this kind to be developed. By ranking the profitability drivers, uncertainties about renewable energy projects could be reduced and as such profitability could increase, which would incentive more investments. It is fundamental for CDM to verify that sustainable development reaches the population in most need of it, and for that the checklist of criteria proposed in this investigation could be used to make a system of points for projects to use as a multiplying factor for CERs. By doing so a compensation would occur between the projects providing more benefits for sustainable development, like renewable energies, and those that generate many low-cost emission reductions but provide almost no benefits. In that way renewable energy projects would gain a competitive advantage and the CDM would be able to actually fulfill both of its objectives.

2 PROFITABILITY DRIVERS FOR CLEAN DEVELOPMENT MECHANISM (CDM) RENEWABLE ENERGY PROJECTS IN LATIN AMERICA AND A CASE STUDY IN CHILE

Abstract

Renewable energy projects present the highest potential within the CDM to contribute to countries' sustainable development. However, they deliver fewer carbon credits than other project alternatives and present higher risks, such as high investment costs, limited available experience and inadequate diffusion. So far, the CDM's incentives have promoted projects delivering higher dividends, leaving renewable energies and sustainable development behind, thereby exposing the need to understand renewable energy projects and their profitability drivers better. This would reduce their risks, thus increasing their profitability. This paper studies the drivers associated with projects' profitability by replicating 44 cash flows from renewable energy projects in Latin America. It also analyzes the different assumptions taken by project developers for projects with similar characteristics in Chile, aiming to expose that no methodologies are used to choose parameters for evaluating projects. The results of the study of drivers demonstrate that for the sample the plant factor is the key driver for profitability, followed by electricity price, investment cost and a one-year delay. This paper primarily proposes the CDM to be restructured to promote renewable energies and to establish universal criteria for the investment additionality assessment, avoiding data manipulation solely with the goal of increasing CDM revenues.

2.1 Introduction

Since the industrial revolution the consumption of fossil fuels has increased at alarming rates, which has precipitated global warming (Fujime, n.d.). The United Nations Framework Convention on Climate Change (UNFCCC) adopted the Kyoto Protocol in 1997 in order to stabilize greenhouse gas (GHG) concentrations in the atmosphere, mainly due to human activity (Rose, 2008). To do so, industrialized countries have committed themselves to reduce their emissions of GHGs to an average of 5% below their 1990 levels by 2012. Three flexible mechanisms were created to help developed countries to meet their targets in the most cost-effective way. These include Emissions Trading, Joint Implementation, and the Clean Development Mechanism (CDM), the only market-based mechanism under the Protocol that also involves developing countries. Through its double-objectives of cost-effectiveness and sustainable development, CDM allows developed countries to be credited for emissions reductions (known as a "Certified Emission Reduction" or "CER") achieved by investing in projects located in developing countries. Hence, developed countries benefit from the lower abatement costs, while simultaneously increasing financial flows and contributing towards sustainable development in host (developing) countries. Sustainable development is supposed to offer energy security according to human needs, to increase energy efficiency and mainly minimize the waste of valuable resources (Jefferson, 2006). However, while reductions in the CDM are regulated at an international level, sustainable development is left to each country's sovereignty. This has led to a trade-off between CDM's two purposes during the first commitment period (2008-2012), favoring low-cost emission reductions and incentivizing competition amongst host countries to attract CDM projects by lowering their sustainability requirements.

The Kyoto Protocol stated that emission reductions from a CDM project should be in addition "to any that would occur in the absence of such activities" (UNFCCC, 1997), meaning that without the CDM, the project would encounter severe disadvantages or obstacles (Yunna and Quanzhi, 2011). However, this definition is too subjective and open to interpretation, which is why in 2008 a CDM tool to assess additionality, in order to be registered under the CDM and receive CERs, was introduced. The tool asks the project developers to define the alternatives to the project and to perform a common practice analysis, a barrier analysis, and an investment analysis. The common practice analysis requires having to prove that no similar activities to the project can be observed, or that if they are, they have key distinctions. The barrier analysis requires demonstrating that at least one exists to prevent the implementation of the project, or that in any of the other alternative scenarios that barrier does not exist. Finally, the investment analysis, which is the one we focus on this paper, is the only quantitative test and also the most objective (Au Yong, 2009). It requires to prove that the project is either not the most economically attractive option or that it is not feasible (UNFCCC 2007b). Since the choice of criteria is left to the project participants (Greiner and Michaelowa, 2003), there is need to establish clear guidelines in order to ensure both cost-effectiveness and that real sustainability contributions exist.

In the context of the CDM, renewable energy projects present the highest potential to achieve the duality of objectives. Not only can they help to decarbonize the power sector (Schneider et al., 2010), but they also have the potential to assist developing countries in achieving greater independence from foreign oil producers (Jhirad, 1990; Martinot et al., 2002; Weiss et al., 2008), while simultaneously providing higher sustainable development benefits than most technologies (Ellis et al., 2007; Sutter and Parreño, 2007; Nussbaumer, 2009). They are of special importance to diversify the energy matrix, considering that the world faces several energy problems in the future, such as the scarcity of oil, environmental degradation and the continually increasing needs of the developing world (Dorian et al., 2006). Nevertheless, since renewable energy is capital-intensive, it is necessary for host countries to support and promote it. If left only to the market, renewable energy will inevitably be excluded because of its higher costs and low competitive advantages compared with other CDM project alternatives such as methane reductions, N2O reductions or sink projects

(Xingang et al., 2011). Moreover, in some countries there is a need to reform power markets so they offer better quality of service and more affordable access to electricity to the poorer population (Besant-Jones, 2006). This is the case of several Caribbean countries fueled by costly diesel, where renewable energy could play a relevant role in this task.

This paper therefore focuses on the study of profitability drivers for renewable energy CDM projects, aiming to find the key economic parameters of these types of projects through the investment analysis, in order to be able to understand them better, to lower their associated uncertainties, and thus promote investments in renewable energy that makes a strong contribution to sustainable development.

There are four main streams of literature in the economic context of the CDM. A first stream studies investment additionality as a general term (Philibert, 1998; Shrestha and Timilsina, 2002; Greiner and Michaelowa, 2003; Au Yong, 2009). The stream focuses its debate on which option (barriers, Internal Rate of Return (IRR), Net Present Value (NPV), Difference between the IRR with without CDM revenues (ΔIRR), payback period, etc.) is the best to prove a project's additionality, with the dominant view agreeing that the IRR is the least prone to manipulation alternative. A second stream analyzes the investment additionality related to renewable energies (Schneider et al., 2010; Masini and Menichetti, 2013; Monjas-Barroso and Balibrea-Iniesta, 2013) but no study focuses on a particular region or on the profitability drivers of actual projects throughout the CDM first commitment period (2008-2012), as evaluated in this paper. A third stream concentrates on techno-economic performance of determined projects in a particular area (Weiss et al., 2008; Xingang et al., 2011; Yunna and Quanzhi, 2011; Purohit, 2008; Bergqvist et al., 2008; Yang, 2010), emphasizing the need to promote renewable energies to contribute towards sustainable development. The final stream studies risk, pricing, and how to promote CDM (Lee et al., 2012; Cormier and Bellassen, 2012; Tang et al., 2012; Bode and Michaelowa, 2003), but most of the evaluations are in regard to CDM specific risks, like high transaction costs and delays in registering projects, but do not address most risks associated with the profitability of a project.

This is the first paper assessing and ranking the drivers for profitability in a sample of renewable energy projects through the replication of cash flows from Project Design Documents (PDDs). It compares the results against a calculated IRR used as benchmark, taking into account the specific risk factor of each country (and its components) and attempting to provide concrete ways in which renewable energy may be promoted within the CDM. No other study has evaluated this type of technology for a whole region or focused on the different assumptions made by project developers that end up producing the variety of results observed in PDDs concerning the investment additionality analysis.

The investigation is focused in Latin America, the first region where all of its eligible countries (those that both ratified the Kyoto Protocol and have a designated national authority – DNA) have hosted a CDM project and also the region in which renewable energy projects are most spread throughout countries. This is also the region where the authors have participated in several projects, including some that have made the sample, providing better understanding of them.

Within Latin America, hydro and wind projects in Chile will be examined more closely, given the fact that it is the third most active country in the CDM in the region, after giants such as Brazil and Mexico, and 6th worldwide after China, India, Korea, Brazil and Mexico, and first in CERs registered among small countries. In addition, Chile is one of the main economies in the region, occupying the first place in human development, GDP per capita, life expectancy and peace as well as high political stability, absence of violence, government effectiveness, access to capital, regulatory quality, rule of law, control of corruption and the lowest murder rate of the region, making it an ideal place to develop CDM projects (World Bank 2012; UNDP, 2012; International Monetary Fund, 2012; UNODC, 2012; IEP, 2012). Thus, an assessment of Chile’s situation should provide one of the most conservative examples regarding the difference of assumptions made for CDM projects since in this country project developers have the lowest incentives to manipulate parameters.

The article is organized as follows: Section 2.2 provides a background on investment additionality. Section 2.3 describes the sample of projects studied and the methodology used. Section 2.4 presents the results for Latin America and Chile and discusses the main findings of the investigation. Section 2.5 concludes.

2.2 Background on investment additionality for renewable energy

This section first discusses papers dealing with investment additionality, in particular analyzing the different methods used to compare profitability. A description of the different approaches used to prove additionality and their advantages and disadvantages follows. Finally, the section concludes with a focus on the difficulties associated with renewable energy projects.

2.2.1 Previous Studies on investment additionality

Several papers have taken their field of study in the investment assessment of the additionality test for CDM registration, concentrating on the impacts of additionality on particular projects or technologies. In order to compare the financial performance of a project, a range of indicators exist, from which the NPV (Net Present Value), IRR (Internal Rate of Return) and ΔIRR (Difference between the IRR with without CDM revenues), seem to be the most used. For example, Yang et al. (2010) use both the NPV and IRR for their study of a wind farm investment and find that the uncertainty of CDM benefits significantly affects the project's NPV while at the same time in order for a project to meet the benchmark, very hard to achieve conditions on CERs and electricity prices have to be met. Bergqvist et al. (2008) also use both indicators to perform a techno-economic assessment of rice husk-based generation and find that for this case operating hours and investment costs are the most critical parameters influencing the lifetime cost of electricity. Others, like Monjas-Barroso and Balibrea-Iniesta (2013) decide upon the NPV to evaluate an investment in a wind-renewable energy project, modeling the main uncertainties that affect this kind of project, such as the cost of electricity, production of electricity and investment costs in order to evaluate the regulatory options present in three different countries. Their focus however remains on identifying which countries support wind projects the most. On the other hand this paper ranks the uncertainties in the order in which they affect profitability. Some revisions focusing on the IRR include Weiss et al. (2008) and Yunna and Quanzhi (2011), who study the impacts of CDM in the Thai electricity sector and the additionality for small-scale hydropower, respectively. The first study finds that a sectorial approach to the CDM could help financing renewable energy projects (Weiss et al, 2008), while the second mainly performs a full additionality assessment for the hydro project, proving that it should be registered under the CDM (Yunna & Quanzhi, 2011) . Au Yong (2009) on the other hand, uses ΔIRR to assess the degree of additionality for a sample of registered CDM projects, and finds that almost a third of the projects exhibit ΔIRR of less than 2%, indicating that CDM only makes a small contribution and suggesting to set a minimum for the value. Another significant study conducted by Schneider et al. (2010) analyzed six renewable energy technologies and their drivers for financial and environmental aspects. They perform the evaluation using a profitability index (NPV/Invested Capital) and the GHG specific reductions (Total GHG emissions/Invested Capital) and evaluate how project level parameters, regional and global variables impact the financial and environmental performance of a project. The data is not representative of a country, but an average of parameters found in developing countries, not allowing the cash flows to truly represent each country's case or the performance of a particular region, as it is presented in this study, nor does it comprise the entire first commitment period, but only about half of it. In fact, all parameters are discounted using the same rate, not taking into account a country's specific risk, which in our study will be conducted by setting an IRR benchmark adjusted by each country's own risk.

2.2.2 Different criteria to define investment additionality

Greiner and Michaelowa (2003) in their study describe the different types of approaches towards proving the investment additionality of a project. The criteria can be separated into two groups: qualitative and quantitative. The qualitative group mainly focuses on barriers, here projects can be deemed additional if they face more barriers than a reference case or if they need the CDM funding to remove barriers for implementation. While different countries and technologies have different criteria, barriers are usually divided into investment (for projects presenting high costs or unable to raise enough funds), technology (the technology is not yet mature), habit disorder (the technology is not yet popular in the local region or country) and other barriers, such as policies, laws, institutional, information or resource barriers (Yunna and Quanzhi, 2011). The quantitative group can be divided into three cases: reference-case-based criteria, threshold-based criteria and contribution of CERs to the revenue. The reference-case-based criteria consists in comparing financial indicators (investment costs / total costs / IRR / NPV) of the project with those of a reference case, and the project is additional if it is less economically attractive to the project developer than the reference one. The threshold criterion consists of comparing financial indicators (IRR / payback period) to a benchmark value. Only if the project is less economically attractive than the threshold is it considered additional. In the case of the contribution of CERs to the revenue, a project is considered additional if CERs contribute significantly to increase the incomes and/or profitability of a project and can be demonstrated using the IRR, NPV or payback period. However the latter does not help to eliminate profitable projects since the project may have been profitable even without the incomes generated by CERs and this method would only show how much incomes or profitability increases.

While all of these criteria may be used to prove the investment additionality, some indicators are more fit than others depending on the situation. For the barriers criteria, in a study by Schneider (2007), it was found that only 6% of the validation reports contain a detailed assessment of each barrier, so most of the times the barriers are just accepted as such with no more requests made to register the project. Also, there is usually no proof on how the CDM helps to overcome those barriers, only listing the barriers to the project, which can be considered prone to manipulation. Moreover, if the economic attractiveness of a project is to be determined, the barrier analysis is not the best indicator since it does not provide an economic sense of the project. The criteria based on financial indicators such as NPV or IRR are the least prone to manipulation and should always be considered first to prove additionality. If the decision corresponds to which technology to use and not whether a project should be carried out, then the reference case is the best option, but if the decision lies in the investment itself, then the threshold method is the best alternative. For this paper, several projects will be compared with each other to discover the drivers that influence the most in the profitability of a project, hence the threshold methodology is most appropriate. Thus the final decision lies on whether to compare projects using the payback period or the IRR. Since the payback period is not a comprehensive indicator for economic attractiveness because even long payback periods can have high IRR, the IRR benchmark is chosen as the indicator for the study of renewable energy projects. Greiner and Michaelowa (2003) also recommend a combination of the threshold IRR with a country-specific risk factor, which will be taken into account when the IRR benchmarks used to compare against projects are calculated for each country.

2.2.3 Investment additionality for renewable energy projects

Renewable energy faces particular troubles like high-capital and maintenance costs, limited experience with new energy technology, under-valuing long-term benefits of environmental investments and limited diffusion because private investments remain insufficient. This imposes additional risks to investors, who must wait longer than with other technologies before their investments provide returns (Dunkerley, 2006). Renewable energy also lacks of scale effects on costs because most of the projects are not large enough to reach them. The fact that the externalities of polluting are not internalized into conventional energies also demonstrates prejudice against renewable energy, in addition to the fact that most of the sources (like wind, sun or water) are intermittent (Finon and Perez, 2007), thus making long-term agreements hard to obtain and ultimately discouraging investing in them. Moreover, non-financial drivers such as a priori beliefs, institutional pressure and the investor's knowledge of the technology also play a significant role when considering on which type of technology to invest (Masini and Menichetti, 2013). Renewable energy depends on large financial incentives to be able to compete with conventional generation methods (Tang et al., 2012), which is why studying the main drivers associated with profitability is fundamental so that project developers can focus to reduce their associated uncertainties.

2.3 Valuation of renewable energy CDM projects in Latin America

This section describes the sample and methodology used for the study, including an explanation of the cash flow model used and sensitivity analysis performed.

2.3.1 Sample for the study

Up to December 2012, a total of 668 projects were registered in Latin America, issuing a total of 128,155.51 kCERs, from which 376 projects generate electricity with a capacity of 11,431.76 MW. From the total capacity, 93% belongs to renewable energy, corresponding to 305 projects, hence making it the most relevant technology to study, both for its electricity production in a region looking to diversify its energy matrix and for its alleged sustainable development benefits.

In order to obtain the sample for the study, a previous analysis on additionality was performed, selecting 180 renewable energy projects from 18 countries in the region, in particular hydro, wind and biomass projects, since other types are not numerically substantial enough as registered CDM projects. From this sample, projects are chosen to study their profitability drivers following a set of rules: they have to perform a benchmark analysis and present the IRR as a financial indicator; they have to provide enough information in order to be able to replicate their cash flows; and for the biomass projects only those generating electricity are considered. 83 projects from the initial sample have a benchmark analysis and of those, 44 meet the rest of the requirements, including 20 hydro, 18 wind and 6 biomass projects, representing in total 24% of the original sample and 14.4% of all registered renewable energy projects in Latin America.

2.3.2 Methodology

All the data is obtained from the PDDs. For each project, first the necessary information to replicate their cash flows is obtained, including lifetime, net capacity, plant factor, generated CERs, electricity and capacity price, total costs with and without CDM, used taxes, depreciation method, and firm power when it corresponds. For simplicity, when average prices are provided, no growth rate will be considered. For biomass projects, heat sales are only considered when the PDD states so. The IRR is computed for each project from its cash flow, and the replication is considered successful as long as the difference between the original IRR and the calculated one is smaller than 1%.

After the cash flows are performed, a sensitivity analysis is carried out as a simple method often used in other studies to assess risk (Diakoulaki et al., 2007; Bergqqvist et al., 2008; Yunna and Quanzhi, 2011), in order to rank the profitability drivers. The parameters varied in the sensitivity analysis correspond to the investment cost, total costs, prices on electricity, prices on capacity and plant factor, as well as simulating a one-year delay and studying the inclusion of a residual value. Finally, in order to compare projects, a benchmark IRR is also calculated, as well as CERs prices, which are obtained as an average of historical values, so as to include a comparable measure for ΔIRR between projects.

A special case study is done in Chile in order to assess how much parameters can vary in one of the main economies of the region for hydro and wind technologies (no biomass project in Chile met all the requirements).

2.3.3 Cash flow model

The cash flow model used to evaluate the 44 projects is presented in Table 2.1. The IRR is calculated from the cash flow total for the case with and without the stream of revenues from CDM. To do this, we subtract from the EBITDA the depreciation, obtaining the profit before tax, onto which we apply the taxes to compute the profit after tax, to finally add back the depreciation in order to correct the non-cash activities, obtaining the total cash flow. We find the EBITDA by subtracting the total costs (from the PDD) to the calculated revenues, which can include electricity, capacity, CERs and in rare cases heat revenues which were not included in the model, but are also obtained directly from the PDD.

Table 2.1 : Cash-Flow Model

	Unit	Value
Parameters		
Lifetime	Years	A
Net Capacity	MW	B
Plant factor	%	C
Electricity price	US$	D
Firm Power		E
Capacity Price		F
Generated CERs	tCO_2e/year	G
CERs price	US$/CER	H
Tax rate	%	I
Cash Flow		
Investment	US$	J
Electricity produced	US$/MWh	$K = B \times C \times 24 \times 365 \div 100$
Electricity revenues	US$	$L = D \times K$
Capacity sold	US$/MW	$M = E \times F$
CERs revenues	US$	$N = G \times H$
Total revenues without CERs (with CERs)	US$	$O = L + M$ $(O = L + M + N)$
Total Costs without CERs (With CERs)	US$	P
EBITDA without CERs (With CERs)	US$	$Q = O - P - J$ $(Q = O - P - J)$
Depreciation	US$	R
Profit before tax without CERs (With CERs)	US$	$S = Q - R$ $(S = Q - R)$
Tax without CERs (With CERs)	US$	$T = S \times I$ $(T = S \times I)$
Profit after tax without CERs (With CERs)	US$	$U = S - T$ $(U = S - T)$

Correction of non-cash activities (+ Depreciation)	US$	R
Cash Flow total without CDM (With CDM)	**US$**	$\mathbf{V = U + R}$ $(\mathbf{V = U + R})$

2.4 Results and Discussions

This section presents the main findings obtained through the analysis of the 44 cash flows from renewable energy projects in Latin America, considering the differences in IRR benchmark, the effects of CERs on revenues, the key profitability drivers and a case study in Chile to assess the different assumptions used amongst similar projects in a country.

2.4.1 Previous to the cash flow evaluation

Before evaluating the results, two important parameters need to be calculated, which correspond to the IRR benchmark for each host country and to the CERs' price to be used in all the cash flows.

2.4.1.1 Model to calculate IRR benchmark

The chosen method to calculate the IRR benchmark is the Weighted Average Cost of Capital (WACC), which is selected for being the most comprehensive as it considers the specific risk associated to each country, following the recommendations provided by Greiner Michaelowa (2003).

Its calculation is based in market standard parameters, taking into account project-specific characteristics and it is not linked to the subjective profitability expectation or risk profile of any particular project developer. The WACC is calculated according to formula 1.

$$WACC = E/C \times k_e + D/C \times k_d \quad (1)$$

From which:

E: Equity

C: Capital

D: Debt

k_e: Cost of equity

k_d: Cost of debt

The cost of equity, k_e, estimated according to the Capital Asset Pricing Model (CAPM):

$$k_e = R_f + Beta \times R_m + R_c \quad (2)$$

From which:

R_f: Risk-free rate

R_c: Country risk

R_m: Market risk premium

Beta: Risk measure comparing the returns of the asset to the market over a period of time

Table 2.2 presents the nominal IRR values (since the cash flows do not consider inflation) used for the analysis. N/A means that the corresponding project type is not present in the sample taken from that country.

Table 2.2 : IRR Benchmark for hydro, wind and biomass projects in Latin America

	IRR Benchmark		
Country	Hydro	Wind	Biomass

Brazil	11.42%	10.03%	12.16%
Chile	9.61%	9.36%	9.30%
Peru	11.25%	N/A	9.65%
Mexico	10.05%	9.32%	9.82%
Honduras	12.97%	12.11%	15.87%
Colombia	9.36%	10.90%	9.53%
Ecuador	13.40%	13.95%	14.71%
Guatemala	12.90%	12.71%	N/A
Panama	10.06%	10.36%	9.88%
Argentina	15.01%	13.84%	10.92%
Costa Rica	10.20%	10.14%	10.12%
Uruguay	N/A	11.04%	10.80%
Nicaragua	13.85%	11.96%	13.85%
El Salvador	10.88%	N/A	11.74%
Dominican Republic	N/A	14.15%	14.21%
Jamaica	N/A	19.41%	N/A
Bolivia	10.99%	N/A	N/A
Guyana	N/A	N/A	N/A
Average	**11.57%**	**12.09%**	**11.61%**

2.4.1.2 Determination of CERs' price to be used on the cash flows

The Kyoto Protocol was fundamental in developing global carbon markets, including a regulated frame and a parallel one, corresponding to the voluntary carbon market. In the regulated carbon market, projects developed in developing countries can issue CERs if they are registered under the CDM and sell them to the developed countries to meet their Kyoto targets (Benessaiah, 2012; Stanley-Peters et al., 2011).

To calculate the value of CERs to be used on the cash flows, the historic trend from 2005-2011of their price is studied (see

Table 2.3), yielding an average price of 14.46 US$/t$CO_2$ (World Bank, 2006; World Bank 2008; World Bank 2010; World Bank, 2012).

Table 2.3 : Trends of CERs' volume, value and price from 2005-2011

Year	Volume ($MtCO_2e$)	Value (USM$)	Price (US$/tCO2)
2005	359	2,651	7.38
2006	562	6,249	11.12
2007	791	12,877	16.28
2008	1,476	32,788	22.21
2009	1,266	20,221	15.97
2010	1,484	23,128	15.58
2011	1,998	25,313	12.67
Average	**1,134**	**17,604**	**14.46**

2.4.2 Projects in the study: hydro, wind and biomass

A total of 44 renewable energy projects in Latin America were studied, with 20 hydro, 18 wind and 6 biomass projects. Their characteristics regarding their registered capacity, investment cost, plant factor, emission factor and the original IRR from the PDDs as well as the calculated ones through the cash flow replicas are presented in **Table 2.4**, whilst **Table 2.5** groups the main parameters: capacity, investment cost and plant factor by country. It is worth noticing that the difference between the original and calculated IRRs is never higher than 1%, in fact the average difference is 0.24%, permitting the analysis to be as faithful as possible to reality.

Table 2.4 : Description of projects' parameters and differences between original and calculated IRR

Country	Project Title	Type	Registered Capacity (MW)	Investment Cost (US$/kW)	Plant Factor	Emission Factor (tCO2/MWh)	Original IRR	Obtained IRR	Difference (%)
Chile	Chacayes Hydroelectric	Hydro	111	3,862	55.97%	0.66	7.40%	7.36%	0.04
Chile	Lircay Run of River	Hydro	19	1,553	78.11%	0.41	8.62%	8.18%	0.44
Chile	Florín Small Hydro	Hydro	8	2,929	58.47%	0.6	7.40%	7.49%	0.09
Chile	Guayacán Hydroelectric	Hydro	12	1,660	52.25%	0.40	8.42%	8.57%	0.15
Brazil	SHP Santa Carolina	Hydro	11	2,685	52.10%	0.16	8.03%	8.06%	0.03
Brazil	Malagone SHP	Hydro	19	2,425	53.21%	0.31	16.58%	16.45%	0.13
Brazil	Guanhaes Energia	Hydro	44	4,119	56.88%	0.29	9.73%	9.85%	0.12
Brazil	Sao Joao hydro power plant	Hydro	25	1,455	56.40%	0.26	10.71%	10.81%	0.10
Peru	El Platanal Hydropower Plant	Hydro	220	1,159	55.16%	0.47	9.25%	8.71%	0.54
Peru	Huanza Hydroelectric Project	Hydro	91	1,423	54.25%	0.55	8.61%	8.61%	0.00
Peru	La Joya Hydroelectric Project	Hydro	15	1,174	67.55%	0.56	7.74%	7.16%	0.58
Peru	Nuevo Imperial Hydropower Plant	Hydro	4	1,767	81.34%	0.66	10.65%	10.44%	0.21
Argentina	Los Caracoles Hydroelectric Project	Hydro	125	1,161	64.49%	0.50	11.04%	11.05%	0.01
Colombia	Río Amoyá Run of River	Hydro	80	1,575	73.29%	0.34	12.32%	11.85%	0.47
Colombia	Santiago Hydroelectric	Hydro	3	1,739	67.93%	0.35	9.94%	9.71%	0.23
Panamá	Bajo Frío Hydro Power	Hydro	58	3,286	47.91%	0.62	14.05%	13.67%	0.38
Panamá	Barro Blanco Hydroelectric	Hydro	29	3,223	49.41%	0.54	11.09%	10.96%	0.13
Honduras	Coronado Hydroelectric Project	Hydro	6	1,311	62.11%	0.72	14.05%	13.67%%	0.38
Honduras	San Martín Hydroelectric Project	Hydro	3	2,668	45.33%	0.66	11.09%	10.96%	0.13
Guatemala	Palo Viejo Hydroelectric Project	Hydro	88	2,843	47.90%	0.70	12.13%	12.55%	0.42
Chile	Monte Redondo Wind Farm Project	Wind	38	2,895	30.48%	0.68	1.62%	1.51%	0.11
Chile	Totoral Wind Farm	Wind	46	2,891	25.56%	0.68	4.82%	4.43%	0.39
Chile	Lebu 1 Wind Farm	Wind	108	1,842	29.30%	0.69	5.80%	5.13%	0.67
Chile	Ckani Wind Farm	Wind	240	1,564	32.70%	0.59	6.47%	6.51%	0.04
Brazil	Fleixeiras I Wind Power Plant (WPP)	Wind	30	2,237	44.30%	0.39	3.81%	3.43%	0.38
Brazil	Mundaú WPP	Wind	30	2,133	39.67%	0.39	2.60%	2.43%	0.17
Brazil	Porto do Delta WPP	Wind	30	2,330	51.18%	0.39	4.68%	4.38%	0.30
Brazil	Trairi WPP	Wind	25	2,181	43.69%	0.39	3.86%	3.69%	0.17
Mexico	Bii Stinu Wind Energy Project	Wind	164	2,238	44.63%	0.51	7.34%	7.79%	0.45
Mexico	Fuerza Eolica del Istmo Wind Farm	Wind	50	2,458	48.86%	0.62	6.79%	6.92%	0.13
Mexico	Istmeño Wind Farm	Wind	216	2,044	49.60%	0.62	10.34%	10.40%	0.06
Mexico	Piedra Larga Wind Farm	Wind	90	2,406	46.41%	0.57	9.57%	9.64%	0.07
Dominican Republic	Los Cocos Wind Farm Project	Wind	25	2,857	33.61%	0.73	9.21%	9.01%	0.20
Dominican Republic	Matafongo Wind Farm	Wind	31	2,644	34.96%	0.75	7.62%	7.86%	0.24
Argentina	Diadema Wind Farm Project	Wind	6	2,554	44.68%	0.69	6.96%	6.96%	0.00
Nicaragua	Amayo Phase II Wind Power Project	Wind	23	1,672	48.97%	0.71	17.68%	17.27%	0.41
Costa Rica	Guanacaste Wind Farm	Wind	50	1,930	56.57%	0.39	7.85%	7.93%	0.08
Jamaica	Wigton Windfarm II	Wind	18	2,644	34.94%	0.73	9.32%	8.56%	0.76
Brazil	Usina Interlagos Cogeneration Project	Biomass	40	1,260	55.00%	0.17			
Brazil	CDM Project Paragominas	Biomass	8	1,119	90.00%	0.59	2.83%	2.96%	0.13
El Salvador	Central Izalco Cogeneration Project	Biomass	43	540	24.7%	0.50	11.30%	11.45%	0.15
El Salvador	El Angel Cogeneration Project	Biomass	36	414	14.90%	0.54	15.80%	15.77%	0.03
Honduras	Tres Valles Cogeneration Project	Biomass	12	441	40.40%	0.38	20.40%	20.06%	0.34
Argentina	Pindó Biomass Energy Generation from Forest Biomass	Biomass	5	1,231	80.90%	0.65	8.70%	9.00%	0.30
Average			**53**	**2,058**	**50.59%**	**0.53**	**9.24%**	**8.90%**	**0.24**

Table 2.5 : Description of average registered capacity, average investment cost and average plant factor by country

Country	Type	Registered Capacity (MW)	Investment Costs (US$/kW)	Plant Factor
Chile	Hydro	38	2,501	61.20%
Brazil	Hydro	25	2,671	54.65%
Peru	Hydro	82	1,381	64.58%
Argentina	Hydro	125	1,161	64.49%
Colombia	Hydro	41	1,657	70.61%
Panama	Hydro	43	3,254	48.66%
Honduras	Hydro	4	1,990	53.72%
Guatemala	Hydro	88	2,843	47.90%
Chile	Wind	108	2,298	29.51%
Brazil	Wind	29	2,220	44.71%
Mexico	Wind	130	2,286	47.38%
Dominican Republic	Wind	28	2,751	34.28%
Argentina	Wind	6	2,554	44.68%
Nicaragua	Wind	23	1,672	48.97%
Costa Rica	Wind	50	1,930	56.57%
Jamaica	Wind	18	2,644	34.94%
Brazil	Biomass	24	1,189	72.50%
El Salvador	Biomass	39	477	19.81%
Honduras	Biomass	12	441	40.41%
Argentina	**Biomass**	**5**	**1,231**	**80.91%**
Latin America's Average	**Hydro**	**48**	**2,201**	**59.00%**
	Wind	**68**	**2,307**	**41.12%**
	Biomass	**24**	**834**	**50.99%**

2.4.3 Analysis of IRR benchmark and influence of CERs revenues

In this section we compare the average IRR by country obtained through the cash flow replicas with the benchmarks used in the PDDs and with the calculated benchmarks through the WACC model. The average Δ IRR representing the IRR with CERs minus the IRR without CERs, as well as the used and calculated benchmarks are presented on **Fig. 2.1** for hydro projects, **Fig. 2.2** for wind projects and **Fig. 2.3** for biomass projects, grouped by countries.

Considering hydro projects, Colombia is the country where the PDD benchmark presents the highest difference compared with the calculated one. In this case taking as the benchmark the IRR calculated as WACC, the projects in the country (as an average) pass the benchmark even without CERs' revenues, so Colombia would not qualify as CDM under the additionality analysis. The rest of the countries, except for Chile, Argentina and Panama are able to reach the calculated benchmark when considering incomes by CERs, but they would still need the mechanism to be more attractive to investors. Peru is the country which gets the closest to overcome the PDD benchmark, but is 0.75 percentage points short of it. In all cases the PDD benchmark is higher than the IRR calculated as WACC for hydro projects, showing that the values used by project developers may not represent the true reality of the country under which the projects should be evaluated against.

In the case of wind energy, Nicaragua is the only country in which its projects reach the calculated benchmark even without CERs, so it would not be additional under the CDM. However, when considering CERs, only Mexico joins Nicaragua and is able to reach the calculated benchmark. This suggests that the associated risk is higher for wind projects, usually because of the uncertainty of the wind itself. In the cases of Argentina and Jamaica, the calculated IRR benchmarks are higher than the used ones in the PDDs, mainly due to the consideration of country risk in both countries, which are the highest in Latin America.

In biomass projects, no country except for El Salvador (which reaches the calculated benchmark without CERs revenues) is able to overcome either of the benchmarks.

In no case for all the studied projects in the sample does their IRR reach the benchmark used in the PDDs. This may imply that project developers are in fact evaluating their projects against impossible to reach benchmarks which do not reflect the true environment that the project will face. This is corroborated by the fact that the calculated benchmark is reached (on average) in several countries, especially in hydro projects, considering CERs and in some even without them.

In order to ensure a certain degree of additionality, Au Yong (2009) suggests establishing a minimum ΔIRR. However, this would hurt renewable energy the most. Because renewable energy usually generates incomes on its own for the sale of electricity, the impact CERs make is not as pronounced as for other technologies. Nonetheless, as the projects are very capital intensive, CDM needs to become the main frame to promote them, whereas establishing a minimum ΔIRR would soon eliminate them. Instead attention needs to be focused on the choice of a benchmark by project developers. It is necessary to consider the specific risk associated with the country in which the project is to be developed, as well as the type of technology being used. The values used are often so high that the registration under the CDM is not questionable, however they also hurt their possibilities for attracting foreign investors, which helps to promote technology transfer (the least developed in the CDM for renewable energy) and other types of sustainable development benefits. An approach of the IRR benchmark as the one proposed in this paper would allow the majority of renewable energy projects to still be registered under the CDM to obtain revenues from it, but would also make them more attractive to investors, helping to promote this type of energy.

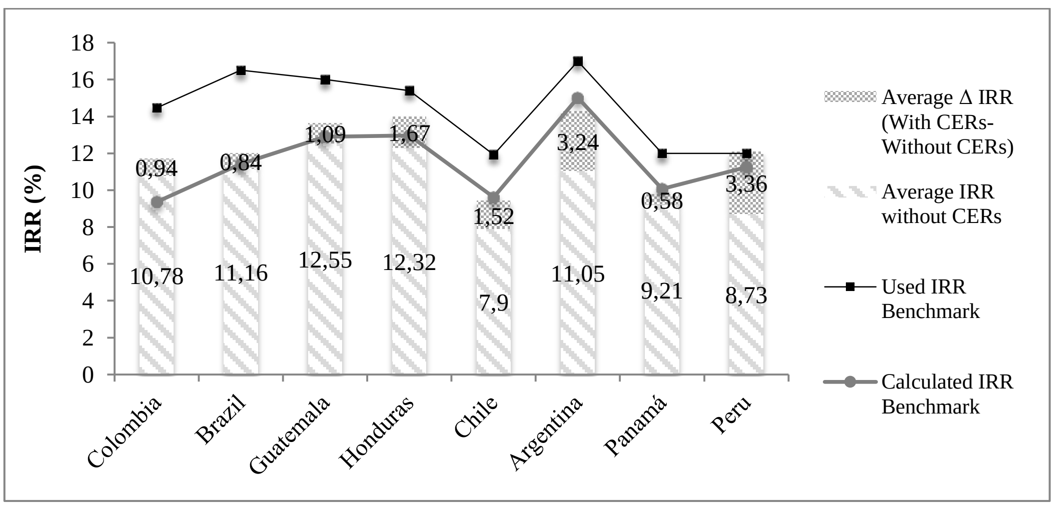

Fig. 2.1: Average Δ IRR (With CERs – Without CERs), used IRR benchmark and calculated IRR benchmark by country for hydro projects

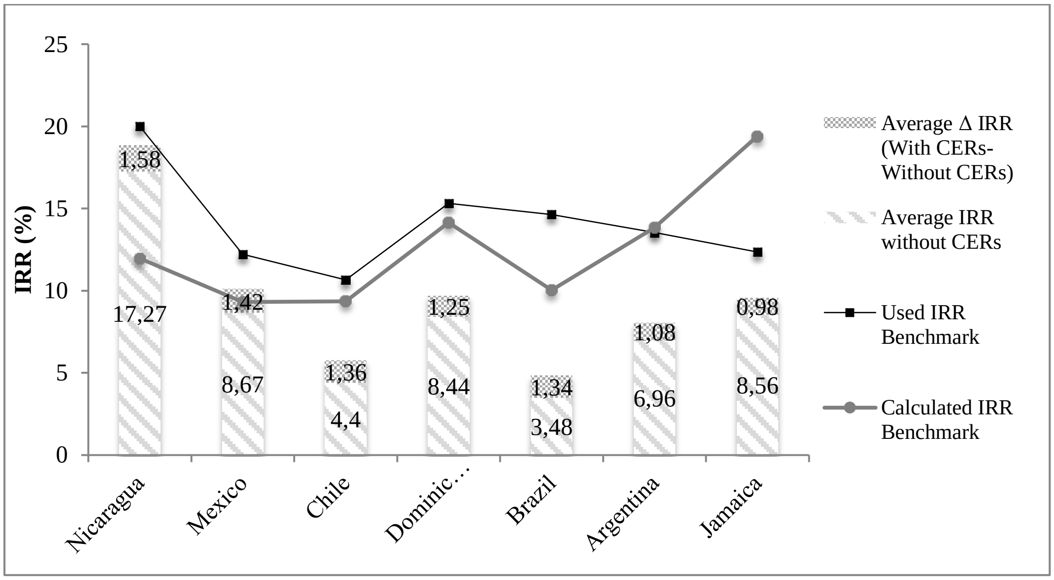

Fig. 2.2: Average Δ IRR (With CERs – Without CERs), used IRR benchmark and calculated IRR benchmark by country for wind projects

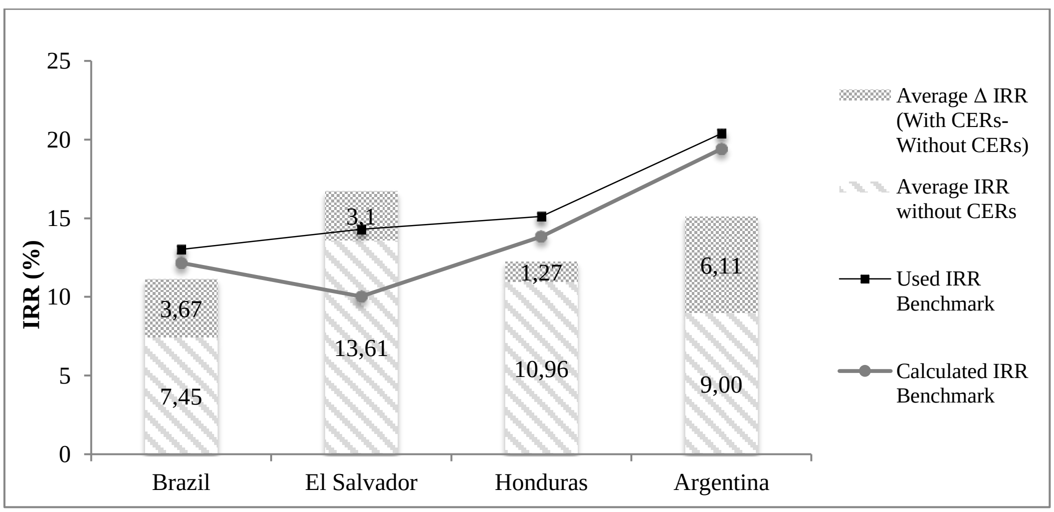

Fig. 2.3: Average Δ IRR (With CERs – Without CERs), used IRR benchmark and calculated IRR benchmark by country for biomass projects

2.4.4 Sensitivity analysis and key drivers of profitability for Latin America

To understand the drivers behind profitability in renewable energy projects in order to better control their associated uncertainties, a sensitivity analysis will be performed varying +10% the investment costs, total costs, electricity and capacity prices, and plant factor. A one-year delay will also be simulated for each project to evaluate its effects on the IRR. The average results for Latin America for hydro, wind and biomass projects are presented in **Table 2.6** and the results divided by large and small-scale hydro projects in **Fig. 2.4**, for wind projects in **Fig. 2.5** and for biomass projects in **Fig. 2.6**.

All projects, including large and small-scale, rank their drivers in the same order. The most important variable towards profitability is the plant factor, whose biggest impact is done in wind projects, being able to increase the IRR in an average of 3.15%. This is due to the fact that these types of projects have a lower performance than hydro and biomass (41% for wind vs. 59% for hydro and 51% for biomass), so a change in the plant factor impacts greatly on income. In second place comes the electricity price, which affects biomass projects almost as twice as the others, particularly the small scale ones which have a more expensive cost structure than large-scale projects. The third most important factor is a change in the investment cost, which affects biomass projects, the ones with the lowest capital requirements 834 US$/kW on average for projects in Latin America vs. 2,201 US$/kW for hydro and 2,307 US$/kW for wind), the most. The one-year delay ranks fourth amongst the drivers and has a similar impact for the three types of technologies, although it influences small-scale projects much more than large-scale, since costs in the first ones are higher. Total costs occupy the fifth place in the drivers and impact biomass projects with the greater intensity, being able to change the IRR more than three times than for hydro or wind projects. Except for the wind case in which costs affect more large-scale projects, the small-scale ones see their profitability much more influenced under a costs' variation. In general, with the exception of the plant factor, which impacts wind projects the most, biomass projects are the ones more sensitive to changes in their parameters, hence being associated with higher risks, probably because they are still new and most of the projects involve different types of fuels, so no familiarity with them can be obtained. Capacity price is in the last place, mainly due to the fact that the common practice is not to sell capacity, and amongst the sample of 18 countries, only Chile, Panama and Peru get revenues from it. It is important to notice that, a change of 10% in the main driver, the plant factor is enough to make most of the hydro projects reach the benchmark without the need for CERs (on average hydro projects have a difference of 1.11 percentage points between the projects' IRR and the calculated benchmark, so an increase of 2.24% would be enough to overcome it). This however does not apply for wind or biomass projects. In summary, the access to the resource: water, wind or type of biomass (plant factor), the energy market (electricity price) and the type of technology used (investment) are the three key parameters determining the profitability of a renewable energy project in Latin America.

Table 2.6 : Key drivers of profitability for Latin America (all projects in the sample)

Average for Latin America	Δ IRR +10% Plant Factor	Δ IRR +10% Electricity price	Δ IRR +10% Investment	Δ IRR 1 year delay	Δ IRR +10% Total Costs	Δ IRR +10% Capacity price
Hydro	+2.24%	+1.25%	-1.05%	-1.03%	-0.30%	+0.17%
Wind	+3.15%	+1.35%	-1.14%	-0.94%	-0.30%	+0.11%
Biomass	+2.74%	+2.17%	-1.30%	-1.07%	-1.08%	N/A
Total	**+2.71%**	**+1.59%**	**-1.16%**	**-1.01%**	**-0.56%**	**+0.14%**

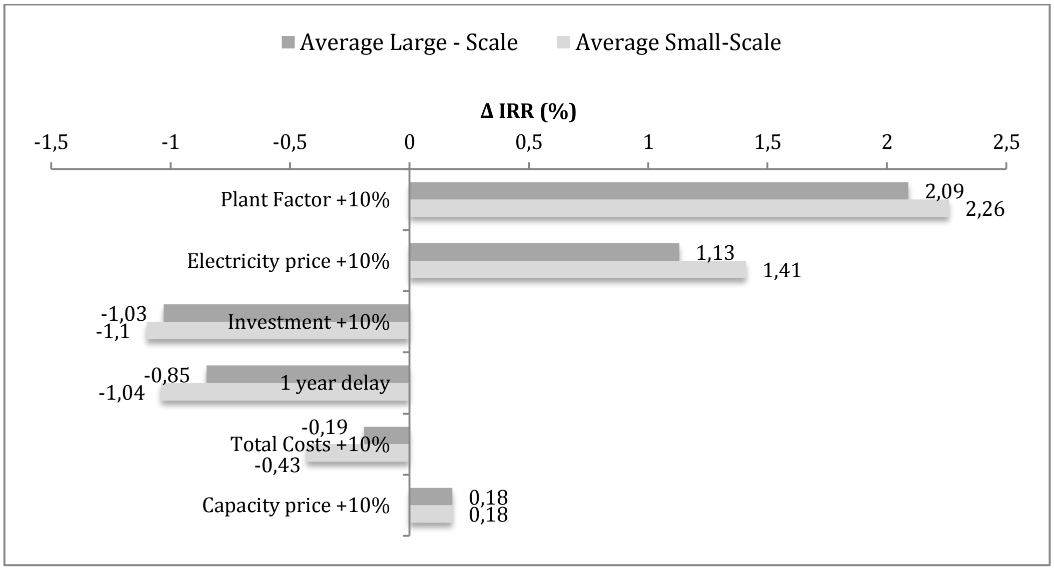

Fig. 2.4 : Key drivers of profitability based on impact on IRR of sensitivity analysis for large and small-scale hydro projects

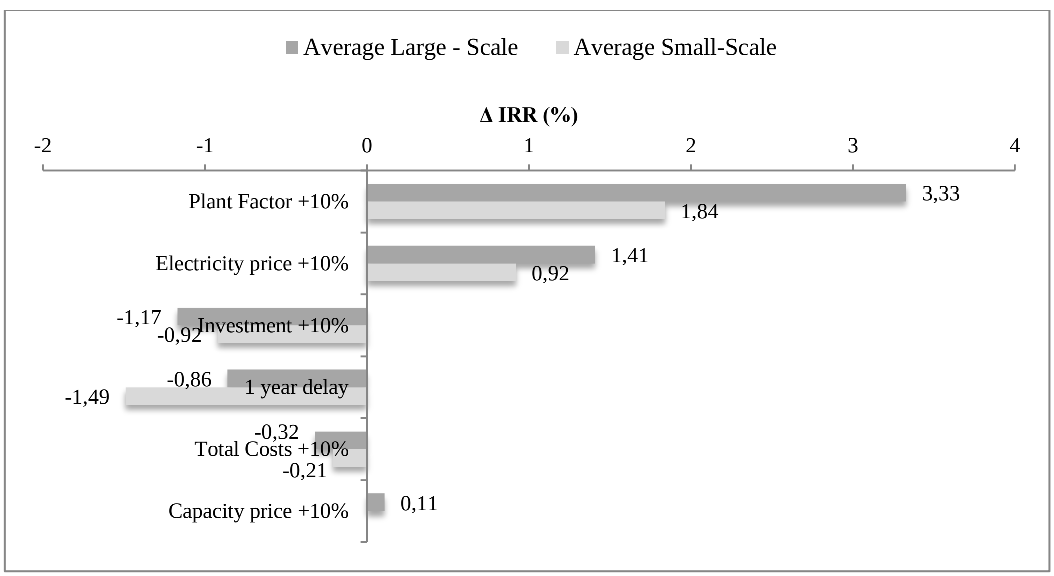

Fig. 2.5 : Key drivers of profitability based on impact on IRR of sensitivity analysis for large and small-scale wind projects

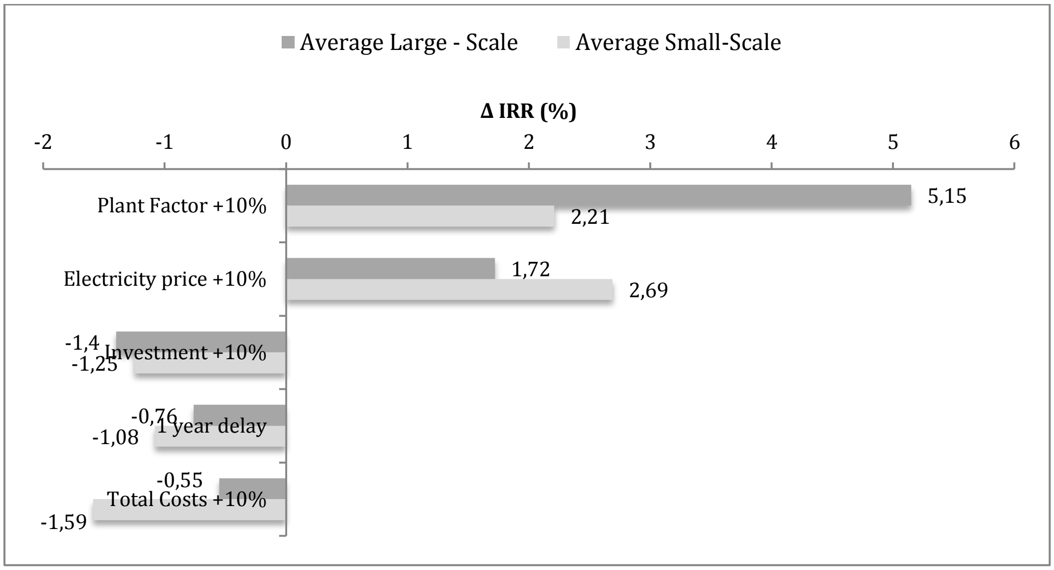

Fig. 2.6 : Key drivers of profitability based on impact on IRR of sensitivity analysis for large and small-scale biomass projects

2.4.5 Inclusion of a residual value in the cash flow

By analyzing the PDDs, we came upon the fact that while some projects explicitly use a residual value in their cash flows others do not. According to the CDM Guidelines on the Assessment of Investment Analysis[2], the fair value of any project should be included as a cash flow in the last year being considered, but it does not provide any more guidance. For the cash flow replicas, we model the residual values only when they are considered on the PDDs. As the differences between the projects' IRR from the PDDs and the ones from the replicas are lower than 1%, it is safe to assume that in the PDDs where the residual value is not explicitly stated means that it was not considered in the cash flow.

Out of 20 hydro projects, 8 use a residual value, 2 out of 18 wind projects also do, as well as 1 out of 6 biomass projects in the sample. We can infer from this that although some project developers choose to include it in the cash flows, it is not the common practice. On

[2] http://cdm.unfccc.int/Reference/Guidclarif/index.html

Table 2.7 we can see the projects that use a residual value and what percentage of the investment it represents, as well as the value in US$/kW and how much it impacts the IRR of the project. Including a residual value can increase the IRR over 2 percentage points for wind projects, 0.51 percentage points on average for hydro projects and 0.23 for wind projects. All the projects that did consider this factor had a very low profitability compared to the benchmarks, which suggests that the residual value may be used to increase the economic attractiveness of a project for investors to get interested, instead of evaluating if the benchmark used is correct.

Comparing this factor to the key drivers for wind projects residual values can be very significant and rank just behind the main driver, which is the plant factor; while for hydro and biomass it is not very significant and ranks almost last. It is also important to consider the time frame of the project, for example at a lifetime of 20 years as wind projects use, considering a residual value makes a great impact on the project, while at 30 years (as some hydro projects use) it starts to become less significant, and for the 50 year horizon it is negligible, no matter the percentage of investment considered.

Table 2.7 : Projects in the sample including a residual value

Country	Projects using a residual value	Type	Lifetime	Type of residual value used? (% of investment)	Residual Value (US$/kW)	Δ IRR (Original IRR– IRR without residual value)
Chile	Guayacán Hydroelectric	Hydro	20	44.74%	742.78	+1.44%
Argentina	Los Caracoles Hydroelectric Project	Hydro	30	66.10%	712.48	+0.33%
Brazil	Guanhaes Energia	Hydro	30	27.72%	1,141.70	+0.43%
Colombia	Río Amoyá Run of River	Hydro	20	20.88%	274.04	+1.44%
Honduras	San Martín Hydroelectric Project	Hydro	20	21.48%	573.23	+0.34%
Honduras	Coronado Hydroelectric Project	Hydro	20	4.09%	68.36	+0.04%
Panamá	Bajo Frío Hydro Power	Hydro	50	0.88%	28.75	+0.00%
Panamá	Barro Blanco Hydroelectric	Hydro	50	80.00%	2,578.12	+0.08%
Average Hydro Projects			**30**	**33.24%**	**764.93**	**+0.51%**
Chile	Totoral Wind Farm	Wind	20	61.70%	1,784.35	+2.71%
Argentina	Diadema Wind Farm	Wind	15	47.08%	1,202.38	+2.64%
Average Wind Projects			**18**	**54.39%**	**1,493.37**	**+2.68%**
Brazil	Usina Interlagos	Biomass	20	13.56%	168.35	+0.23%
Average Biomass Projects			**20**	**13.56%**	**168.35**	**+0.23%**

2.4.6 Case study: Renewable energy performance in Chile

This section presents a case study of Chile for hydro and wind projects (the most common ones) and analyzing the assumptions made for the parameters used in the cash flows in order to explain difference seen in very similar types of projects.

2.4.6.1 Brief overview of Chile's renewable energy portfolio

Up until December 2012, 62 projects were registered in Chile, issuing a total capacity of 10,194.54 kCERs, from which 37 projects generate electricity with a capacity of 1,411.64 MW. From these projects, 99% of the registered capacity belongs to renewable energies, with the remaining 1% corresponding to methane reduction and energy efficiency from the supply side projects. From the renewable energy projects in the country, hydro energy accounts for half of the pie with 48% of the registered capacity and 50% of renewable projects, whilst wind and biomass complete the other half with 37% of capacity and 31% of the projects distributed in wind energy and 15% of capacity and 19% of projects distributed in biomass energy.

2.4.6.2 Different methodologies used to determine the IRR benchmark

One of the main findings regarding the IRR benchmark across Latin American projects is the wide variety of values used in PDDs, many times in very similar projects. In Chile, three types of methodologies are used. First, the default rate for energy projects in the energy sector in Chile under CDM's scope I, which corresponds to 10%. A second method uses the average return on 10-year government bonds (10%) plus the difference between the average return on actions from 1900-2005 and the average long-term government bonds in the same period (2.04%), which yields a benchmark of 12.04%. Finally, a third group uses the 4th National Decree in Chile, which establishes that for the evaluation of transmission and generation activities, the rate will be 10%. The average for benchmarks used on the PDDs for the country is 11.93% for hydro projects and 10.66% for wind projects, while using the WACC criterion as in this study gives a hydro IRR of 9.61% and a wind IRR of 13.66%.

The big problem with the used methodologies by project developers is that they do not take into account specific characteristics for the type of technology used and it considers the energy sector as a whole. That is why the proposed methodology should be taken into account, since it provides a comprehensive list of factors for calculating the IRR, instead of a fixed value. Also, if the calculation of the benchmark was a requisite on the PDDs, then more supervision could exist on the methods and values used for this number, preventing project developers from choosing the value that most accommodates them so they can be registered under the CDM.

2.4.6.3 Cash Flow Models

The values used for all of Chile's cash flows are presented in

Table 2.8 for hydro projects and **Table 2.9** for wind projects. For both types of projects a general cash flow will be modeled (using Chacayes Hydroelectric and Totoral Wind Farm parameters as basis for values). For each model IRR curves without CERs are going to be simulated using the "What-if" tool in Excel and the investment costs are going to be compared against the plant factor and electricity prices (two main drivers for Latin America).

The model for hydro projects is presented in

Table 2.10, and the IRR curves comparing plant factor vs. investment cost are in **Fig. 2.7**, while those comparing electricity prices vs. investment costs are in **Fig. 2.8**. The plant factor was varied between 2.80% and 95%, energy prices between 3.92 US$/MWh and 238.91 US$/MWh, whilst the investment was changed between 193.1 US$/kW and 19,310 US$/kW, leaving constant the rest of the parameters. From the curves we can confirm that in order to go from a lower IRR curve to a higher one, the plant factor is the most important parameter (same as in the ranking); in fact to go from an IRR curve of 7.36% to one of 8.57%, the price of energy needs to increase a 10%, while the plant factor only needs to increase 5.56% for the same achievement.

The model for wind projects is presented in

Table 2.11, and the IRR curves comparing plant factor vs. investment cost are in **Fig. 2.9**, while those comparing electricity prices vs. investment costs are in **Fig. 2.10**. In this case, the plant factor was varied between 1.28% and 77.956%, as wind projects are known for their low capacity factor, energy prices change between 4.10 US$/MWh and 250.10 US$/MWh and the investment between 144.55 US$/MWh and 14,455 US$/MWh, with the rest of the parameters left constant. For wind projects the plant factor also makes a much more significant impact than the rest of the parameters in consideration; in fact to go from a 1.51% IRR curve to a 3.00% curve, the electricity price needs to increase 23.7%, while the plant factor for the same effect only needs to increase a 9.9%.

We conclude that for hydro and wind projects in Chile, corroborating the results for Latin America, the plant factor is also the key driver of profitability, making a great impact in the projects developed in the country.

Table 2.8 : Main parameters used on hydro cash flows replicas for Chile

Project	Florín Small Hydro	Guayacán Hydroelectric	Chacayes Hydroelectric	Lircay Run of River
Starting year	2010	2008	2008	2007
Registered Capacity (MW)	8.2	12.0	110.8	19.0
IRR	7.49%	8.57%	7.36%	8.18%
Investment Cost (US$/kW)	2,929	1,660	3,862	1,553
Average Electricity Price (US$/MWh)	63.00	61.87	78.33	34.74
Average Capacity Price (US$/MWh)	120,000	129,840	79,066	73,310
Firm Power (MW)	2.71	6.56	45.10	7.10
Plant Factor	58.47%	52.25% (first 4 years); 27.9% (year 5 onwards)	55.97%	78.11%
Total Costs (US$/MWh)	17.47	28.97	8.92	18.15

Table 2.9 : Main parameters used on wind cash flows replicas for Chile

Project	Ckani Wind Farm	Lebu 1 Wind Farm	Totoral Wind Farm	Monte Redondo Wind Farm

Starting year	2013	2011	2009	2008
Registered Capacity (MW)	240	108	46	38
IRR	6.51%	5.13%	4.43%	1.51%
Investment Cost (US$/kW)	1,564	1,842	2,891	2,895
Average Electricity Price (US$/MWh)	69.77	69.50	81.99	79.70
Average Capacity Price (US$/MWh)	110,439	94,800	94,800	94,200
Firm Power (MW)	38.40	23.80	8.55	8.11
Plant Factor	32.70%	29.30%	25.56%	30.48%
Total Costs (US$/MWh)	18.33	14.85	11.43	16.41

Table 2.10: Cash flow model for hydro projects

Parameter	**Value**
Lifetime (years)	30
Registered Capacity (MW)	110.8
Plant Factor	55.97%
Sold Energy (GWh)	543.25
Firm Power (MW)	45.10
Generated CERs (tCO2/year)	357,011
CER Price (US$/CER)	14.56
Tax Rate	17%
Investment Cost (US$/kW)	3,862
Electricity Price (US$/MWh)	78.33
Capacity Price (US$(MWh)	79,07
Total Costs (US$/MWh)	8.92

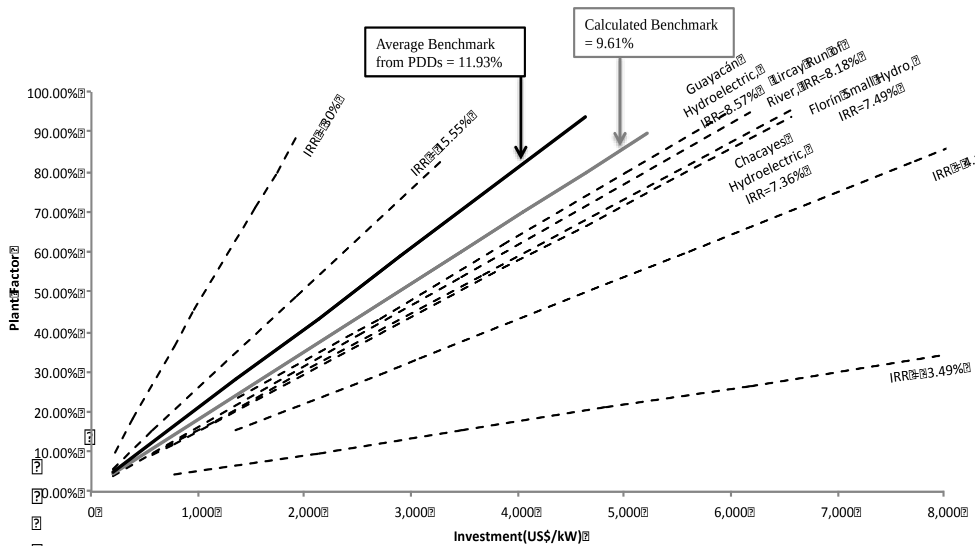

Fig. 2.7 : Plant Factor vs. Investment IRR curves for hydro projects

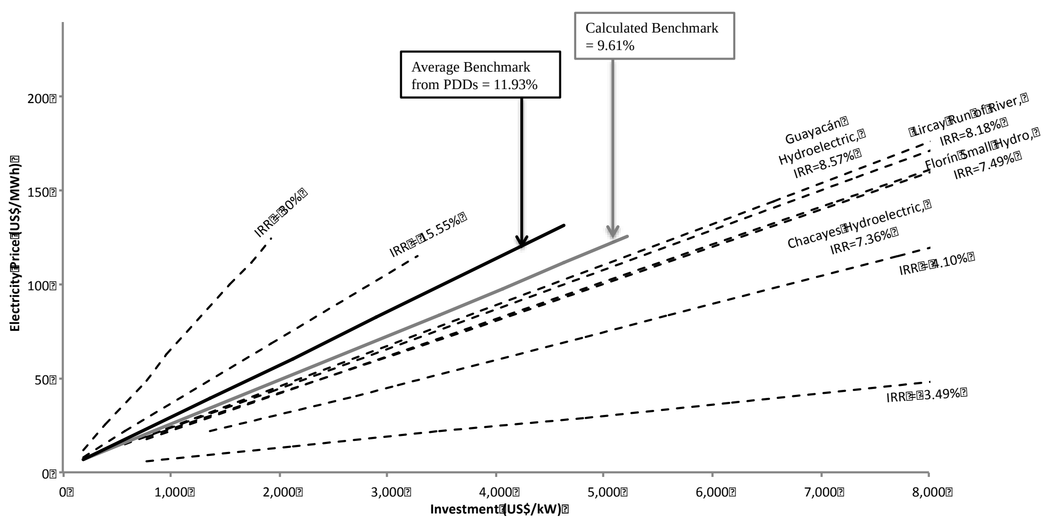

Fig. 2.8 : Electricity Price vs. Investment IRR curves for hydro projects

Table 2.11: Cash flow model for wind projects

Parameter	Value
Lifetime (years)	20
Registered Capacity (MW)	46
Plant Factor	25.56%
Sold Energy (GWh)	102.99
Firm Power (MW)	8.55
Generated CERs (tCO2/year)	70,511
CER Price (US$/CER)	14.56
Tax Rate	17%
Investment Cost (US$/kW)	2,891
Electricity Price (US$/MWh)	81.99
Capacity Price (US$(MWh)	94,800
Total Costs (US$/MWh)	11.43

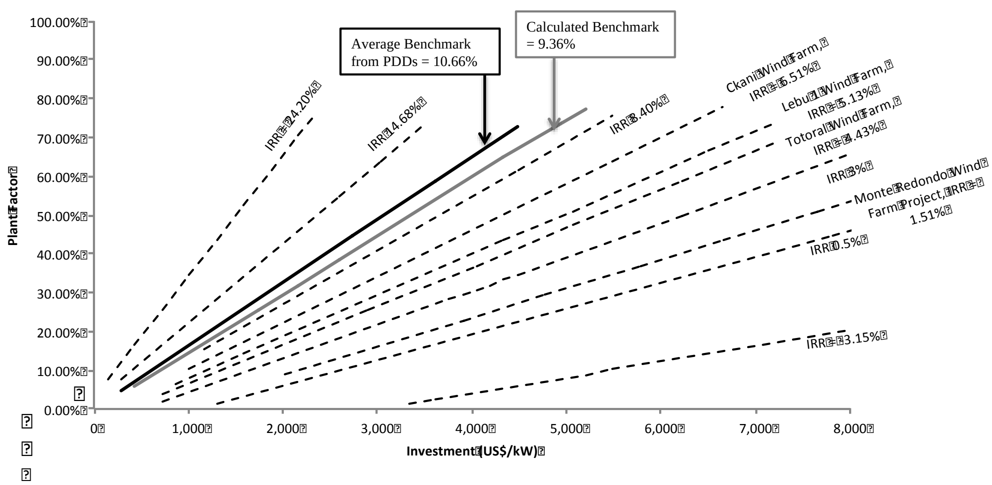

Fig. 2.9: Plant Factor vs. Investment IRR curves for wind projects

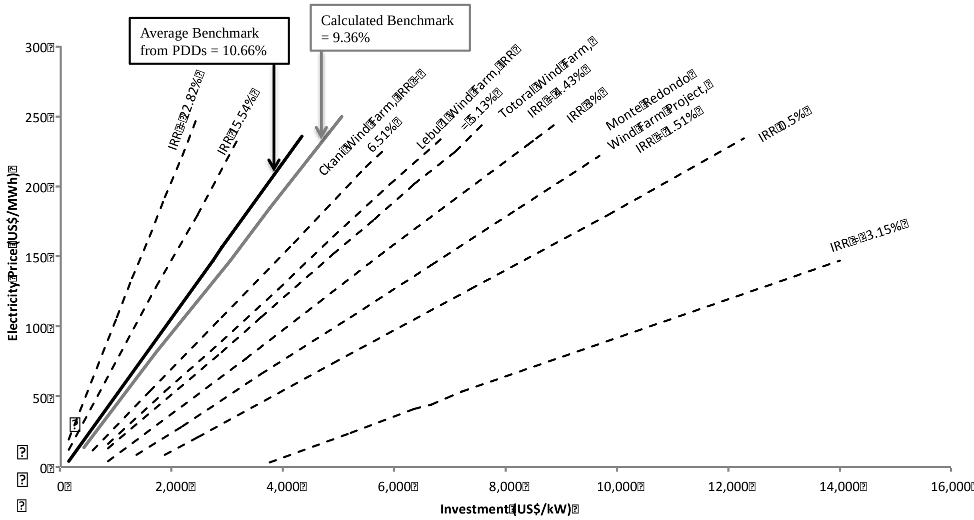

Fig. 2.10: Electricity Price vs. Investment IRR curves for wind projects

2.4.6.4 Changing assumptions within the projects

One last important fact to examine has to do with changing assumptions within projects, meaning to observe which are the changes that lead from one project's IRR to another one. Since wind projects present the biggest differences in IRR despite having similar parameters, they will be examined in this section.

The chosen example to be studied corresponds to a change in assumptions to get from Monte Redondo Wind farm, with an IRR of 1.51%, to Totoral Wind Farm, having an IRR of 4.43% (see **Fig. 2.11**) for the whole explanation of the process). Since Monte Redondo has a plant factor of 30.48%, while Totoral has a 25.56% plant factor but achieves a higher profitability, we seek to explain the reasons for that. By doing this exercise we can see how small variations in all parameters can yield IRRs different in almost 3 points. In this case the biggest difference in assumptions has to do with the consideration of a residual value by Totoral Wind Farm. When including a residual value of the same magnitude (61% of the investment) for Monte Redondo Wind Farm, the IRR increases 2.73 percentage points. This confirms once again that the residual value can have a big influence in profitability for wind projects and that a unification of criteria is required in this subject.

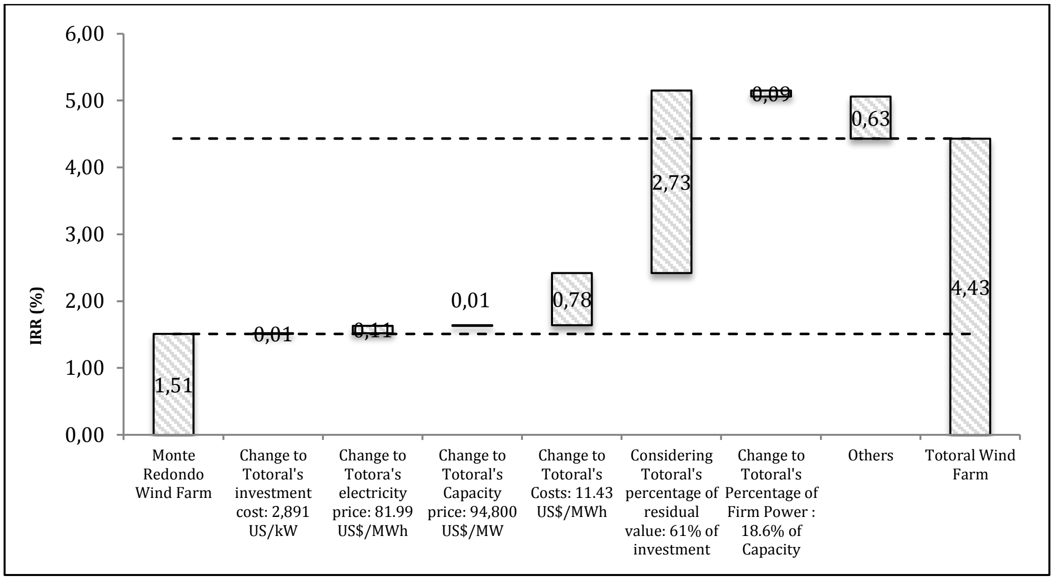

Fig. 2.11: Change of Assumptions: from Monte Redondo Wind Farm to Totoral Wind Farm

2.5 Recommendations and Conclusions

The present paper develops an approach to the study of profitability drivers for CDM renewable energy projects in Latin America. This is done by replicating 44 cash flows from projects in region and later performing a sensitivity analysis on the main factors to evaluate which of them affect profitability the most.

All the projects in the study, large and small, rank their drivers in the same order. The results show that the most important factor affecting the IRR of a project is the plant factor, with a bigger impact done in wind projects, being able to increase the IRR of these projects in over 3 percentage points with a 10% increase. This is mainly due to the fact that these projects present lower performance than hydro and biomass (41% of plant factor for wind projects compared to an average in Latin America of 59% for hydro and 51% for biomass). In second place is the electricity price, affecting biomass projects almost twice as much as the others, particularly small scale projects with a more expensive cost structure. While hydro and wind projects generate large amounts of income for electricity sales, biomass projects only produce low amounts of energy, hence an increase in electricity price has a greater impact on them. In the third place is the investment cost, affecting biomass projects, the ones with the lowest capital requirements (834 US$/kW on average for projects in Latin America vs. 2,307 US$/kW for wind and 2,201 US$/kW for hydro) the most. The one-year delay ranks fourth among drivers, which influences small-scale projects much more than large-scale ones, though presenting similar drops in the projects' IRRs for all three technologies. The total costs follow in order, influencing biomass projects the most and having a similar impact for hydro and wind projects. Finally, capacity price ranks last mainly due to the fact that electricity sells represent approximately 90% of the revenues without CERs, while capacity sells only an approximate of 10%; also most countries in Latin America do not sell capacity, thus decreasing the effect of this factor. Another important parameter to consider is the inclusion of a residual value in the cash flow, and though it is not a common practice in the region, for wind projects it can increase the IRR more than 2 percentage points. In this matter the time frame chosen for the project plays a key role since for projects with an evaluation horizon of 20 years (such as wind projects), the inclusion of a residual value makes an impact, while for horizons of over 30 years the effect is almost negligible.

The lack of criteria within the CDM points to two specific problems within the study: the IRR benchmark used in the PDDs and the consideration of a residual value. We discovered the variety of values used for the IRR benchmark across Latin America, but the case of Chile demonstrated that just in one country more than three different criteria are accepted as an appropriate choice for the benchmark. This incentives project developers to use the benchmark that most suits their project so that they can be registered under the CDM, but which in many cases may not reveal the true situation of the market, hindering renewable energy projects by making them appear as risky and unattractive investments even when CERs are considered. That is why the proposed approach of the IRR benchmark would allow the majority of renewable energy projects to still be registered under the CDM to obtain revenues from it, but would also make them more attractive to investors, and by doing so, would help to promote this type of energy. The main need is for the CDM to define a universal criterion to calculate the benchmarks to be used in PDDs, in order to increase transparency and ensure that the figures are not being manipulated to gain CDM revenues. On the other hand, the lack of criteria regarding the use of a residual value is also a flaw in the CDM. Although for hydro and biomass projects the impact in profitability is not that punctuated, for wind projects it makes a huge difference, which suggests that formal rules should be set up on this factor, to either limit its use or to include a section explaining why and how it is calculated in order to prevent manipulation.

Renewable energy presents promising sustainable development benefits, especially compared to the rest of the available technologies in the CDM such as end-of-pipe projects; however the fact that they are very capital intensive and also rank very low in generated CERs harms them. To help overcome this problem, the CDM could measure the amount of sustainable benefits generated, and use this as a performance indicator to either increase the amount of CERs a project can produce or to reduce its transaction costs. The possibility of establishing taxes has also been analyzed by some authors (Baranzini et al., 2000; Midttun, 2003; Owen, 2004, Owen, 2005), in order to internalize into conventional energies the costs of polluting, which could result in renewable energies being competitive with other technologies more intensive in fossil fuels. This measure was proposed in Europe in 1992, but had to be removed due to strong opposition by businesses (Dunkerley, 2006). Another option to help the most impoverished countries to participate in renewable energy projects would be to fast-track some proposals according to host country, type and sector so that transaction costs can be minimized, as long as the majority of the countries still prove investment additionality to ensure that non-additional projects are not registered. This is essential since renewable energy projects have barely been developed in the poorest countries, because they lack the institutional frameworks and infrastructure, the policies to plan these technologies and the skilled labor and strategies to promote cleaner energies (Karekezi and Kithyoma, 2003). Other ways to help encourage renewable energies is to provide long-term governmental programs to support them, to set standards for equipment, buildings and cars to limit their amount of emissions. By increasing the performance of the projects, in the future investment requirements should decrease (Brown et al., 2001; Karekezi and Kithyoma, 2003; Geller et al., 2004). However other measures such as establishing a minimum ΔIRR (Au Yong, 2009) would hurt renewable energy projects instead of promoting them. This is due to the fact that these projects usually also sell electricity, so the effect of CERs is not as dramatic as for projects whose only incomes come from carbon credits.

As it has been seen, it is fundamental to take more action to promote both CDM and renewable energies. The succeeding document to the Kyoto Protocol is to be presented in 2015, so changes to the structure of the agreement should be made now. The next agreement should also impose short-term goals and not only long-term targets, as stated by Verbruggen (2009), in order to keep a more detailed control of how many reductions are being accomplished, and to be able to take sooner action in case of need. The CDM should be placed directly below the United Nations, and not just as a mechanism within the Kyoto Protocol. Its framework should also be restructured, so that incentives are put in the correct path: to promote renewable energies, to build capacities and give opportunities to develop projects in the poorest countries and most importantly to give the CDM the attention it deserves as the main effort aimed to help developing countries to adapt to climate change.

3 SUSTAINABLE DEVELOPMENT PROFILES THROUGH CDM RENEWABLE ENERGY PROJECTS IN LATIN AMERICA

Abstract

The clean development mechanism (CDM) is the only market-based mechanism under the Kyoto Protocol aimed to help developing countries grow following a cleaner path. However, research has proved that CDM is not fulfilling its sustainable development claim, favoring financial incentives instead. In this paper 180 renewable energy CDM projects from Latin America have been studied regarding sustainable development benefits they claim to contribute with. Since these types of projects are associated with the highest sustainability benefits, their analysis aims to portray the best possible scenario for the contribution of CDM towards sustainable development. The research shows that while no trends exist between host country, scale or type of project with sustainability, all of the evaluated projects claim to deliver at least one type of benefit. Nonetheless, technology transfer, which helps countries to build their own capacities, is left behind. The main policy proposed considers the use of a checklist of categories and subcategories of benefits as suggested in this paper to be used as an international standard in CDM to aid the poorest countries in the development of institutional capacities in order to help them adapt to climate change.

3.1 Introduction

In the context of an increasingly alarming climate change, primarily due to human activities, the industrialized countries accepted under the Kyoto Protocol to abide by a set of legally binding obligations to reduce their emissions of greenhouse gases (GHG) to an average of 5% below their 1990 levels over the first commitment period from 2008 to 2012 (UNFCCC, 1997; Toth, 1998, Rose and Wei, 2008). The Protocol includes flexible mechanisms aimed to help developed countries achieve their targets by investing in GHG emission reduction projects in other countries. From these instruments, the Clean Development Mechanism (CDM) represents the main effort to incorporate developing countries to participate in the mitigation of climate change (van der Gaast et al., 2008).

Sustainable development's purpose is to ensure energy supply according to human needs, to minimize the waste of resources and at the same time to help in subjects such as education, health and infrastructure amongst others (Jefferson, 2006). However, the effective contribution of CDM to sustainable development has been questioned many times (Ellis et al., 2007; Muller (2007); Liu (2008); Nussbaumer, 2009). The duality of objectives of the CDM, to help developing countries to achieve sustainable development, and developed countries to reach their targets in a cost effective manner, has seen a trade-off in favor of the latter due to a series of measures to promote projects with greater incomes.

Whilst developed countries are responsible for the majority of both historical and current GHG emissions, developing countries are also contributing to the problem by rapidly increasing emissions as a consequence of their accelerated economic growth, and CDM is the only market-based mechanism under the Protocol aiming to provide them the opportunity to achieve a clean development path (van der Gaast et al., 2008; Schneider et al., 2008). The access to technologies, and specially to those not available in the host countries (Haites et al., 2006), is a prerequisite for reducing emissions in developing countries, to combat climate change and to modify developing countries course of growth, which makes technology transfer a key pillar to any future agreement intended to replace the Kyoto Protocol (UNFCCC, 2007b; de Conick et al., 2008; Pachauri, 2008; Schneider, 2008). So far CDM has not formally defined sustainable development or even outlined a technology transfer mandate, leaving these subjects as a sovereign matter for each host country to decide upon, as it was instructed during the 2001 Marrakech Accords (Dechezleprêtre et al., 2008; Olsen and Fenham, 2008). Moreover, without the industrialized countries effectively transferring technology to the developing nations, the Kyoto Protocol or any other climate agreement cannot reach the purpose for which they may be intended (Verbruggen, 2009).

Another problem surrounding the CDM has to do with critics upon the host countries' right to define whether a project contributes to sustainable development or not, which may be influenced by national values. This is aggravated by the fact that no ex-post verifications, meaning that when designated operational entities (DOEs) are required to validate projects, sustainable development is not included in that assessment. Another concern has to do with preferences changing in favor of end-of-pipe projects, which imply lower-cost GHG reductions but provide very few sustainable development benefits, rather than more capital-intensive options such as renewable energies, which are associated with a higher contribution to sustainability (Ellis et al., 2007; Nussbaumer, 2009).

Some of the main literature reviewing sustainable development benefits includes Ellis et al. (2007) who studied the first 12 registered projects, Sutter and Parreño (2007), who assessed 16 officially registered projects, Nussbaumer (2009) who studied 39 CDM projects with high sustainable development benefits and Boyd et al. (2009) who took a random sample of 10 projects to evaluate them according to qualitative measures of direct and indirect benefits based on sustainable development criteria. So far, Olsen and Fenham's study (2008) is the most complete, analyzing 296 projects of all types, but not including in their evaluation technology transfer benefits. A number of assessments have been conducted only for the purpose of studying technology transfer benefits, such as Haites et al., (2006), who analyzed 854 registered and proposed projects, Dechezleprêtre et al., (2008), who took on 644 registered projects and analyzed the frequency and nature of technology transfer, including a study on its drivers, Schneider et al., (2008) who focused on the purchase of technology via trade-off and transfer of technology as part of an investment, showing how CDM lowers the barriers for technology transfer and Seres et al., (2009) who provided an update of the situation covering a larger base of projects (3,296) and analyzed trends in technology transfer via CDM. However, no study conducted has analyzed all sustainable development benefits including technology transfer focused on a large volume of renewable energy projects, the ones that should provide the higher benefits, nor is there an evaluation that comprises an up to date analysis of the situation for the first commitment period up to the Conference of Doha in which a second commitment period was approved. This paper contributes by assessing 180 renewable energy projects in Latin America, the first region where all of its eligible countries (those that both ratified the Kyoto Protocol and have a designated national authority – DNA) have hosted a CDM project and where renewable energy projects are distributed in a more homogeneous manner. For the analysis we investigate the way in which CDM has contributed to sustainable development through renewable energy projects by analyzing the trends regarding frequency of benefits, types of projects and leading countries associated with different benefits.

The article is organized as follows. In Section 2.2 we review the CDM portfolio. Section 2.3 includes a description of previously used methodologies by other authors to assess sustainable development and explains the methodology for this paper. Section 2.4 discusses the findings and Section 2.5 analyzes the biggest problems remaining in the CDM and how to overcome them. Section 2.6 concludes.

3.2 Overview of the CDM portfolio

An unequal distribution of CDM projects has marked the first commitment period, accompanied by a trade-off between the two objectives of the CDM in favor of lower cost emission reductions and leaving behind sustainable development. This section presents the general distribution of projects in the world together with the reasons behind the trade-off and the implications for sustainable development.

3.2.1 CDM: Distribution of projects and its challenges

A total of 5,193 CDM projects were registered up until December 8, 2012, the date of the Conference of Doha, which marked the milestone to the continuity of the Kyoto Protocol into another commitment period, issuing a total of 1,115,241.36 kCERs. From these projects, 4,238 generate electricity with a total capacity of 191,204.93 MW, with an average size of 36.82 MW (see Table 3.1). China, India and Brazil are the three countries with the highest number of projects, with 52%, 19% and 4% of them respectively. Asia & the Pacific is the region with the most issued CERs, with 86% of them, being the majority from HFC and N2O projects.

The spread of CDM projects is concentrated in renewable energies, which account for 71% of the registered projects, followed by methane reductions (17%) and energy efficiency projects from the supply side (6%). The remaining 6% corresponds to HFC and N2O reductions, energy efficiency from the demand side, fuel switch, sinks and transportation projects. Renewable energies, in particular from the exploitation of hydro, wind and biomass sources, also hold 72% of the registered capacity (136,790.96 MW) in CDM projects generating electricity. Asia & the Pacific have 90% of the renewable energy projects, while Latin America is in second place, but far behind with 8% of them (see

Table 3.2).

The distribution of projects across host countries is very unequal. Regions like Africa and the Middle East have been poorly represented, with only 2% and 1% of the world's registered CDM projects, respectively. For investors to get interested in financing projects, it is necessary to meet certain conditions, like effective government pillars, being open to the market, good infrastructures, high return on investments and an experienced human capital, most of which are missing from the poorest countries (Ellis et al., 2007). From a sustainable development policy point of view, these regions are in most need for foreign investment. The countries most involved in CDM, correspond to those with the highest FDI confidence index: China, India and Brazil (Kearney, 2012), and are also the most polluting developing countries. Because of this, they have more opportunities for reductions, which combined with their strong conditions for investment, are then able to attract the majority of CDM projects, whilst the poorest countries lack the means to build capacities to do so.

Whilst sustainable development is not clearly defined under the CDM, project developers are asked to include in their Project Design Documents (PPDs) a description of the sustainable development benefits provided by their project, including how environmentally safe and sound technology is transferred to the host countries (Seres et al., 2009). Nonetheless, the PDDs might be misleading for evaluating the projects since the developers might be biased to choose some stakeholders for consultation, under-representing critical views about the project. Furthermore, the PDDs are available only through the Internet for public scrutiny after all verifications, but before their final registration, and people in the countries in most need of sustainable development benefits do not have regular access to Internet, hence they cannot voice their opinions (Boyd et al., 2009). For more information on sustainable development, see Olsen (2007).

Table 3.1: Nº of Projects, Capacity and Issued CERs by region. *Source:* Author's calculations based on projects' information from UNEP Risϕe and UNFCCC.

Region	**Nº of Projects**	**%**	**Registered Capacity (MW)**	**%**	**Average Size (MW)**	**Issued kCERs**	**%**
Asia & Pacific	4,326	83	172,169.49	90	39.80	959,247.78	86
Latin America	668	13	11,431.76	6	17.11	128,155.51	12
Africa	100	2	2,194.12	1	21.94	16,370.90	1
Middle East	54	1	4,335.52	2	80.29	6,810.93	0
Europe & Central Asia	45	1	1,074.03	1	23.87	4,656.24	1
Total	**5,193**	**100**	**191,204.93**	**100**	**36.82**	**1,115,241.36**	**100**

Table 3.2: Nº of Projects, Capacity and Issued CERs by region and type of technology

Technology	Asia & Pacific	Latin America	Africa	Middle East	Europe & Central Asia	Total	%
Renewable Energy	3,288	305	38	13	15	**3,659**	71
CH_4 Reductions	519	294	30	18	16	**877**	17
Energy Efficiency - Supply	275	12	2	4	1	**294**	6
HFC & N_2O Reductions	80	15	8	7	7	**117**	2
Energy Efficiency - Demand	97	5	5	3	3	**113**	2
Fuel Switch	49	10	5	9	1	**74**	1
Reforestation & Afforestation	11	15	12	0	2	**40**	1
Transport	7	12	0	0	0	**19**	0
Total	**4,326**	**668**	**100**	**54**	**45**	**5,193**	100
%	83	13	2	1	1	100	

3.2.2 CDM: Trade-off in favor of cost effective emission reductions leaving behind sustainable development

CDM is supposed to incentivize the private sector to finance emissions abatement projects in developing countries, promoting sustainable development in them while offering industrialized governments credits against their Kyoto targets and consequently contributing to the transfer of technologies previously unavailable in the host countries (Zhang, 2006, Schneider, 2008). Nonetheless, the market has been seen to promote the most economic options, producing a trade-off of CDM's double objectives in favor of cost-effective GHG mitigations, leaving sustainable development only as an option.

Furthermore, the potential of low-cost options to generate large amounts of CERs is significant. While renewable energies are expected to generate between 0.2 and 780 ktCO2-eq credits per year, reductions of HFC-23 and N2O projects obtain millions of credits per year (Ellis et al., 2007). These types of projects offer almost no benefits regarding substantial development. Renewable energies on the other hand offer long term values by increasing resource security, often improving air quality, attract income and generate technology transfer, but they deliver higher cost emission reductions, require more investment for projects' infrastructure and present high price volatilities (Owen, 2006; Nussbaumer, 2009).

3.3 Analysis of sustainable development benefits due to renewable energy projects

Two types of methodologies have been used by authors to assess sustainable development, the checklist approach and the multi-criteria approach. This section provides an overview of the main researches under those methodologies, along with their strengths and weaknesses, followed by a description of the used methodology for this study.

3.3.1 Previously used methodologies for sustainability assessment

Existing methodologies can be classified as checklist approach and multi-criteria assessment. The checklist approach consists in a qualitative analysis of the PDD and is easily adapted for different interests amongst host countries. In studies conducted (Ellis et al., 2007; Olsen and Fenhann, 2008; Boyd et al., 2009) several pre-defined sustainable development criteria is checked against the selected documents PDDs and the obtained information analyzed for tendencies. The multi-criteria approach on the other hand, consists in combining qualitative and quantitative data and weighting the relative significance of all factors to arrive at a single measure for sustainability. Some of the most commonly used methods include the Multi-Attribute Assessment (MATA-CDM), developed by Sutter (2003), and later on by Sutter and Parreño (2007) in a study of 16 registered projects, which is modified by Nussbaumer (2009) for a study comparing normal CDM projects with those with Gold Standard qualification. The Gold Standard proposes a methodology to develop high-quality emission reduction projects with high environmental integrity and secured sustainable development benefits (Nussbaumer, 2009).

Both types of methodologies have their weaknesses as the matters evaluated are subjective and no ex-post verification of sustainable development claims is carried out by the DOE. Also, the fact that no international standard exists for measuring sustainable development benefits can lead to a "race to the bottom" (Kolshus et al., 2001), in which countries lower their requirements to attract more projects. However, the multi-criteria approach also poses the complication of collecting large amounts of data from projects' stakeholders, and since the focus of this study in through public information from PDDs, a checklist approach is chosen instead.

3.3.2 Methodology used for the analysis

The utilized methodology will take on a checklist approach based on the criteria selected by Olsen and Fenhann (2008), and Nussbaumer (2009). The first article includes a detailed set of sub-parameters from which to measure sustainable development as part of the macro parameters of social, environmental and economic benefits used in most studies, however it does not include technology transfer amongst them. The second study on the other hand does include technology transfer as part of the potential economic benefits, but as it was mentioned, it does not use a checklist approach. To complement this analysis, we include the works done by Haites et al., (2006), Dechezleprêtre et al., (2008) and Seres et al., (2009), which analyze exclusively technology transfer, defined as "a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders…" (Metz and Turkson, 2000). The two aspects examined by all papers regarding technology transfer include the use of equipment and/or knowledge not previously available in the country hosting the CDM project.

The sample of projects evaluated is based in 180 CDM renewable energy projects in Latin America. A total of 668 CDM projects were registered up until December 2012 in Latin America, issuing a total of 128,155.51 kCERs, from which 376 projects generate electricity with a capacity of 11,431.76 MW. From the total registered capacity 93% belongs to renewable energies, corresponding to 305 projects, hence making them the most relevant technology to study, both for its electricity production in a region looking to diversify its energy matrix and for its alleged sustainable development benefits. The strongest countries in the region are Brazil, Mexico and

Chile. Brazil has 34% of all the projects and 36% of the registered capacity. Mexico owns 22% of the projects and 19% of the capacities and Chile 9% of the projects and 12% of the capacities. Latin America has issued a total of 127,390.71 kCERs, with 59% of them belonging to Brazil (see **Fig. 3.1**)

The totality of renewable projects in Latin America was filtered as follows: from 21 countries in the region, only countries with at least one renewable energy project are considered, reducing the total to 18 countries (Bahamas, Cube and Paraguay do not have registered renewable energy projects). For those remaining countries, if they have less than 8 projects, all of them are included in the sample, if they have more than 8 projects, 20% of all the projects in the country are considered randomly. Chile is the only country in which all the renewable energy projects are considered, with a total of 36. This is due to the fact that it is the second country in Latin America with the most projects in this category, but its quantity is still possible to evaluate, whilst Brazil, the country with most renewable energy projects, has 116, so assessing each one of them would have been a biased analysis representing only that country's reality. The final result leads to a sample of 180 projects registered up until December 8, 2012, belonging to 18 countries: Brazil, Chile, Peru, Mexico, Honduras, Colombia, Ecuador, Guatemala, Panama, Argentina, Costa Rica, Uruguay, Nicaragua, El Salvador, Dominican Republic, Jamaica, Bolivia and Guyana (see **Table 3.3**).

The proposed methodology for this study consists first in defining a set of criteria based on previous studies, including some modifications for re-naming or inclusion of different aspects in each classification. The data is obtained exclusively from the selected projects' PDD because they represent the best coverage of CDM projects, having to describe the project in terms of its contribution to sustainable development, and explicitly stating when technology transfer occurs. Moreover, the purpose of this study is to assess the information publicly available, which would correspond to those that stakeholders of each country are able to see before the registration of the project, and not to private data that is not available for the public scrutiny. PDDs are easy to access from the UNFCCC website (http://cdm.unfccc.int/Projects/projsearch.html) and they are free to download. Nonetheless it is important to consider that PDDs are far from perfect in terms of obtaining quality data. On one hand, sustainable development benefits, in particular technology transfer, are usually found throughout the document (they are in average 50 pages long), which makes it hard to find and process the information. On the other hand, since the project developers are in charge of generating the PDDs, they may be inclined to exaggerate a project's sustainable development benefits, and since no official measurements exist in this matter, what is included in the PDD is usually believed to be true (Olsen and Fenhann, 2008).

For the study, the PDD's section containing the "description of activity" is evaluated to obtain the sustainable development benefits claimed by the project by performing text analysis for each PDD and taking note on the checklist for each benefit if it is declared. For the special case of technology transfer, in many cases several mentions about it are made implicitly along the PDD, but since evaluating the whole document for 180 projects would take a lot of time, besides checking for technology transfers in the description of activity section, the keywords "technology transfer", "technology", "transfer", "equipment", "knowledge", "imported" and "know-how" are searched along the document. The decision to make for each sustainable development criteria in the classification is a "1" if the project involves the sustainable development benefit in question, and a "0" if it does not. For technology transfer unless it appears under one of the keywords or in the same section as the rest of the benefits, no recognition is made. As Olsen and Fenhann (2008) note, manual coding is subjective in the sense that different authors could interpret information in different ways, but it still is more effective than programming for automatic coding, which was only used for technology transfer claims. Since project developers can express the same idea for a sustainable development benefit in different ways, trying automatic coding only lead to benefits not being considered.

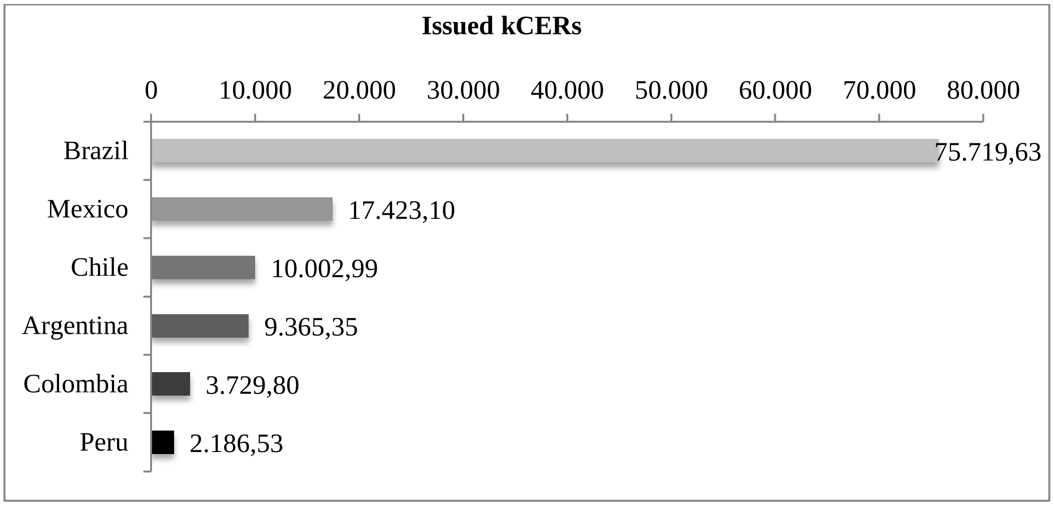

Fig. 3.1: Issued kCERs from Latin America's top 6 countries. *Source:* Author's calculations based on projects' information from UNEP Risφe and UNFCCC.

Table 3.3: Sample of renewable energy projects used for the study. *Source:* Author's calculations based on projects' information from UNEP Risφe and UNFCCC.

	Hydro		**Wind**		**Biomass**	
	Total	**Sampled**	**Total**	**Sampled**	**Total**	**Sampled**
Brazil	58	12	12	8	46	9
Chile	18	18	7	7	11	11
Peru	25	8	0	0	1	1
Mexico	3	3	15	8	3	3
Honduras	13	8	1	1	4	4
Colombia	10	8	1	1	2	2
Ecuador	7	7	2	2	2	2
Guatemala	7	7	1	1	0	0
Panama	7	7	1	1	1	1
Argentina	1	1	2	2	5	5
Costa Rica	3	3	3	3	2	2
Uruguay	0	0	2	2	5	5
Nicaragua	1	1	3	3	1	1
El Salvador	1	1	0	0	2	2
Dominican Republic	0	0	4	4	1	1
Jamaica	0	0	2	2	0	0
Bolivia	1	1	0	0	0	0
Guyana	0	0	0	0	1	1
Total	**155**	**85**	**56**	**45**	**87**	**50**

3.3.3 Criteria for evaluating sustainable development benefits in projects' PDDs

Sustainable development benefits are classified into four categories: environmental, economic, social and technology transfer. For each of these organizations, sub-categories are established to better evaluate the projects (see **Fig. 3.2**). The definitions for each of these sub-categories are presented on

Table 3.4.

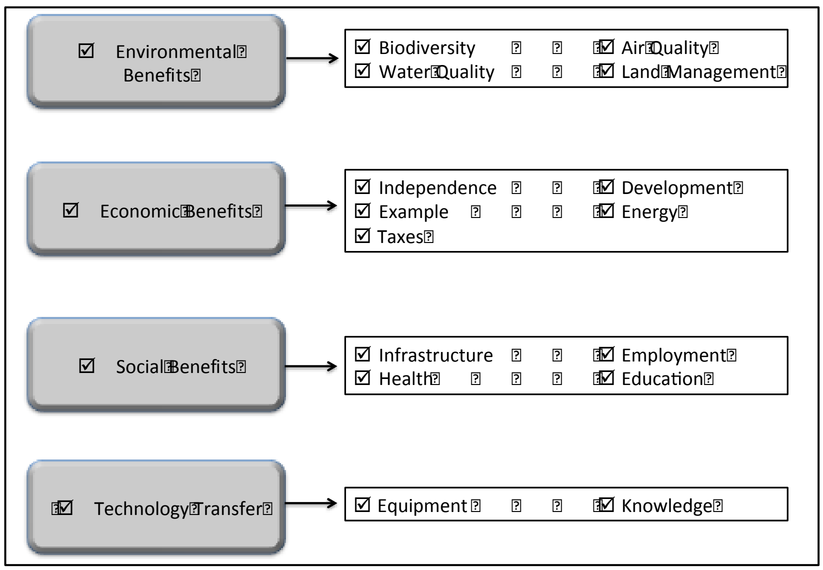

Fig. 3.2: Categories and sub-categories for the classification of sustainable development benefits. Source: Own elaboration from information taken from Ellis et al., 2007; Olsen and Fenhann, 2008; Nussbaumer, 2009.

Table 3.4: Scope of work for categories and sub-categories of benefits. Source: Own elaboration from information taken from Ellis et al., 2007; Olsen and Fenhann, 2008; Nussbaumer, 2009.

Category	**Sub-Category**	**Scope**
Environmental	Biodiversity	Includes resource protection, minimizing the environmental impact of the project, environmental protection programs, creation of reserves, restorations and reforestations.
	Air quality	Includes reductions in particulate material and other pollutants, not considering GHG reductions since all projects are supposed to do so.
	Water quality	Includes all situations that improve the quality or access to water, like better irrigation, lower costs, purification and distribution.
	Land management	Includes better handling of waste, avoiding contamination of the soil and reducing erosion.

Economic	Independence	Includes all projects that claim to help in the reduction on foreign dependence of fossil fuels and settling the balance of payments of their host countries.
	Development	Includes several subjects like the creation of new companies, the disbursement of funds to the community, financing investments, paying land-owners for the use of their lands without them sacrificing the space as they can continue carrying on their activities, leasing other services, diminishing costs in near municipalities, using resources in a more efficient manner. All this subjects are included in development, unless they make a specific improvement to air quality, water quality, land, health or education programs, so they are not counted twice.
	Example	Includes projects contributing to develop a non-common technology in the host country and helping to promote it by serving as an example to replicate and lower barriers to other project developers.
	Energy	Includes all improvements made to the electricity system in the host country: achieving sustainable prices, more efficiency, helping to supply the demand, decreasing electrical faults, helping the country reach its energy plan (for example that certain percentage of the matrix belongs to renewable energies), diversifying the energy matrix and increasing the availability for remote areas.
	Taxes	Include those projects that help the area in which they are developed by paying taxes.
Social	Infrastructure	Includes the improvement of social works (roads, bridges, etc.), creation of touristic places (like viewpoints), the construction of roads to access remote places or the construction of general infrastructure as long as it is not destined for schools or hospitals, which go into another category.
	Employment	Includes the creation of temporal and permanent jobs because of the projects activity.
	Health	Includes funds destined for hospitals, health programs or health education, the construction of health-related infrastructure and projects that diminish health risks.
	Education	Includes the creation of environmental awareness, building capacity for future projects at a national level, implementing workshops on the technology used for the project and setting guided visits to the plants.
Technology Transfer	Equipment	Includes importing pieces or machines involved in the production process not previously available in the host country. In the equipment used was acquired from a local manufacturer, it is not considered.
	Knowledge	Includes the education strictly related to the transfer of technology from another country. It considers the transfer of knowledge, information, know-how or technical assistance from a foreign partner.

3.4 Findings of the sustainability evaluation for renewable energy projects in Latin America: In spite of renewable energy's good performance, technology transfer is left behind

Sustainable development benefits need to be analyzed in four dimensions, environmental, economic, social and technology transfer. In this section we provide a detailed description of the sustainable development benefits occurring in CDM renewable energy projects in Latin America.

3.4.1 Sustainable development benefits of all CDM projects in the region

From the 180 renewable energy projects in the sample, 100% of them claim to have some sort of sustainable development benefit. **Table 3.5** shows that 88% of the projects representing 92% of the annual emission reductions for the sample, declare to have economic benefits. The distribution of sustainable development benefits among the social and economic dimensions is fairly even, followed by the environmental and in last place by technology transfer, which seems to be the most rare benefit for renewable energy projects. In fact technology transfer is in the last place both considering the benefits as percentage of number of projects and annual emission reductions. Sustainable development profiles describe either the percentage of projects contributing to a particular sustainable development benefit or the sustainable benefit as a percentage of the annual emissions reductions. **Fig. 3.3** shows the profiles for all renewable energy CDM projects in the sample for the major categories, **Fig. 3.4** for the sub-categories, as a percentage of the number of projects and **Fig. 3.5** for the sub-categories as a percentage of the annual emissions reductions. As for the sub-categories, employment outperforms the rest of the benefits and accounts for 70% of the annual emissions reductions, while energy in the second place accounts by itself for 66%. This is very important since the access to energy has been recognized as fundamental to growth by two international supports of sustainable development: the Millenium Development Goals and the World Summit on Sustainable Development. In fact, in a high-level electrification area, people living below the poverty line are much fewer than in low-level electrification areas

(Srivastava and Rehman, 2006). Within the social category, the majority of the projects are related to employment benefits, with just a little over 30% claiming education benefits and almost none recognizing health or infrastructure benefits. Meanwhile, in the economic category, though energy is in the lead, about half of the projects claim development benefits, and approximately 40% independence of fossil fuels.

Table 3.5: Sustainable development benefits for all projects as a percentage of the number of projects and the annual emission reductions. *Source:* Author's calculations based on projects' information from UNEP Risϕe and UNFCCC.

		Environmental Benefits	Economic Benefits	Social Benefit	Technology Transfer
Number of Projects in the Sample		180			
Average Project Size ($ktCO_2e$/year)		80,32			
Sustainable Development claim as percent of	Nº of projects (%)	58%	88%	79%	26%
	Annual emission reductions (%)	56%	92%	77%	24%

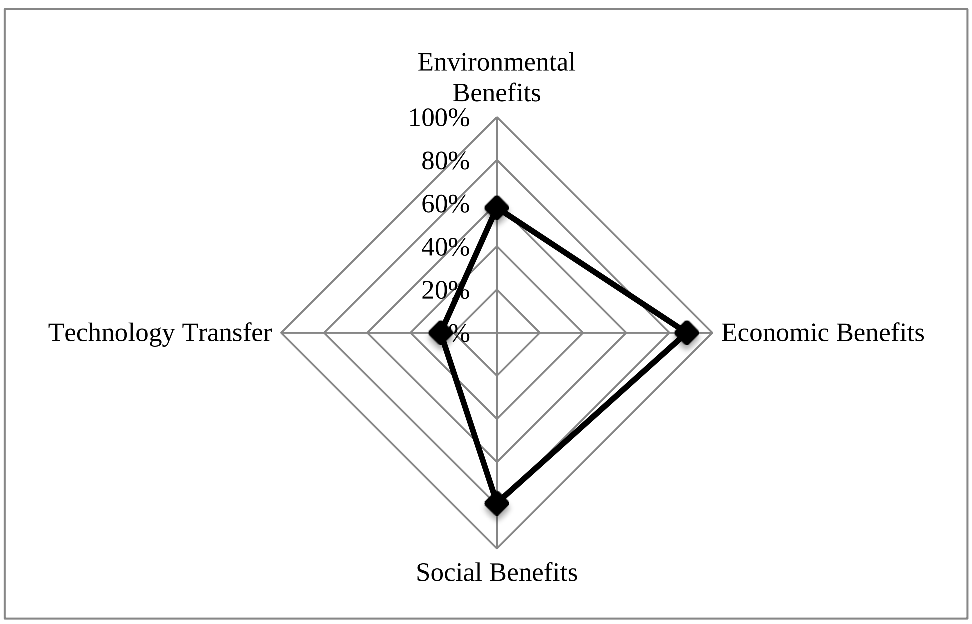

Fig. 3.3: Sustainable development profile for major categories of benefits for all CDM renewable energy projects in Latin America in the sample as percentage of number of projects. *Source:* Author's calculations based on projects' information from UNEP Risϕe and UNFCCC.

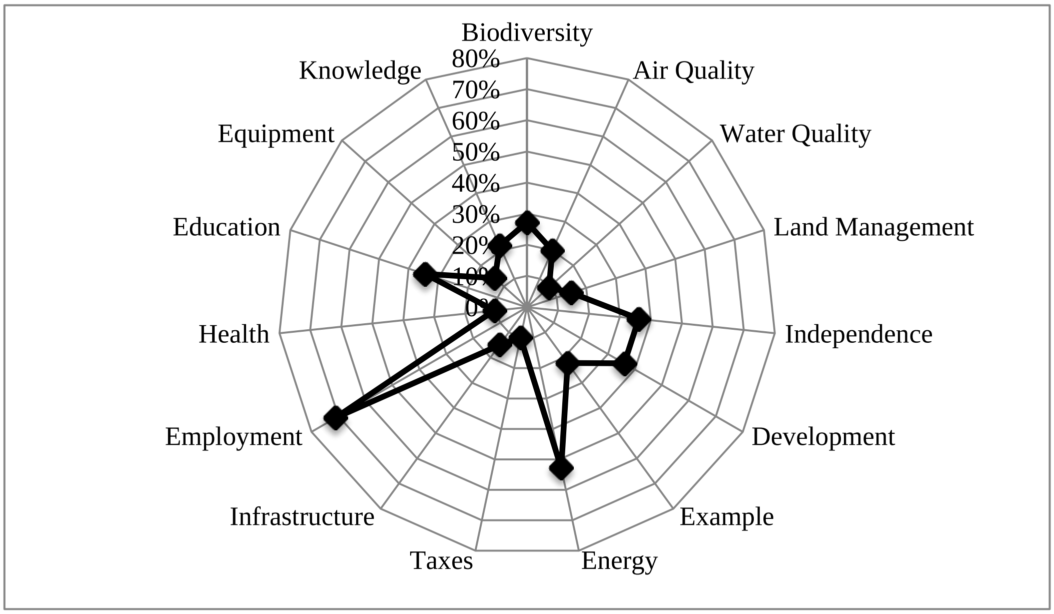

Fig. 3.4: Sustainable development profile for sub-categories of benefits for all CDM renewable energy projects in Latin America in the sample as percentage of number of projects. *Source:* Author's calculations based on projects' information from UNEP Risϕe and UNFCCC.

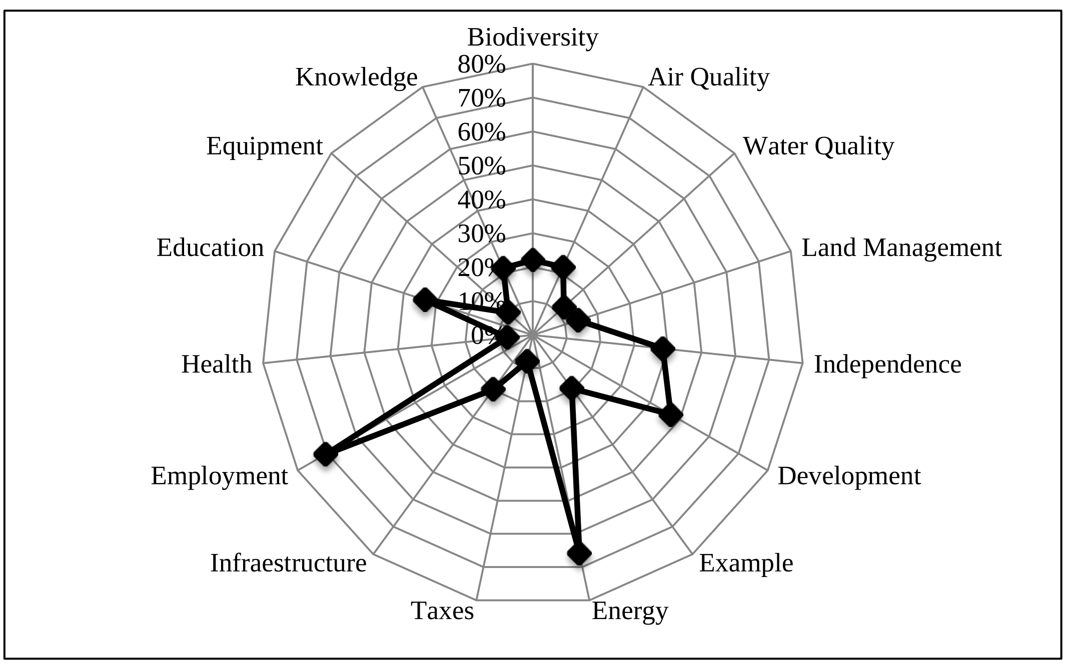

Fig. 3.5: Sustainable development profile for sub-categories of benefits for all CDM renewable energy projects in Latin America in the sample as percentage of annual

emissions reductions. *Source:* Author's calculations based on projects' information from UNEP Risϕe and UNFCCC.

3.4.2 Sustainable development benefits by host country

While renewable energy CDM projects in Latin America are located in 18 developing countries, Brazil, Chile, Peru and Mexico are the ones attracting the majority of renewable energy projects in the region, with 38%, 12%, 10% and 7% respectively, summing up 67% of the total number of projects. The distribution of sustainable development benefits appears to be very heterogeneous amongst host countries. Though some countries only presented one project, we did not want to leave them out of the analysis, so special attention needs to be given to this fact when reading the graphs. **Fig. 3.6** shows the environmental benefits according to percentage of number of projects and in the order of the countries with more of these benefits. Argentina is the country were its CDM renewable energy projects make the highest impact on environment, due mainly to improvements of the air quality. Guatemala is in second place, fairly close to Argentina, but with benefits mostly due to biodiversity benefits, followed in third place by Chile, almost 30 points below. **Fig. 3.7** shows the economic benefits according to the same ruling as before. In this case the sustainable profile is much more equitably distributed. Bolivia is in the first place, but that only means that the country's only project claims to have economic benefits. Colombia, which is the country with the lowest percentage of economic benefits, still has 7 out of 11 projects in the sample claiming economic benefits, hence this type of category is the one for which the most sustainable development claims are made. **Fig. 3.8** presents the social benefits, which are the second majority in terms of benefits declared by project developers, and shows a slightly less equal distribution amongst the host countries, were all the projects in the sample belonging to six countries: Argentina, Bolivia, El Salvador, Guatemala, Jamaica and Peru, affirmed to have social benefits. In this case the one project in Guyana does not have social benefits. Ecuador, which is second to last, claims social benefits for almost half of their projects. Finally, **Fig. 3.9** presents the technology transfers occurring in Latin America. This category is by far the most unequally distributed, in which

Dominican Republic leads with 100% of its projects indicating to help the country by transferring new technologies, all of them corresponding to the transfer of both equipment and knowledge. Ecuador follows, with 10 out of 11 projects claiming technology transfer, in which 36% of them declare transfer of equipment and knowledge and 27% of only equipment, however none state to transfer only knowledge. Panama, Chile and Honduras have over 30% of projects claiming technology transfer, whilst countries like Bolivia, El Salvador, Guyana and Jamaica do not account for any projects. This is very serious because these countries are amongst the poorest in Latin America (Global Finance, 2013), and as technology transfer is essential to help developing countries to develop following a sustainable path, if binding emissions are set for developing countries in the future, these countries will be the most unprepared and the ones which will suffer the most negative consequences.

Fig. 3.10 presents the sustainable development profile for the sub-categories of sustainable development benefits as percentage of number of projects for Brazil, Chile, Peru and Mexico, the ones attracting the majority of CDM renewable energy projects in Latin America. From all the countries, Brazil has a lot of projects claiming air quality benefits, however they still only correspond to less than 30% of them. The benefit in which the country excels the most is education, in which almost half of its projects declare to contribute in this matter. It is important to mention that in the case of transfer of technology Brazil is very low because most of the technologies used for renewable projects come from within the country itself. In the case of Chile, it only occupies the first place for transfer of knowledge, although it has very little equipment transfer. Peru on the other hand is in the lead for independence of fuels, indicating that between these countries it is probably the one that depends the most on fossil fuels, hence CDM renewable energy projects can contribute in an effective way. It is also in the first place regarding taxes (the projects belonging to other countries did not attribute as much as Peru that the payment of taxes for the projects would help municipalities to reduce costs and have more funds), water quality, employment (which is also very high comprising almost 90% of the projects), health and equipment. Finally, Mexico also occupies the first position in several categories like biodiversity, land management, development, energy and infrastructure.

Countries seem to be very diverse in attracting different types of sustainable development benefits, and no direct connection appears to exist between how active a country is and the amount of sustainable development benefits it gets. In fact this is consistent with a declaration made by the Hindustian Times New Delhi (2012) in which it was mentioned that despite the fact that India was considered as a leader in CDM, the internal feeling of the country regarding it was of failure because sustainable development had not reached the poorest population in most need of it.

The top CDM countries in Latin America have DNAs, which measure sustainable development utilizing different criteria. In Brazil the CIMGC corresponding to the Brazilian Interministerial Commission on Global Climate Change, including representatives from the ministries of Foreign Affairs, Agriculture, Livestock and Supply, Transportation, Mines and Energy, Development, Industry and Foreign trade and the Chief of Staff of the Presidency of the Republic, was created to approve CDM projects. The opinions of the Minister of Science and Technology and the Minister of Environment are also taken into account. In the submission of the PDD, Brazil asks for a description of the contribution of the project to sustainable development and tests it against a set of criteria including local environmental sustainability, improvement of working conditions, net employment creation, fair income distribution, technology development and regional integration. In Chile the CONAMA, the national environmental commission reporting to the Ministry of Environment, acts as DNA, Pro-Chile, the agency that endorses external commerce, as promoter of the CDM and CORFO, the economic development agency, as a facilitator by promoting both regulations and feasibility studies for CDM projects. For accepting a project, the DNA only cares that the participation of the parties is voluntary and that the project contributes to sustainable development in the country, but no extra measures are added to assess the project. In Peru the actions related to evaluation and approval of CDM projects are handled by CONAM, the national environmental council reporting to the

Ministry of Environment and acting as the DNA, while FONAM, the national environmental fund, is in charge of signing agreements for its promotion in the country. Peru in the requirements for the design of the PDD asks for a one page maximum description of the contribution of the project to sustainable development. For technology transfer it asks for a description of how environmentally sound and safe technology will be transferred to the country and the specialized knowledge to be used. In Mexico, the Mexican Committee for Capture and Reduction of Greenhouse Gases Emissions (COMEGEI), in which representatives from the ministries of environment, energy, agriculture, transport and economy participate, is the DNA. In the design of the PDD Mexico asks for a description of how the project will contribute to sustainable development, and the criteria for evaluating the projects focuses in three points: the fulfillment of national environmental regulations, the contribution to improve the economic and competitive situation of Mexico and to maintain or improve the quality of life (Energy Efficiency, 2005).

Looking at these DNAs we can conclude that not much is being demanded in terms of sustainable development, and what is worse, no clear standards exist, which only leave room for projects claiming vague benefits without much proof of them. Even though the projects in the sample all claim to contribute in some sort to sustainable development, one of the most important measures which ensures a country can learn and in the future develop on its own, is technology transfer, which is by far the least spread benefit in the region.

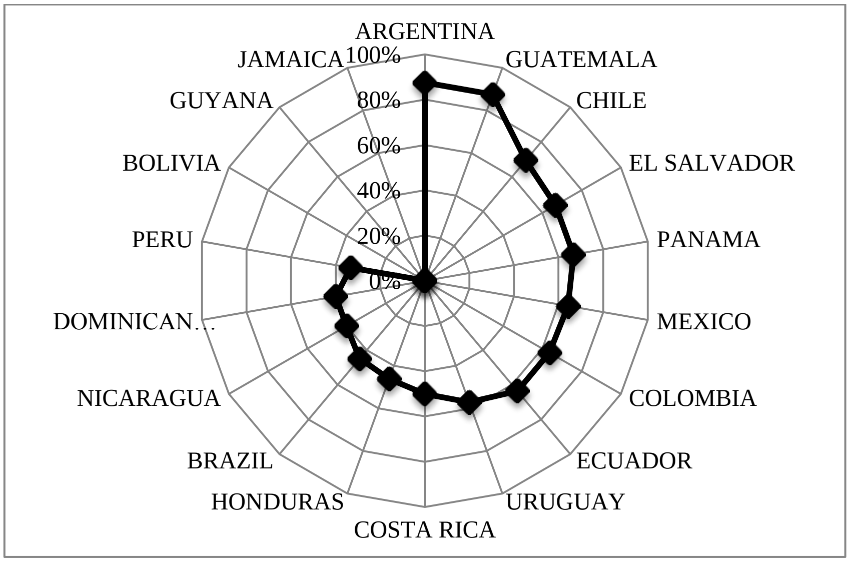

Fig. 3.6: Sustainable development profile for environmental benefits as percentage of number of projects according to host country. *Source:* Author's calculations based on projects' information from UNEP Risϕe and UNFCCC.

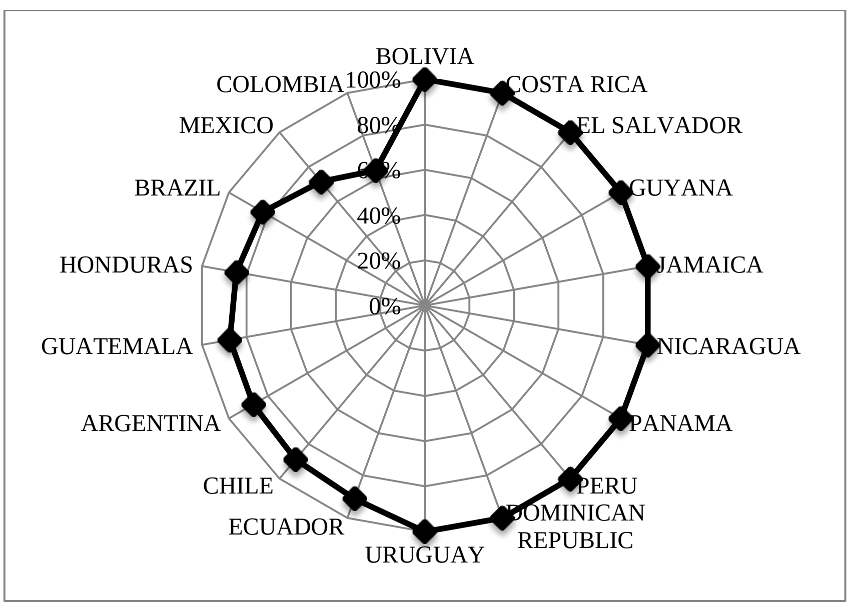

Fig. 3.7: Sustainable development profile for economic benefits as percentage of number of projects according to host country. *Source:* Author's calculations based on projects' information from UNEP Risϕe and UNFCCC.

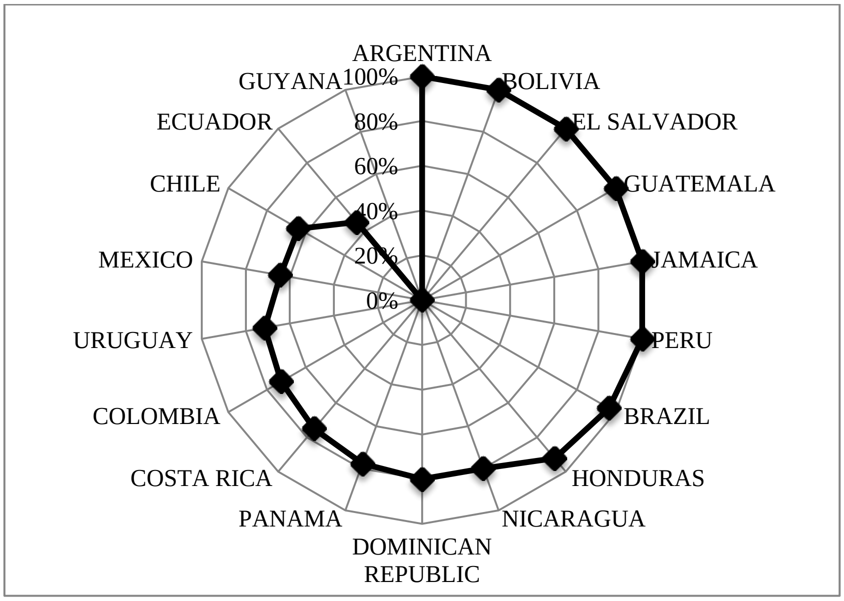

Fig. 3.8: Sustainable development profile for social benefits as percentage of number of projects according to host country. *Source:* Author's calculations based on projects' information from UNEP Risφe and UNFCCC.

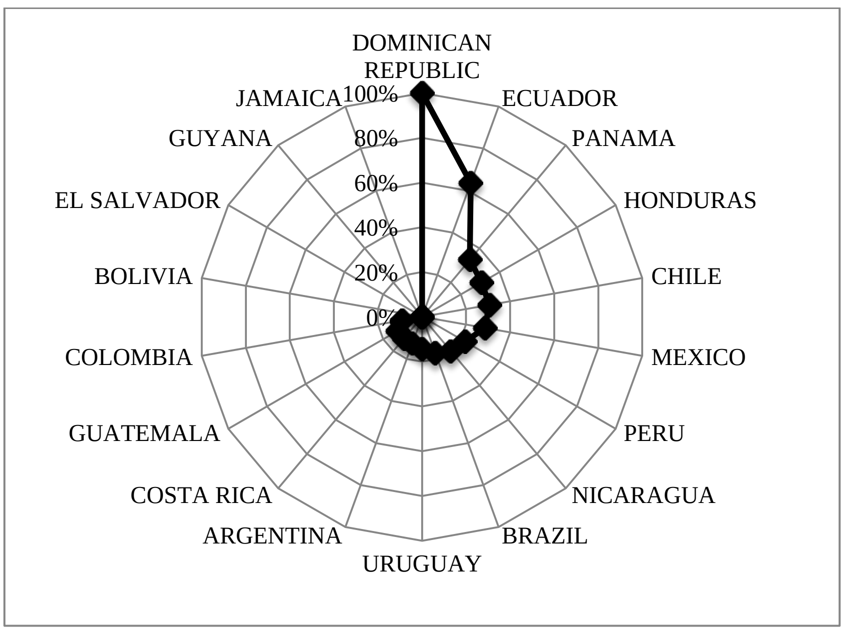

Fig. 3.9: Sustainable development profile for technology transfer as percentage of number of projects according to host country. *Source:* Author's calculations based on projects' information from UNEP Risφe and UNFCCC.

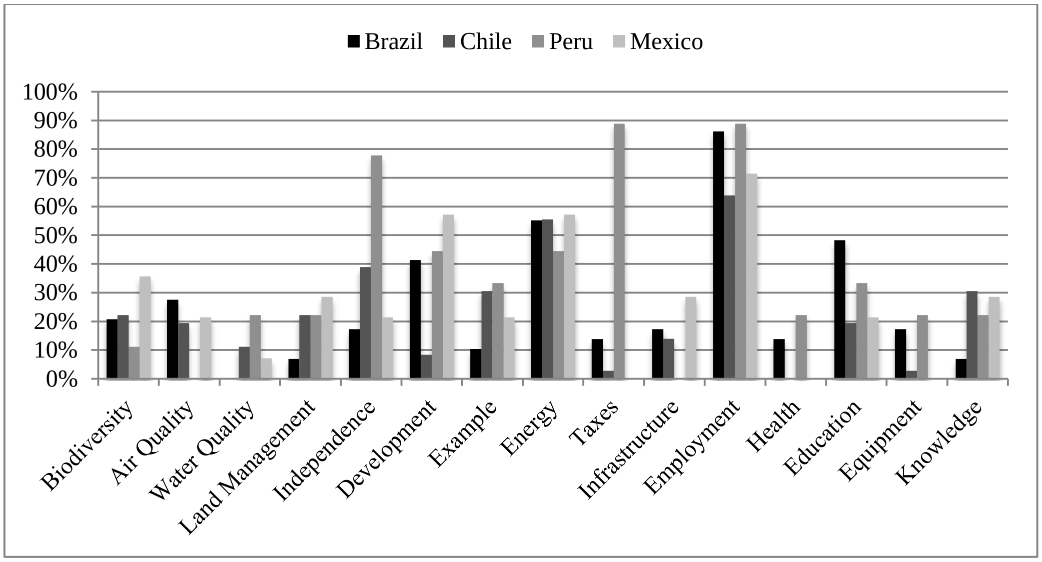

Fig. 3.10: Sustainable development profile for sub-categories of benefits as percentage of number of projects according to top CDM host countries in Latin America. *Source:* Author's calculations based on projects' information from UNEP Risϕe and UNFCCC.

3.4.3 Sustainable development benefits by project size

In order to compare small and large-scale projects and following the methodology proposed by Olsen and Fenhann (2008), a scaling factor is applied to small projects since they are less in number in the sample. Considering that there are 101 large-scale projects, and 79 small-scale projects, the factor corresponds to 1.28. **Fig. 3.11** presents the sustainable development benefits for large and small-scale projects. While small-scale projects are usually associated with higher sustainable development benefits (Cosbey et al, 2005), in the case of renewable energies the results between large and small-scale projects are very similar, only varying according to the type of benefit. In fact, small-scale projects deliver slightly less benefits than large ones, with an average of 3.9 benefits per small-scale project, and 4 benefits per large-scale project.

The analysis shows that large-scale projects tend to deliver more economic (1.62 benefits per project vs. 1.51 for small-scale), social (1.32 benefits per project vs. 1.30 for small-scale), and technology transfer benefits (0.37 benefits per project vs. 0.34

for small-scale), while small-scale projects represent higher environmental benefits (0.75 benefits per project vs. 0.69 for large-scale). Within environmental benefits, large-scale projects only excel at land management, whereas small-scale projects are in the lead for biodiversity, air quality and water quality. In the economic category, large-scale projects deliver much higher development benefits than small-scale projects, while the latter provide more benefits due to payment of taxes, corresponding to small-scale hydro projects from different countries that contribute to the local communities in which they are immersed by paying taxes. Regarding social benefits, large-scale projects tend to deliver more infrastructure, health and education benefits, except for employment benefits. Another important fact is that for technology transfer, large-scale projects are in the lead for the transfer of knowledge, which is usually the most important in order to help developing countries to reach a cleaner developing path, meanwhile small-scale projects account for higher transfers of equipment.

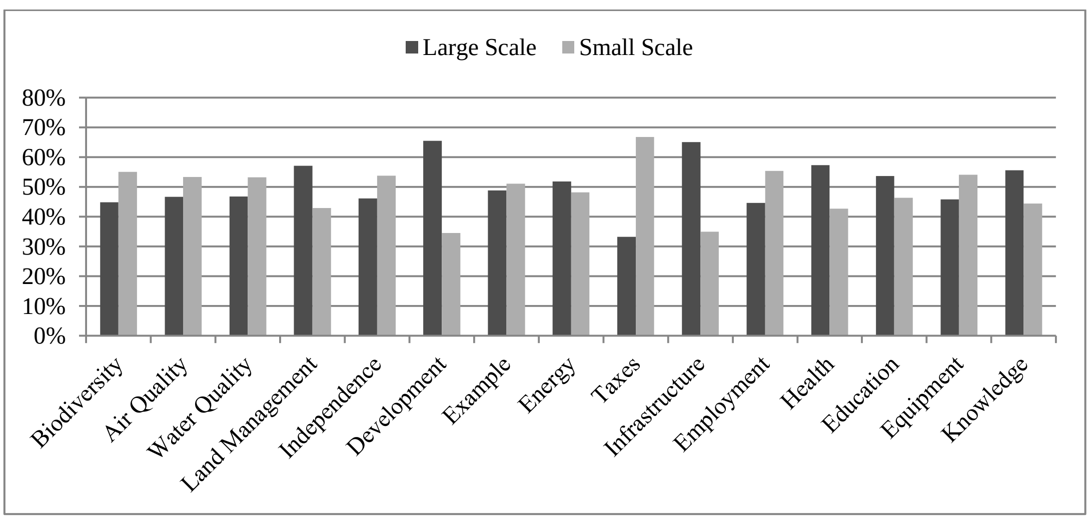

Fig. 3.11: Sustainable development profile for sub-categories of benefits in Latin America as percentage of number of projects, according to size of project. *Source:* Author's calculations based on projects' information from UNEP Risϕe and UNFCCC.

3.4.4 Sustainable development benefits by type of project

Since in Latin America three types of renewable energy projects are the most common, these were studied, corresponding to hydro, wind and biomass projects. **Fig. 3.12** presents the sustainable development profile according to the type of technology. The likelihood of providing benefits varies greatly across them. **Table 3.6** presents the average number of benefits provided by type of technology for the categories and sub-categories of benefits. In comparison, wind projects provide higher sustainable benefits in the economic and technology transfer category, delivering on average 1.96 economic benefits per project and 0.67 technology transfer benefits per project. Biomass projects are the ones with greater environmental benefits, with 38 out of 50 projects claiming contributions, due mainly to land management, in which biomass projects average 0.48 benefits per project, whilst hydro and wind average barely 0.02. For social benefits hydro and wind projects are fairly similar, with the biggest difference in favor of hydro projects being the delivery of health benefits. Amongst all categories, and as it has been seen so far, technology transfer is the least common benefit between renewable energy projects, with differences seen as high as in biomass projects, in which they deliver an average of 1.24 economic benefits per project, while only contributing to 0.18 benefits per project regarding technology transfer.

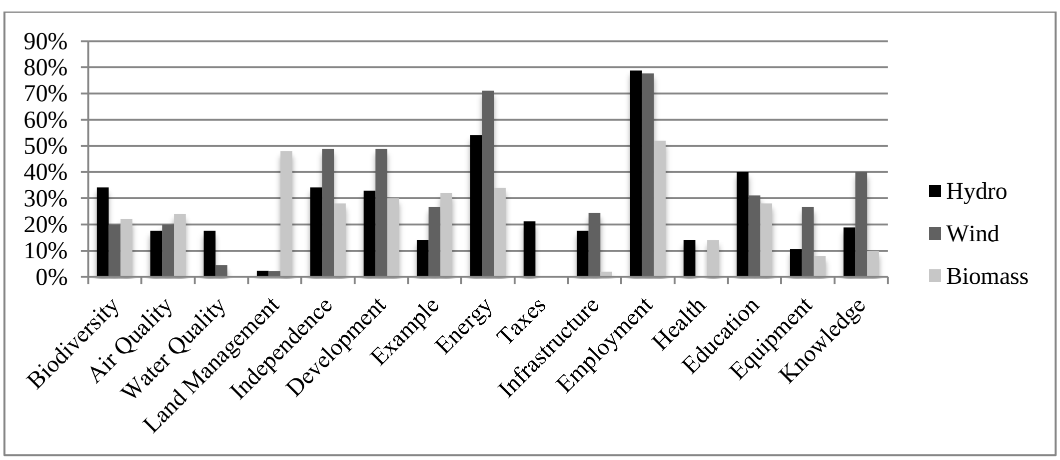

Fig. 3.12: Sustainable development profile for sub-categories of benefits in Latin America as percentage of number of projects, according to type of technology. *Source:* Author's calculations based on projects' information from UNEP Risϕe and UNFCCC.

Table 3.6: Average number of sustainable development benefits according to type of technology. *Source:* Author's calculations based on projects' information from UNEP Risϕe and UNFCCC.

Benefit	**Hydro**	**Wind**	**Biomass**
Biodiversity	0.34	0.20	0.22
Air Quality	0.18	0.20	0.24
Water Quality	0.18	0.04	0
Land Management	0.02	0.02	0.48
Independence	0.34	0.49	0.28
Development	0.33	0.49	0.3
Example	0.14	0.27	0.32
Energy	0.54	0.71	0.34
Taxes	0.21	0.00	0
Infrastructure	0.18	0.24	0.02
Employment	0.79	0.78	0.52
Health	0.14	0.00	0.14
Education	0.40	0.31	0.28
Equipment	0.11	0.27	0.08
Knowledge	0.19	0.40	0.1
Environmental	**0.72**	**0.47**	**0.94**
Economic	**1.56**	**1.96**	**1.24**
Social	**1.51**	**1.33**	**0.96**
Technology Transfer	**0.29**	**0.67**	**0.18**

3.4.5 Trends in sustainable development during the first commitment period

The trends seen for sustainable development benefits vary greatly according to type of technology and type of benefit. Social and economic benefits have been the most claimed on the first commitment period, were hydro projects have always been in the lead. However, especially for economic benefits, growth has stalled, and from 2010 onwards, biomass and wind projects have been delivering higher benefits of this type. The distribution from the three types of renewable energies in environmental benefits has been much more equitable, and although hydro projects began delivering benefits before the rest, biomass quickly caught up, and by the end of 2012 was delivering almost as much social benefits as hydro projects, while wind was left behind. Nonetheless it is important to have in mind that there are 45 wind projects in the sample, 50 biomass and 85 hydro projects, so the latter have the advantage. Especially for economic benefits, wind projects are delivering the least accumulated benefits only because there are fewer projects registered than the other two types, but in average these projects are associated with higher benefits than hydro or biomass projects. Finally, in the case of technology transfer while hydro projects were the only ones providing the transfer of technology during the first year of the commitment period, wind projects started accumulating projects with technology transfers much faster. This has to do with the fact that wind projects deliver more than twice technology transfers than hydro projects and as much as four times more benefits than biomass projects in this category. **Fig. 3.13** presents the evolution over time of environmental benefits during the first commitment period for registered renewable energy projects. **Fig. 3.14**, **Fig. 3.15** and **Fig. 3.16** do the same for economic, social and technology transfer benefits, respectively.

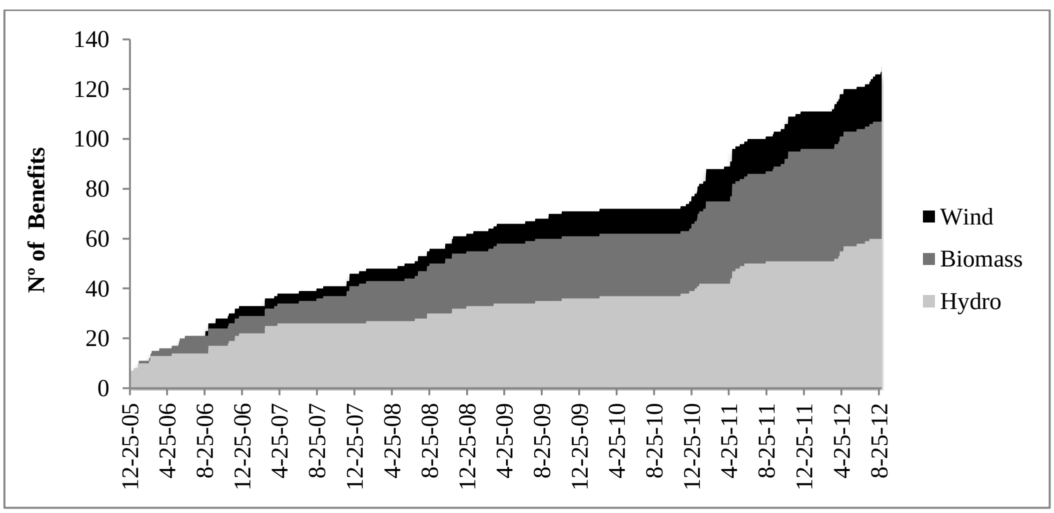

Fig. 3.13: Evolution over time of environmental benefits on renewable energy registered projects. . Source: Author's calculations based on projects' information from UNEP Risφe and UNFCCC.

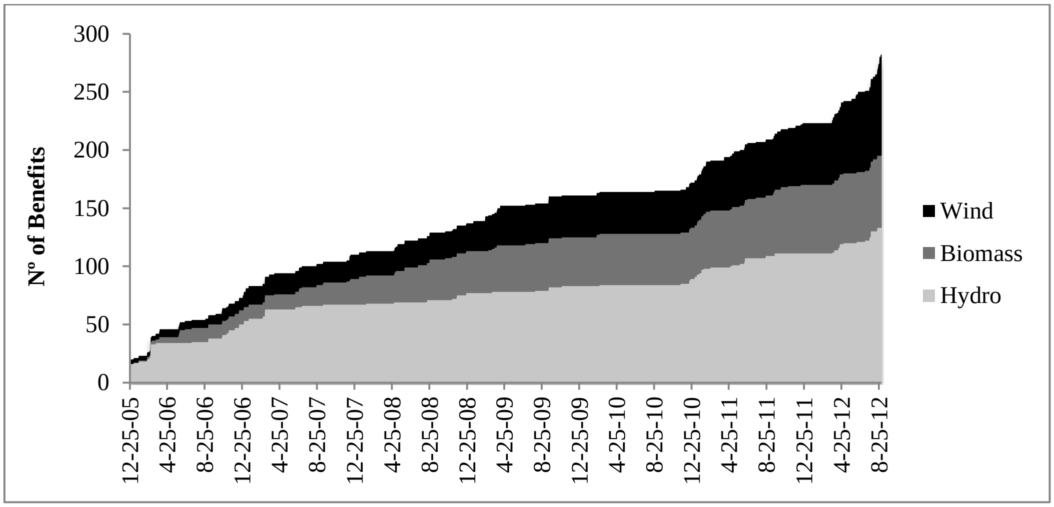

Fig. 3.14: Evolution over time of economic benefits on renewable energy registered projects. Source: Author's calculations based on projects' information from UNEP Risφe and UNFCCC.

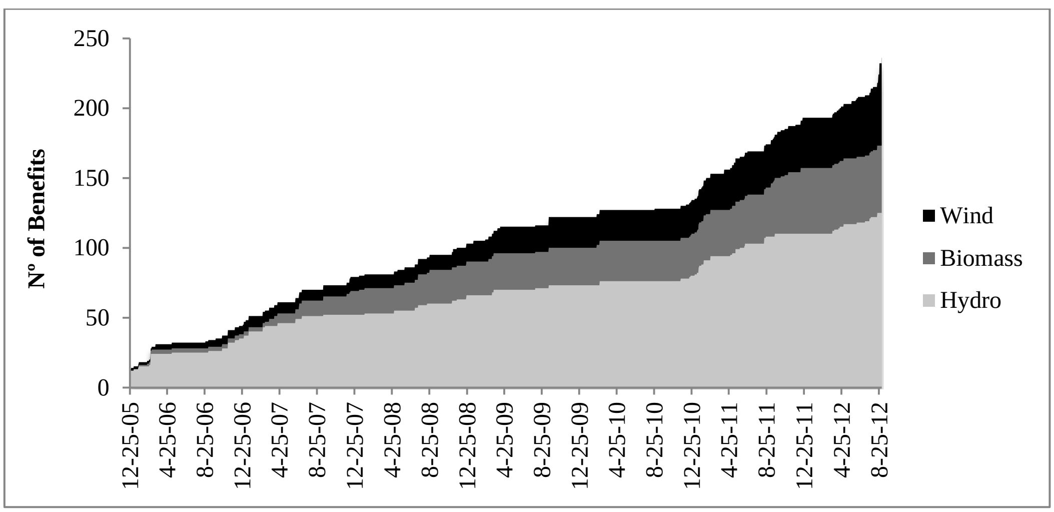

Fig. 3.15: Evolution over time of social benefits on renewable energy registered projects. Source: Author's calculations based on projects' information from UNEP Risφe and UNFCCC.

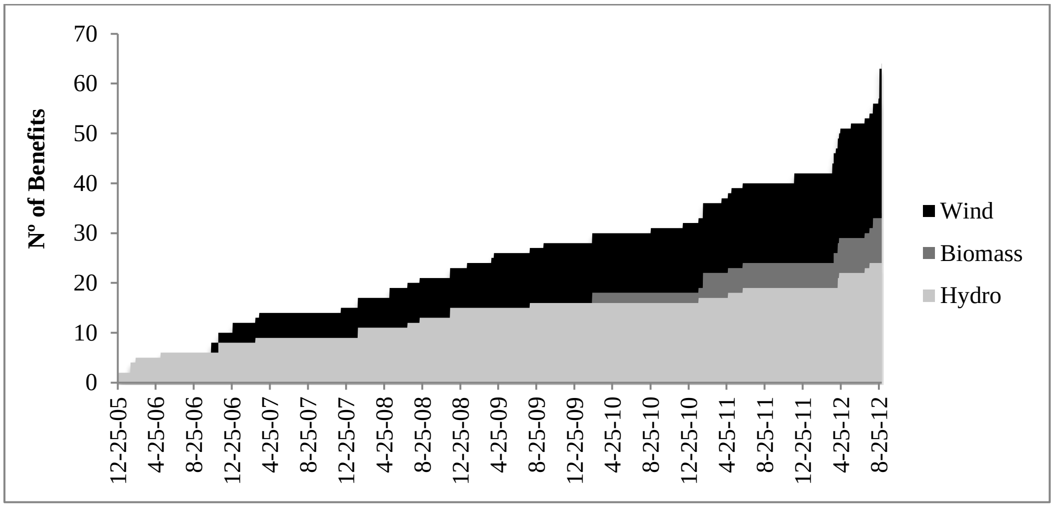

Fig. 3.16: Evolution over time of technology transfer on renewable energy registered projects. Source: Author's calculations based on projects' information from UNEP Risφe and UNFCCC.

3.4.6 Summary and discussion of findings

The sustainability analysis of registered renewable energy CDM projects shows in first place that the most common sustainable benefits provided are the generation of employment, improvements in the energy matrix, development, independence from the importation of fossil fuels and education. From these results and comparing with studies considering all technologies (Olsen and Fenhann, 2008), it can be said that renewable energies contribute more than other types of technologies in the subjects of improving the energy matrix, providing independence from the importations of fossil fuel and by promoting education.

Regarding the distribution amongst host countries, the sustainable development profiles are very heterogeneous, with different countries leading in different categories. Brazil, Chile, Peru and Mexico are the ones most active in CDM, however from this study no connection seems to exist between how active a country is in the CDM and the amount of sustainable development benefits it delivers, results which concur with other investigations (Haites et al., 2006; Olsen and Fenhann, 2008). All renewable energy projects claim at least one type of benefit, but technology transfer is the least developed. The countries with the fewest technology transfer benefits are Bolivia, El Salvador, Guyana and Jamaica, which are also amongst the poorest in Latin America. This is a great concern, since this type of benefit is essential for helping developing countries to develop following a sustainable path, and considering that a replacement to the Kyoto Protocol may involve the inclusion of developing countries into legally binding emission reductions, these countries will be the most unprepared and suffer the greater consequences.

Considering the project's size, large-scale projects provide more economic, social and technology transfer benefits, with the exception of environmental benefits in which small size projects are in the lead, but no significant differences exist amongst the categories. Even if large-scale projects lead in three of the four categories, within the sub-categories the situation still varies, showing no type of tendency. These findings agree with Olsen and Fenhann (2008), who assess all sustainable development benefits and consider project's size, but differ with other investigations focused only on technology transfers (Haites et al., 2006; Dechezleprêtre et al., 2008; Seres et al., 2009) that discover a relation between project's size and technology transfer, which is more likely to occur in large-scale projects usually associated with more foreign participants, thus making technology transfer more common. Although this relationship may be clear if all types of technologies are considered, for renewable energies alone as presented in this research no connection is seen.

Within types of technologies, wind dominated in economic and technology transfer benefits and biomass in environmental, mainly due to land management benefits through avoidance of waste. For social benefits, hydro and wind are similar, with the biggest difference being health benefits in favor of hydro projects. Considering the trends in sustainable development benefits, while hydro projects have the highest accumulated numbers of projects providing benefits, wind many times deliver more but occupy a second position due to fewer registered projects.

In summary, no trends are seen as to whether sustainable development benefits are more common according to scale of projects, host country or type of renewable energy. However, there is more difference in benefits among host countries and type of renewable energy, with wind projects exceling other types more frequently, than with size of projects. Renewable energy is usually one of the categories associated with more sustainable development benefits, so it is worth mentioning that all the projects in the sample exhibit at least one benefit, which suggests that these types of projects do bring sustainable benefits fulfilling at least in theory the dual objectives of CDM for host countries in Latin America. The problem lies within the fact that sustainable development is not regulated, and while projects claim to help in this matter, as no ex-post verification exists and most of the time the population affected by CDM projects do not get to voice their opinions, we cannot prove that sustainable benefits are actually being provided to them.

3.5 Policy implications for CDM to promote sustainable development

In the Conference of Doha it was decided that the guidelines of the replacement document to the Kyoto Protocol would be presented in 2015, to start its operation in 2020 (UNFCCC, 2012). This document is supposed to include developing countries in the efforts to mitigate climate change, by also setting targets on them. However, at the end of the first commitment period sustainable development, and especially technology transfer, had not reached the poorest countries. For example in countries in Africa renewable energies have barely been developed because of poor institutional frameworks and infrastructure, lack of policies to plan these technologies and of skilled labor and strategies to promote cleaner energies (Karekezi and Kithyoma, 2003). That is why it is fundamental to help these countries to develop institutional capacities and provide them funds to be able to attract CDM projects. This is also why renewable energies need to be promoted, for which several measures have been discussed, like long-term governmental programs, setting standards for equipment, buildings and cars to limit their amount of emissions. Also, by increasing the performance of these technologies, investment requirements should drop down (Brown et al., 2001; Karekezi and Kithyoma, 2003; Geller et al., 2004). Another method to promote renewable energies has been widely studied and corresponds to establishing taxes in order to internalize the externalities of those who emit higher GHGs, which on one hand helps to promote renewable energies, but on the other also provides an incentive for existing technologies to increase their efficiency, thus reducing other pollutants (Baranzini et al., 2000; Midttun, 2003; Owen, 2004, Owen, 2005). An energy/CO2 tax was proposed in Europe in 1992, but after strong opposition from businesses it had to be removed (Dunkerley, 2006). Technology transfer is fundamental in sustainable development since it provides energy security, helps to mitigate climate change and eradicate poverty while preserving the environment (Martinot et al., 1997; Khatib, 2000). If technology is adopted on time by developing countries, it can provide them a way to grow following a sustainable path while their contribution to current concentrations of GHG are still small compared to developed countries, and not to repeat the same mistakes made by the latter (Goldemberg, 1992, Goldemberg et al., 1998).

An important critic surrounding the problem with sustainable development, is that even though PDDs are made public in the Internet before registering (Boyd et al., 2009), that limits the stakeholders who can review the claims made for sustainable development since usually the poorest population in most need of these benefits do not have the access to go online and read the documents. That is why DNAs should include in their approval of projects a verification of the stakeholders' opinions, and not bound them to what project developers chose as stakeholders for their PDDs, which in many cases might be biased for their own economical desires to get the project approved.

Since sustainability was left to countries sovereignty, no international standard exists to measure the benefits provided by projects. Albeit it might be true that countries have the right to set their own requirements as they are supposed to know what is better for themselves, still an international standard should be established setting the base for the minimum benefits that a project should contribute with. For this purpose, the categories and sub-categories defined in this article may be used as a checklist, and a certain percentage of benefits to be fulfilled according to the project type should be established. In that way countries could still make their own requests, whilst submitting the projects developed in them to a standardized measure in order to ensure more equity amongst host countries. Another way to promote sustainable developments would be to lower transaction costs according to the amount of benefits that the project presents. For this a detailed quantitative and not only qualitative measure would be needed, for example the temporary and definite employments generated should be weighted differently, also the amount of jobs provided according to the size of the project should be taken into account. Furthermore, it is fundamental that an ex-post verification of sustainable development benefits exists: for DOEs to go to the project's site and validate how the community has been actually aided by the project.

Many of the changes needed were not defined in Doha for the second commitment period. That is why the replacement document of the Kyoto Protocol needs to address these problems and give CDM the importance it should have as the main effort to help developing countries to prepare for climate change. Boyd et al. (2009), state that a possibility would be to remove CDM from the Kyoto structure and place it directly under the UNFCCC in order to enable a renegotiation of the treaty, placing CDM at the center of the effort to bring sustainable development to the poorest nations. Since the successor of Kyoto is now to be soon developed, it would be a good time to restructure the whole framework, and considering that CDM did not achieve the success it expected, it is more necessary that ever to reconsider how the protocol was defined and change it in order to both include the most polluting developed countries and to help developing countries to tackle climate change.

3.6 Conclusions

This paper has studied the performance of renewable energy CDM projects concerning sustainable development, confirming that the mechanism has failed at this purpose. Renewable energies are usually associated with the highest benefits, however the uncertainty surrounding the second commitment period whether CDM would continue to be valid hurt this type of project since they require greater investments in infrastructure and for that stability and continuity are required.

The sample of projects presents no tendencies between sustainable development and a host country's activeness in CDM, the project's size or a clear leadership of any kind of technology within renewable energies. Nonetheless, benefits are much more heterogeneous when considering host countries or types or technology than with project's size. The likelihood of providing benefits varies greatly across types of technology, with wind projects providing higher sustainable benefits in the economic and technology transfer category and biomass projects providing greater environmental benefits, mainly due to land management. For social benefits hydro and wind projects are fairly similar, with the biggest difference in favor of hydro projects being the delivery of health benefits. Amongst all categories technology transfer is the least developed, with average benefits per project far below the rest of the categories. In fact, the countries presenting no technology transfer in Latin America: Bolivia, El Salvador, Guyana and Jamaica are amongst the poorest in Latin America, and as technology transfer is an essential help for developing countries to grow without polluting as much as developed countries have done so far, if binding emissions are set for developing countries in the future as it has been announced for the successor of the Kyoto Protocol, these countries will be the most unprepared.

Although all renewable energy projects claimed to contribute with at least one type of benefit, these statements are not checked after the project is registered, nor are the stakeholders amongst the poorest population consulted for their opinion. That is why urgent action is needed in order to regulate the sustainable development aspect of the CDM so that it can fulfill its potential and at the same time provide justice for developing countries if emission reduction targets are to be set upon them. The proposed policies consider in the first place the crucial need to help the most impoverished countries to develop institutional capacities so the can attract CDM projects. At the same time DNAs should verify stakeholders' opinions before issuing a letter of approval, and not just limiting their analysis to what project developers present in the PDDs. On the same matter an international standard should be set in spite of the country's sovereignty right to decide upon their own sustainability requirements, since this framework has proved to be inefficient in terms of sustainable development. The definition of the categories and sub-categories used in this article may help in this matter as a checklist, but other incentives such as lowering transaction costs for projects presenting more types or quantities of benefits (which should be previously defined), would encourage project developers to ensure real sustainable development benefits.

Finally, considering that the successor of the Kyoto Protocol is soon to be developed, it would be a good time to restructure the whole framework and consider the possibility of separating CDM from the protocol and making it the center mechanisms of the United Nations aimed to help developing countries to adapt to climate change and at the same time to develop following a cleaner path.

4 References

Au Yong, H. W. (2009). Investment additionality in the CDM. *Econometrica* Technical Paper. Available at http://www. ecometrica. co. uk/wp-content/uploads/Technical_Paper_-_Investment_Additionality_in_the_CDM. Pdf, last viewed 23 July, 2013.

Baranzini, A., Goldemberg, J., Speck, S. (2000). A future for carbon taxes. Ecological Economics, 32, 395–412.

Benessaiah, K. (2012). Carbon and livelihoods in Post-Kyoto: Assesing voluntary carbon markets. Ecological Economics, 77,1-6.

Bergqvist, M. M., Samuel Wårdh, K., Das, A., & Ahlgren, E. O. (2008). A techno‐economic assessment of rice husk‐based power generation in the Mekong River Delta of Vietnam. International Journal of Energy Research, 32(12), 1136-1150.

Besant-Jones, J. E. (2006). Reforming power markets in developing countries: what have we learned?. Washington, DC: World Bank.

Bode, S., & Michaelowa, A. (2003). Avoiding perverse effects of baseline and investment additionality determination in the case of renewable energy projects. Energy Policy, 31(6), 505-517.

Boyd, E., Hultman, N., Rimmons, J., Corbera, E., Cole, J., Bozmoski, A., Ebeling, J., Tippman, R., Mann, P., Brown, K. & Liverman, D. (2009). Reforming the CDM for sustainable development: lessons learned and policy futures. Environmental Science and Policy, 12(7). 820-831.

Brown, M. A., Levine, M. D., Short, W., & Koomey, J. G. (2001). Scenarios for a clean energy future. Energy policy, 29(14), 1179-1196.

Capoor, K., & Ambrosi, P. (2006). State and trends of the carbon market 2006. World Bank Carbon Finance Unit.

Capoor, K., & Ambrosi, P. (2008). State and trends of the carbon market 2006. World Bank Carbon Finance Unit.

Chadwick, B. P. (2006). Transaction costs and the clean development mechanism. Natural Resources Forum, 30(4), 256–271.

Cormier, A., & Bellassen, V. (2012). The risks of CDM projects: How did only 30% of expected credits come through?. Energy Policy.

Cosbey, A., Parry, J. E., Browne, J., Babu, Y. D., Bhandari, P., Drexhage, J., & Murphy, D. (2005). Realizing the development dividend: Making the CDM work for developing countries. International Institute for Sustainable Development= Institut international du développement durable.

Dechezleprêtre, A., Glachant, M., & Ménière, Y. (2008). The Clean Development Mechanism and the international diffusion of technologies: An empirical study. Energy Policy, 36(4), 1273-1283.

De Coninck, H., Fischer, C., Newell, R. G., & Ueno, T. (2008). International technology-oriented agreements to address climate change. Energy Policy,36(1), 335-356.

Diakoulaki, D., Georgiou, P., Tourkolias, C., Georgopoulou, E., Lalas, D., Mirasgedis, S., & Sarafidis, Y. (2007). A multicriteria approach to identify investment opportunities for the exploitation of the clean development mechanism. Energy Policy, 35(2), 1088-1099.

Dorian, J. P., Franssen, H. T., & Simbeck, D. R. (2006). Global challenges in energy. Energy Policy, 34(15), 1984-1991.

Dunkerley, J. (2006). Lessons from the past thirty years. Energy policy, 34(5), 503-507.

Efficiency, E. (2005). CDM INVESTMENT NEWSLETTER.

Ellis, J., Winkler, H., Corfee-Morlot, J., & Gagnon-Lebrun, F. (2007). CDM: Taking stock and looking forward. Energy Policy, 35(1), 15–28.

Finon, D., & Perez, Y. (2007). The social efficiency of instruments of promotion of renewable energies: A transaction-cost perspective. Ecological Economics,62(1), 77-92.

Fujime, K. Assessment of Market Systems for CO2 Emissions Trading As Environmental Policy Options, with Special Emphasis on Evaluation of Intertemporal Trading.

Geller, H., Schaeffer, R., Szklo, A., & Tolmasquim, M. (2004). Policies for advancing energy efficiency and renewable energy use in Brazil. Energy Policy, 32(12), 1437-1450.

Global Finance, 2013. The Richest and Poorest Countries in The World, 2013. Available at < http://www.gfmag.com/component/content/article/119-economic-data/12537-the-poorest-countries-in-the-world.html#axzz2Ys1c5t8h>, last viewed 12 July, 2013.

Goldemberg, J. (1992). Energy, technology, development. Ambio, 14-17.

Goldemberg, J., Reid, W., Suárez, C. E., Salatai, E., Amaral, W., do Santos, A. A., ... & Baumert, K. (1998). Promoting development while limiting greenhouse gas emissions. United Nations Development Programme.

Greiner, S., & Michaelowa, A. (2003). Defining investment additionality for CDM projects—practical approaches. Energy Policy, 31(10), 1007-1015.

Haites, E., Duan, M., & Seres, S. (2006). Technology transfer by CDM projects. Climate Policy, 6(3), 327-344.

Hindustian Times, 10 September 2012, Gangadhar Patil. Carbon credit fraud: How big firms faked green to mint gold. The Hindustian Times, Mumbai, India. Available at <http://www.dnaindia.com/mumbai/report_carbon-credit-fraud-how-big-firms-faked-green-to-mint-gold_1738940>, last viewed, 27 June 2013.

IEP, Global Peace Index 2012. Institute for Economics and Peace.

International Monetary Fund, 2012. World Economic Outlook Database. Available at < http://www.imf.org/external/pubs/ft/weo/2013/01/weodata/weorept.aspx?pr.x=29&pr.y=16&sy=2013&ey=2013&scsm=1&ssd=1&sort=country&ds=.&br=1&c=311%2C336%2C213%2C263%2C313%2C268%2C316%2C343%2C339%2C273%2C218%2C278%2C223%2C283%2C228%2C288%2C233%2C293%2C238%2C361%2C321%2C362%2C243%2C364%2C248%2C366%2C253%2C369%2C328%2C298%2C258%2C299&s=PPPPC&grp=0&a=>, last viewed 3 July 2013.

Jefferson, M. (2006). Sustainable energy development: performance and prospects. Renewable energy, 31(5), 571-582.

Jhirad, D. (1990). Market potential of renewable energy technology. Non-conventional energy, Wiley Eastern Ltd., India, 7.

Karekezi, S., Kithyoma, W., & Initiative, E. (2003, June). Renewable energy development. In workshop on African Energy Experts on Operationalizing the NEPAD Energy Initiative, June (pp. 2-4).

Kearney, A. T. (2012). AT Kearney foreign direct investment confidence index.

Khatib, H. (2000). energy security. World Energy Assessment: Energy and the Challenge of Sustainability. New York: United Nations Development Programme (UNDP), United Nations Department of Economic and Social Affairs, and World Energy Council, pp113–114.

Kolshus, H. H., Vevatne, J., Torvanger, A. & Aunan, K., (2001). Can the Clean Development Mechanism attain both cost-effectiveness and sustainable development objectives ?. Center for International Climate and Environmental Research, Oslo.

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

Kossoy, A. & Guigon, P. (2012). State and trends of the carbon market 2012. World Bank Carbon Finance Unit.

Lee, H., Park, T., Kim, B., Kim, K., & Kim, H. (2012). A real option-based model for promoting sustainable energy projects under the clean development mechanism. Energy Policy.

Liu, X. (2008). Rent extraction with a type-by-type scheme: An instrument to incorporate sustainable development into the CDM. Energy policy, 36(6), 1873-1878.

Martinot, E., Sinton, J. E., & Haddad, A. B. M. (1997). International technology transfer for climate change mitigation and the cases of Russia and China.Annual review of energy and the environment, 22(1), 357-401.

Martinot, E., Chaurey, A., Lew, D., Moreira, J. R., & Wamukonya, N. (2002). Renewable energy markets in developing countries*. Annual Review of Energy and the Environment, 27(1), 309-348.

Masini, A., & Menichetti, E. (2012). Investment decisions in the renewable energy sector: An analysis of non-financial drivers. Technological Forecasting and Social Change.

Metz, B., & Turkson, J. K. (Eds.). (2000). Methodological and Technological Issues in Technology Transfer: A Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Midttun, A., & Koefoed, A. L. (2003). Greening of electricity in Europe: challenges and developments. Energy policy, 31(7), 677-687.

Monjas-Barroso, M., & Balibrea-Iniesta, J. (2013). Valuation of projects for power generation with renewable energy: A comparative study based on real regulatory options. Energy Policy.

Muller, A. (2007). How to make the clean development mechanism sustainable—The potential of rent extraction. Energy Policy, 35(6), 3203-3212.

Nussbaumer, P. (2009). On the contribution of labelled Certified Emission Reductions to sustainable development: A multi-criteria evaluation of CDM projects. Energy Policy, 37(1), 91–101.

Olsen, K. H. (2007). The clean development mechanism's contribution to sustainable development: a review of the literature. Climatic Change, 84(1), 59-73.

Olsen, K. H., & Fenhann, J. (2008). Sustainable development benefits of clean development mechanism projects: A new methodology for sustainability assessment based on text analysis of the project design documents submitted for validation. Energy Policy, 36(8), 2819-2830.

Owen, A. D., Hanley, N., & Owen, A. D. (Eds.). (2004). The economics of climate change. New York: Routledge.

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

Pachauri, R. K. (1998). Some early next steps. Climate Changes-Post Kyoto perspectives from the South". TERI.

Peters-Stanley, M., Hamilton, K. E Marketplace (2011). Back to the Future: State of the Voluntary Carbon Markets 2011. Washington DC, London, The EcoSystem Marktplace, New Carbon Finance.

Peters-Stanley, M., Hamilton, K. (2012). Developing Dimension: State of the Voluntary Carbon Markets 2012. Washington DC, London, The EcoSystem Marktplace, New Carbon Finance.

Philibert, C., & Senior Consultant, U. N. E. P. (1998). The Clean Development Mechanism: An economic approach to "environmental additionality". Ad-hoc International Working Group on the Clean Development Mechanism.

Purohit, P. (2008). Small hydro power projects under clean development mechanism in India: A preliminary assessment. Energy Policy, 36(6), 2000-2015.

Rose, A., & Wei, D. (2008). Greenhouse gas emissions trading among Pacific Rim countries: An analysis of policies to bring developing countries to the bargaining table. Energy Policy, 36(4), 1420-1429.

Schneider, L. (2007). Is the CDM fulfilling its environmental and sustainable development objectives? An evaluation of the CDM and options for improvement. Öko-Institut for Applied Ecology, Berlin, 248, 1685-1703.

Schneider, M., Holzer, A., & Hoffmann, V. H. (2008). Understanding the CDM's contribution to technology transfer. Energy Policy, 36(8), 2930-2938.

Schneider, M., Schmidt, T. S., & Hoffmann, V. H. (2010). Performance of renewable energy technologies under the CDM. Climate Policy, 10(1), 17-37.

Seres, S., Haites, E., & Murphy, K. (2009). Analysis of technology transfer in CDM projects: An update. Energy Policy, 37(11), 4919-4926.

Shrestha, R. M., & Timilsina, G. R. (2002). The additionality criterion for identifying clean development mechanism projects under the Kyoto Protocol. Energy Policy, 30(1), 73-79.

Srivastava, L., & Rehman, I. H. (2006). Energy for sustainable development in India: Linkages and strategic direction. Energy Policy, 34(5), 643-654.

Sutter, C. (2003). Sustainability Check-Up for CDM Projects: Multi-Criteria Assessment of Energy Related Projects Under the Clean Development Mechanism of the Kyoto Protocol. Zürich: ETH.

Sutter, C., & Parreño, J. C. (2007). Does the current Clean Development Mechanism (CDM) deliver its sustainable development claim? An analysis of officially registered CDM projects. Climatic change, 84(1), 75-90.

Tang, A., Chiara, N., & Taylor, J. E. (2012). Financing renewable energy infrastructure: Formulation, pricing and impact of a carbon revenue bond. Energy Policy, 45, 691-703.

Toth, F. L., Petschel-Held, G., & Bruckner, T. (1998, September). Kyoto and the long-term climate stabilization. In OECD Workshop on Climate Change and Economic Modelling, Background Analysis for the Kyoto Protocol, September 17 (Vol. 18).

UNDP, Human Development Report 2013. United Nations Development Programme.

UNFCCC (1997) Kyoto Protocol to the United Nations Framework Convention on Climate Change. FCCC/CP/1997/L.7/Add.1. 10 December 1997: 24 pp.

UNFCCC (2007b). Investment and Financial Flows To address Climate Change, Bonn.

UNFCCC. 8 December 2012, Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP) (8 December 2012), Outcome of the work of the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol. Draft decision proposed by the President (EN). Notes: Agenda item 4: Report of the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol. Meeting: Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP), Eighth session, 26 November - 7 December 2012, Doha, Qatar. FCCC/KP/CMP/2012/L.9, Geneva, Switzerland: United Nations Office, pp.6-7

UNODC, Homicide Statistics 2012. United Nations Office on Drugs and Crime.

van der Gaast, W., Begg, K., & Flamos, A. (2009). Promoting sustainable energy technology transfers to developing countries through the CDM. Applied Energy, 86(2), 230-236.

Verbruggen, A. (2009). Beyond Kyoto, plan B: A climate policy master plan based on transparent metrics. Ecological economics, 68(12), 2930-2937.

Weiss, P., Lefèvre, T., & Möst, D. (2008). Modelling the impacts of CDM incentives for the Thai electricity sector. Energy Policy, 36(3), 1134-1147.

Winkelman, A. G., & Moore, M. R. (2011). Explaining the differential distribution of Clean Development Mechanism projects across host countries. Energy Policy, 39(3), 1132-1143.

Xingang, Z., Xiaomeng, L., Pingkuo, L., & Tiantian, F. (2011). The mechanism and policy on the electricity price of renewable energy in China. Renewable and Sustainable Energy Reviews, 15(9), 4302-4309.

Yang, M., Nguyen, F., De T'Serclaes, P., & Buchner, B. (2010). Wind farm investment risks under uncertain CDM benefit in China. Energy Policy, 38(3), 1436-1447.

Yunna, W., & Quanzhi, C. (2011). The demonstration of additionality in small-scale hydropower CDM project. Renewable Energy, 36(10), 2663-2666.

Zhang, Z. (2006). Toward an effective implementation of clean development mechanism projects in China. Energy Policy, 34(18), 3691-3701.