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Opportunities to Use the Clean Development Mechanism (CDM) and Other Options to Face the Climate Change. An Application to Peru.

Master's Thesis within the Nordic Master in Innovative Sustainable Energy Engineering

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Master of Science Thesis

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Cover pictures:
[Left] Seedlings for reforestation, photo by *Nina Pardo*, [Center] View of Aricota hydropower plant in Tacna-Peru, photo by *CESEL Ingenieros*, [Right] Transportation in Lima, photos by *Peru.com* and *La República*.

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Opportunities to Use the Clean Development Mechanism (CDM) and Other Options to Face the Climate Change. An Application to Peru.

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Abstract

Climate change is forcing countries to increase their awareness and their actions to mitigate and/or adapt to the new situation. Recognizing their responsibility in the historical accumulation of anthropogenic greenhouse gases (GHG) in the atmosphere (widely accepted as the main cause of the global warming), most of the developed countries accepted binding targets for their emissions. To keep their emissions inside the limits or to offset their excess, these countries develop mitigation actions worldwide, which at the same time produce incomes through the transaction of carbon credits in the carbon markets.

Peru is one of the countries were these mitigation actions are applied. The country has good potential to develop carbon projects in the energy and forest sectors, but the actions have been very limited until now: Peru only holds 0.7% of the total incomes generated.

This thesis has the objective of analyzing and presenting the current situation of Peru as a host country of climate change mitigation actions financed by the carbon markets. Nowadays, the country has more information available than ever, but the independence of the involved sectors keep environmental, energy and investments information separated among them, making it difficult for investors to have a broad idea of the situation. Thus, this paper also aims to join dispersed research efforts in order to make visible the current state, the trends of investments, as well as the barriers and opportunities that the carbon markets face in Peru.

As a result of the investigation, it was clarified that Peru's industrial sector is small, being transportation sector the principal energy consumer and a potential area for developing carbon projects. Even though it's relatively small size, the power sector offers profitable opportunities of investment, highly attractive to be complemented with incomes from carbon sales. Finally, the forest sector, which is Peru's main source of GHG emissions due to deforestation, holds the largest potential for developing carbon projects by implementing reforestation and conservation actions. Forest projects are needed, not only due to the business opportunities, but to avoid destroying one of the most valuable resources of the country: its biodiversity.

Recent environmental information is lacking, so mainly data from year 2000 was used.

Keywords:
Peru, carbon markets, Clean Development Mechanism, CDM, voluntary carbon market, GHG emissions, energy, reforestation.

ACKNOWLEDGEMENTS

Writing this Thesis represented much more than just making a document of academic investigation: I got to know my country much better, and I understood the importance and need of taking action in order to create more opportunities in Peru for the Peruvian people.

Ending this short road would not have been possible without the help, contribution or even just unplanned intervention of some people, whom I want to thank here.

First, I want to thank my Thesis's Supervisor, Mr. Germán Maldonado, from the Division of Energy Technology in Chalmers Tekniska Högskola for his invaluable help with practical details and the time we invested together in discussions about the developing countries, the real role of the international cooperation and analyzing some options to improve the current situation.

These two years studying in Europe gave me the chance to meet great friends and colleagues: my days in Stockholm, Copenhagen and Gothenburg were always interesting and certainly productive thanks to you guys. The list is long and I cannot mention everyone here, so I have to summarize it saying that it has been a pleasure to meet you: Ajeet, Pedro, Tuyet, Michele, my dear Group 15 in Copenhagen, Michail, Delia, Sean, Kostas and in general to all my good friends in the Royal Institute of Technology (KTH), Technical University of Denmark (DTU) and in Chalmers University of Technology. Thank you so much to you all for your positive influence and the most important: for your real friendship.

Perú, mi querido país. Aunque físicamente lejano, te he mantenido siempre cerca a mí. Vine aquí pensando en ti, y termino esta etapa hablando de ti. Sin duda nunca nos separamos, y me alegra.

Quiero terminar agradeciendo a las personas que desde lejos siempre estuvieron conmigo: Gracias a mi familia, y gracias a ti Jani. He sentido en todo momento su apoyo y he disfrutado cada conversación que tuvimos a la distancia durante este tiempo. Gracias por sus consejos y constantes palabras de ánimo, sepan que los he tomado siempre en cuenta y en verdad me han ayudado. Costó separarnos, pero aquí empieza nuestra retribución. Esto es en parte de ustedes.
Muchas gracias, ¡los quiero mucho!

Compared to what I knew before coming to Europe, I feel now that my view of the world is definitely much broader. I feel glad of having had this experience, even though now I know there are much more steps to be walked than I thought before. However, that is something good: more challenges, more work to be done, which finally means… more life.

Thank you very much. I hope you find this work interesting.

Carlos Quiroz Melgar
Göteborg, 2012

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List of Acronyms

A/R	Afforestation/reforestation
AWG-C	Ad-hoc Working Group on Long-Term Cooperative Action under the Convention
AWG-KP	Ad-hoc Working Group under the Kyoto Protocol
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	CO2 equivalent
COES	Comission of Economic Operation of the Peruvian Electric System
COP	Conference of the Parties (Kyoto Protocol)
DNA	Designated National Authority
DOE	Designated operational entity
DREM	Regional Direction of Energy and Mines
EB	Executive Board of the UNFCCC
ERPA	Emission Reduction Purchase Agreement
ET	Emissions Trading
FONAM	National Fund of the Environment
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GoP	Government of Peru
GWP	Global Warming Potential
HDI	Human development Index
HFC	Hexafluocarbons
INEI	National Institute of Statistics and Informatics
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Return Rate
KP	Kyoto Protocol
LDC	Least Developed Countries
LULUCF	Land Use, Land Use Change and Forestry
MINAM	Ministry of Environment
MINEM	Ministry of Energy and Mines
MSW	Municipal solid waste
MUSD	Million US dollars
N_2O	Nitrous oxide
NAMAS	National Mitigation Actions
OSINERGMIN	Supervisor Organism of Investments in Energy and Mining
PAAMCC	National Action Plan for Adaptation and Mitigation against Climate Change
RDF	Refuse derived fuel
REDD	Reducing Emissions from Deforestation and Forest Degradation
RER	Renewable energy resources
SF_6	Sulfur hexafluoride
SIDS	Small Islands Developing States
UNFCCC	United Nations Framework Convention on Climate Change
USD	US dollars
VCM	Voluntary Carbon Markets

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1. INTRODUCTION

Climate change is occurring. Independently from the discussion about the anthropogenic origin of the global warming in the planet, temperature is getting higher over the world and its consequences are affecting especially the developing countries, where resources for adaptation are scarcer.

The United Nations through the U.N. Framework Convention on Climate Change (1992) developed a strategy to fight against the climate change by decreasing the anthropogenic emissions of greenhouse gases (GHG). With the entry into force of the Kyoto Protocol (1997), emissions binding targets were determined for the developed countries, as historically they were who emitted most of the GHG currently accumulated in the atmosphere. The Protocol defined flexible mechanisms that permitted developed countries to reduce their emissions outside from their borders, in order to maximize the efficiency of their reduction efforts. One of these mechanisms, called Clean Development Mechanism (CDM), permits developed countries to perform their reduction actions in developing countries, maximizing the use of resources, transferring technology and helping to the sustainable development of the host country.

Peru is a developing country. Almost 60% of its territory is covered by forests, which includes part of the Amazon rainforest. Peru has been experiencing continuous economic growth, which is reflected in the increase of the demand of energy and the growing consumption of resources.

Peru is not a large emitter of GHG. The country's industry is relatively small and its power generation sector is clean due to a high hydroelectric component. However, its condition of tropical country and the large economic unbalance inside the country are the cause of a continuous and dangerous deforestation: 150 000 ha of forests are destroyed annually, mainly due to slash-and-burn practices to increase agricultural land in the Amazon region. Deforestation destroys natural carbon sinks, freeing the carbon dioxide (CO_2) present in biomass to the atmosphere (carbon dioxide is one of the GHG). Measures to control deforestation and GHG emissions in the country are resource scarce, thus achieving poor results.

The availability of energy resources, large forest areas and the world experience in the use of mechanisms against climate change have opened a window to Peruvian investors. By utilizing cleaner energy sources, recovering and protecting forests and putting more interest into the carbon market, they have the opportunity to run a profitable business while collaborating with the fight against climate change.

This thesis is made to analyze the current situation of the application of the mechanisms to face the climate change in Peru, to give the interested investors a general view of the carbon market and its potential, and to analyze the interests of current investors in this market.

1.1. OBJECTIVE

This thesis has two main objectives:

a. To analyze the current situation of use of the Clean Development Mechanism (CDM) and other carbon market mechanisms in Peru.

b. To analyze the possibilities of increasing the use of those mechanisms in sustainable investments.

1.2. Question formulation

The following questions are expected to be answered as a result of this work:

a. Should Peru put attention on the climate change-associated business?

b. What are the investment opportunities in carbon markets in Peru? What is required for investing on it?

c. Is CDM suitable for energy projects in Peru? What type of projects is it suitable for?

d. What are the expectations for carbon markets in Peru in a post-2012 scenario?

1.3. Methodology

This Thesis required carrying out an extensive literature review about climate change, the institutions that work trying to control it, the mechanisms developed with that aim and the relationship between this established system and Peru. The research about local (i.e. in Peru) greenhouse emissions, related institutions and the carbon markets has been extensive as well. The content of this work has been organized so that the reader can get to know the current and future situation of the carbon markets in Peru, as well as the existent investment opportunities.

In Section 2 information about the situation of climate change in the world as well as the measures designed to try to control it are presented. These actions, which are centered in reducing the emissions of greenhouse gases (GHG) to the atmosphere, have created global carbon dioxide markets which are central in this investigation. In this Section the following questions are answered:

What are the global actions to face and control the climate change? How have these actions been performing? What are the markets generated through these actions? What is the future of these actions?

In Section 3 the situation of climate change in Peru is presented. GHG emission levels of different sectors and the country's organizations involved in control are shown. Thus, the most pollutant sectors are identified, which is basis for following analysis. The questions answered here are:

What is Peru's level of greenhouse gases emissions? What sectors are the main sources of Peru's emissions?

In theory, the sectors with highest levels of GHG emissions should present the majority of opportunities to develop GHG emission reduction projects and participate in the carbon markets. For this reason, only the sectors with the highest level of emissions are analyzed in order to determine the potential for project's development. The question to be answered is:

What is the potential for developing greenhouse gases emissions reduction projects in the most relevant sectors, i.e. energy and forestry sector?

In Section 4 these relevant sectors are analyzed in more detail. Involved organizations and legal procedures related to the development of carbon projects in each sector are shown. Some projects already applied in Peru or suitable of being applied are described, including calculations and their positive or negative outcomes. This Section's aim is to show good initiatives that could be used by new project investors.

In Section 5 the carbon projects that have been developed in Peru until the early 2012 are analyzed. The aim is identifying a trend that project investors have been following so that the scenario of future developments in the carbon markets could be determined.

In Section 6 all the information presented during the report is discussed in order to form a compact picture of the situation. An important outcome here is identifying potential barriers that an investor will probably face when planning a carbon project in Peru.

Finally, the conclusions from this work are presented in Section 7.

2. Actions against Climate Change

The term "climate change" refers to all forms of climatic unsteadiness, which is any difference between long-term statistical values of the meteorological parameters calculated for different periods but relating to the same geographical area. Climate change may result from factors such as changes in solar activity, changes in the planet's orbital elements, natural internal processes of the climate system, or anthropogenic forcing (source: *NSIDC, 2012*).

2.1. Greenhouse Effect and Global Warming

The greenhouse effect is a natural phenomenon that occurs when radiation coming out from the earth is reflected in the atmosphere, returning to the surface and heating it. Without this phenomenon, the temperature in our planet would be at least 33°C colder. An energy balance in the surface of the earth is shown in Figure 2-1 (source: *IPCC b, 2007*). Near half of the incoming solar radiation (168 Wm^{-2}) is absorbed by the surface. In turn, the earth surface reacts emitting energy in form of infrared radiation (350 Wm^{-2}), which is partly reflected to the earth's surface by the layer of gases in the atmosphere. That re-incoming radiation causes the greenhouse effect.

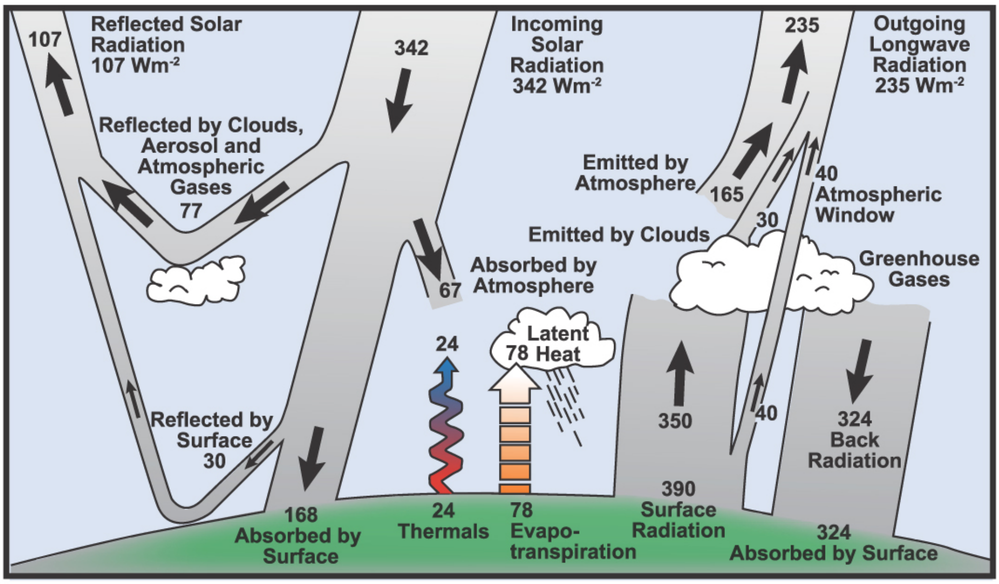

Figure 2-1. Energy balance in earth's surface (IPCC b, 2007)

There are several gases that cause the greenhouse effect. The most abundant ones are water vapor (H_2O) and carbon dioxide (CO_2). Water vapor is part of the natural cycle of the planet. The contribution of human is too small to be representative in comparison with the natural processes. However, CO_2 is a different case, since it is well known that human activities are an important source of emissions (through fossil fuel combustion in vehicles, power plants, etc.).

The concentration of CO_2 in the atmosphere has increased rapidly during last two centuries. Studies made on ice cores permitted to known the concentration of greenhouse gases in the atmosphere since thousands of years ago. Figure 2-2 shows the change in concentration of CO_2 for the last 10 000 years, where an increasing trend is clear from middle-19th century. IPCC's analysis of ice cores reveal that current CO_2 concentration, around 396 ppm (in Mauna Loa observatory, source: *CO2now, 2012*), is far above the values for the last 650 000 years (180 to 300 ppm) (*IPCC, 2007*).

Measures in different parts of the planet give additional evidence for the rising of temperature. Figure 2-3 (adapted from *IPCC b, 2007*) shows results from measures made in different parts of the planet, with different methods and under different studies. They coincide in one thing: the trend increases from the beginning of 20th century.

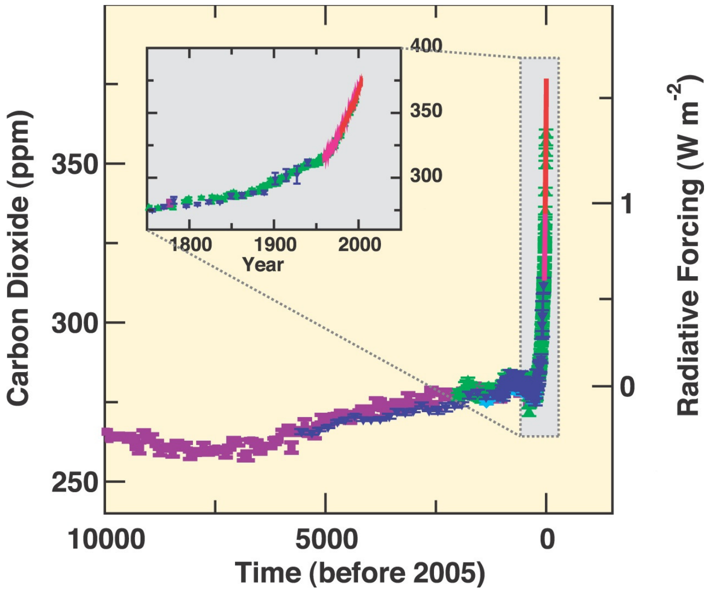

Figure 2-2. Change of CO_2 in the ice cores from 10 000 years ago (IPCC, 2007)

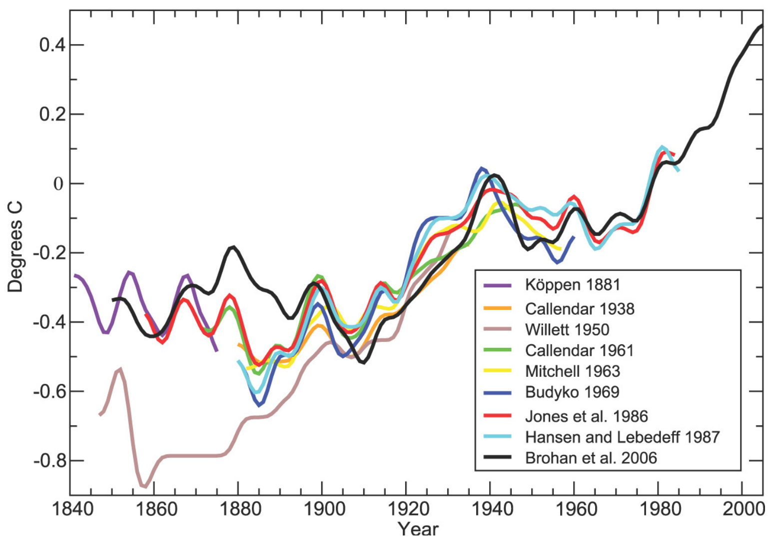

Figure 2-3. Temperature time series measured in different zones of the planet (IPCC b, 2007)

The period where CO_2 concentration increases coincides with the period when humanity increased the use of fossil fuels, especially petroleum, which began to be extracted in large volumes since 1859 (Drake's first well in Pennsylvania).

A direct analysis of these coincidences could suggest that temperature in the earth is increasing due to increase of concentration of CO_2 in the atmosphere, which in time is caused for anthropogenic emissions due to combustion of fossil fuels. However, the interaction between all involved factors is more complicated. In fact, the complexity of the climate system is a scientific challenge that could be likely solved through experiments at global scale, which is in practice, near to impossible (*Rydén, 2008*).

Even though discussions arise about the certainty of the science behind global warming, it is true that climate is changing around the world. Consequences of global warming are becoming clear: increase of sea levels, temperatures, change in length of seasons are signal that risks of a change in the climate system are high for humanity. Impacts could be catastrophic in sensitive ecosystems: loss of biodiversity, shortage of water supply and food availability could have a huge impact on society.

In order to face global warming, actions to mitigate the consequences are highly necessary world-wide. The available scientific research indicates that CO_2 is directly a main reason of this problem, so the actions to mitigate CO_2 emissions deserve to be supported. It is clear that economic activities are directly related to the use of fossil fuels, deforestation and other ways to emit or free CO_2 to the atmosphere, mitigation actions should be considered to lower the impact of mankind on the earth's climate system.

2.2. The United Nations Framework Convention on Climate Change

In 1992 in Rio de Janeiro, countries joined an international treaty, the United Nations Framework Convention on Climate Change (UNFCCC), to consider what they could do in order to limit average global temperature rising, its consequences and necessary solutions in order to cope with these changes. The Agreement entered into force in 1994 (*UNFCCC, 2012*). The ultimate objective of the Framework Convention is "*to prevent dangerous anthropogenic interference on the climate system*".

In 1995 the countries Parties to the UNFCCC began to meet annually in the "Conferences of Parties" (COP), aiming to assess the progress in dealing with climate change. Currently there are 195 Parties to the Convention (*UNFCCC, 2012*).

This treaty itself sets no mandatory limits on emissions for individual countries and contains no enforcement mechanisms. Therefore, the treaty is considered legally non-binding. Instead, it provides for updates (called "protocols") that would set mandatory emission limits. The principal update is the Kyoto Protocol. The Kyoto Protocol was adopted in 1997 after finishing negotiations aimed to strengthen global response to climate change.

Liabilities of country members were categorized into three groups: *Annex I countries,* which are the industrialized countries and economies in transition; *Annex II countries,* which are developed countries paying for costs of developing countries; and *Non-Annex I countries,* the developing countries.

Annex I countries are those who ratified the Protocol and committed to reduce their GHG emission levels to targets that were mainly set below their 1990 levels. This can be done by allocating maximum emission allowances to big industries inside their borders. These industries can only exceed their allocations if they buy emission allowances, or they could compensate their excesses through a mechanism that is agreed by all the parties to UNFCCC.

Annex II countries are a sub-group of the Annex I countries. They are the OECD members, excluding those that were economies in transition in 1992.

Non-Annex I countries, the developing countries, are not required to reduce emission levels during the first commitment period.

Climate change is a complex problem, with consequences in all the aspects of existence on our planet. The response to it lies in the need to reduce emissions. In 2010, governments agreed that emissions need to be reduced so that global temperature increases are limited to below 2° C (*UNFCCC, 2012*).

2.3. THE KYOTO PROTOCOL

The Kyoto Protocol (KP) is an international agreement linked to the UNFCCC. The KP was adopted in Kyoto, Japan, on 11 December 1997 during the third COP, and entered into force on 16 February 2005. The KP is what "operationalizes" the UNFCCC. It commits industrialized countries to stabilize their GHG emissions.

Box 2-1. Greenhouse gases under the KP and global-warming potential

> Global-warming potential (GWP) is a relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide. A GWP is calculated over a specific time interval, commonly 20, 100 or 500 years. GWP is expressed as a factor of carbon dioxide (whose GWP is standardized to 1). For example, the 20 year GWP of methane is 72, which means that if the same mass of methane and carbon dioxide were introduced into the atmosphere, that methane will trap 72 times more heat than the carbon dioxide over the next 20 years. (*IPCC, 2007*)
>
> The substances subject to restrictions under the KP are the ones that are rapidly increasing their concentrations in the atmosphere or the ones that have a large GWP. Six are these GHG:
> *Carbon dioxide ($C0_2$), Methane (CH_4), Nitrous oxide (N_20), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6).*

The KP sets binding emission reduction targets for 37 industrialized countries and the European community. These targets result in an average 5.2% emissions reduction compared to 1990 levels over the first "commitment period" of 5 years, from 2008 to 2012.

KP only binds developed countries because it recognizes that they are largely responsible for the current high levels of GHG emissions in the atmosphere, as result of more than 150 years of industrial activity (*UNFCCC, 2012*).

In 2005, when KP entered into force, the first Meeting of the Parties to the Kyoto Protocol (MOP 1) took place. In accordance with KP requirements, the parties launched negotiations on the next phase of the KP under the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP).

Due to USA's negative to ratify the KP, and to include them in conversations, a parallel stream for negotiations on post-2012 outcomes was created in 2007: the Ad-Hoc Working Group on Long-Term Cooperative Action under the Convention (AWG-C).

In 2011, at COP-17 in Durban, the Parties to the KP decided that a second commitment period, from 2013 onwards, would follow the end of the first commitment period. The length of the second commitment period still needs to be determined (*UNFCCC, 2012*).

2.3.1. Flexible Mechanisms

Under the KP, three market-based mechanisms were created in order to provide *Annex I* countries with tools to offset their emissions when they were not able to make enough emission reductions inside their borders. These mechanisms create a market for the emission allowances, making possible to reduce a party's emissions by developing projects that reduce emissions where it is more cost-effective, for example in developing countries. These mechanisms are:

a. *Joint Implementation*: Permits *Annex I* countries to implement emission reduction projects in another *Annex I* country, in order to receive certificates of reduction of emissions (called Emission Reduction Units, ERU) to meet their allowance targets.

b. *Clean Development Mechanism*: Permits *Non-Annex I* countries to generate Certificates of Emission Reduction (CER) by implementing emission reduction projects in their territory. Those generated CERs could later be traded with Annex I countries that require to buy emission allowances in order to meet their targets.

c. *Emissions Trading*: The market mechanism that permits certificates of emission reductions to be traded by the *Annex I* countries in order to meet the targets imposed by the KP.

2.3.2. Current status of the Kyoto Protocol

There are 193 Parties to the KP, including several of the *Annex I* countries. Together, they correspond to 63.7% of the total emission presented in the *Annex I* of the KP (*UNFCCC b*). However, KP's first commitment period ends-up on 31 December 2012, and a new agreement to extend it to a second period has still not been signed. Some parties have expressed their intentions of not signing-up new commitments alleging that the current major GHG emitters worldwide (China and USA) are not included in the agreements (*GUARDIAN UK a, 2011*). Canada already signed on November 2011 its withdrawal from the KP at the end of the first commitment period (Canada's emissions are 3.3% of the *Annex I* parties' emissions).

During the last COP held in November 2011 in Durban, South Africa, governments could not agree all the terms of the second commitment period of the KP. Instead, they came up with the also-called "Durban Platform", which states that the Protocol will remain operative until year 2015, when they should have designed a legally forcing and binding instrument applicable to all nations, which would entry into force in year 2020 (*GUARDIAN UK b, 2011*).

2.4. Clean Development Mechanism (CDM)

CDM is one of the three flexible market-based mechanisms created in the KP. It brings Annex I countries to develop projects that could reduce emissions where it is more cost-effective, for example, in developing countries. The emissions that these projects avoid are transformed into certificates of emission reduction (CER). One ton of CO_2e avoided generates one CER. The project owner can then trade its CERs in the world emissions market, known as "emissions trading" market (ET). During the process the country where the project is implemented (called "host party") is expected to be benefitted by technology transfer and improvement of local facilities, which must agree the local criteria of sustainable development (*CDM, 2012*)

The amount of CERs generated by a project is obtained through procedures called CDM methodologies, which are specific for each type of project. In short, for this calculation, a baseline scenario is determined, which represents the situation if business-as-usual continues to be applied. The baseline is compared with the situation where the proposed project is implemented. As the emissions in the proposed situation are going to be lower than in the baseline scenario, then this difference is the amount of avoided metric tons of carbon dioxide equivalent (tCO_2e).

Baseline determination, verification of reduction of emissions and certification have to be made by a third party, authorized by the UNFCCC. Once verified, the CERs are issued by the UNFCCC Executive Board, becoming a product that could be traded in the market of emissions.

The most important requirement in CDM is that the proposed project can prove that it produces additional reduction of emissions when compared with the baseline scenario. The process becomes especially difficult if the project is unique in its class, since a new CDM methodology has to be developed. Then, of course, baseline determination, verification, monitoring and certification become tougher as well, increasing transaction costs and time used (*Junqueira, 2005*).

2.4.1. Situation of CDM in the World

To March-2012, there were 3977 CDM projects registered by the UNFCCC Executive Board. Currently an annual average of 579.18 million CERs is being generated worldwide. To the end of 2012, it is expected that 2 130 million CERs will be generated (*CDM, 2012*).

The country which is currently producing the highest number of CERs annually is China with 370.42 million CER/year (63.86 % of the total), followed by India with 64.39 million CER/year (11.10% of total). Table 2-1 and Figure 2-4 show the worldwide distribution of issued CERs by the main host countries. For comparison, the participation of South American countries is shown in Table 2-2 .

Table 2-1. Annual distribution of issued CERs by principal host countries (April, 2012)

Country	CERs	% Total
China	370 420 596	63.86
India	64 385 666	11.10
Brazil	23 782 093	4.10
Republic of Korea	19 489 715	3.36
Mexico	11 078 975	1.91

Table 2-2. Annual distribution of issued CERs in South American countries (April, 2012)

Country	CERs	% Total
Argentina	5 998 381	1.03
Chile	5 447 930	0.94
Peru	4 034 548	0.70
Colombia	3 224 929	0.56
Bolivia	1 438 541	0.25
Ecuador	563 991	0.10
Uruguay	427 239	0.07

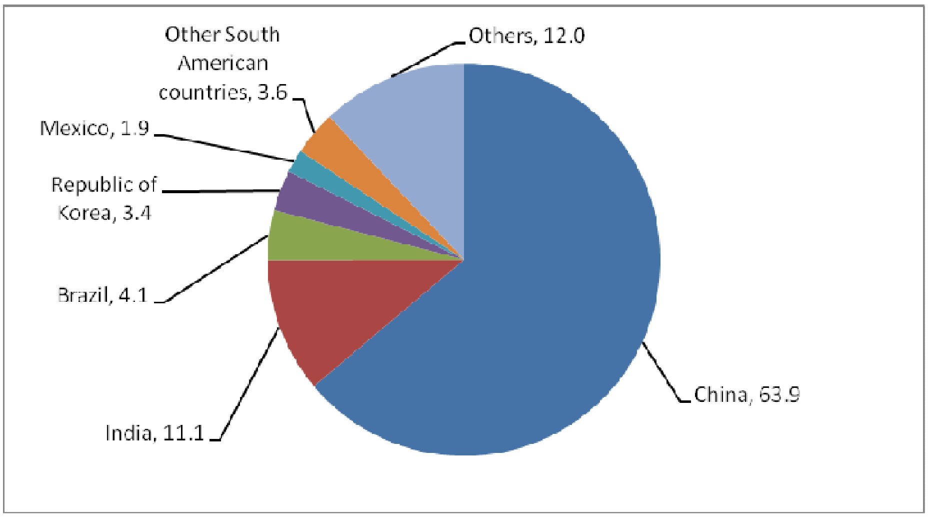

Figure 2-4. Current distribution (%) of annual issued CERs by host country (April, 2012)

To April-2012, the majority of registered projects (68.61%) are energy related, followed by waste handling and disposal projects (13.47%). For current distribution of projects by scope, see Figure 2-5 (*CDM, 2012*).

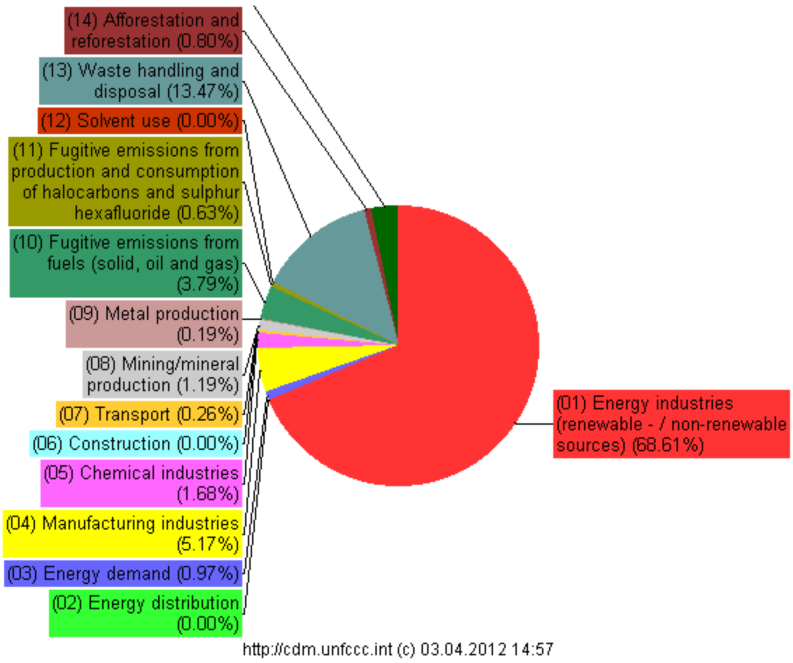

Figure 2-5. Distribution of registered project activities by scope (April, 2012)

Several critics were done to CDM. However, it has noticeably gaining acceptation around the world. The positive experience of early actors encouraged others to develop new and diversed projects. Figure 2-6 shows the number of presented projects per month during last 8 years. The slowdown of the trend between years 2008-2011 is related to various factors such as the world economic crisis in 2008 and the lack of strong and clear agreements in the UNFCCC's COP in Copenhagen (2009) and Cancún (2010). It is remarkable that since year 2011 a new growing trend of presented projects appears, maybe trying to catch the last year of the first commitment period of the KP.

The second commitment period of the KP [2013-2016] is still unclear. However, it is noticeable that the UNFCCC has recognized a need to “force” the expansion of the CDM to the least developed countries (LDC), small islands developing States (SIDS) and other countries in Africa. In October 2010, the AWG-KP proposed that for the next commitment period at least 10% of the CERs will be generated from projects hosted in such nations (*Winkelman, 2011*).

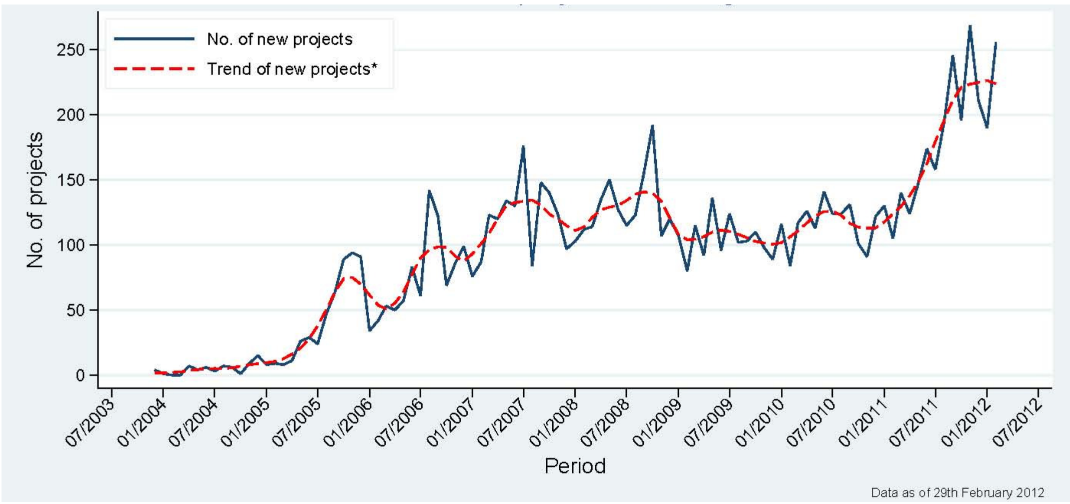

Figure 2-6. CDM Projects entering to validation [2004-2012] (*CDM, 2012*)

2.4.2. Situation of the CDM Carbon Market

It is possible that the CDM market could change its current trends after the end of 2012 when KP’s first commitment period is over. The EU expressed that during the “transition period 2013-2015” it will continue with the carbon emissions trading system as it is known, but putting more attention on the LDC countries (*EU a, 2009*). Thus, LDC and SIDS countries could tend to concentrate the new post-2012 CDM projects. This situation could probably cause a decrease in number of new CDM projects in Latin American and Asian countries.

In the meanwhile, CERs continue being an important commodity in the EU’s emissions market (EU-ETS), even though spot prices have been decreasing lately. Evolution of CER’s market spot price is shown in two diagrams in Figure 2-7 (sources: *ENL, 2012* and *FClim a, 2012*).

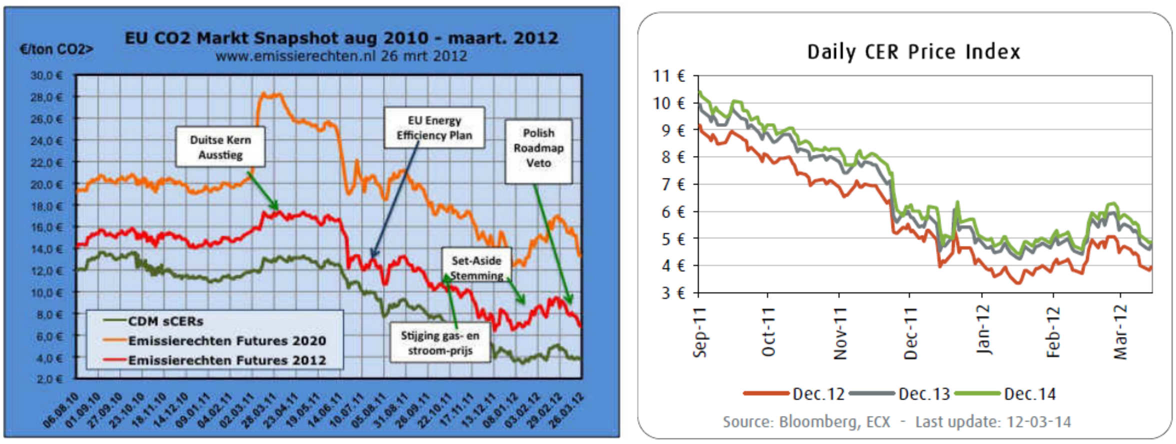

Figure 2-7. Evolution of CER price [2010-2012] (*ENL, 2012; FClim a, 2012*)

2.4.3. Effectiveness of CDM for financing projects in developing countries

The CDM has two main purposes: a) Permit *Annex I* countries to reach their binding emission limits in a cost-effective way; and, b) help n*on-Annex I* countries that host the CDM projects to develop sustainably through technology and capital transfer from developed countries.

As shown in previous sections, the CDM has been successful developing GHG emission reduction projects worldwide. However, there has been a large concentration of the projects and signed CERs in the big transition economies (China, India, Brazil) instead of investing in poorer countries. Thus, there are several opinions against the ability of CDM to contribute to the sustainable development in host countries (*Olsen & Fenhann, 2008*) or to promote a real cleaner development (*Pearson, 2007*).

However, if financial issue is analyzed, it cannot be denied that CDM has been effective to make additional projects profitable. This is especially clear in those projects that produce abundant and cheap carbon credits, such as projects that reduce hexafluorocarbons (HFC-23) emissions, even though they are claimed neither to contribute to the growth of the renewable energies nor support cleaner production. As *Pearson* (2007) explains, since CDM is a market-based mechanism, it was clear to see from the beginning that the actors were going to focus their investments only in producing large volumes of cheap CERs as it was possible, ignoring cleaner production projects. Investors focused their investments in already-known industries and activities, where the reduction of emission of GHG with high GWP could be afforded in a relatively easy way. Projects for reducing the emission of HFC-23 and nitrous oxide (N_2O) rapidly appeared in the early years of CDM, being highly profitable: In 2007, a couple of large projects for reducing HFC-23 emissions were expected to generate 40 million CERs up to 2012, investing just 0.34–0.51 USD/CER, while negotiating the generated CERs in the carbon market at prices above 10 USD/CER.

Those projects recovered their initial investments in short periods (less than one year in some cases), thus becoming more attractive for receiving loans than other options such as renewable energies. Since renewable energy projects displace just emissions of carbon dioxide and no other high GWP gases, the latter produce much less CERs for a similar financial investment.

Even though investing in renewable energies or cleaner production is not such a big CDM business as it is for HFC-23 or N_2O projects, considering the “financial carbon component” (i.e. the net incomes from sales of the generated CERs) is important for improving the project’s internal return rate (IRR). For instance, the Institute for Global Environmental Strategies (IGES) shows in its CDM Investment Analysis Database (updated 2 April 2012) that sales of CERs improve project’s IRR by approximately 2-5% for hydroelectric projects (the effects are higher in smaller projects) and by 2-4% for wind energy projects. The energy projects are in almost every case, economically benefitted from the CDM carbon business (*IGES, 2012*).

2.5. Voluntary Carbon Markets

Since the agreements made in the UNFCCC and the Kyoto Protocol did not receive the acceptation of all the nations worldwide, several institutions in diverse countries decided to design “parallel carbon markets” in order to attract those interested in voluntarily taking actions against the global warming.

The voluntary carbon market (VCM) is an option to companies, individuals, and other economic participants that are not subject to mandatory limitations to offset their GHG emissions. For instance, it is a widely accepted option for companies that decide to offset their carbon emissions in order to reduce their "carbon footprint" and in that way, get a competitive advantage.

The voluntary market has been small compared to the regulated market (CDM, EU emissions trading market), but it is gaining acceptation among investors due to the lower transaction costs than, for example, in CDM. The requirements to validate a project in the voluntary market are commonly more flexible than those for the regulated market. Thus, the VCM becomes attractive for those small scale projects that cannot deal with the high costs, longer validation periods and possibility of failure of participating in the CDM.

How does it work?

Buyers in the voluntary markets could be companies that demand carbon credits to offset their operation's emissions, agencies that buy credits on behalf of their customers[1], events that want to be promoted as "carbon neutral", or individuals.

The sellers in this market are retailers who buy and resell carbon credits. Also, project developers who develop GHG reduction projects could directly sell the generated credits.

There are several standards developed for the voluntary market. Some of them are widely recognized and accepted as trustable worldwide, making it easier for the project developers to find buyers for the credits awarded. The Gold Standard (www.cdmgoldstandard.org) and the Verified Carbon Standard (http://v-c-s.org/) are two well-known standards.

[1] These companies offer to offset any activity of the client (e.g. flights for attending a conference, electricity or paper use, etc.) that directly or indirectly causes GHG emissions.

3. PERU

Peru is a country located in the west part of South America. The country has an area of 1 285 216 km^2, the capital is Lima, and is divided in 24 Regions and one Constitutional Province. Peru has a total population of 27 412 157 (census of year 2007, *INEI, 2012*), and most of people live in urban locations (75.9%).

Peru is rich in natural resources due to its varied climates originated by its geographical location: with the Pacific Ocean to the West, the Andes crossing the country by the middle in north-south direction and the Amazon rainforest to the East. Almost 60% of Peru's surface is covered by forests.

During the period 2002 - 2011, Peru was a flourishing economy in the region. Country's GDP has grown since 2002 averaging a yearly increase of around 7%. However, at the end of 2010 still 30.8% of the population was living below the poverty line, with special incidence on rural population where the percentage of poor was 61.0% (*INEI b, 2012*). Figure 3-1 shows the geographical context of the country (source: *airspirit3.tripod.com*).

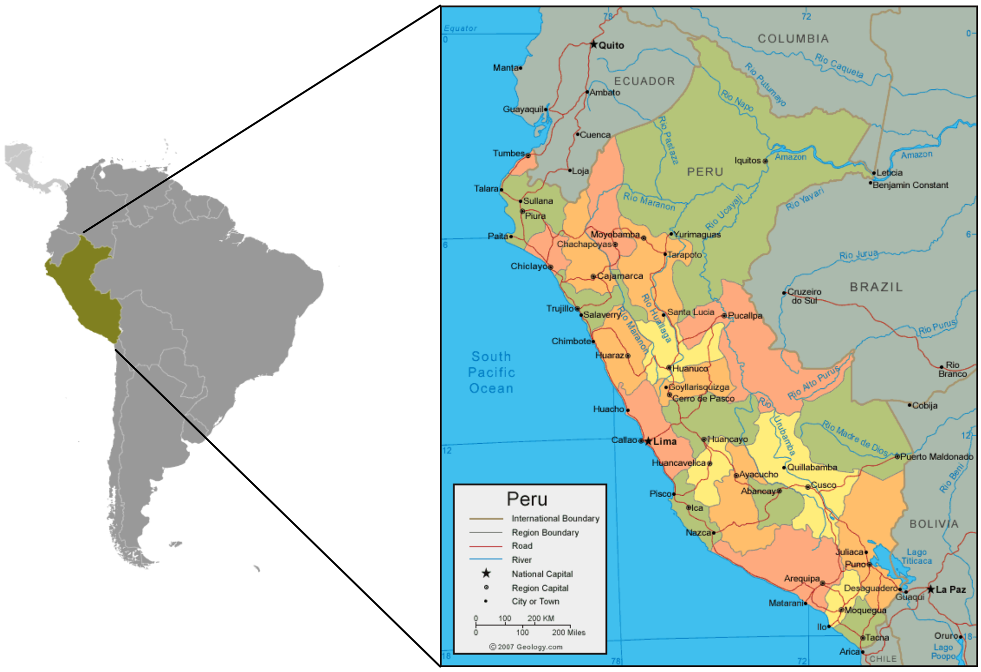

Figure 3-1. Political Map of Peru and referential location in South America

3.1. ENVIRONMENTAL ASPECTS

Peru has three very well differentiated natural climate zones: *Costa*, the coast, located between the Pacific Ocean and the Andes, mainly composed by large deserts and valleys where the cities are settled down; *Sierra*, the mountains, composed by the Andes which cross the country from north to south; and *Selva*, the rainforest, mainly composed by the Amazon forest, which runs from the Andes towards the East.

Peru has one of the largest biodiversities in the planet (*CONAM a, 2007*). The country has highly sensitive ecosystems dependent on a climate system that has been relatively stable during long time. However, this stability is currently being threatened by the consequences of climate change.

The country's coastal region concentrates the biggest, richest and most populated cities. However, the coast is a semi-desertic zone, highly dependent on supply of water coming from the rivers from the Andes. In turn, those depend mainly on water stored in lakes and glaciers located along the high Andean mountains above 5000 m.a.s.l. A big part of the Peruvian population depends on traditional activities like agriculture or fishing, which are highly dependent on weather and seasons. The electricity production in Peru is also water dependent: 58.48% of the total energy produced during 2010 was supplied from hydro power plants (*COES, 2010*).

Consequently, Peru's economy and society strongly depend on climate, especially on water resources. Population is more vulnerable to changes in the climate in poorer areas due to lack of resources for "adaptation". The effects of climate change are already present in the country: changes in seasons length (especially the "rainy season") affect the yield of harvest, while absence of rains reduces available water in natural and man-made storages in the Andes (these ones receive important contribution from the glaciers, which are melting very fast, see Figure 3-2).

Figure 3-2. Surface reduction of Pastoruri glacier (5200 masl.) in the Peruvian Andes [2001-2007]

The country has 70% of the world's tropical glaciers, however 22% of them have already meltdown during last 30 years (*MINAM b, 2010,* pg.118). Dependence of the country on glaciers for storing water is one of Peru's biggest problems due to the accelerated rate of reduction of glacier's surface (see Figure 3-3).

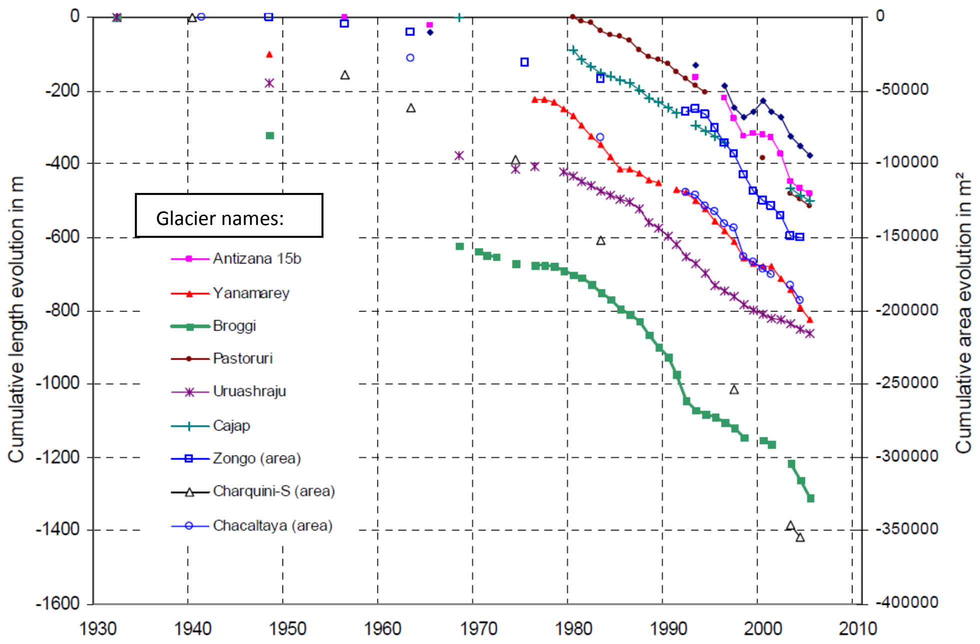

Figure 3-3. Surface variation of 10 glaciers in the tropical Andes (*Francou & Vincent, 2007*)

Change of temperatures due to climate change also affects directly daily activities in Peru. In the valley of Mantaro river, located in central Andes and highly dependent on agricultural activities, maximum temperature has been increasing at a rate of 0.24 °C/decade during last 50 years. Also, the number of "frozen days" per agricultural year has been growing by 6 days/decade, consequently reducing the number of days with normal rain precipitations (*Iturregui, 2007*). Reduction of precipitations reduces the available water for agricultural and human consumption; this is the main problem Peru is beginning to face.

3.1.1. Structural Organization

Accelerating effects of climate change inside the country such as reduction of water availability, changes in temperatures and length of rainy seasons, pushed the Government of Peru (GoP) to develop a national structure in charge of the processes of mitigation and adaptation to climate change during last decade.

In Peru, the Ministry of the Environment (MINAM) takes responsibility in management and planning of the environmental affairs of the country. As required by CDM procedures, MINAM was appointed as the Designated National Authority (DNA) in Peru, while its internal office FONAM (National Fund for the Environment) is the organization that promotes the CDM projects in the country. Until 2009, MINAM had approved 39 CDM projects, from which 27 are already registered and one is waiting for its registration by the UNFCCC's Executive Board (*CDM, 2012*). Among these projects 6 are already receiving incomes from sales of the CERs (*MINAM a, 2012*).

3.1.2. Peru's Greenhouse Gas Emissions

Peru's GHG emissions are not high compared to other countries. In year 2000, emissions were 120 Mt CO_2e, which corresponded only to 0.4% of worldwide emissions (*MINAM b, 2010*, pg. 60).

MINAM's National Commission on Climate Change (CNCC) produced the *Second National Communication to UNFCCC* in 2010, as part of its obligations as a Party to the UNFCCC (*MINAM* *b, 2010*). This document is the most up-to-date summary of the status of environmental policies and effects of climate change in the country during the period 2000-2010. Table 3-1 shows Peru's official GHG emissions data divided in five categories according to IPCC's methodology (*MINAM b, 2010*, pg. 18).

Table 3-1. Total annual GHG emissions per category in Peru (in 2000)

Category	Total (Mt CO_2e/yr)	(%) Total
Land Use, Land Use Change and Forestry (LULUCF) [2]	56.8	47.3
Agriculture	25.5	21.3
Energy	25.4	21.2
Industrial processes	7.9	6.6
Waste	7.3	6.1
TOTAL	120.0	100.0

As a non-industrialized country, Peru's main source of CO_2 emissions is deforestation instead of production sector. Emissions due to LULUCF represent the 47.3% of total, much higher than the other two important components: energy sector (mainly from transportation) and agriculture sector (composed basically by emission of methane -CH_4- from animal enteric fermentation, and nitrous oxide -N_2O- from the use of fertilizers).

In order to identify specifically the *sources* and *sinks* of emissions, Table 3-2 shows the categories of emissions and their principal sub-categories. LULUCF's sub-categories are by far the largest *source* and *sink* of emissions. In order to make more visible the effect of the rest of the sectors, Table 3-3 shows the same analysis without including LULUCF (source: *MINAM b, 2010*, pg. 72). In both Tables, only the principal sub-categories are included, i.e. the ones that when added, represent 95% of total emissions and sinks (*MINAM b, 2010*, pg. 72).

Table 3-2. Analysis of principal sub-categories of emissions. LULUCF is included.

Category	Sub-Categories	GHG	CO_2eq (Mt)	Evaluated level (%)	Accumulated (%)
LULUCF	Conversion of forests and pastures	CO_2	110.06	48.5	48.5
LULUCF	Change of forest biomass and other stocks[3]	CO_2	53.54	23.6	72.1
Agriculture	Enteric fermentation	CH_4	10.41	4.6	76.7
Energy	Transport	CO_2	9.88	4.4	81.1
Agriculture	Agricultural soils	N_2O	9.67	4.3	85.4
Waste	Solid waste (landfills)	CH_4	6.19	2.7	88.1
Industry	Metal processing	CO_2	5.83	2.6	90.7

[2] "Land Use, Land Use Change and Forestry" (LULUCF) is a greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities" (from: http://unfccc.int/essential_background/glossary/items/3666.php#L).

[3] "Change of forest biomass and other stocks" is the main sink of carbon dioxide in Peru. It "captures" CO_2.

Energy	Residential, Commercial, Public	CO_2	4.55	2.0	92.7
Energy	Manufacture and construction industries	CO_2	3.24	1.4	94.1
Energy	Energy industries	CO_2	3.07	1.4	95.5

Table 3-3. Analysis of principal sub-categories of emissions. LULUCF is not included.

Category	Sub-Categories	GHG	CO_2eq (Mt)	Evaluated level (%)	Accumulated (%)
Agriculture	Enteric fermentation	CH_4	10.41	16.5	16.5
Energy	Transport	CO_2	9.88	15.6	32.1
Agriculture	Agricultural soils	N_2O	9.67	15.3	47.4
Waste	Solid waste (landfills)	CH_4	6.19	9.8	57.2
Industry	Metal processing	CO_2	5.83	9.2	66.4
Energy	Residential, Commercial, Public	CO_2	4.55	7.2	73.6
Energy	Manufacture and construction industries	CO_2	3.24	5.1	78.7
Energy	Energy industries	CO_2	3.07	4.9	83.6
Energy	Fishing	CO_2	2.12	3.4	87.0
Industry	Mineral products	CO_2	2.00	3.2	90.2
Energy	Mining	CO_2	1.35	2.1	92.3
Agriculture	Rice cultivation	CH_4	0.89	1.4	93.7
Waste	Waste water	CH_4	0.67	1.1	94.8
Agriculture	Manure management	N_2O	0.62	0.9	95.7

If LULUCF sector is not considered, energy sector owns the majority of sub-categories as seen in Table 3-3 (6 out of 14), as well as the highest added percentage of emissions (38% versus 34% for agriculture's sub-categories).

3.1.3. Relation between GHG emissions and country's growth

Peru officially communicated its GHG emissions in the two versions of the *National Communication to the UNFCCC*, published in years 1994 and 2000. Table 3-4 presents the emissions for those two years (*MINAM, 2012*), which is also displayed in Figure 3-4.

Table 3-4. Peru's national GHG emissions for years 1994 and 2000

Category	GHG Emissions (Mt CO_2e/yr)		Variation of emissions (%)
	1994	2000	
Energy	22.1	25.4	15
Industrial processes	9.9	7.9	-20
Agriculture	22.8	22.5	-1
LULUCF	41.2	56.8	38
Waste	2.7	7.3	168
TOTAL	98.82	120.03	21

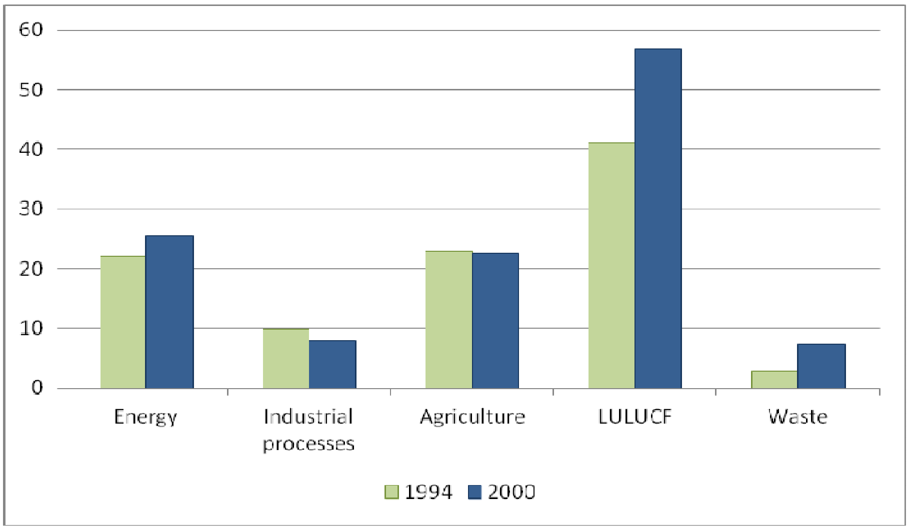

Figure 3-4. Peru's national GHG emissions in 1994 and 2000 (in Mt CO_2e/yr)

During the period 1994-2000, Peru's GDP increased in 23%, which is parallel to the total increase of GHG emissions of 21%.

The analysis per categories in Figure 3-4 shows that during 1994 and 2000 the increase of emissions was especially important for LULUCF and waste sectors, where emissions increased 38% and 168%, respectively. Both percentages exceed the country's increase of population (12%) and GDP growth (23%). This effect is probably caused by accelerated and uncontrolled deforestation in the Amazon, and by inefficient waste treatment programs in the country.

Interestingly, emissions of some sectors during that period were reduced: a.) Emissions from industrial processes were reduced in 20%, which could be explained by important efficiency improvements and fuel consumption. b.) Agriculture sector reduced its emissions by 1%, even though its economical participation in GDP grew 43% (*MINAM, 2012*). This could be related to the use of smaller volumes of fertilizers as well as improvements in animal growth methods (enteric fermentation from manure is the main source of emissions in this sector).

3.2. Measures to face the Climate Change in Peru

The GoP approved in 2010 the *National Action Plan for Adaptation and Mitigation against Climate Change* (PAAMCC). This document proposes and prioritizes mitigation and adaptation actions at national and regional levels, supports the inclusion of the actions into regional budgets and orientates the international cooperation to better implement the proposals (*MINAM d, 2010*).

The PAAMCC considers CDM as one of the most important tools for funding the proposed mitigation and adaptation projects and plans. The Plan considers using CDM in the energy and agriculture sectors: a.) In the energy sector, measures are mainly required in transportation, where emissions are caused by the use of diesel and gasoline, old vehicles, informality in public transportation and lack of mandatory technical controls; b.) In agriculture, the Plan proposes better use of fertilizers and efficiency improvement in cattle farm to reduce the emissions from animal enteric fermentation (*MINAM d, 2010*, pg. 25-26).

The Plan puts attention to the improvement of the capacities inside the Regions of the country. As the country is not a big GHG emitter, efforts are mainly centered in adaptation rather than mitigation projects (*MINAM d, 2010*, pg. 27). For implementing mitigation actions, the PAAMCC considers participating in the carbon market with CDM projects, which have a good potential in the country and increased acceptation. In Peru, both, adaptation and mitigation actions are needed since emissions from the three main sectors (LULUCF, energy and agriculture) are expected to grow dramatically in following years (*MINAM b, 2010*, pg.72). See Figure 3-5.

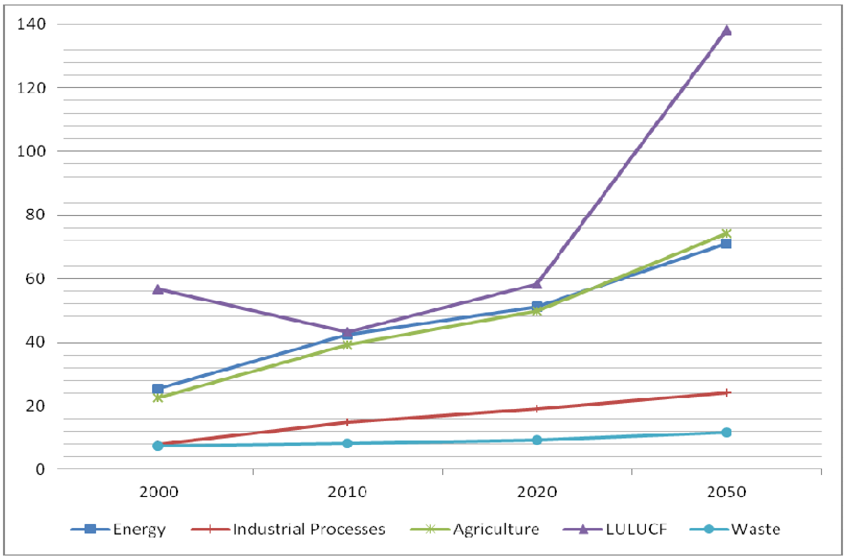

Figure 3-5. Projection of Peru's GHG emissions (in Mt CO_2e/yr) [2000-2050]

Since LULUCF is the most important component in the country's GHG emissions, the Plan proposes to strengthen capacities for using the program *Reducing Emissions from Deforestation and Forest Degradation* (REDD). This program would permit to generate incomes while preserving forests in the country.

3.3. Utilization of CDM in Peru

Peru has got some experience in CDM projects development. To April 2012, 27 CDM projects hosted by Peru have already been registered by the UNFCCC Executive Board. However, FONAM (which promotes CDM in the country) has a project pipeline of 176 proposals for CDM energy projects and 58 proposals related to LULUCF at diverse stages of development (*FONAM, 2012*). Table 3-5 shows the 27 CDM registered projects hosted by Peru (*CDM, 2012*).

Table 3-5. Registered CDM projects hosted by Peru (to April, 2012)

	Number of projects	Annual expected GHG reductions (tCO_2e/yr)	(%)
Hydroelectric	17	2 057 468	63.8
Energy Efficiency	1	407 296	12.6
Waste management	3	379 872	11.8
Fuel switching	3	300 754	9.3
Forestry	1	48 689	1.5
Biomass	2	30 850	1.0
TOTAL	27	3 224 929	100

Most of the projects (17) are hydroelectric, which represent also the majority of the expected emissions reduction (63.8%). There is one large project of energy efficiency consisting of the conversion of an open-cycle gas turbine power plant to combined cycle, which alone represents 12.6% of the country's expected annual reductions.

The category waste management presents 3 projects of landfill management for methane recovery and use or destruction (11.8% of annual reduced emissions). In fuel switching category there are 3 projects: 2 industrial plants switching from the use of diesel to natural gas, and one mine that switches its diesel generators for a small hydroelectric project built for auto-supply. They together represent 9.3% of annual reduced emissions.

The sole forestry project (reforestation) represents 1.5% of the annual emissions reduction. Finally, there are 2 biomass projects (representing together 1% of the reduction): one recovers methane from agro-industrial effluents for heating purposes and the other one avoids production of methane from anaerobic digestion occurred in waste from wood industry.

CDM project developers in Peru have been centered in hydroelectric projects. This is understandable, since incomes from CDM may help a project to become profitable, but in most of the cases they cannot sustain the project as the main incomes source. As *Winkelman & Moore* (2011) explains, the countries that have more activity in the CDM market are those where the levels of GHG emissions are high, which is directly linked to having a large and growing power sector. In those cases, CDM is used to help the power sector's growth through cleaner power plants, but the investor is always focused on the main purpose of the project: selling electricity.

As Peru is a relatively small economy (GDP in 2010 was approximately 155 000 MUSD), its power sector is relatively small as well (maximum demand of electricity was 4 322 MW in 2009). The annual growth of demand in 2010 was 5.9% (*COES, 2010*), which corresponds to a need of additional 274 MW per year to keep appropriate reserve levels in the system. This annual demand increase is relatively small and limits the number of new projects needed. However, the GoP launched in 2009 a program to buy energy from non-conventional energy sources (see Section 4) in order to impulse new investments in renewable energy projects. The CDM hydropower projects registered until 2012 are shown in Table 3-6.

Table 3-6. Registered CDM hydroelectric projects hosted by Peru (*CDM, 2012*)

Registration date	Project	Other parties	Annual expected GHG reductions (tCO_2e/yr)	Installed Capacity (MW)
23-Oct-05	Santa Rosa	Canada, Netherlands, Italy, Denmark, Finland, Austria, Luxembourg, Belgium, Sweden, Germany, Switzerland, Japan, Norway, Spain	13 845	4.2
14-Nov-05	Poechos I Project	Netherlands	31 463	15.2
6-Sep-06	Tarucani I ("the project")		153 957	49.0
6-Apr-07	Quitaracsa I ("the project")		249 463	114.6
4-Jan-08	Rehabilitation of Callahuanca hydroelectric	Ireland, Spain	18 189	7.5
8-Feb-08	Caña Brava Hydroelectric Power Plant	Spain	21 974	5.6
17-Mar-08	La Virgen Hydroelectric Plant		220 218	64.0
3-May-08	Carhuaquero IV Hydroelectric Power Plant	Spain	23 909	9.7

22-Nov-08	La Joya Hydroelectric Plant	Switzerland	41 987	15.0
24-Nov-08	Poechos II hydroelectric plant project	Spain	22 771	10.0
12-Feb-09	Cheves Hydro Power Project		393 831	168.0
17-Sep-09	El Platanal Hydropower Plant	Spain	501 814	220.0
17-Sep-09	Santa Cruz I Hydroelectric Power Plant	Netherlands, Germany, Spain	16 927	6.9
12-Oct-10	Santa Cruz II Hydroelectric Power Plant	Netherlands, Spain	25 644	6.9
18-Dec-10	Yanapampa Hydroelectric Power Plant		29 690	9.0
24-Feb-11	Huanza Hydroelectric Project		235 494	90.6
1-Dec-11	Pias I Hydroelectric Power Plant		56 292	12.6
		TOTAL	2 057 468	808.8

3.4. Situation of the Energy sector

Final energy consumption in Peru in year 2009 was 605 095 TJ, which was 4.1% above previous year's. The sector was dominated by the use of hydrocarbons, which represented 61.8% of total final consumption. Electricity represents 17.7%, fuel-wood and similar biomass 14.1% (*MINEM a, 2009*, pg.18). See Figure 3-6, where information is presented in TJ and percentages.

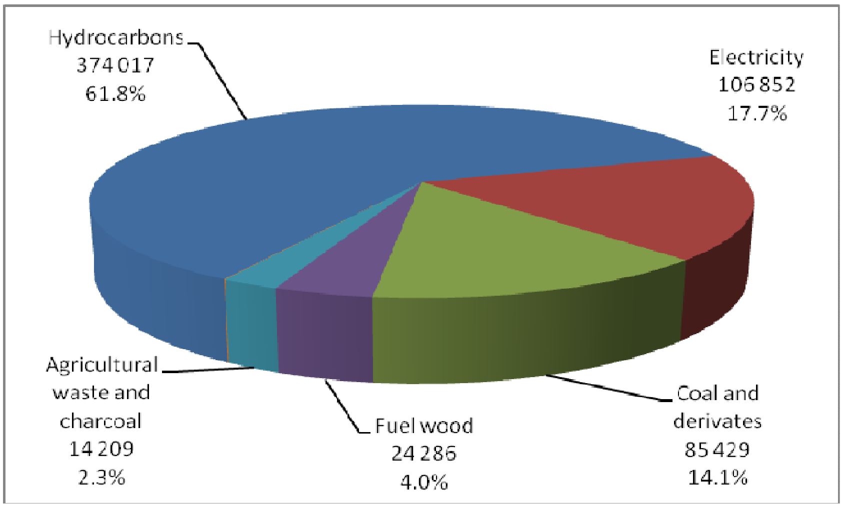

Figure 3-6. Structure of final energy consumption by source in TJ (in 2009)

Analyzing consumption of final energy[4] by sectors, Transport has the highest consumption, which represents 37.8% of the total. Residential, commercial and public sector and the Industry and Mining are the following energy consumers. Figure 3-7 shows the distribution of energy consumption by sector in year 2009 (source: *MINEM a, 2009*, pg.19).

[4] Final energy is referred to the amount of energy available to use after all transformation processes.

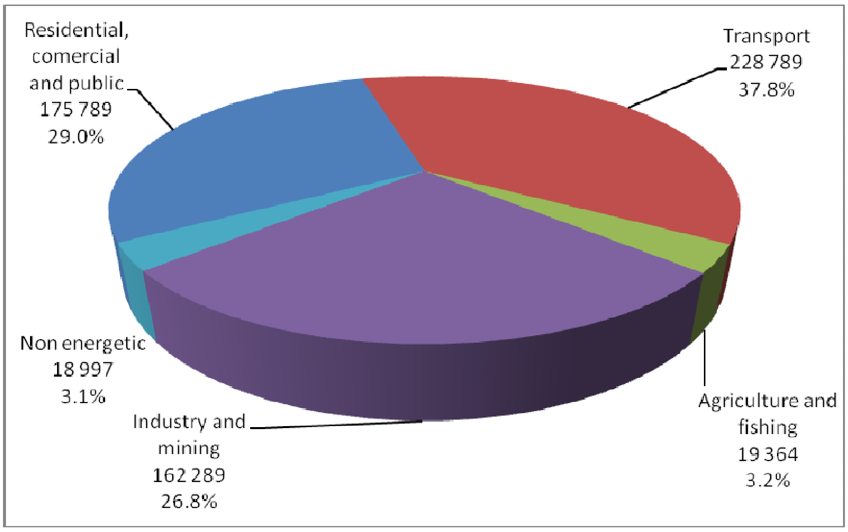

Figure 3-7. Final energy consumption by sector in TJ (in 2009)

Use of hydrocarbons

The country's transportation system is highly dependent on diesel oil and gasoline, even though cleaner fuels such as LPG and natural gas are already available in gas stations (the latter since 2004 but only in Lima). Figure 3-8 shows a noticeable increase in consumption of diesel around 1993 due to GoP's decision of allowing importation of used vehicles to increase the availability of units for public transportation, as well as the start of use of natural gas for vehicles around year 2005 (source: *MINEM b, 2011*).

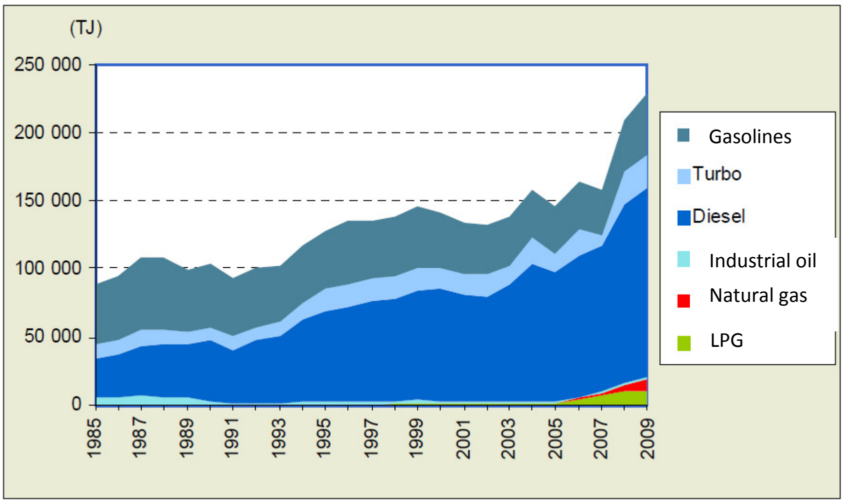

Figure 3-8. Energy sources for Transportation sector [1985-2009]

Transportation sector is the major among final consumers of hydrocarbons (63% of total). Industrial consumption represents 17% and uses mainly industrial gas, natural gas, diesel and LPG. Residential, commercial and public sector shares 11% and its main consumption is LPG and vegetal carbon (houses). Final consumption of hydrocarbons by sector is shown in Figure 3-9

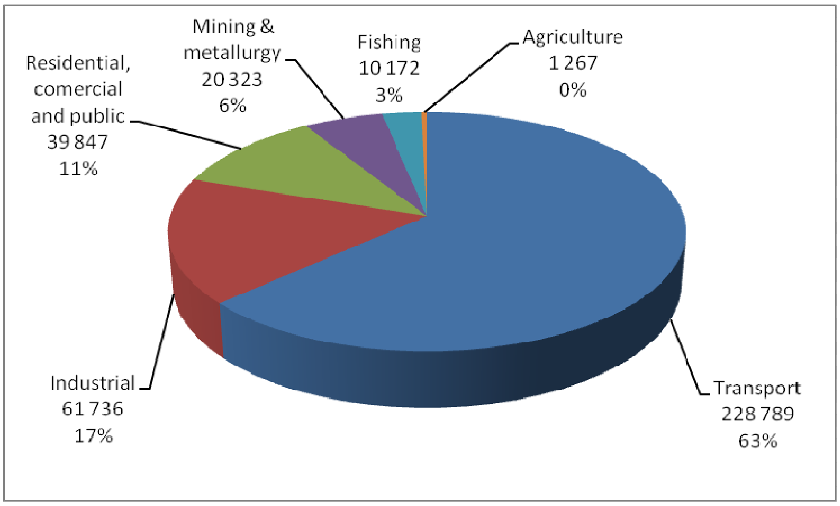

Figure 3-9. Final consumption of hydrocarbons by sector in TJ (in 2009)

Use of Electricity

In year 2009 Peru's total installed power capacity was 7 986 MW. Same year the maximum demand was 4 322 MW, and the annual energy production was 32.95 TWh. Country's main energy source has been traditionally hydroelectricity, but during last decade the thermoelectric component has grown fast, representing 40% of the total energy production in 2009 (*MINEM b, 2011*). Figure 3-10 shows a clear increase of use of natural gas for power generation around year 2006 (source: *MINEM b, 2011*).

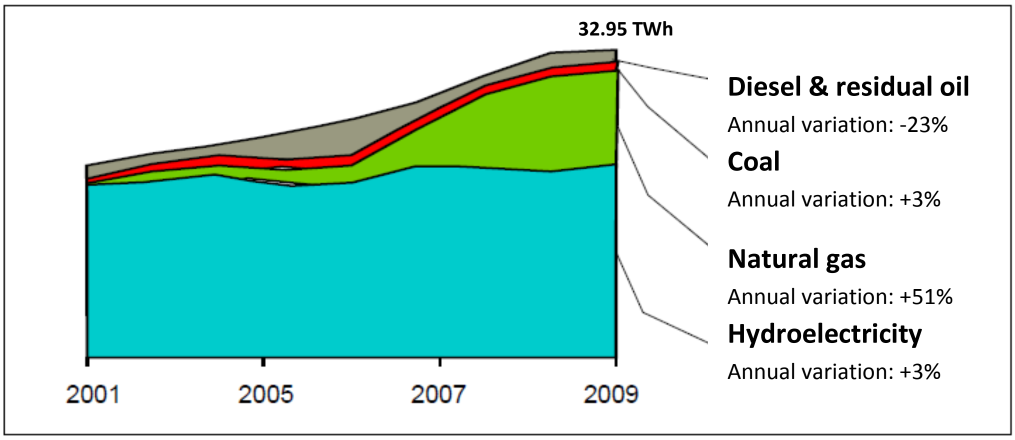

Figure 3-10. Energy sources of the electricity sector [2001-2009]

Electricity demand is expected to continue growing. MINEM's studies forecast a probable growth of 7.8% until year 2019. For the optimistic and pessimistic cases, the growth rate is expected to be 8.9% and 6.8%, respectively. Figure 3-11 shows the three scenarios (source: *MINEM b, 2011*).

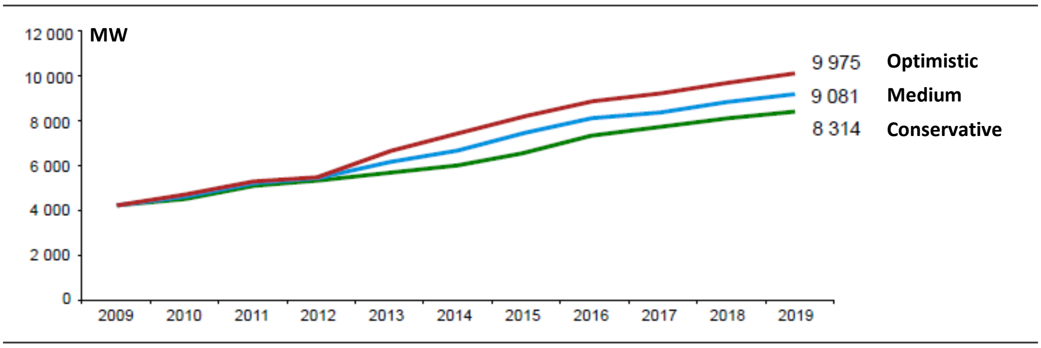

Figure 3-11. Power demand forecast [2009-2019]

Final electricity consumption is driven by the "residential, commercial and public" sector, which represents 45.1% of total. Industrial and mining & metallurgy sectors are the other important categories. In Figure 3-12 the information is presented in TJ and percentage (source: *MINEM a, 2009*, pg. 56).

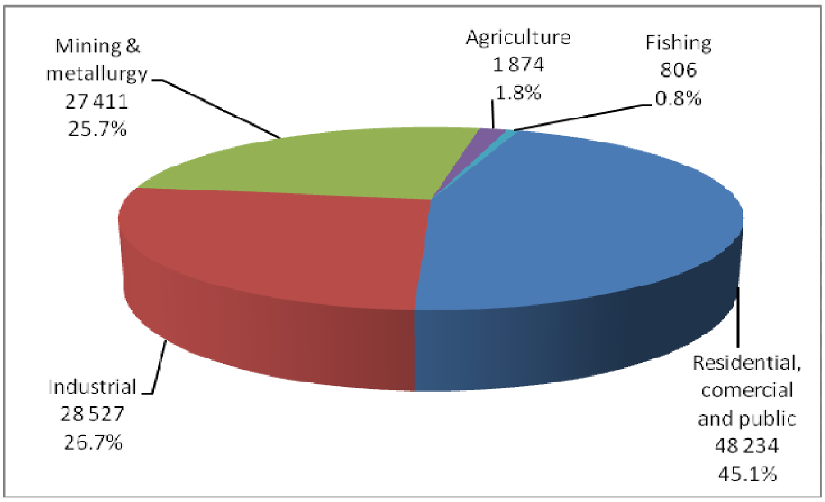

Figure 3-12. Final consumption of electricity per sector in TJ (in 2009)

3.4.1. POTENTIAL OF ENERGY SOURCES

In 2009, Peru's main energy reserves were hydrocarbons (natural gas and its associated liquids, and crude oil) and hydroelectricity[5]. Information is shown in Table 3-7 and plotted in Figure 3-13 (source: *MINEM a, 2009*, pg. 6).

Table 3-7. Proven reserves of commercial energy (in 2009)

Source	(TJ)	(%)
Natural gas	11 943 980	45.1
Hydroelectricity	5 965 666	22.5
Liquids of natural gas	3 483 693	13.2
Crude oil	3 084 456	11.7

[5] Proven hydroelectricity reserves is the energy expected to be produced during next 50 years from all hydropower plants in operation, under construction or approved to be built (*MINEM a, 2009, pg. 49*).

Coal	1 115 007	4.2
Uranium	878 639	3.3
TOTAL	26 471 441	100.0

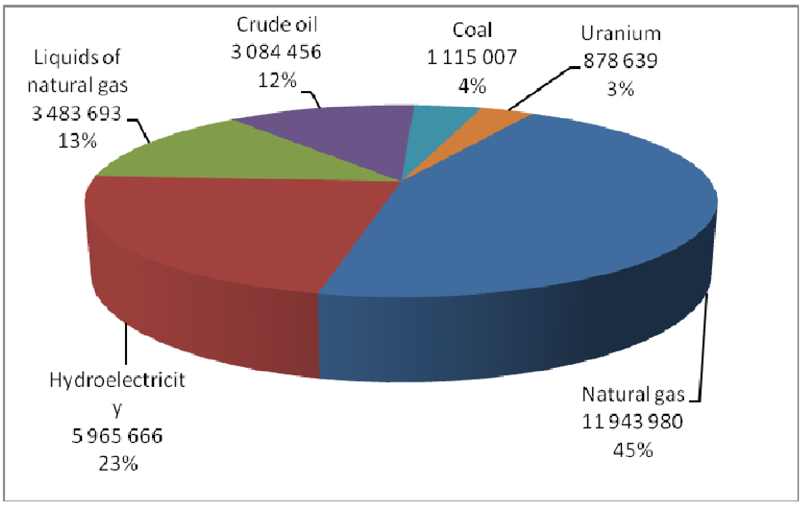

Figure 3-13. Proven reserves of commercial energy in TJ (in 2009)

3.4.1.1. Hydrocarbons

In 2012, Peru's largest reserves of hydrocarbons are based on natural gas and its associated liquids. Natural gas became one of the most important energy sources in the country since the start of operations of "Camisea" natural gas fields in 2004.

In 2009, Camisea produced 9 949 million m^3 of natural gas, corresponding to 83.6% of total country's production. Same year, Camisea's extracted liquids from natural gas reached 4 121 000 m^3, corresponding to 48.9% of the total production of liquid hydrocarbons in Peru (source: *MINEM a, 2009*, pg. 61, 66).

In 2009, natural gas was mainly used to produce electricity (72.3%) and in industries (18.4%). Transportation sector is continuously increasing the use of this fuel. To December 2009, 81 029 vehicles had already been converted to use natural gas (*MINEM a, 2009*, pg. 63).

3.4.1.2. Hydroelectricity

The big difference of altitudes found in the Andes, and the large rivers that flow from them to lower zones are favorable conditions that permit Peru to possess considerable hydrological resources for electricity production. A comprehensive study to assess the country's hydroelectric potential was carried out by the MINEM in 1979. The study determined that the potential for power plants with capacity above 30 MW was 58 937 MW, with an annual energy production of 395 118 GWh (*MINEM d, 1979*, Vol. I, pg. 2.33).

Since the realization of this study, hydroelectric capacity in the country has increased from 1 406 MW (in 1976) to 3 276 MW (December 2009) (*MINEM d, 1979*, pg. 2.4, *MINEM b, 2011*, pg. 8). After almost a decade without developing important hydro projects, in 2012 the MINEM and private investors have new projects with a combined capacity of 4 325 MW to be developed until year 2019 (*MINEM b, 2011*, pg. 11).

3.4.1.3. Potential of non-conventional and renewable energy sources

Due to the variable geography of its territory, Peru possesses good potential of non-conventional energy resources. Solar energy is one of the most promising resources.

Peru's three natural regions (coast, mountains and rainforest) define the distribution of solar energy in the country. The region with largest potential is located in the southern coast (16-18 °S), where daily insolation[6] reaches values of 6.0 - 6.5 kWh/m^2. In the northern coast (3-8 °S) it reaches 5.5 – 6.0 kWh/m^2, as well as in the major part of the highlands above 2500 m.a.s.l. (*MINEM e, 2003*).

The rainforest region does not offer high values of insolation (< 4.5 kWh/m^2) since it is frequently affected by cloudy seasons and rain, which considerably reduce the periods of solar irradiation.

The highest insolation occurs during the Austral summer months, being especially good the period from November to March, where the southern coast experience daily values above 7 kWh/m^2. The highlands are the region with the most regular solar exposition during the year. In the southern and central highlands, the values are above 5 kWh/m^2 during the period from September to May. Figure 3-14 shows daily values for the average monthly insolation (from left to right) in November, January and March (source: *MINEM f, 2003*).

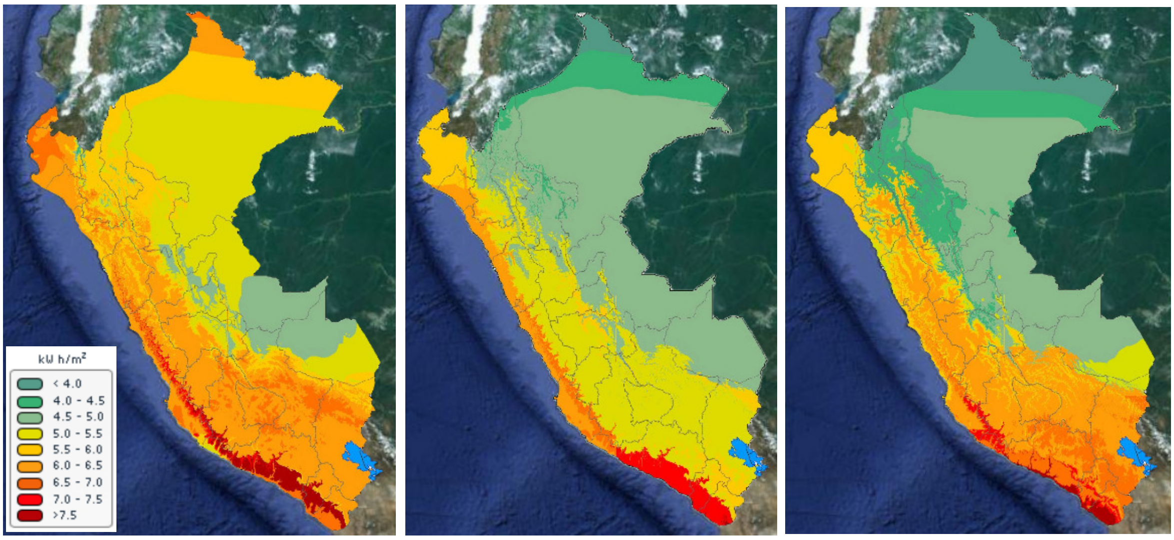

Figure 3-14. Average solar insolation in Peru (November, January, March)

The application of solar energy is still limited in Peru. Until year 2012 there are no solar power plants, but two are expected to be in operation in 2013. The solar resource in the country has currently two main uses: for solar heating of water in houses and hotels, and in photovoltaic (PV) modules used in the rural electrification of the country.

3.4.2. Energy projects in Peru – Current Trends

Large scale power projects in Peru have been mainly related to thermoelectric power production during the decade 2000-2010. This was related to the increasing use of natural gas from the

[6] *Solar insolation* is the measure of solar radiation energy received on a given surface during a given time. It is expressed in hourly, daily or annual insolation. Its units are J/m^2, kWh/m^2, etc.

Camisea gas field. Some large hydroelectric projects were also put into operation, but proportionally their capacity was much smaller than thermal projects.

Until 2012, the country does not possess any large wind or solar power installations. When the first of these projects enter into operation in 2012 – 2013, they are expected to represent nearly 8% of the total demand of the country.

3.5. SITUATION OF THE FOREST SECTOR

60% of Peru's territory is covered by forests, with a large area corresponding to the Amazon rainforest. The country possesses approximately 72 million hectare (ha) of forests, being 15.9 million ha under protection or inside nature preservation reserves (*MINAM b, 2010*, pg. 44).

Deforestation occurs in the country. Approximately 150 000 ha/yr have been deforested since 1990, and even though the process has slow down its rate during the period 2000-2005, it still happens and is continuous (*MINAM b, 2010*). Until 2005, approximately a total of 7.2 million ha had been deforested.

3.5.1. DEFORESTATION AND REFORESTATION

Slash-and-burn agriculture is the main cause of deforestation: in 2001, it represented 81.1% of the total forest area that was lost. Consumption of wood for direct use as fuel represented 16.5%, and timber extraction represented only 2.5% of deforested areas (*Galarza & La Serna, 2004*).

In Peru, forest lands are classified into six territorial categories by the Law 29763 - "Law of Forests and wild animal life" (2011): 1. Permanent production forests (PPF); 2. Local forests; 3. Reserve forests; 4. Protection forests; 5. Forests in native and peasant's lands; 6. Forests in private lands (*GOP h, 2011*).

This classification permits to geographically organize and concentrate forest activities, making easier for the Government to control them. Productive activities inside forest lands are performed in the "permanent production forests" (PPF). Land inside PPF is transferred to interested investors through a "concession", which is awarded in public auctions for a specific type of activity, such as timber extraction, reforestation, eco-tourism, etc. In this way, land "ownership" is created, which lowers possibilities of informal slash-and-burn agriculture to spread indiscriminately, since concession owners will defend the lands they hold. Figure 3-15 shows the forest lands in Peru, and the concessions granted inside the PPF.

Even though deforestation has not been stopped in Peru, some efforts to reforest old forest areas have already begun: until year 2006, 0.797 Mha were reforested. However, still an area of 9.7 Mha are available for reforestation projects (*MINAM b, 2010*, pg. 101). Largest reforestation projects are highlighted in Figure 3-15.

Around 39 Mha of forest land are available for performing forestry activities, but this potential has not yet been developed in Peru.

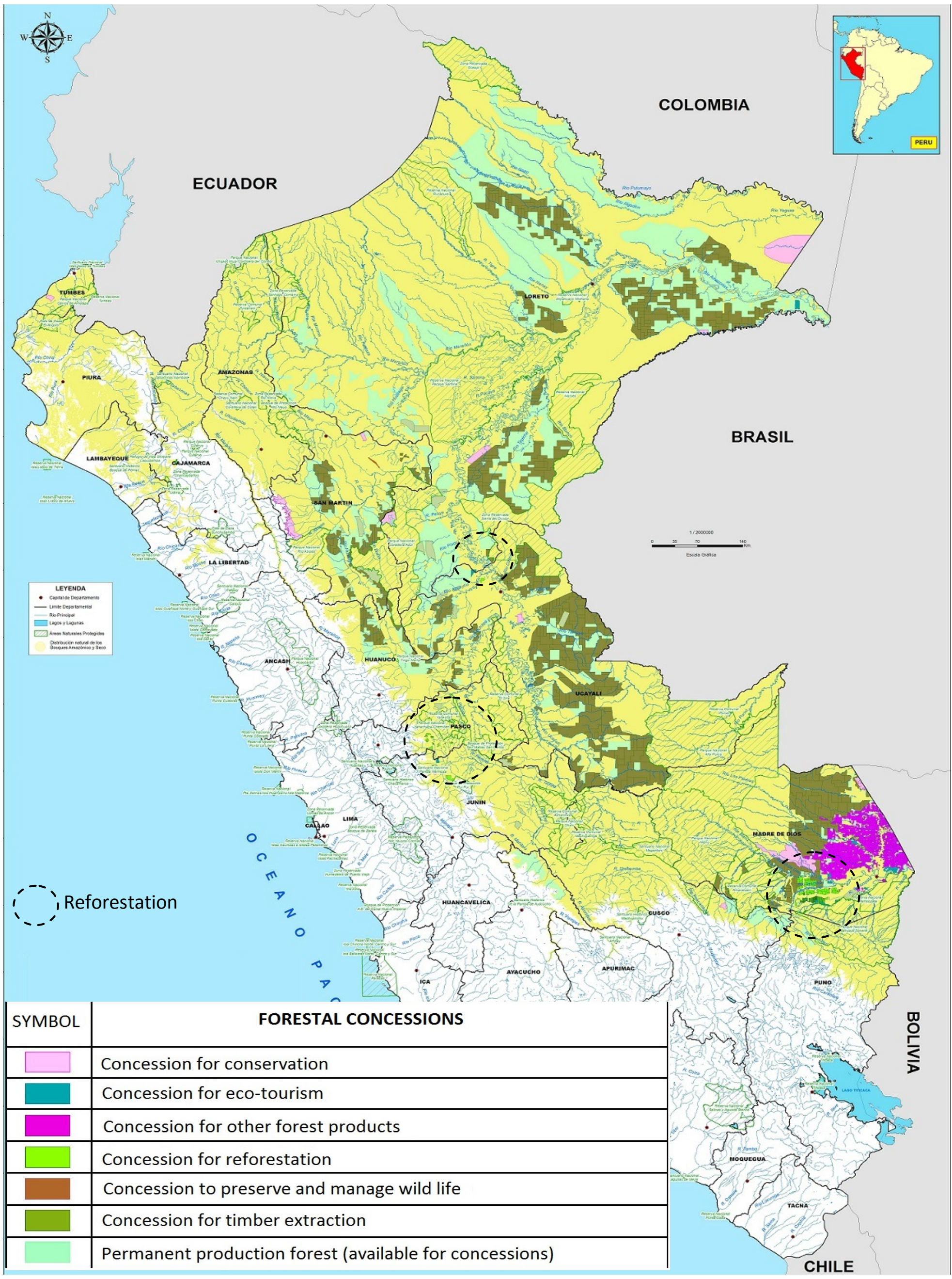

Figure 3-15. Distribution of the Permanent Production Forests (PPF) in Peru (*MINAM b, 2010*)

4. DEVELOPING CLIMATE-RELATED PROJECTS IN PERU

Peru is not among the large GHG emitters, but it has the possibility of participating in the actions against climate change through the mechanisms developed by the UNFCCC, the Kyoto Protocol and other private initiatives.

Winkelman & Moore (2011) state that most CDM projects are made in developing countries where GHG emissions are high, which explains why Peru was not a big participant in the carbon markets until 2012. However, the country is not free of sources of emissions: deforestation represents a big threat to the country's forests and it is the most important source of GHG emissions.

The growing global interest in using carbon markets to preserve forests as natural carbon sinks, with multiple additional benefits for local population, opens an opportunity to Peru. By reforesting and avoiding deforestation, Peru could further develop its industry of carbon credits, which would help the country to become an important participant in the carbon market. By developing the carbon markets in the country, other sectors would be also benefited from experience and new capacities, permitting to develop more and diverse carbon projects.

4.1. ENERGY SECTOR

Emissions from the Energy sector are mainly due to combustion of fossil fuels in Transportation. Table 4-1 shows the distribution of emissions in the sector, divided per type of economic activity. Same information is presented graphically in Figure 4-1 (*MINAM b, 2010).*

Table 4-1. Annual emissions in the energy sector (in 2000)

	CO_2 emissions (Mt CO_2)	CH_4 emissions (Mt CO_2e)	N_2O emissions (Mt CO_2e)	Total (Mt CO_2e)
A. Fossil fuels combustion	24.2	0.6	0.2	25.0
Transport	9.9	0.0	0.0	9.9
Commercial, residential, public and agriculture	4.6	0.6	0.1	5.2
Manufacturing and construction industries	3.2	0.0	0.0	3.3
Energy industries	3.1	0.0	0.0	3.1
Fishing	2.1	0.0	0.0	2.1
Mining	1.3	0.0	0.0	1.4
B. Fugitive emissions from fuels	0.0	0.4	0.0	0.4
Oil and natural gas		0.4		0.4
Total Energy (A+B)	24.2	1.0	0.2	25.4

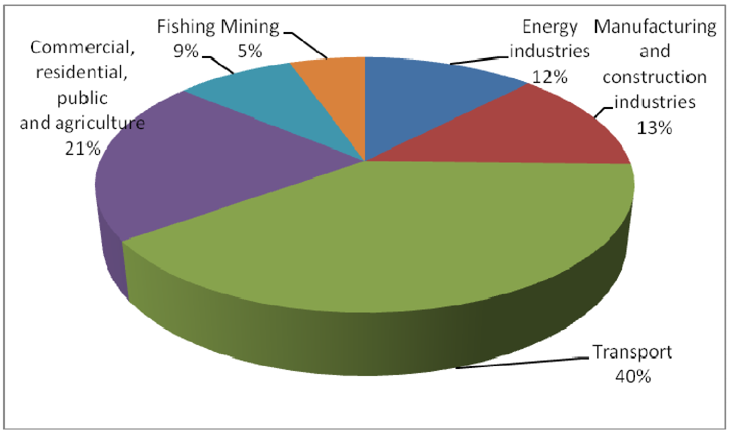

Figure 4-1. Annual GHG emissions in the energy sector (in 2000)

In the Energy sector, the activities that offer most opportunities to develop carbon businesses are power production, transportation and industry (energy efficiency improvements, fuel-switching).

4.1.1. Electricity sub-sector

Peru has experienced a continuous positive growth during last decade, which is reflected in the rising demand for electrical energy. This situation is expected to continue during current decade due to growth of number of extractive-mining projects which are energy intensive. The growth of the power sector will be mainly based in thermal units using natural gas and some big hydroelectric plants that are planned to be built. Figure 4-2 shows planned power generation projects (CH: hydro, CT: thermal) until 2019 (source: *MINEM b, 2011*).

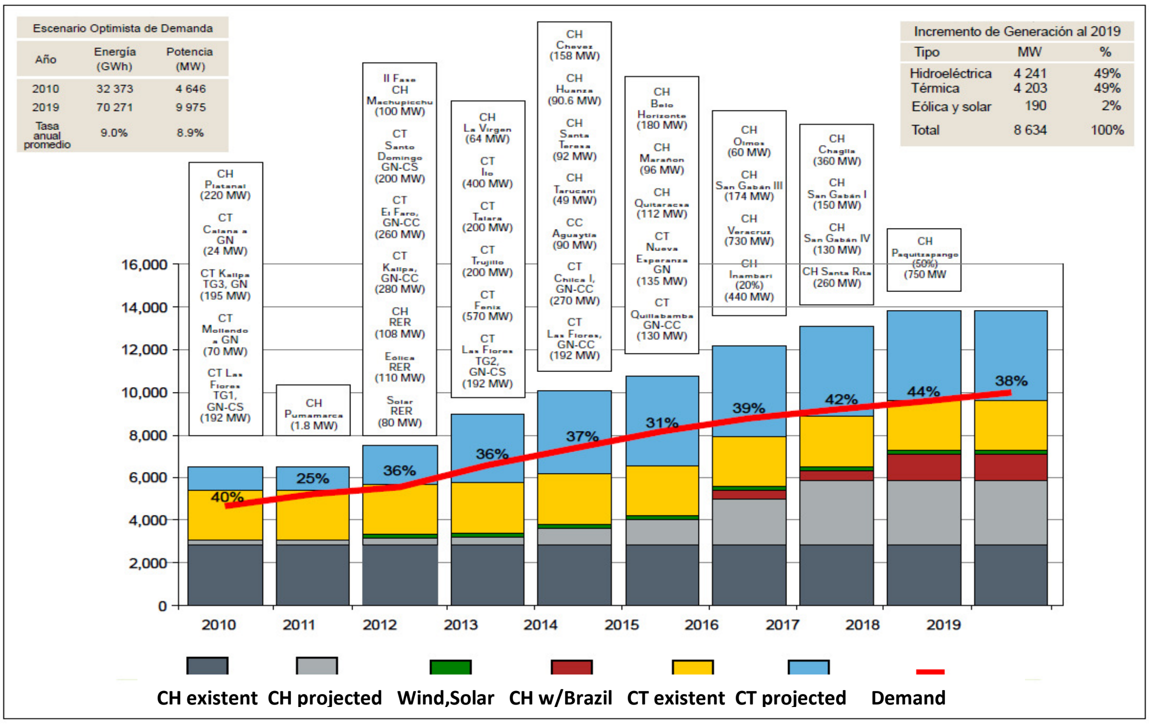

Figure 4-2. Referential plan of new power generation capacity [2010-2019] (*MINEM b, 2011*)

Even though Peru's available energy resources permit the country to continue growing based on large hydroelectricity and natural gas-fired power plants, the GoP passed the Law 1002 (May 2nd, 2008) to promote electricity production using renewable energy resources (RER).

To confirm actions in this direction, in 2010 it was approved the *National Energy Policy 2010-2040* (*GoP a, 2010*), which supports the diversification of energy sources in the power sector. It supports the use of both, conventional and non-conventional renewable energy resources, and foments the use of cleaner energies. Additionally, it is encouraged the use of CDM to generate certificates of emission reduction (CER) from the new energy projects.

4.1.1.1. OPPORTUNITIES: RENEWABLE ENERGY AUCTIONS

Law 1002 promotes electricity production using RER. For doing so, it establishes auctions to buy specific amounts of energy from new RER projects of specific technologies. Box 4-1 summarizes main aspects of the Law.

Box 4-1. Law 1002, Law to promote power production from RER (*GoP b, 2008*)

Main points:
- Are considered renewable energy resources (RER): biomass, wind, solar, geothermal, tidal and small hydroelectricity plants (less than 20 MW).
- It is mandatory that 5% of the total annual electricity produced in the country comes from RER.
- Preference in the dispatch order for RER generators.
- A fixed tariff for the electricity produced, based on the company's offered price during the auction.
- Energy-purchase agreements are signed between the representative of the GoP and the investors for no less than 20 years nor more than 30 years.
- Use of distribution and transmission lines: the investor whose project is qualified as distributed generation or cogeneration will only cover costs of incremental installations needed to be connected to the electrical system. Moreover, the electricity distribution company (owner of the transmission lines) will provide an accessible connection point to the investor within 60 days.
- Announces the first energy auction made specifically for RER in the country for year 2009. The first requirement of energy is equivalent to 500 MW with a load factor of 0.3.
- The energy auctions will be held each 2 years.

Until 2012, two energy auctions have been carried out. They have permitted Peru to have its first wind and solar power plants (to start operations from middle 2012), as well as opening the power generation market to small and medium sized investors through profitable contracts.

<u>First RER energy auction (2009-2010)</u>

It was conducted by OSINERGMIN[7] under the framework of the Law 1002. This first RER energy auction was called on August-2009 and ended in March-2010 with the signature of contracts among the GoP's representatives and the auction's winners. It requested 1314 GWh/year of energy produced from RER (except hydroelectricity). The maximum amounts per each technology were:

Technology	Biomass	Wind	Solar	Total
Requested annual energy (GWh/year)	813	320	181	1314

For hydropower plants (smaller than 20 MW), a total combined capacity of 500 MW was requested.

[7] Governmental organism that supervises the investments in energy and mining in the country.

Requirements

To participate in the public auction, the investor needs to be or have been owner of a temporary concession for producing electricity, and have met the deadlines of its concession's schedule. Other standard requirements applicable to all power producers could be found in the regulations of the Law 1002, determined by the MINEM's Supreme Decree 050-2008 (October 2nd, 2008).

Expected incomes

Produced energy is paid to the value of the auction-winner tariff during the agreed time. Moreover, as the rest of Peruvian power generators, the investor receives a payment for power capacity (dependent on its "firm capacity"). Payment to the RER power producer is made by the Power System Operator (COES), from the additional tariff charged to all the users of the service of electricity.

Results

Since it was the first experience in energy auctions of this kind in the country, several investors offered prices above the maximum prices (these were not made public until the same day of the auction). It caused that only part of the requested energy and capacity were covered. The auction permitted the construction of the first large scale wind and solar power plants, and it largely supported the installation of small hydroelectric projects in all the country. Table 4-2 shows the summary of the results of the auction. In hydroelectricity, 18 plants with a combined power of 180 MW out of the requested 500 MW were awarded (*OSNG a, 2012*).

Table 4-2. Summary results of the first RER energy auction in Peru (year 2010)

Technology	Biomass	Wind	Solar	Total
Requested energy (GWh/year)	813	320	181	1314
Awarded energy (GWh/year)	143	571	173	887
Percentage Awarded (%)	18	178	96	68

Second RER energy auction (2011)

The GoP announced the second RER energy auction in April-2011 with some variations: biomass projects were divided in projects using either municipal solid waste (MSW) or agricultural waste, and energy instead of power was requested from hydroelectricity projects. Requested energy was:

Technology	Biomass with MSW	Biomass with agric.waste	Wind	Solar	Hydro	Total
Requested energy (GWh/year)	235	593	429	43	681	1981

Results

The auction succeeded in awarding required energy from hydro, wind and solar resources, but the situation was different for biomass projects, which offered energy prices above the maximum prices. However, the auction became easier to understand this time, so it is expected that improved criteria of the investors when preparing their offers will make a better process in the auction of 2013. Table 4-3 shows the summary of the results of the auction.

Table 4-3. Summary results of the second RER energy auction in Peru (year 2011)

Technology	Biomass with MSW	Biomass with agric.waste	Wind	Solar	Hydro	Total
Requested energy (GWh/year)	235	593	429	43	681	1981
Awarded energy (GWh/year)	14	0	416	43	680	1153
Percentage Awarded (%)	6	0	97	100	100	58

4.1.1.2. INVOLVED INSTITUTIONS

Peru has improved its institutions and procedures in order to become more attractive to private and foreign investors. The energy sector has shown relevant progress since the privatization process of a large part of the previously government-controlled companies during the 1990's.

The Decree Law 25844, *Law of Electrical Concessions* (*GOP d, 1992*), provides clear procedures to award permits to investors for performing studies, building and operating power plants.

Under D. Law 25844, sales of produced electricity are always made under competition conditions:

a. Competition in the sales of energy at marginal costs (spot market) (D. Law 25844).
b. Competition for a market share for defined periods, through the auctions for selling electricity to the distribution companies. Moreover, offers made by companies that sell hydroelectricity are benefitted during the auction by a discount factor that makes them more competitive (D. Law 28832).
c. Auctions for energy produced in hydroelectricity plants, in order to guarantee the investment through long-term energy purchase agreements (PROINVERSION[8]).
d. Free option to sell produced energy to the regulated or de-regulated market (D.Law 25844).
e. Auctions for energy from RER power plants, which guarantee the investment payback through profitable tariffs and preference in power dispatch (Law 1002).

Additionally, investors are offered tax benefits though a regime of accelerated depreciation, up to 20% per year, for investments in hydroelectric and renewable energy projects (Law 1058). A regime of anticipated recovery of taxes for sales of electricity (Law 28876) is also available.

Currently there are three governmental institutions that provide access to investments in energy in Peru: PROINVERSION, OSINERGMIN and the Ministry of Energy and Mines.

a. PROINVERSION (www.proinversion.gob.pe) promotes and holds the auctions of infrastructure projects qualified as of "National interest". The energy projects are normally large, and consist mainly of large power plants and high voltage transmission lines. The proposed projects are always specific in its characteristics, location and purposes.

b. OSINERGMIN (www.osinerg.gob.pe) organizes and holds the auctions of energy from RER power plants. In the auctions, definite volumes of energy with maximum prices are

[8] PROINVERSION is a governmental agency that promotes private investments in infrastructure projects.

required, from each specific technology. The auctions are held every 2 years, and the investor's payback is guaranteed. Next RER energy auction is expected to be held in 2013.

c. The Ministry of Energy and Mines (MINEM) (www.minem.gob.pe) approves the concessions needed by the investors in order to produce electricity in the country. It holds permanently a portfolio of projects that is offered to possible investors.

At National level

A new investment in power production in Peru requires the investor to (*GoP d, 1992*):

a. Request a "temporary concession" from the MINEM, which is valid during 2 years and permits the investor to perform the feasibility study of the future investment. A temporary concession gives the investor the priority when requesting the "definitive" concession, in case other requests exist for using the same resource and site.

b. Request a "definitive concession" from the MINEM, which grants the investor rights over the existent resources and site for building and operating their project and other additional installations. Any project larger than 500 kW is required to have a definitive concession.

c. Environmental Impact Assessments (EIA) are needed for all the projects, except for those RER projects smaller than 20 MW.

At Regional level

The Regional Direction of Energy and Mines (DREM) of each Region is competent for granting temporary and definitive concessions for power generation projects between 500 kW and up to 10 MW, located inside its territory (*MINEM c, 2009*). Some of the Peruvian Regions have already published their regional energy balances and their energy strategies for coming years, where several possible projects could be found by investors.

4.1.1.3. Developing a CDM power project

The opportunities to invest into the energy sector in Peru do not necessarily require a high capital since options like participating in the RER energy auctions could be made with relatively small investment (some hydropower plants of 2 MW were awarded contracts).

Moreover, not only opportunities and options of profitable businesses by producing cleaner energy are present, but also the option of participating in carbon markets. Peru is highly vulnerable to climate change's consequences, so mitigation actions like producing electricity from cleaner sources are welcome in the country.

For developing a CDM project in the electric sector, some fixed steps are made:

a. The project sponsor (project owner) presents its project idea to the designated national authority (DNA) in Peru, which is the Ministry of the Environment (MINAM).
b. MINAM evaluates if the project accomplishes the criteria of sustainability of the country. If so, it emits a "Letter of authorization" which permits the CDM project cycle to begin.
c. In order to ensure that the generated CERs will be sold, the project sponsor signs an "Emission reduction purchase agreement" (ERPA) with a "Carbon Fund". The latter will transfer the CERs to the industries in *Annex I* countries that require offsetting their emissions.

d. The project sponsor and the Carbon Fund develop together the Project design document (PDD) and follow the process until the project is registered.
e. Third party consultants validate the project on-behalf of the CDM Executive Board.

Figure 4-3 shows the project cycle for developing a CDM project in the Peruvian power sector. The information flow and steps are similar for investments in other sectors.

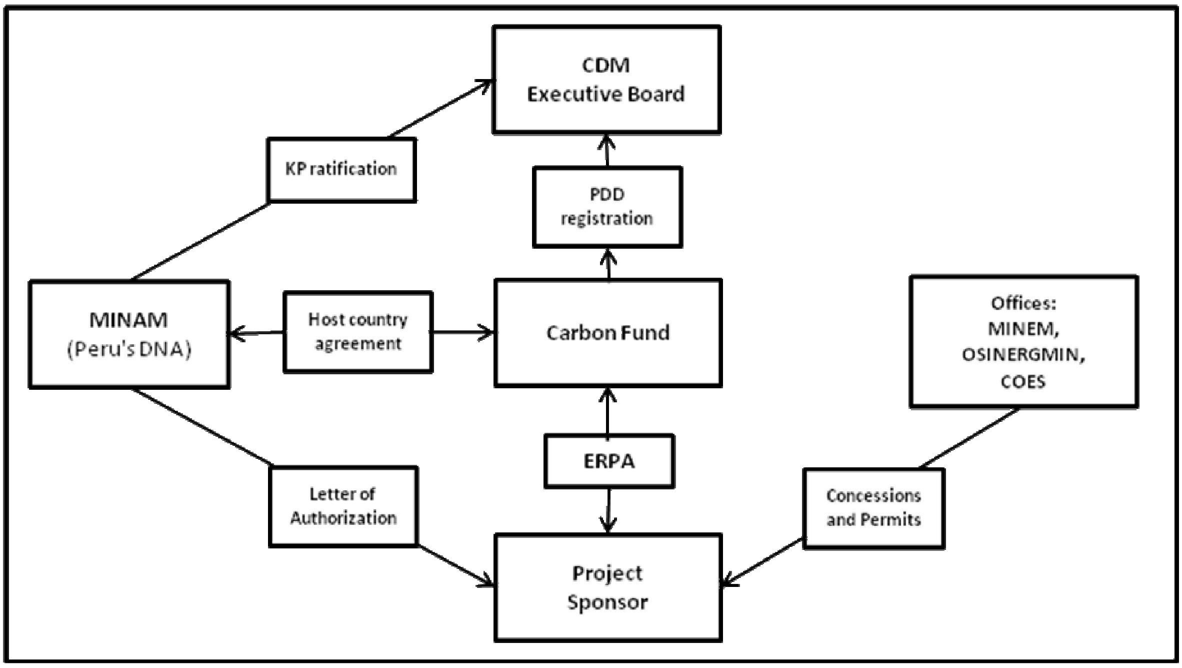

Figure 4-3. CDM project cycle for power projects in Peru (adapted from: *CDM b, 2012*)

4.1.1.4. USE OF CDM TO INCREASE ATTRACTIVENESS OF POWER PROJECTS

As shown in Section 3.3, until early 2012 Peru had 17 CDM hydropower projects registered. From them, 11 are small scale projects (below 20 MW). The CDM is a good option to increase the attractiveness of some of these projects, i.e. open the option to get bank loans or increase the IRR to values that are acceptable to investors.

The project Carhuaquero IV, registered by the UNFCCC Executive Board on May 3rd 2008, is one of those small scale projects. It presented disadvantages that discouraged an earlier investment. The CDM was used to materialize the project, improving its financial indexes.

CDM Project 1424 : Carhuaquero IV Hydroelectric Power Plant (2008)

Project description

Carhuaquero IV is located in the north of Peru, in the Region Cajamarca. It is a run-of-river hydro power plant of 9.7 MW of capacity with a projected annual average generation of 42 GWh. Its design flow is 2.5 m^3/s and it has a net head of 451 m. The project is expected to displace 167 365 tCO_2e during its first 7-year CDM crediting period.

The project uses the excess water flow (2.5 m^3/s) during the rainy season, after having satisfied the water flow needed by the already existing Carhuaquero power plant. Due to this restriction, the project is expected to have a load factor of 49% (*CDM b, 2012*).

Analysis of additionality

Hydro power plants are normally profitable investments. However, this project has some characteristics that made it unattractive to investments unless incomes from CDM were considered:

1. It is designed to operate only during the rainy season, using the excess water flow after the needs of the larger and already existent Carhuaquero hydropower plant are fulfilled. Thus, its load factor is relatively low: 49%.
2. Since it operates in rainy season, incomes are low due to low spot prices of the electricity (country's power capacity is around 60% hydroelectric). Additionally, since the plant is not available at its rated capacity during the whole year, it does not receive "payment for capacity", reducing its possible sources of incomes.
3. The project's IRR is low: 10.46%, basically due to the low load factor. It is even lower than the warranted rate for investments in electricity in the country: 12%. This factor largely discourages investors and possibility of loans.

At the moment of presenting the project, fossil fuel-fired plants were more financially viable than hydropower plants in Peru. They are more stable in terms of operations and power output. Moreover, national policies favored Camisea's natural gas-based power-generation technologies. Also, the geographical conditions of the hydropower plants expose them to risks related to earthquakes and social conflicts.

The project clearly did not match into the business-as-usual classification, consequently being considered "additional" according to the procedures for CDM project activities.

Baseline determination

In order to calculate the GHG emissions reduction (ER), a factor called "Baseline emission factor" is calculated. This requires two components:

a. *Operating Margin emission factor* (OM): involves the average emission factor (tCO_2/MWh) emitted by plants that fall within the top 10% of grid dispatch each hour of the year. For the project, the OM was 0.72756 tCO_2/MWh (for year 2005).

b. *Build Margin emission factor* (BM): involves the average emission factor (tCO_2/MWh) of the most recently built power plants accounting for 20% of all power generation in the country. The BM calculated was 0.41098 tCO_2/MWh.

The *Baseline emission factor* (CM) is calculated according to: $CM = 0.5*OM + 0.5*BM$

$$CM = 0.5*(0.72756) + 0.5*(0.41098) = 0.56927\ tCO_2/MWh$$

Emissions Reduction (ER)

Since the hydropower project does not burn fuels, it does not emit GHGs. Consequently, the emissions reduced are the ones that would have been produced in the absence of the project, under the baseline conditions.

Expected annual electricity generation: 42 GWh
Duration of first crediting period: 7 years

Estimated Annual ER = 0.56927 tCO_2/MWh * 42 GWh = 23 909.34 tCO_2

Estimated ER for the first crediting period = 23 909.34 tCO_2/yr * 7 yrs = 167 365.38 tCO_2

CERs generated for the first crediting period = ER = 167 365.38 CER

Incomes from CERs sales

The project estimated a selling price of 8 USD/CER, thus expecting incomes of:

Total incomes = 167 365.38 CER * 8 USD/CER = 1 338 923 USD

Which is equivalent to expected average annual incomes of 191 274.7 USD. The "carbon component" of the project increased its IRR from 10.46% to 12.23% (*IGES, 2012*).

Assessment of the CDM project

Use of CDM helped this project to be developed by making it financially attractive, despite of several technical disadvantages.

However, the carbon component has not been producing the expected financial incomes. Until 2012, project's monitoring reports show that the incomes are lower than expectations, basically due to lower electricity production than expected (directly associated to changes in water availability). But, losses were offset by the increase of the "Baseline emissions factor" (CM), mainly caused by the installation of several thermal projects in recent years. Table 4-4 shows the data from most recent monitoring reports (*CDM b, 2012*).

Table 4-4. Monitoring data for Carhuaquero IV CDM project [2009-2010]

	2009	2010
Baseline emissions factor (tCO_2/MWh)	0.64185	0.63983
Energy produced (MWh)	22 519	16 734
Emissions reduced (tCO_2)	14 454	10 707
Incomes from CERs (price = 8 USD/CER)	115 631	85 655

Thus, CDM can help projects that require improving their financial indexes. However, as the expected emission reductions (and consequently incomes) are based on projections of future energy production, there is an implicit risk due to the nature-dependency of small hydropower projects. A good investor should be conservative about projections, assuring that even under pessimistic scenarios the carbon component continues being profitable after covering the CDM transaction costs.

4.1.2. Transportation sub-sector

In 2000 transportation generated 40% of the emissions from the Energy sector (see Table 4-1). The main source of emissions corresponds to the use of diesel oil in freight trucks and buses for public transportation (private cars use gasoline). Public transportation (especially in Lima, where 30% of the population is concentrated) remains one of the main sources of emissions due to aging vehicles and lack of appropriate maintenance.

However, since majority of buses used for public transportation are private-owned, planning a renewal of the fleet for less pollutant units is not easy to do due to the multiple actors involved.

The country has not been able to implement a wide and mandatory program of technical supervisions of vehicles, so almost no control of emissions is done. Average age of vehicles is 15 years, with an important number of units over 20 years. Furthermore, a program of subsidies was put in place during 90's decade, making diesel oil artificially cheap compared to gasoline, causing a large increase in number of diesel-fueled private vehicles.

Measures to renew and clean the transportation system have been launched during recent years. The GoP begun in 2011 a "cash by junk" program in order to retire 17 000 old diesel buses in Lima, corresponding to 50% of the units serving the city in early 2012 (*ElComercio a, 2012*). However, this program's results are slow due to a limited available budget. Other measures such as setting the mandatory technical revisions of vehicles are planned to be implemented in order to certify that all vehicles on the roads operate correctly and their emissions are below the maximum permitted limits.

4.1.2.1. OPPORTUNITIES: TRANSPORTATION INFRASTRUCTURE PROJECTS

Since improvements in transportation indirectly lower GHG emissions, the use of CDM is considered in order to improve the financial conditions of the possible projects.

Solutions to some transportation problems in Peru require changes to existent infrastructure. Such projects are capital intensive, which represents a major barrier for their implementation. Public infrastructure investments are not designed to offer large profits in the short-term. Due to this fact, it could be important for this type of projects to apply to CDM since they have a high social impact (one of the requirements of sustainability evaluated by the national DNA) and have a visible positive environmental impact due to improved use of energy.

Experience shows there are types of projects where CDM could really support major changes in transportation. An example of these projects is the Bus Rapid Transit (BRT) system, a way of improving transportation in densely populated cities at relatively low cost. A BRT system consists on a transportation system that uses buses in more efficient way than normal bus lines. The idea behind BRT is to provide the advantages of a rail system by using buses, e.g. direct connection between stations, private lanes to avoid the traffic, high frequencies, off-bus fare collection, stations separated from the street, quality of service, etc.

Peru, especially in Lima, faces similar transportation problems than other large cities in developing countries. In order to solve them, two important initiatives were launched in recent years: the first one, a BRT system, called "Metropolitano" which was put in service in 2010. This project copied the characteristics of other BRT systems already existent, which made the implementation simpler. The second one is an electric train for massive transportation inside the city, which was inaugurated in 2011 and is currently being expanded to cover more sectors.

According to FONAM, until 2012 there are 5 CDM project ideas in the Transportation sector in the country (see Table 4-6). Two of these ideas are the "Metropolitano" BRT system, and the electric train, better known as "Tren Eléctrico" (*FONAM a, 2011*).

Table 4-5. Peru: CDM project ideas in Transportation sector (2012)

Sector	Project	Emissions reduction (tCO_2/yr)	Investment (MUSD)
Transportation	Bus Rapid Transport (BRT) System based on High Capacity Buses using Exclusive Roads	199 743	214.5
Transportation	Electric Mass Transit System for Lima and Callao Project	725 585	408.0
Transportation	Integrated Transport System in Lima/GTU	436 543	333.3
Transportation	Renewal Program of Automotive Fleet to Promote Change of Energy Matrix	73 563	50.2
Transportation	BRT system in Arequipa city, based on High Capacity Buses using Exclusive Roads.	69 040	170.0
	TOTAL	1 504 474	1 176.0

Four first projects in Table 4-5 are planned for Lima and the last one for Arequipa, the second largest city in Peru. The impact of "cleaning" the transportation sector becomes clear here: the BTR project could avoid the emission of 199 743 tCO_2e/yr, approximately equivalent to the emissions avoided through 7 small hydropower projects.

4.1.2.2. INVOLVED INSTITUTIONS

Actions in public transportation are dependent mainly on two institutions: the Ministry of Transportation (www.mtc.gob.pe), and the City's government. Initiatives like the ones in Table 4-5 are highly government-dependent, so private investors could begin their participation from the public auctions that the government hold to develop specific infrastructure projects. In case the project is held outside from Lima, then the responsibility over the project corresponds to the Regional government.

4.1.2.3. USE OF CDM IN TRANSPORTATION

The cycle of the CDM transportation projects is similar to the one described for power projects. It can be seen in the diagram in Figure 4-3.

Worldwide, until June 2012, there are 15 CDM transportation projects registered. Nine among them are BRT system projects, while two of them correspond to implementation of "Metro-type" systems. The CDM design documents (PDD) of these projects show how they are evaluated according to "social return rates" since they are not expected to create revenues but to improve social indicators such as reduced time spent in transport, reduced operational cost of the public transit, reduced health costs due to less air pollution, less accidents and reduced transport costs for users of public transport (*CDM c, 2011*). It is also frequently mentioned in the PDD's that the costs of infrastructure are normally higher than expected, reducing the project's social IRR to values below their benchmarks.

4.1.2.4. TRANSPORTATION IMPROVEMENT THROUGH CDM PROJECTS

Since the city of Lima began very recently the projects to improve its transport infrastructure, the potential is high for developing additional expansions of both, the BRT system and the electrical train. These initiatives to improve the public transportation represent an opportunity to Peru and the investors in the country. Following lines will show how CDM is used to improve financially these projects through a review of the main aspects of one of the CDM BRT system projects, named "TransMilenio".

CDM Project 0672: Bus Rapid Transit (BRT) Bogotá, Colombia: TransMilenio Phase II to IV

BRT systems are a good option to improve transportation in cities where larger investments such as rail transport or an underground Metro are difficult to implement due to high costs or technical impossibilities. This Section shows the experience of "TransMilenio" project in Colombia, a project aimed to solve problems similar to the ones existing in Peru.

Project description

Bogotá, capital of Colombia, as many other big cities in developing countries, is a city with problems of public transportation.

The government of the city proposed in 2002 the project Bus Rapid Transport (BRT) Bogotá, known as "TransMilenio", Phase I. The project built exclusive roads inside the existent avenues in order to provide free-of-traffic routes to be exclusively covered by large capacity buses that would permit to reduce the number of smaller units needed for public transportation, consequently reducing the traffic inside the city and the pollution caused by an excessive number of vehicles.

In year 2006, the next stages of TransMilenio, Phases II to IV, applied to CDM in order to cover the unexpected over costs of the project due to different technical characteristics than Phase I. During the verification stage in the CDM project cycle, it was demonstrated that the project really required the additional financial support from CDM for covering its investment and operation costs (as a public infrastructure project it was not supposed to generate profits), consequently proving its "additionality" (one of the mandatory requirements for CDM projects).

The project was finally registered on December 2006. It expects to reduce 246 563 tCO_2e/yr and has a crediting period of 7 years (*CDM a, 2012*). Figure 4-4 shows some images of the project in operation.

Figure 4-4. "TransMilenio" BRT system in Bogotá, Colombia (2009)

In this project, GHG emissions are avoided through the replacement of old inefficient vehicles with new, larger and more efficient buses, centrally managed in order to improve the buses' load factor[9].

[9] In transportation, "load factor" is interpreted as the percentage of the total capacity of a vehicle that is occupied with passengers during a determined period of service.

Baseline determination

In order to define the baseline of the project, reasonable alternatives are analyzed and compared with the proposed project. Four alternatives were analyzed:

1. Establishment of a rail-based public transport system
2. Complete operational restructuring of the public transport system
3. Continuation of the current system including improvements based on national or local policies
4. Implementing the project (TransMilenio phase II and following) without CDM

Option 1 is discarded due to much higher costs than the project. Option 2 is discarded due to practical impossibility of restructuring the current system: atomized public transportation, multiple actors involved and lack of organizational capacities, among other reasons. Option 4 is discarded since costs of the project were much higher (around 78%) than expected: previous experience, "TransMilenio - Phase I", had much lower costs than the new project. This option made it clear that the project would not be built if additional economical incomes were not secured.

Option 3 was considered to be the most realistic scenario in absence of the project, since it did not imply additional high costs, conflict with the actors inside the public transportation system nor political risks. Thus, Option 3 was considered the baseline of the project.

Emissions reduction (ER) and generation of CERs

The ER is calculated comparing emissions that occur with the project and those that would occur under the baseline, i.e. without the project. The annual ER is (*CDM a, 2012,* pg. 49):

$$ER_y = BE_y - PE_y - LE_y$$

Where: ER_y=Emissions reduction in year "y", BE_y=Baseline emissions in year "y", PE_y=Project emissions in year "y", LE_y=Emissions leakage in year "y". Finally, total ER = ΣE_y.

Project emissions: mainly due to emissions from fuel use in the trucks and "feeder" buses. Statistical data such as truck's average fuel consumption and annual number of passengers is used. The total estimated project emissions over the 7-year crediting period is 1 053 194 tCO_2e.

Leakage emissions: the implementation of the project causes some unavoidable emissions, which have to be accounted. In the project they were classified as upstream emissions, emissions due to change of vehicles' load factor and reduced vehicular congestion:

a. Upstream emissions: Construction, reduced life-span (due to earlier replacement of buses - scrappage), life-cycle effect of reduced fuel usage.
b. Change of load factor of the baseline transport system: the project potentially influences the occupancy rate of the remaining vehicles.
c. Reduced congestion in remaining roads provoking higher average vehicle speed, less stop-and-go traffic and a rebound effect (additional trips).

Calculations were carried out using formulas from CDM Methodology AM-0031. Results are:

Upstream emissions:

Construction emissions	=	229 424 tCO_2e
Vehicle replacement emissions	=	56 826 tCO_2e
Upstream fuel emissions	=	-243 389 tCO_2e
Total Upstream emissions	=	42 861 tCO_2e

Change of load factor: zero (not significant variations respect to the baseline)

Reduced congestion:

Rebound effect	=	43 328 tCO_2e
Increased vehicle speed	=	-77 421 tCO_2e
Total reduced congestion emissions	=	- 34 113 tCO_2e
Total Leakage emissions[10](LE)	=	12 555 tCO_2e

Then: Project Activity Emissions = Project Emissions (PE) + Leakage (LE)
Project Activity Emissions = (1 053 194 + 12 555) = 1 065 749 tCO_2e

Thus, total estimated project activity emissions over the crediting period are 1 065 749 tCO_2e.

Baseline emissions (BE): the emissions for the business-as-usual case are calculated. Data such as emissions per passenger transported per vehicle category, vehicle categories, emission per kilometer, among others are needed. Total expected baseline emissions are 2 791 689 tCO_2e.

Emissions Reduction (ER):

Project's Emission Reduction: ER = BE – (PE + LE)
ER = (2 791 689 – 1 065 749) tCO_2e

Total expected ER due to the project activity during the first crediting period is 1 725 940 tCO_2e.

Incomes from CERs sales

The project initially estimated that the price of the CERs in the international market would be between 3 and 19 USD/tCO_2e. Thus, expected incomes were between 5.2 and 32.8 million USD.

Assessment of the CDM project

According to project's PDD, unexpected additional costs of the project reached 125 million USD. The carbon component was expected to provide incomes to significantly reduce this financial gap (expectations about CERs' price were high in 2006). If successful, it was planned to renew the project's crediting period for 14 additional years, which could have generated a total of (3 x 32.8 = 98.4 million USD).

[10] Leakage emissions are not (42 861 – 34 113 = 8 748 tCO2e) (Upstream + Red. congestion) because in the analysis year per year, leakage emissions (LE_y) are negative in two years. Those values are replaced by zero since the methodology does not consider the option of having negative annual leakages. Consequently, the sum of leakage emissions per year gives a higher value: 12 555 tCO2e (*CDM a, 2012*, Annex 3).

However, real incomes during first 5 years of operation (2006-2010) were 2.63 million USD (*NYT a, 2011*) instead of expected 6 million USD (CER's average price = 6 USD/tCO_2e). The main cause of the deviation was that real number of passengers was only around 37% of expected. This happened mainly due to the delay in the construction of phases III and IV of the project, which were necessary to cover larger areas of the city and then attract more users.

Until June 2012, only 3 BRT projects, including "TransMilenio", have issued CERs. In all cases, the avoided emissions have been lower than expected. A common problem has been the delay in the start of operations of some lanes in the city, which did not permit to reach the number of expected passengers. Still, these projects continue being attractive since the amount of CERs that they produce annually is high compared to other options (around 100 000 tCO_2e/year). Close attention to the initial project's budget and an effort not to delay the expansions have to be considered in order to reduce the possibility of large reductions of the expected incomes from CERs sales.

4.2. AGRICULTURE SECTOR

Agriculture is an important economic activity in Peru. In 2010 it represented 7.5% of country's GDP (*INEI, 2012*).

Emissions corresponding to this sector come mainly from enteric fermentation from cattle ranching, and emission of nitrogen oxides (N_2O) from fertilizers used in agricultural and grazing soil.

Cattle ranching produce methane emission due to enteric fermentation of the livestock. This is a natural process from ruminant animal digestion, which could mainly be controlled by reducing the number of animals required. Peru faces a problem in this aspect, since the yields of animal products are lower respect to other countries: In Japan, average daily milk production is 29.9 kg/day, while it is 5.7 kg/day in Peru; in beef cattle, New Zealand's animals weigh 429.6 kg/unit, while in Peru weigh between 350 and 375 kg/unit. Lack of extensive technical improvements in livestock management causes this, which makes necessary to grow more number of animals to cover the demand (*MINAM b, 2010*, pg. 79).

Farming activities also emit GHG. Artificial fertilizers used to grow crops contain nitrogen, which after reacting on the soil, is released to the atmosphere as nitrous oxide (N_2O). Table 4-6 is extracted from Table 3-2 and Table 3-3, it shows the sub-categories of the Agriculture sector that emit more GHG.

Table 4-6. Annual emissions in the agriculture sector (2000)

Category	Sub-Categories	GHG	CO_2eq (Mt)	% of Total with LULUCF	% of Total without LULUCF
Agriculture	Enteric fermentation	CH_4	10.4	8.7	16.4
Agriculture	Agricultural soils	N_2O	9.7	8.1	15.2
Agriculture	Rice cultivation	CH_4	0.9	0.7	1.4
Agriculture	Manure management	N_2O	0.6	0.5	1.0
	TOTAL		21.6	18.0	34.0

Methods to reduce enteric fermentation are still under development (*CliTec, 2009*). Research efforts are centered on changes in cattle's diet and genetic manipulation, presenting promising results: increase in the amount of oils in the diet reduces methane production, while at the same time, meat yields are increased by reducing energy loses due to less fermentation (*Moate et al., 2011*). However, there is still not conclusive evidence that provides large-scale solutions to this problem.

Enough tools are not yet available for developing projects to reduce methane emissions from enteric fermentation worldwide. Until April 2012, no enteric fermentation-emission reduction projects have been registered nor in CDM nor in the Voluntary carbon markets. Thus, this sector is not promising for carbon markets in Peru, yet.

4.3. LAND USE, LAND USE CHANGE AND FORESTRY (LULUCF)

Deforestation represented 47.4% of total GHG emissions in Peru in 2000, being the largest source of emissions. Main causes of deforestation are slash-and-burn[11] agriculture, illegal timber extraction and fuel-wood consumption. Table 4-7, extracted from Table 3-2, shows the two sub-categories of emissions (and sinks) related to forest activities.

Table 4-7. Annual Emissions in the LULUCF sector (2000)

Category	Sub-Categories	GHG	CO_2eq (Mt/yr)	% of Total
LULUCF	Conversion of forests and pastures	CO_2	110.1	
LULUCF	Change of forest biomass and other stocks (sink)	CO_2	-53.2	
	TOTAL		56.8	47.3

"Change of forest biomass and other stocks" represents the carbon that is captured by nature itself through the natural growth of trees and vegetal biomass. Sign minus (-) means that it does not emit GHG but captures them instead.

4.3.1. OPPORTUNITIES: CARBON PROJECTS IN FORESTS

There are two types of carbon projects that could be carried out in forests: reforestation/afforestation and forest conservation.

In Peru, reforestation projects could be made as private or government-supported initiative. In this paper only private climate business-related reforestation projects are analyzed, i.e. using CDM or the Voluntary Carbon Markets. Forest conservation projects do not apply to CDM but to REDD+ instead.

As shown in Section 3.5, even though a large area of the country is covered by forests, deforestation has been occurring continuously and represents an actual problem for Peru. Approximately 9.7 Mha of land are available for reforestation projects, being mainly concentrated in the highlands (71%) and the forest (24%) (*MINAM e, 2011*, pg. 101). This is not a minor issue, since in 2010 Peru's forest area was around 72 Mha[12].

[11] Slash-and-burn is an agricultural technique that consists on cutting down trees from a forest area, burning the remains and use that land as agricultural field. The ashes from the fire will fertilize the burned field before plantations are made. However, without trees, the soil become unable to sustain crops for long time, causing farmers to move to new areas and repeat the process (*EoE, 2012*).

[12] To better understand the scale of these magnitudes, Sweden's total area is approximately 52.8 Mha.

4.3.1.1. INVOLVED INSTITUTIONS

The legal framework for forest activities in Peru is the Law 29763 - "Law of Forests and wild animal life", passed on 2011 (*GOP h, 2011*).

It is necessary to secure the land where the project plans to be developed. Non defined land ownership could lead to problems or carbon leakage, non-permanency or even conflict for the carbon payments (*Benessaiah, 2012; Luttrell, 2007*). If the investor does not own the land and prefer to invest in Government-owned lands, it is necessary to apply and be awarded a forest concession. The forest concession is granted by the corresponding Regional government. Maximum area and duration of the concession depend on the type of project (reforestation, forest conservation). If the investor owns the land, it is just necessary to apply for a forest permit from the Regional Forest Authority (*GOP h, 2011*, chapters IV, V).

4.3.1.2. CDM AND VOLUNTARY MARKETS FOR SUSTAINABLE REFORESTATION

Until 2012, there were 38 afforestation/reforestation (A/R) LULUCF CDM projects registered by the UNFCCC (*CDM, 2012*). These projects are designed to invest in reforestation on degraded soils, capture CO_2 through trees' photosynthesis, generate CERs from captured carbon, harvest the timber and finally replant the trees that were cut-off. Economic incomes of these projects come from sales of the CERs generated and sales of the timber harvested once the trees have completed their growth.

Trees capture effectively CO_2 when they grow. However, once they are cut-down for using their wood, there is a risk that the carbon will be released again to the atmosphere if the wood is burned. This is called "risk of non-permanence". Due to this risk, CERs generated from A/R activities are not equal to CERs from other reduction projects.

There are two types of "A/R CERs": temporary CERs (*t*CERs) and long term CERs (*l*CERs). *tCERs* expire at the end of the next commitment period, subsequent to the commitment period where they were issued. *lCERs* are valid until the end of the project's crediting period. The buyer that acquired them to offset its emissions will have to buy new CERs (of any type) once its A/R CERs have expired. This caused these CERs to be less attractive than "normal" CERs, consequently having lower price in the market (K*arousakis, 2007*).

Until 2012, Peru had only one A/R LULUCF CDM project: "Reforestation, sustainable production and carbon sequestration project in José Ignacio Távara´s dry forest, Piura". It was registered in 2009, and is expected to capture 48 689 tCO_2/year.

The voluntary carbon markets (VCM) have been a more active platform than CDM for Peruvian reforestation projects: until 2012, three projects had been validated under the Verified Carbon Standard (VCS), one of the VCM standards. These projects together are expected to capture 66 093 tCO_2e/yr during their 30-40 years of validity period (see Table 4-8).

Table 4-8. Peru: Forest projects in the Voluntary Carbon Market (2012)

Project	Standard	Sector	Year of validation	Project duration (years)	Annual Emissions Reduction (tCO2e/yr)
Reforestation of pastures in Campo Verde with native species, Pucallpa, Peru	Verified Carbon Standard	Agriculture, Forestry	2009	30	5 600
Alto Huayabamba	Verified Carbon Standard	Agriculture, Forestry	2011	40	28 756
Reforestation of pastures - Joven Forestal Project, Perú	Verified Carbon Standard	Agriculture, Forestry	2011	30	31 737
TOTAL					66 093

The VCM attracts buyers and investors by focusing on transparency of their mechanisms (*PCF, 2012*) and the sustainable social component of their projects. Also, by having fewer requirements than CDM, the VCM has lower transaction costs. Nevertheless, costs are not that low, marginalizing very small projects from participating (*Benessaiah, 2012*).

Even though the possible markets and mechanisms are well known, reforestation projects are not widely spread in the country due to diverse factors such as high transaction costs, the need of specialized consultants to develop the project and contact the buyers (*Luttrell, 2007*), the inherent difficulty of measuring the carbon captured in large forest areas and the risk of making a long-term land-connected investment, highly dependent on social involvement.

4.3.1.3. VCM FOR DEVELOPING REFORESTATION PROJECTS

The existence of large areas to reforest and the good geographical conditions permit reforestation projects to have a high potential in Peru. However, as few experiences have been consolidated until now (2012), it is difficult that large scale projects emerge soon.

Under the current situation, developing projects with as few risks as possible is possibly the best option. Proven land ownership, low initial investment, local communities' involvement and early contact with the potential credit buyers are aspects that will define a good reforestation project in Peru. As the VCM compete for credit buyers, their projects tend to be of public awareness and have visible positive impact over the local communities. Following lines show the experience of one of the Peruvian reforestation projects developed under the VCM.

VCM project: Reforestation of pastures in Agricultural Society of Social Interest "José Carlos Mariátegui" (SAIS-JCM) - Joven Forestal Project, Perú

This project applied to the Verified Carbon Standard (VCS), being registered in 2011.

Project description

The "Joven Forestal" project in Region Cajamarca, Peru, is classified as an afforestation, reforestation and revegetation project according to Voluntary Carbon Standards (VCS).

This is a reforestation project developed on 1450 ha of private-owned lands (by the SAIS-JCM). The land was selected based on their state of abandon for a long period of time. It is projected to capture an annual average of 31 730 tCO_2e during 30 years, through plantation of exotic species (pine) with high market value. Plantation occurs in three consequtive years 2008, 2009 and 2010. Thus, final wood harvesting and final replanting is expected to occur in 2038, 2039 and 2040.

Project's registration was initially rejected in 2008 since it did not meet the financial sustainability criteria. Problem was overtaken when the carbon component was added. The project is intended to benefit local population with incomes from the carbon credits sales and the harvesting of wood in year 30.

The project is an association among three actors: an NGO specialized in forestry and agriculture, the SAIS-JCM as land owner and labor provider and a company specialized in carbon projects (*VCS a, 2011*).

Analysis of additionality

To analyze if the project was additional, barriers and common practices were analyzed.

Several barriers to the project were detected: previous similar activities have only been developed through donations or other non-commercial funding, the SAIS lacked of investment capital and had low access to credit, forestry was not seen by the community as a profitable activity and instead it was seen as foreign to the local socio-cultural conditions of the community.

The common practice analysis indicated that the project could not have been developed without the scheme proposed. The project was not common practice, and consequently, it was additional.

Baseline determination

Three possible scenarios were defined to define the baseline:

1. Continuation of the pre-project land use: semi-abandoned and extensive cattle ranch.
2. Afforestation / reforestation of the land within the project boundary performed without being registered as A/R CDM project.
3. Extrapolation of other observed forestation activities in the geographical area with similar conditions to the proposed A/R.

Alternatives 2 and 3 were discarded since previous efforts of reforestation in the zone failed due to the lack of involvement of local communities, mainly because those were government-driven reforestation projects with unclear economic benefits for local inhabitants. Moreover, governmental investments in reforestation in the zone are low, making it difficult to reforest the zone of the proposed project. Consequently, the baseline chosen was the alternative 1.

Emissions avoided and carbon credits generated

Under the VCS standard, VER is the equivalent to CDM's CER. To calculate the number of VERs generated by the project, it is necessary to calculate the GHG emissions removed by sinks under baseline conditions and compare them with the carbon captured by the project.

The project area was characterized for the presence of grasses and small shrubs. Trees were not present in the zone, and consequently not considered in the baseline scenario. Since no trees existed, net GHG emissions removal in the baseline was considered zero.

To calculate the carbon captured by the project, the VCM Methodology defines how to calculate the carbon stock in *above-ground* and *below-ground* biomass of the trees present. It was calculated that the total CO_2 captured during the 30-year crediting period, namely "net anthropogenic GHG removals by sinks", would be 952 118.9 tCO_2, corresponding to an annual average of 31 737.3 tCO_2. Figure 4-5 shows the expected evolution of CO_2 captured in the trees during the duration of the project (*VCS a, 2011*).

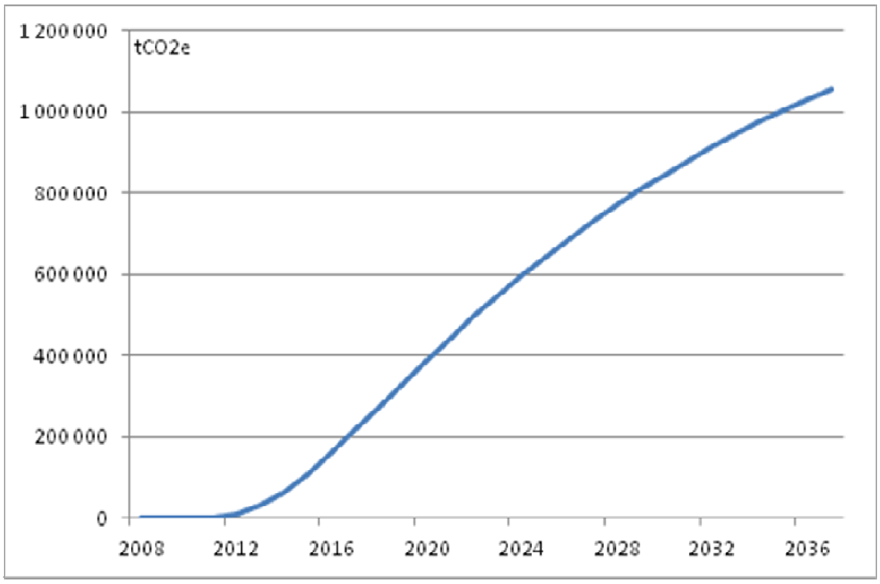

Figure 4-5. "Joven Forestal" VCM project. CO_2 captured during the 30-year crediting period

Assessment of the project

Even though this project is not technically complicated, it requires close attention to fulfill all the methodology's requirements, as any observation made by the DOE[13] could cause important delays. For instance, this project's verification process took around 7 months (May to December 2011) due to multiple observations made to the initial project documents, such as lack of clarity in the calculations of carbon capture and the real number of planted trees (*VCS a, 2011*). Until June 2012, the project had not issued VERs yet.

[13] DOE: Designated Operational Entity. Third party entity that performs an independent assessment of the project at the different stages of its lifetime.

5. The future of climate business in Peru

Peru has not been an early starter in the worldwide “carbon business”. However, the opportunities that show up in this fast-growing developing country inside sectors that could be ”cleaned” from GHG emissions, open a window of opportunities that investors have already seen. This Section analyzes private investors’ ideas of carbon projects that have been made public, aiming to extract some conclusions about what the future of CDM in Peru could be.

5.1. Private investors’ CDM project ideas

FONAM, the office of the Ministry of Environment (MINAM) that promotes CDM in Peru, permanently holds a portfolio where private initiatives/ideas for carbon projects are made public. At early 2012, this portfolio shows 234 proposed projects: 176 in the energy sector, 40 afforestation/reforestation (A/R) projects and 18 forest conservation projects (*FONAM a, b, c, 2011*). Energy and A/R projects are planned to apply to CDM, whereas forest conservation projects should apply to REDD+.

Following graphs show the relation between the investment planned for each energy project versus the factor “investment” divided per “project’s expected avoided emissions” (USD/tCO_2e). In the graphs, the volume of each “balloon” represents the expected annual emission reductions for each project (ton CO_2e/year).

Figure 5-1 shows 35 hydropower CDM projects from FONAM’s portfolio (there are 83 in total). The ones in red color represent projects executed and already registered as CDM projects, while the ones in blue color are those still at the level of “CDM project idea”.

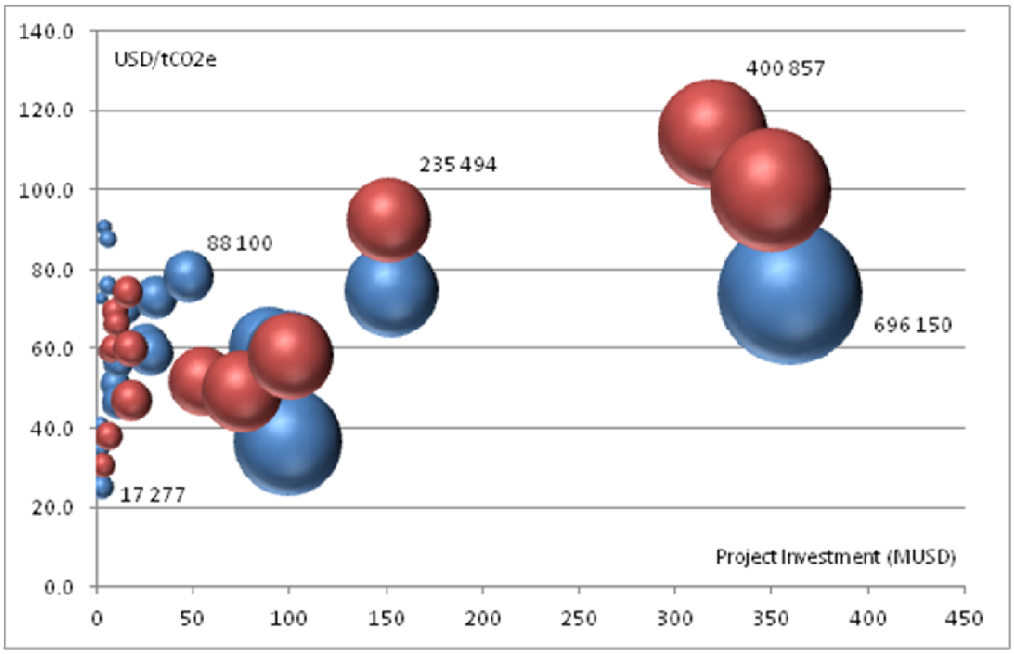

Figure 5-1. Hydropower projects in FONAM’s CDM portfolio

Figures 5-2 and 5-3 show biomass and waste management projects in FONAM’s portfolio. These two types of projects are worth to be analyzed due to their low cost and high potential, as it will be discussed in following lines. As in Figure 5-1, red colored balloons represent projects already registered under CDM, while blue ones are project ideas.

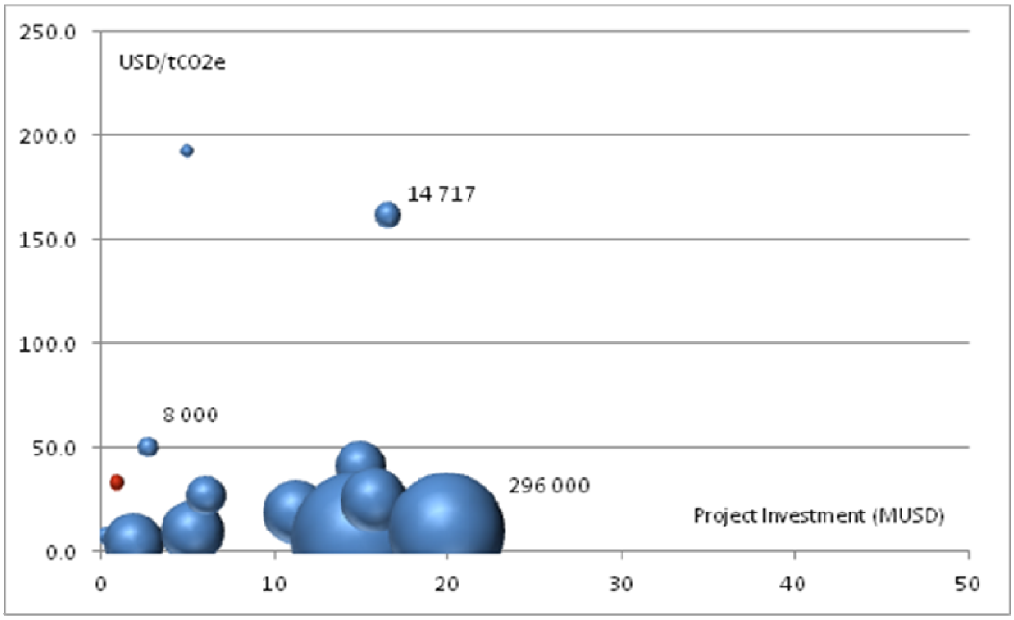

Figure 5-2. Biomass projects in FONAM's CDM portfolio

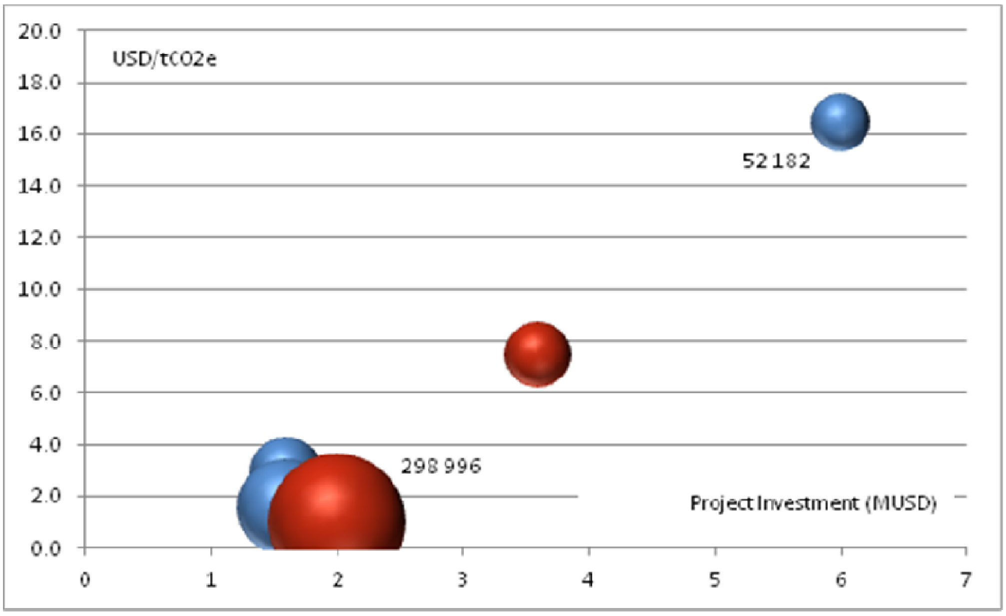

Figure 5-3. Waste management projects in FONAM's CDM portfolio

It can be seen that most of the hydroelectric, biomass, and waste management projects have relatively low individual investments per project: less than 30 MUSD each.

Individual investment for hydroelectric projects is concentrated below 30 MUSD, in biomass projects it is below 20 MUSD and in waste management it is below 10 MUSD. Moreover, the investment per expected reduced emissions (USD/tCO_2e) is in the range 40-80 USD/tCO_2e for hydro projects, 3.8-30 USD/tCO_2e for biomass projects, and 1-7.5 USD/tCO_2e for waste management projects.

The majority of hydroelectric CDM projects are concentrated in small power plants (Figure 5-1). The cost of reduction of emissions in hydro projects (40–80 USD/tCO_2e) is higher than in biomass and waste management projects, which is understandable since main business for hydroelectric plants is sales of electricity and no the carbon component (CERs). Figure 5-1 shows also the existence of much larger projects in the CDM portfolio (investments of 50-350 MUSD). For them, CDM is normally a marginal financial complement to their main incomes.

Biomass projects (Figure 5-2) are the second best option according to the cost of reduction of emissions (3.8–40 USD/tCO_2e). There are two predominant types of projects: capture of methane from accumulation of residues from biomass industries (wood, wine, etc.), and use of biomass waste products from other main industries (bagasse, rice husk) as fuel for industrial boilers. Methane capture projects are relatively cheap projects (less than 10 MUSD of investment), while the biomass-to-heat projects have investments between 10-20 MUSD. The reason behind this difference is that the projects for methane capture/destruction have simpler infrastructure, not needing to produce any co-product to become profitable. These projects base their business model in sales of the CERs generated due to the high GWP potential of the methane ($GWP_{methane}$= 25).

Generating CERs from waste management projects (Figure 5-3) is the most profitable among these first three options (1.0-7.5 USD/tCOe). This is reasonable since waste management emissions reduction projects do not always have a co-product that could produce additional profits, such as electricity. Thus its profitability depends exclusively on producing cheap emission reductions. In this category, FONAM's portfolio has 19 projects, four of which have much higher investments (over 70 MUSD) and consequently are not shown in Figure 5-3. Those larger projects are mainly governmental-driven: 3 wastewater treatment plants for whole cities, and the national plan for solid waste management.

Figure 5-4 shows fuel switching projects in FONAM's portfolio. Again, red colored balloons are registered CDM projects, while blue ones are project ideas.

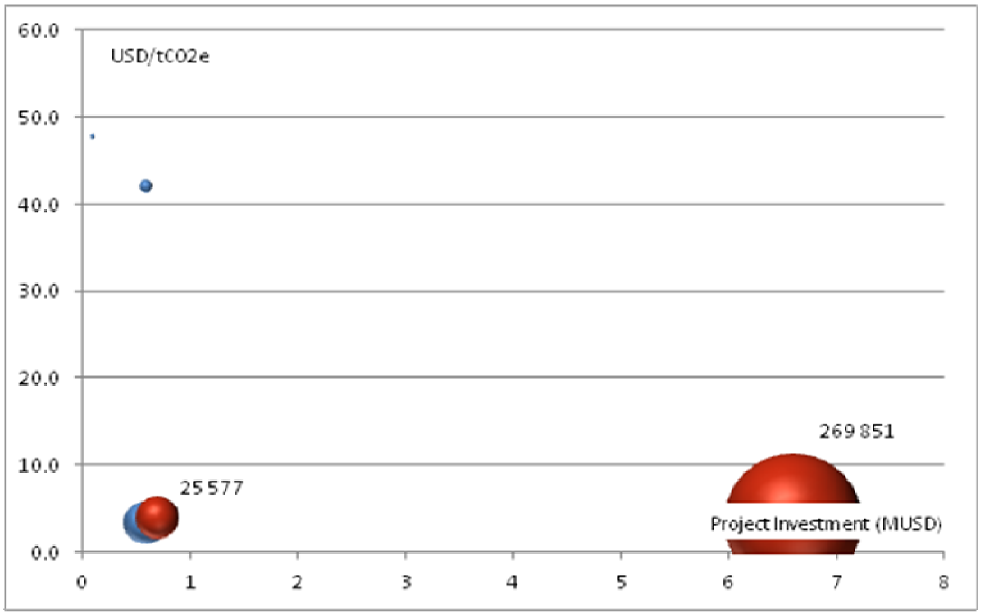

Figure 5-4. Fuel switching projects in FONAM's CDM portfolio

The majority of fuel switching projects in FONAM's portfolio have low-cost. Four projects with investments below 1 MUSD are designed for small or medium industries, whose aim is to switch from oil or coal to natural gas in their furnaces. The largest project shown in Figure 5-4 has an investment of 6.6 MUSD and avoids the emission of 269 851 tCO_2e/year. This is an economically excellent project that switches coal by natural gas in a cement production plant, with a cost of emissions reduction of 3.5 USD/tCO_2e.

Figures 5-5 and 5-6 show wind power and transportation projects in FONAM's portfolio. Until early 2012, there are no registered CDM projects of these categories in Peru. As it is shown, these projects require high capital investment, but they also reduce high amounts of GHG emissions that could be transformed into incomes through CDM.

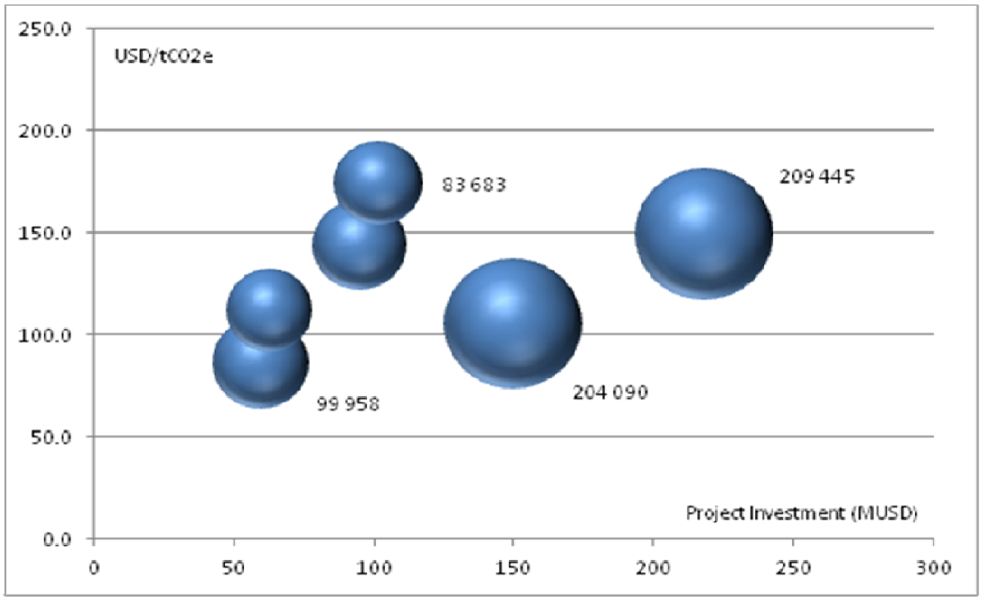

Figure 5-5. Wind energy projects in FONAM's CDM portfolio

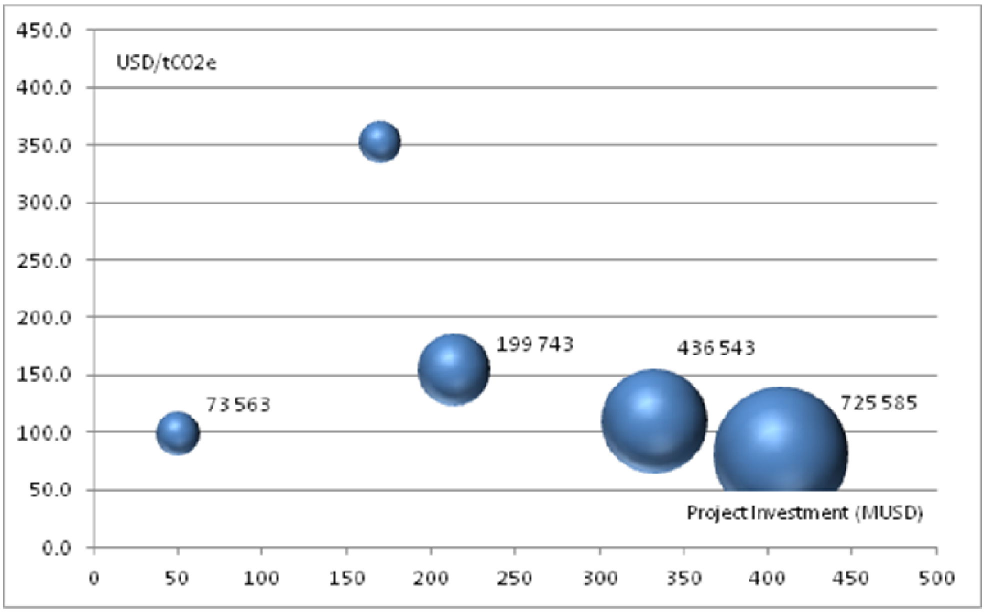

Figure 5-6. Transportation projects in FONAM's CDM portfolio

From available data, it is calculated that the investment cost for wind energy projects is around 2 000 USD/kW installed. The cost of reduction of emissions for the six wind power projects presented in FONAM's portfolio is between 85-174 USD/tCO_2e (Figure 5-5). This is a high cost compared to previous categories, which just confirms that for these projects CDM represents only a marginal economic support. To be profitable, wind power depends on sales of electricity, premiums, feed-in-tariffs, etc.

Figure 5-6 shows the transportation project ideas. The Bus Rapid Transit (BRT) and the electrical train projects that were commented in sub-section 4.1.2 are shown here (their emissions reduction are 199 743 and 725 585 tCO_2e/year, respectively). These projects are the costliest ones among all the analyzed categories, but their capacity to generate large amounts of CERs and their social impact make them good prospects to apply to CDM.

FONAM's portfolio holds 40 afforestation/reforestation (A/R) projects. Figure 5-7 plots these projects, being balloons' volume the expected carbon to be captured per project (for a time horizon of 20 years). Red colored balloon represents the only registered CDM project, while green colored ones are A/R CDM project ideas.

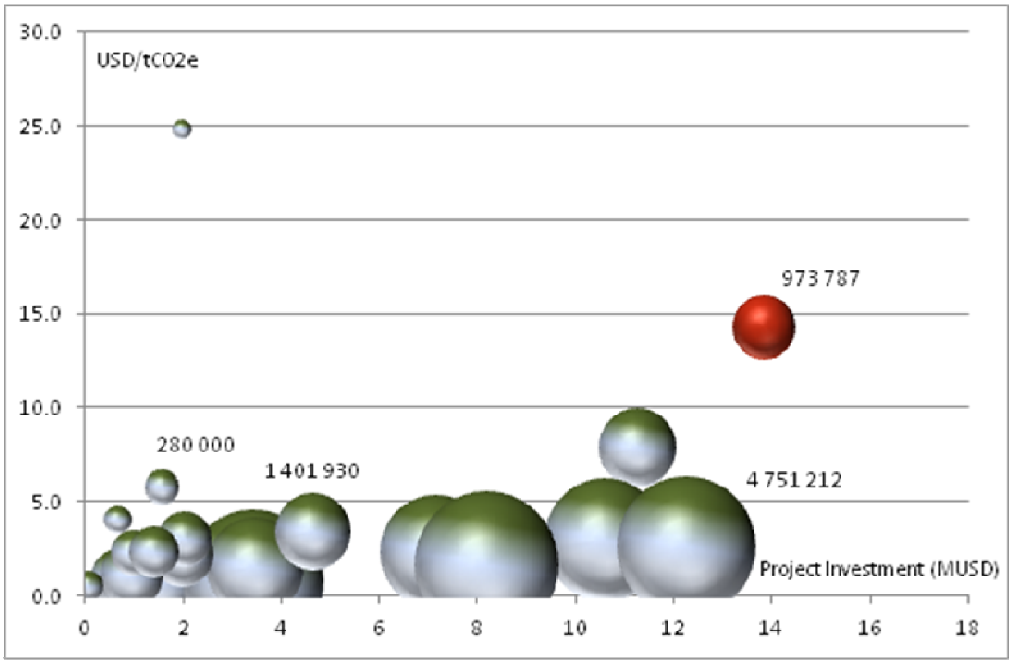

Figure 5-7. Afforestation/Reforestation projects in FONAM's CDM portfolio

For the majority of A/R projects, the individual investment is below 12 MUSD, and the cost of reduction of emissions is below 5 USD/tCO_2e. Economically, almost all the projects in the portfolio result profitable just from the sales of CERs (valuing the CERs' market price in, for example 5 USD/tCO_2e). Moreover, incomes from wood harvesting during the project lifetime are also possible, which would additionally improve projects' profitability. Until 2012, only one A/R project in Peru had been registered as CDM, which expects to capture 973 787 tCO_2e during its 20-year crediting period (red color balloon).

5.2. FUTURE OF THE VOLUNTARY CARBON MARKET IN PERU

The voluntary carbon market (VCM) represents an alternative option for trading carbon credits apart from the market regulated by the Kyoto Protocol. There are several Voluntary Standards that assess the projects according to their own regulations, representing a broad offer to the project sponsors to promote their investments and produce incomes from the generated credits.

Until May 2012, only four projects in Peru were registered in the databases of the VCM programs. However, Peru and many of the other developing countries with large deforested areas have big potential in reforestation projects. However, appropriate management and coordination of these investments need to be done by the Government, especially in the Amazon rainforest, due to the possibility that incorrect practices such as excessive external pressure on native populations' life-style or conflictive use of lands for reforestation projects could occur (*GUARDIAN UK c, 2011*). Table 5-1 shows the Peruvian projects registered in the voluntary carbon market until May 2012.

Table 5-1. Peru: Projects in the Voluntary Carbon Market (May 2012)

Project	Voluntary Standard	Sector	Year of validation	Project duration (years)	Annual Emissions Reduction (tCO_2e/yr)
Paramonga bagasse boiler project	Verified Carbon Standard	Energy	2009	7	123 136
Reforestation of pastures in Campo Verde with native species, Pucallpa, Peru	Verified Carbon Standard	Agriculture, Forestry	2009	30	5 600
Qori Q'oncha – Improved Cook Stove Diffusion Programme in Peru	Gold Standard	Energy	2010	7	47 393
Fuel switching at Atocongo cement plant in Lima, Peru	Verified Carbon Standard	Industries	2010	7	130 000
Alto Huayabamba	Verified Carbon Standard	Agriculture, Forestry	2011	40	28 756
Reforestation of pastures - Joven Forestal Project, Peru	Verified Carbon Standard	Agriculture, Forestry	2011	30	31 737
Solar Cookstoves Project in Peru	Gold Standard	Energy	2012	7	3 837
TOTAL					370 459

Peru's options for participating in the voluntary market with reforestation projects are good due to the extensive areas to reforest and the possibility to market the project in the media due to the public attractiveness of forest projects. In energy, some small projects that are not attractive to CDM due to its low generation of CERs could instead opt for the voluntary market since associated costs are lower and the procedures relatively shorter.

Among these energy projects, there is one with high social impact and relevant media coverage: The project "Qori Q'oncha" is a project of efficient cooking stoves (ECS), which are installed in small rural locations above 2500 m.a.s.l. The project's aim is to provide poor families with standardized stoves that reduce wood-fuel consumption by 50%, reducing at the same time the presence of smoke and other combustion components inside the houses. This project agreed the price for selling the carbon credits (generated under the Gold Standard) in 11 USD/tCO_2e (*Qori, 2010*).

Larger energy projects such as "Fuel switching at Atocongo cement plant" or "Paramonga Bagasse boiler" could have applied to CDM but both decided for the voluntary market. These are large scale projects and are a good example of private investment in cleaner technologies applied to industrial processes. The former is a project that substituted coal with natural gas in the burning process of production of cement, while the latter is a project to switch fossil fuel with bagasse in the boiler of a sugar production plant. The project "Fuel switching at Atocongo…" moved to the CDM market after being two years in the VCM, showing that this platform could be useful to accelerate the process of registration and generation of incomes of the projects, while requirements for the less-flexible CDM mechanism are accomplished.

Another important characteristic of the VCM is the possibility to develop projects of forest conservation, which in the regular carbon market should apply to REDD+. Until June 2012, Peru does not have any registered REDD+ project. However, this situation could be starting to change: The project "Madre de Dios Amazon REDD project" is waiting for registration in the Voluntary Carbon Standard (VCS). This project has already been validated by the Standard "Climate, community and Biodiversity Alliance (CCB)" in 2009 (*CCB, 2012*), having sold its first 40 000 tCO_2 of avoided emissions in 2010 (*WroGre, 2010*). This project's registration under CCB and VCS standards is considered to be the first step towards the registration of the project under the UNFCCC REDD+ mechanism (*ForCar a, 2012*). Again, as in the case of energy projects, the voluntary market permits to accelerate the cycle of forest conservation projects towards a future registration under REDD+.

Until June 2012, there were other 3 REDD+ type projects waiting for validation under the CCB standard (*CCB, 2012*). Before applying to REDD+, probably they will follow a similar process than the "Madre de Dios…" project.

6. DISCUSSION

The Kyoto Protocol, mechanisms such as CDM and REDD, and the Voluntary Carbon Market are opportunities to face the climate change, generate new businesses in developing countries and support the growth of clean industries, e.g. renewable energies or well managed forestry (*Shujinga, 2012*).

However, as *Winkelman & Moore* (2011) explain, the opportunities of creating CERs with CDM projects and consequently benefiting from the resources in developing nations are directly linked to the country's emission levels. This makes more profitable and consequently attractive to invest in countries with higher emission levels, which is also related to more availability of human capital and a larger energy sector. This in part explains why China and India are currently (2012) the countries with more projects and the highest number of issued CERs per year (63.9% and 11.1%, respectively).

The development of CDM projects is driven by economic factors. CDM projects in the power sector are an example of this: they reduce GHG emissions but their main objective is producing incomes from electricity sales. Surveys performed in developing countries with a large industrial sector show how policy makers, academia and industry representatives, consultants and other stakeholders agree to support the development of power production CDM projects since these ones benefit the industry by providing electricity that is needed or by reducing expenses when improving the energy efficiency (*Adhikari et al., 2008*).

6.1. CARBON BUSINESS IN PERU

Peru is not among the main GHG emitters in the world, but due to its geographical location and biodiversity, it is expected to be hardly affected by the climate change.

Peru's relatively small industrial sector does not possess the conditions stated by *Winkelman & Moore* (2011) to become a large producer of CERs. Moreover, the country's energy consumption is not driven by the power sector but by the transportation sector. It is consequently difficult in Peru to develop its carbon market industry based on the installation of renewable energy power plants that displace fossil fuels such as coal or oil.

Even though there is some good potential to develop power projects in Peru (using hydropower, solar, wind, biomass energy), Peru's investors should shift the focus away from electricity onto other economic sectors for increasing the country's participation in the carbon markets. Reforestation and forest preservation have great potential due to the large extension of Peru's forest region.

Sectors such as waste management or biomass remain nearly untouched, even though there are plenty of opportunities for both of them. Waste management in the big cities is not well managed: few of them use proper landfills, making it difficult to develop projects of methane destruction or electricity production. However, this situation could be exploited by using other technologies such as "refuse derived fuel" (RDF). *Unnikrishnan & Singh* (2010) present the case of India, where indigenous RDF technology has been developed to make use of the municipal solid waste (MSW) in areas where, as in some of Peru's cities, proper landfills do not exist. On the other hand, biomass projects are likely profitable where large agricultural activities are held. Most of sugar or rice production facilities in Peru should consider analyzing the possibilities of using the bagasse or rice husk as energy products linked to CDM energy projects, which would boost their financial indexes.

For the biomass projects, focusing the CDM project on producing electricity is better option than producing only heat due to the high revenues from electricity sales (*Amatayakul & Berndes, 2012*).

6.2. THE ENERGY SECTOR IN PERU: ELECTRICITY

The abundant availability of natural gas and hydrological resources for power generation will be the base for the expansion of the Peruvian power system during the next 10-15 years. The use of these two resources will keep the power sector relatively clean of GHG emissions. Moreover, the Government decided that every new natural gas-fired simple-cycle power plant will be converted to combined cycle configuration[14] after a maximum of 36 months from starting operations (Decree Law 1041, *MINEM g, 2008*).

As shown in Section 3.5, CDM has been actively required by investors to support the growth of the power sector. Seventeen (17) hydroelectric plants with a combined power of 808.8 MW (Table 3-6) have been registered as CDM projects since 2005, which according to projections are expected to avoid the emission of 2.06 Mt CO_2e/yr, equivalent to 63.8% of country's expected annual emissions reduction using CDM.

The power sector is perhaps one of the most organized industries in the country, and has been receiving several supporting measures in order to increase its attractiveness for investments that permit to increase the available power supply for sustaining the country's economic growth. The energy auctions with renewable energy resources (RER) are expected to continue in 2013 and beyond, which should represent new options to invest in renewable energies. Furthermore, cleaner energy projects have the option to be additionally supported by incomes from CDM or the voluntary carbon market, which increases projects' IRR between 1.2-1.7% for large projects, and between 1.7-3% for small ones (*IGES, 2012*). Undoubtedly, these additional incomes are more important for small projects, where the financial "carbon component" could make profitable a project that initially is not.

Small-hydroelectricity projects are all similar, being its registration under CDM highly probable if financial investment is found and an early contact made with a consulting company to develop the documentation. Registration chances are boosted by a careful definition of the baseline, the additionality criteria and barriers in the Project Design Document (PDD) (*Purohit, 2008*).

Peru's first solar and wind power plants are being built in 2012 (*OSNG a, 2012*) and it is highly probable that these projects will apply to CDM. However, this new plants are not installed due to the power system requirements, but due to Government's initiative of supporting new generation with non-conventional energy resources (*GoP b, 2008*). These projects are awarded a type of "feed-in-tariff" in order to become attractive for the investors. It is unlikely that solar or wind power projects will drive the increase of the number of CDM power projects in Peru as it occurs in several other countries. These projects will provide good technical know-how but their massive expansion is not probable in the short-term.

The case of CDM power projects from biomass or waste is interesting. Two of the main agro-industries in the country are rice and sugar production, which have plenty of waste available to use

[14] A combined cycle uses the natural gas more efficiently, decreasing plant's emissions by approximately one third.

as fuel. However, this resource has a large unused potential, existing only around 30 MW of grid-connected electrical power from biomass in operation or in construction (*OSNG b, 2011*).

Municipal waste (water and solid) is not properly treated in most of the Peruvian cities, where it is mostly dumped in open sites. This situation could become an opportunity by transforming the solid waste in fuel (refuse derived fuel, RDF) or by capturing the methane emissions for energy purposes from waste water. As shown in *Unnikrishnan & Singh* (2010), it is possible to develop indigenous RDF technology, which would boost the incomes of local metalworking industries and provide electricity and heat for other industrial processes. Furthermore, as waste management projects avoid methane emissions, the generation of CERs from this type of CDM project could be really attractive for investors. Further analysis about the energy potential from waste dumping sites in Peruvian cities, as well as the possibilities of linking it to energy projects, would provide a good indicator for interested investors. This information was not found while writing this Thesis.

Finally, it is important to say that all the carbon projects linked to power production in Peru and developed until 2012 have been registered under the CDM and none under the voluntary carbon market. However, since the latter has proven being useful to boost initiatives with high social impact, it is possible to use it for developing waste-to-energy projects in smaller cities than Lima, where a proper waste treatment could have a more visible and measurable positive impact.

6.3. ENERGY SECTOR: TRANSPORTATION

In 2000 transportation sector generated 40% of the emissions from the energy sector (9.9 out of 25.4 Mt CO_2e/yr, see Table 4-1), which in turn is the largest source of country's emissions after LULUCF.

The main source of emissions corresponds to the use of diesel oil in freight trucks and buses. Public transportation (especially in Lima, where 30% of country's population is concentrated) remains one of the main causes of this sector's emissions. However, since majority of buses used for public transportation are private-owned, planning a renewal of the fleet for new or less pollutant units is not an easy task due to the multiple actors involved.

Measures to renew and clean the transportation system have been launched during recent years. Lima's Government began in 2011 a "cash by junk" program in order to retire 17 000 old diesel buses in Lima, corresponding to 50% of the units serving the city in early 2012 (*ElComercio a, 2012*). However, this program's results are slow due to the limited available budget. Other measures such as setting the mandatory technical revisions of vehicles are planned to be implemented in order to certify that all vehicles on the roads operate correctly and their emissions are below the maximum permitted limits.

The Government is taking action to improve the transportation system. Since improvements in transportation will directly reduce GHG emissions, the use of CDM has been mentioned in order to improve the economic conditions of the projects.

Until May 2012, there are 5 CDM project ideas in FONAM's projects portfolio (*FONAM a, 2011*), mainly focused on solving the problem of public transportation in Lima (in 2009 there were around one million vehicles in Lima, corresponding to 70% of country's total). Two of those projects have already begun to operate with positive results: the "Metropolitano" Bus Rapid Transport (BRT) system, and the Electric Mass Transit System for Lima and Callao, locally known as "Tren Eléctrico". Table 6-1 shows projects in FONAM's portfolio.

Table 6-1. Peru: CDM project ideas in Transportation sector (2012)

Sector	Project	Emissions reduction (tCO_2/yr)	Investment (MUSD)
Transportation	Bus Rapid Transport (BRT) System based on High Capacity Buses using Exclusive Roads	199 743	214.5
Transportation	Electric Mass Transit System for Lima and Callao Project	725 585	408.0
Transportation	Integrated Transport System in Lima/GTU	436 543	333.3
Transportation	Renewal Program of Automotive Fleet to Promote Change of Energy Matrix	73 563	50.2
Transportation	BRT system in Arequipa city, based on High Capacity Buses using Exclusive Roads.	69 040	170.0
	TOTAL	1 504 474	1 176.0

The four first projects in Table 6-1 are planned for Lima and the last one for Arequipa, the second largest city in Peru. The impact of "cleaning" the transportation system becomes clear here, since the amount of GHG emissions reduction that could be afforded by any of the three first projects in Table 6-1 is comparable to the country's most important emission reduction projects in power generation: a 220 MW hydroelectric project that avoids the emission of 501 814 tCO_2e/yr, or the conversion of a power plant from simple cycle to combined cycle, which avoids 407 296 tCO_2e/yr (*CDM, 2012*).

Possibilities of BRT projects to be registered under CDM are high since, until 2012, seven BRT projects hosted by Colombia, Mexico, India and China have been registered by the UNFCCC's Executive Board. The project with the largest amount of reduced emissions, "Electric Mass Transit System for Lima and Callao", does not have other similar among the registered CDM projects, but it has chances to get registered since its functionality could be compared with two projects for implementing Metro systems in India ("Metro Delhi" and "Mumbai Metro One"), which were registered as CDM projects in 2011. These Indian projects avoid the emission of 529 043 tCO_2e/yr and 195 547 tCO_2e/yr, respectively (*CDM, 2012*).

Even though it was not analyzed in this Thesis, the potential for mitigation of GHG emissions from individual cars is also high. Due to excessive importation of diesel-fueled vehicles during 1990s decade, it exist a large share of relatively old vehicles (more than 15 years) on the roads. The Government or private actors could design programs to pool a large number of private units and convert them to natural gas or to change them for new units. These type of projects could apply to CDM.

6.4. REFORESTATION AND FOREST CONSERVATION IN PERU

In year 2000, Peru's net[15] GHG emissions due to deforestation (LULUCF) were 56.8 Mt CO_2e/yr (*MINAM b, 2010, pg. 63*). It represented 47.3% of country's total emissions (see Table 3-1).

[15] The term "net" is used since it is calculated deducting the carbon captured by the plants from the atmosphere (via photosynthesis) from the emissions calculated from deforestation.

The forest area in Peru is 77.54 Mha. To year 2000, 9.25% of the total area had been deforested (7.2 Mha). Even though increase of public awareness and more control of natural reserves, deforestation has not disappeared: the annual deforestation rate in the period 1990-2000 was 0.149 Mha/yr (*MINAM b, 2010, pg. 69*), and it continues.

This work analyzes the sustainable opportunities derived from the preservation of forests in the country. The Peruvian forests could provide the surplus of funds that permit to finance the measures to face the climate change effects and furthermore, to keep the forests for future generations. It is important to show local inhabitants that the forest is a valuable resource that nowadays offers more business opportunities than current traditional practices. In fact, the Government is working through its institutions such as MINAM and FONAM for increasing technical capacities inside the country and helping interested investors. The interest in the sector is shown in the project ideas registered in FONAM's portfolio: 40 for afforestation/reforestation (A/R), and 18 for REDD+ (*FONAM b,c, 2011).*

The carbon market (CDM and voluntary market) could represent an important option for Peru. Benefits are multiple and reach groups historically margined in the country, such as small villages inside the Amazon forest. However, Peru has not yet used extensively these mechanisms for financing afforestation/reforestation (A/R) projects. To date, in Peru only one A/R project has been registered under CDM (it captures 48 689 tCO_2e/yr). The voluntary carbon market (VCM) has been a more efficient platform for this type of projects in the country: already 3 of them have been verified and are generating carbon credits (together, they capture 66 093 tCO_2e/yr).

Some entrepreneurs have begun developing reforestation projects focused on bringing sustainability to the forest projects and the small populations that live there. For example "Peru Carbon Fund", a new private organization in the country, creates an added-value chain in order to maximize the profits for the participating small villages. It proposes to generate carbon credits under the VCM by reforesting private-owned lands exclusively with native tree species. The project is designed so that the wood is supplied to local wood industries, that in turn can offer higher added-value products to be dealt with previously contacted clients in large cites (*PCF, 2012*).

An investor should have clear that the requirements to be validated in the voluntary market use to be more flexible than in CDM. The voluntary carbon market strongly focuses on the social impact of the projects it registers. The Voluntary Standards (organizations that evaluate and register the projects under the VCM) improve their market reputation assuring that the projects they register have strong social and environmental components: positive economic impact on the population involved in the projects, improvement of their quality of life, clearly accountable environmental effects, etc. Small forest projects or first-time initiatives in Peru should consider the voluntary market as the better option to start. If successful, the projects can always scale-up and stay in the voluntary market, or step-up towards CDM.

The case of forest conservation is different. CDM does not admit this type of projects, which have to apply to REDD+ instead. However, forest conservation projects are different from reforestation ones: the latter involve direct action from the population, making themselves partly owners of the project, while the former could even involve keeping out populations from the project area in order to avoid deforestation. Naturally, several problems have arised with REDD+ projects. For instance, the members of the "Indigenous Peoples' biocultural Climate Change assessment" (IPCCA) during UNFCCC's meeting in Durban (November 2011) declared that REDD+ negatively affects the communities that live in the forests, since it does not recognize the value that the traditional interaction human-forest have. IPCCA argues that REDD+ projects impose a lock over the forests that will end up the normal relation between the population and the resources that they traditionally extract. Moreover, IPCCA claims that REDD+ is designed and supported by the multinational organisms, NGOs and governments that at the same time invest in the industries that cause GHG emissions, originating a counter-sense where the local communities are "two-fold" affected: first, due to the consequences of global warming, and second, due to the forced intervention over their habitat and their traditions (*WroGre b, 2011*).

Another problem for REDD+ is the possibility to be associated to cases of corruption. In his report for the U4 Anti-corruption Research Centre[16], *Standing* (2012) claims that REDD+ projects are threatened by corruption, but they could also produce it. It is easy to predict that the projects' outcomes will suffer efficiency loses due to corruption, but it is maybe not so clear to realize that REDD+ could create new types of corruption. Since REDD+ increases the value of lands previously marginalized, *Standing* (2012) detected three possible types of corruption problems: land grabbing and tenure rights, elite capture of REDD+ revenues and conflicts of interest in the monitoring, reporting and evaluation of the projects. It is logic that as land possession is directly linked to the revenues, conflicts between involved communities or even illegal land transactions made by powerful political minorities could transform in negative a project designed to benefit the local communities. Since Peru is not corruption-free, REDD+ initiatives will require a very strong planning that permits to accurately identify the involved actors at every level and how to better interact with them, in order to detect early the scenarios where future corruption cases could appear and deal with them in advance.

Using climate-related financial instruments to keep the forests in Peru not only saves a unique reserve in the world and avoids GHG emissions to the atmosphere, but it provides opportunities to local populations to grow economically while preserving their environment and quality of life. By being offered the opportunity to participate in this new business, the illegal farmers and wood harvesters could feel attracted to leave their current practices and embrace a new activity, legal and profitable. An appropriate national plan about the type of forest-related carbon projects and their more suitable location is needed to better exploit this opportunity.

6.5. OTHER SECTORS

The first commitment period of the Kyoto Protocol (KP) is over at the end of 2012. After it, the EU has decided to shift its focus to the least developed countries (LDC), which likely will cause a decrease of interest in projects in continents such as Latin America or Asia, directly affecting Peru's opportunities to participate in the CDM.

However, as awareness about carbon projects has spread in the country, it is likely that new projects will shift attention onto the voluntary market. Reforestation, forest conservation, fuel switching and energy efficiency projects can be developed in small or medium scale. These projects can be designed to have a direct social impact, which is very important for the marketing of the carbon credits generated from voluntary initiatives. Some examples of these projects are: efficient cooking stoves programs in rural locations, fuel switching to decrease local pollution in small and medium

[16] *U4 Anti-corruption Research Centre's* website: www.U4.no

sized industries and reforestation or forest conservation programs with direct impact in the economy of local villagers.

Really, more discussion on the use of waste as energy source would have been necessary in this report, but trustable information was not found. To June 2012, three are the CDM registered projects in the country to capture methane from landfills. Only one of them, "Huaycoloro landfill gas capture and combustion" which was registered in 2007, is related to electricity production. However, there is much more potential to be exploited: in addition to Lima, Peru has 8 cities with population over 380 000 inhabitants each, which represents a considerable source of municipal solid waste. Just over 19% of municipal waste is kept in landfills, while around 70% of the waste is dumped in poorly controlled sites (*FONAM d, 2012*). Then, there is opportunity to develop new landfills with an appropriate design that permit to collect the methane and use it in energy projects or GHG destruction, and apply to the carbon markets. However, this opportunity is linked to get the necessary funding for building the installations, which could be partly supplied by the Government and the interested investor. If new installations are going to be built, considering the option to fix installations to use anaerobic digestion instead of a simple landfill could considerably improve the production of methane for a posterior energy use (*Unnikrishnan & Singh, 2010*). Maybe it would be practical to begin with "refuse derived fuel" (RDF) projects in the waste dump existent sites, where the techniques to transform the fuel in usable pieces of fuel could be also locally developed. Again, since these actions have direct impact on society, Government support (political and economic) is expected at the start of these projects, sustaining the investors' initiatives.

The potential for using biomass in energy production is present due to the existence of large forest areas and the agricultural production in Peru. The main problem here is that appropriate data of biomass energy potential is not available (MINEM's energy-biomass balance is obtained through mathematical models). Private investors working in sugar industry use bagasse as energy source since long time ago in their own processes, but their involvement in supplying electricity to the national grid is very recent. Still, there are producers of rice and other goods that could develop energy projects and apply to CDM. If the project were one of small-scale, mainly designed to produce heat, it could apply to the voluntary market through the category of energy efficiency.

The south of Peru has abundant and unused potential for using solar power. An average annual insolation of 6.5 kWh/m^2/day is present in the zone (see Figure 3-14). This potential could fulfill the needs of heat in local industries by means of the use of solar energy for vapor generation. Appropriately designed, these projects displace amounts of fossil fuels that could generate carbon credits in the voluntary carbon market. If some pilot projects of this type are successfully introduced, there is possibility of bounding several small projects into one big that could apply to CDM.

6.6. BARRIERS TO CARBON PROJECTS

As it was shown, there is high potential to develop projects in the sectors that were analyzed: energy, forests and waste management. However, these long-term investments are expected to face barriers that are important to be known by any interested investor.

First barrier to mention is economic. This barrier is especially tough for small and medium sized projects, where investors usually do not posses large capital. A common economic barrier to the carbon projects is the cost of transaction, which represent a larger obstacle to the smaller investments. These costs are almost fixed since they are mainly directed to hiring UNFCCC's registered consulting firms to carry out the validation and monitoring processes.

Electricity production projects are less vulnerable to economic barriers since these investors use to have larger economic capacity to face the high capital investment required by the projects. Moreover, electricity sales represent a much larger income than the revenues from carbon credits sales. In general, the also called “carbon component” of large power projects is marginal and represents just a complementary income to their main business. For small projects, carbon credits sales represent a big share of their net incomes, being even necessary to make the project profitable and attractive to investors.

Second barrier is technical. Developing countries do not produce major equipment for industries such as power generation, making investment costs high. Moreover, even in case that new technologies help to reduce the investment costs, the increase of technical complexity requires new operational and maintenance expertise and access to spare parts in the local market, which ends up increasing the risk of investing (*Adhikari et al., 2008*). Expertise in building infrastructure for hydropower is good in Peru, so investments in small and medium sized hydroelectric plants have their technical risks reduced. However, power-producing projects that use agricultural or forestry biomass require combustion processes whose machinery is not locally manufactured. Gasification equipment, gas engines, pelletizers, turbines and boilers need to be bought abroad, increasing costs and falling into the dependence on foreign expertise. Even though the project could be profitable, the risks of the technical dependence decrease de possibilities of investment.

Forest projects are not technically complicated, and the economic investment is low compared to other options to develop a carbon crediting project (as long as land does not have to be bought). Due to Peru’s large extension, there are still locations where individual or community land ownership is unclear. This is an important aspect that needs to be checked and solved early. Some institutional barriers could appear here since issues-solving times and predictability of decisions are two aspects that governmental offices do not manage completely well.

Expected barriers in forest projects are mainly political and social. Since most of these projects interact with populated areas, they involve an implicit risk of social disagreements that could negatively affect them. In general, a good relation with the population needs to be developed since the very early stages of the project, having in mind that the project horizon is around 30-40 years. Positive lessons can be learned from early starters: it is important that local communities participate in the project with labor, land property or investment in order to make them feel the project as theirs. Moreover, making clear deals about the share of future incomes among stakeholders is an aspect of the highest importance.

In the case of forest conservation projects (REDD+), a careful study of the interaction of the population with the project area is needed, so that their traditional and economic activities do not be abruptly disrupted by the project. Additional economic activities related to the preserved forest such as tourism or fruits processing would improve project’s sustainability and also economic conditions of involved population.

Finally, the fact that Peru’s participation in the carbon markets (regulated and voluntary) has been small during the First Commitment period of the Kyoto Protocol creates a group of complex barriers: lack of enough local expertise, loss of opportunities to the neighbor countries (Brazil, Chile, Argentina, Colombia) and having lost the chance of the early-starters. The end of 2012 seals one period of opportunities, leaving now a market with several competitors and tougher regulations in the carbon markets that Peru will have to face in order to use all the opportunities that it possesses.

7. Conclusions

a. The possibilities of developing carbon projects in the electricity, transport and forestry sectors were analyzed, as well as in waste management and biomass sectors. Most of the local investments in the carbon market correspond to small hydropower projects. It is true that Peru possesses large potential for this technology, but it is noticeable that involved investors have been just copying a winner formula, which has not helped the sector to grow in expertise nor in technique. Moreover, the governmental support to the development of non-conventional energy resources has made it even easier for the investors in hydroelectricity to continue this trend. This situation has not permitted to develop projects in other sectors with large potential but with few or no experiences at all in the country such as energy projects from waste or the increase of use of biomass for industrial energy projects.

b. Transportation sector is the country's largest energy consumer and an important source of GHG emissions, but no carbon project has been developed in the sector until June 2012. However, two large projects to improve transportation in Lima have been put in operation since 2010, which coincide with the type of transportation projects that are being registered under CDM in other countries. As these projects are in their initial phases, their expansions have good chances to apply and get registered under CDM.

c. Forestry carbon projects have a good projection in Peru. An area of approximately 7 Mha to be reforested and a much larger extension to be preserved represent an important opportunity to generate incomes while positively affecting the local communities. However, the deep interaction existent with the local population in these projects requires careful planning in order to ensure the project's sustainability. Existent criticisms to the REDD+ mechanism should be taken into account in order to plan locally applicable solutions that permit to offer a fair deal to local populations. Land ownership, clear incomes sharing and fair legal agreements are needed to successfully carry out these long-term initiatives.

d. The voluntary carbon market (VCM) is an excellent platform for launching carbon projects due to its flexibility compared to CDM. Being validated under VCM permits the projects to accumulate expertise and capital in order to be scaled up and then have the option to apply to CDM.

e. The VCM can provide valuable economic support to small scale projects with a high social impact. VCM's ability to bound very small scale activities (efficient cooking stoves, solar cookers, etc.) makes of it a useful tool to increase economic attractiveness of projects designed to reach dispersed and poor locations, which are abundant in Peru. This type of projects, as well as medium sized reforestation projects would fit well into VCM.

f. A low percentage of municipal waste is properly treated in Peru: only 19% goes to landfills while 70% is dumped in open storage sites. Those open dump sites offer good opportunities to develop energy + carbon projects by utilizing "refuse derived fuel" (RDF) techniques which could be locally developed. Out of Lima, there are 8 cities with over 380 000 inhabitants each, which represents a good opportunity to develop these projects and apply to the carbon markets. Even if not properly used as fuel, methane capture and destruction projects would help to improve waste treatment conditions in the country's largest cities, giving again options to apply to carbon markets due to social benefits.

g. The south of the country has high levels of solar insolation (annual average of 6.5 $kWh/m^2/day$), which makes it very attractive to develop projects that use solar energy for thermal or electricity purposes. What is missing until 2012 is a joint private-governmental action that helps to develop local capacities and start the use of this resource. Indigenously designed solar energy systems applied in small and medium sized industries could form a bounded carbon project, apply to VCM and benefit from carbon credits sales.

h. The end of the First Commitment period of the Kyoto Protocol in December-2012 closes a period of opportunities that was not significantly exploited in Peru. After that, the market size is expected to be reduced due to the shift of interest of Annex I countries towards the least developing countries (LDC). In order to exploit the potential for carbon projects, Peruvian investors will have to efficiently manage the gained expertise and be aware of all the opportunities that the good geographic conditions offer in the country.

REFERENCES

Adhikari S., Mithulananthan N., Dutta A., Mathias A., 2008. Potential of sustainable energy technologies under CDM in Thailand: Opportunities and barriers. Renewable Energy 33 (2008) 2122-2133.

Ahlborg, H., 2012. Electricity for better lives in rural Tanzania and Mozambique. Licenciate Thesis. Department of Energy and Environment, Chalmers University of Technology, Sweden, 2012.

Amatayakul W., Berndes G., 2012. Determining factor for the development of CDM biomass power projects. Energy for Sustainable Development 16 (2012) 197–203.

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

BIC, 2010. Bank Information Center (BIC). Brasil y Perú firman acuerdo de integración energética (June 22, 2010). Available at:
http://www.bicusa.org/es/Article.11924.aspx [Accessed on Apr. 24, 2012]

CCB, 2012. Climate, community and Biodiversity Alliance website. Projects status. Available at:
http://www.climate-standards.org/projects/index.html

CDM a, 2012. CDM website, Project cycle search. Project 0672 : BRT Bogotá, Colombia: TransMilenio Phase II to IV. Project Design Document (PDD). Available at:
http://cdm.unfccc.int/Projects/DB/DNV-CUK1159192623.07/view

CDM b, 2012. CDM website, Project cycle search. Project 1424 : Carhuaquero IV Hydroelectric Power Plant. Project Design Document (PDD). Available online at:
http://cdm.unfccc.int/Projects/DB/DNV-CUK1159192623.07/view

CDM c, 2011. CDM website, Project cycle search. Project 5618 - BRT Metroplus Medellin, Colombia. Project Design Document (PDD). Available at:
http://cdm.unfccc.int/Projects/DB/SQS1324991317.69/view

CDM, 2012. Clean Development Mechanism (CDM) website.
Available at: http://cdm.unfccc.int/

CIP a, 2012. Online presentation: Usos productivos de la electricidad (Productive uses of the electricity) (March 20-21, 2012). Association of Engineers of Peru (CIP), 2012.

CliTec, 2009. Climate TechBook - Enteric Fermentation. Available at:
http://www.pewclimate.org/docUploads/Enteric-Fermentation-09-09.pdf

COES, 2010. Memoria Anual del Comité de Operación Económica del Sistema Eléctrico Peruano (COES-SINAC). Lima, Perú, 2010.

CONAM a, 2007. El Futuro del Perú ante el cambio climático. Exposition by Luis Geng on behalf of CONAM. Available at:
http://www.comunidadandina.org/desarrollo/cl_LuisGeng.pdf

CO2now, 2012. Earth's CO2 home page.
Available at: http://co2now.org/

ElComercio a, 2012. El Comercio (Peruvian newspaper). Chatarreo de vehiculos con más de veinte años no tiene fecha de inicio (Jan. 17, 2012). Available at:
http://elcomercio.pe/lima/1361995/noticia-chatarreo-vehiculos-mas-veinte-anos-no-tiene-fecha-inicio_1 [Accessed on Apr. 20, 2012]

ElComercio b, 2007. El Comercio (Peruvian newspaper). INRENA entregó concesiones en selva virgen (May 7, 2007). Available at:
http://elcomercio.pe/edicionimpresa/html/2007-05-06/ImEcTemaDia0718382.html [Accessed on May 20, 2012]

ENL, 2012. Emissierechten. Nl De website over emissie-handel milieuzorg. Available at:
http://www.emissierechten.nl/

EoE, 2012. Website: Encyclopedia of Earth. Slash and burn. Available at:
http://www.eoearth.org/article/Slash_and_burn

ESCO, 2009. Economic Coopereation and Development - Peru: Strategy 2009-2012. Swiss Confederation, Federal Department of Economic Affairs, Switzerland, 2009.

EU a, 2009. Directive 2009/29/EC of the European Parliment and of the Council of 23 April 2009 (improve and extend the greenhouse gas emission allowance trading scheme of the Community).

FClim a, 2012. "First Climate" Market Report (March 14, 2012). Online version for members.

FONAM, 2012. Fondo Nacional del Ambiente (FONAM) website. Available at:
http://fonamperu.org/default.php

FONAM a, 2011. Carbon Portfolio Peru - 2011. Available at:
http://www.fonamperu.org/general/mdl/documentos/Summary_E.pdf

FONAM b, 2011. Carbon Portfolio Peru 2011 - Afforestation and Reforestation. Available at:
http://fonamperu.org/general/mdl/documentos/Summary_A.pdf

FONAM c, 2011. Portafolio de Carbón Peru 2011 - REDD (in Spanish). Available at:
http://fonamperu.org/general/mdl/documentos/REDD_esp.pdf

FONAM d, 2012. Residuos sólidos en el Perú. In FONAM's website. Available at:
http://www.fonamperu.org/general/agua/residuos.php

ForCar a, 2012. Forest carbon Portal. Project description: "Madre de Dios Amazon REDD project". Available at:
http://www.forestcarbonportal.com/project/madre-de-dios-amazon-redd-project

Francou, B., Vincent, C., 2007. Les glaciers a l'éprueve du changement climatique. IRD and Belin Editions, Paris, 2007.

Galarza, E., La Serna, C., 2004. Las concesiones forestales en el Perú. Cómo hacerlas sotenibles?. Universidad del Pacífico, Lima, Perú, 2004. Available at:

http://www.fsc.org.pe/pdf/Masinformacion/Peru/LasConcesionesForestalesenelPeru.pdf

GoP a, 2010. Política Energética Perú 2010-2040. Available at: http://www.minem.gob.pe/minem/archivos/file/DGEE/eficiencia%20energetica/Normativa/Generales/DS%20064-2010-EM.pdf

GoP b, 2008. Decree Law 1002, Law of promotion of investments in power generation using renewable energies. Available at: http://www2.osinerg.gob.pe/EnergiasRenovables/contenido/Normas/DL_No_1002.pdf

GoP c, 2009. Regulations of power production using renewable energies. Available at: http://www2.osinerg.gob.pe/EnergiasRenovables/contenido/Informacion/DS012-2011NuevoReglamentoRER.pdf

GoP d, 1992. Decree Law 25844, Law of Electrical Concessions. Available at: http://intranet2.minem.gob.pe/web/archivos/dge/publicaciones/compendio/dl25844.pdf

GoP e, 1993. Suprem Decree 009-93-EM, Regulations of the Law 28832, Law of Electrical Concessions. Available at: http://www2.osinerg.gob.pe/MarcoLegal/pdf/REGLACE.pdf

GOP f, 2006. Law 28832, Law for the efficient development of the power sector. Available at: http://www2.osinerg.gob.pe/MarcoLegal/pdf/LEY%2028832.pdf

GoP g, 2008. Decree Law 1041, Law to ensure efficient development of the electrical sector and promotion of hydropower plants. Available at: http://www.congreso.gob.pe/ntley/Imagenes/DecretosLegislativos/01041.pdf

GOP h, 2011. Law 29763, Law of forests and wild animal life. Available at: http://www.congreso.gob.pe/ntley/Imagenes/Leyes/29763.pdf

GUARDIAN UK a, 2011. The Guardian [online]. Russia supports Canada's withdrawal from Kyoto protocol (Dec. 16, 2011). Available at: http://www.guardian.co.uk/environment/2011/dec/16/russia-canada-kyoto-protocol [Accesed on Feb. 15, 2012]

GUARDIAN UK b, 2011. The Guardian [online]. Global climate change treaty in sight after Durban breakthrough (Dec. 11, 2011). Available at: http://www.guardian.co.uk/environment/2011/dec/11/global-climate-change-treaty-durban [Accessed on Feb. 15, 2012]

GUARDIAN UK c, 2011. The Guardian [online]. Peruvian Amazon could become global centre of 'carbon piracy': report (Nov. 30, 2011). Available at: http://www.guardian.co.uk/environment/2011/nov/30/peruvian-amazon-carbon-piracy [Accessed on Apr. 16, 2012]

IGES, 2012. IGES CDM Investment Analysis Database. Updated 2 Apr. 2012. Institute for Global Environmental Strategies. Available at: http://www.iges.or.jp/en/cdm/report_cdm.html#reject

INEI a, 2009. INEI, map of poor in Peru 2009 - Electronic application. Available at:

http://iinei.inei.gob.pe/iinei/SIRTOD/

INEI b, 2012. Press Note: INEI presentó serie actualizada de cifras de la pobreza al año 2010. Available at:
http://www.inei.gob.pe/web/NuestrasActividadesFlotantePrincipal.asp?file=13901.jpg

INEI, 2012. Instituto Nacional de Estadística e Informática (INEI) website. Available at:
http://www.inei.gob.pe/

IPCC, 2007. Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC b, 2007. Le Treut, H., R. Somerville, U. Cubasch, Y. Ding, C. Mauritzen, A. Mokssit, T. Peterson and M. Prather, 2007: Historical Overview of Climate Change. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Iturregui, P., 2007. Los temas centrales del nuevo acuerdo internacional post Kyoto y los intereses del Perú. Presentation.

Junqueira, M., 2005. Chapter 15 - Carbon Credits from Cogeneration with Bagasse, Bioenergy - Realizing the Potential, 2005, Pages 201-212.

Karousakis, K., 2007. Incentives to reduce GHG emissions from deforestation: Lessons learned from Costa Rica and Mexico. Organization for Economic Co-operation and Development (OECD), France, 2007.

LaRepublica, 2011. Línea de crédito ambiental para pymes del Perú (Aug. 19, 2011). Available at:
http://www.larepublica.pe/19-08-2011/linea-de-credito-ambiental-para-pymes-del-peru

Luttrell, C., Schrekenberg, K., Peskett, L., 2007. The implications of carbon financing for pro-poor community forestry. Forestry Briefing 14. Overseas Development Institute, London, 2007.

MINAM a, 2012. MINAM, Approved CDM projects list. Available at:
http://cambioclimatico.minam.gob.pe/mitigacion-del-cc/avances-en-la-mitigacion/a-nivel-de-mecanismos-de-mitigacion/mecanismo-de-desarrollo-limpio-mdl/proyectos-mdl-aprobados/

MINAM b, 2010. MINAM, Segunda Comunicación Nacional a la Convención Marco de las Naciones Unidas sobre Cambio Climático 2010. Available at:
www.minam.gob.pe/dmdocuments/SCNCC-MINAM.pdf

MINAM d, 2010. MINAM, Plan de Acción de Adaptación y Mitigación contra el Cambio Climático 2010. Available at:
http://cambioclimatico.minam.gob.pe/plan-de-accion-de-adaptacion-y-mitigacion-frente-al-cambio-climatico/

MINAM e, 2011. Guía práctica para desarrolladores de proyectos MDL.

MINAM, 2012. Website of the Ministry of the Environment (MINAM). Available at: http://www.minam.gob.pe

MINEM a, 2009. MINEM, Balance Nacional de Energía 2009. Available at: http://www.minem.gob.pe/publicacion.php?idSector=12&idPublicacion=363

MINEM b, 2011. MINEM, Sector Eléctrico 2010 - Documento Promotor. Available at: http://www.minem.gob.pe/publicacion.php?idSector=6&idPublicacion=52

MINEM c, 2009. Decreto Supremo 056-2009-EM - Facultad Gobiernos Regionales para otorgar concesiones eléctricas. Available at: http://www.minem.gob.pe/minem/archivos/file/DGEE/eficiencia%20energetica/Normativa/Recursos%20Renovables/DS%20056-2009-EM.pdf

MINEM d, 1979. Evaluación del potencial hidroeléctrico nacional. Ministerio de Energía y Minas y Cooperación Técnica Alemana. Lima, Perú, 1979.

MINEM e, 2003. Atlas de Energía Solar del Perú. Ministerio de Energía y Minas y Servicio Nacional de Metereología e Hidrología del Perú. Lima, Perú, 2003. Available at: http://dger.minem.gob.pe/atlassolar/ATLAS_SOLAR.pdf

MINEM f, 2003. MINEM, Dirección General de Electrificación Rural. Atlas solar del Perú - Sistema GIS interactivo online. Available at: http://dger.minem.gob.pe/atlassolar/#

MINEM g, 2008. MINEM, Dirección General de Electrificación Rural. Atlas eólico del Perú. Lima, Perú, 2008. Available at: http://dger.minem.gob.pe/AtlasEolico/atlaseolicolibro/presentacion.pdf

MINEM h, 2008. MINEM, Dirección General de Electrificación Rural. Atlas eólico del Perú - Sistema GIS interactivo online. Available at: http://dger.minem.gob.pe/atlaseolico/PeruViento.html

MINEM, 2012. Website of the Ministry of Energy and Mines, 2012. Available at: http://www.minem.gob.pe

Moate, P., Williams, S., Grainger, C., Hannah, M., Ponnampala M., Eckardb, R., 2011. Influence of cold-pressed canola, brewers grains and hominy meal as dietary supplements suitable for reducing enteric methane emissions from lactating dairy cows. Animal feed Science and Technology 166– 167 (2011).

NSIDC, 2012. National Snow and Ice data center (NSIDC). Available at: http://nsidc.org/arcticmet/glossary/climate_change.html

NYT a, 2011. The New York Times. Can CDM bring Bogota's Surface Subway to your city? (Apr. 27, 2011). Available at: http://www.nytimes.com/cwire/2011/04/27/27climatewire-can-the-clean-development-mechanism-bring-bo-23879.html?pagewanted=all

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 Journal 36 (2008).

OSNG a, 2012. Organismo Supervisor de la Inversión en Energía (OSINERG). Results of renewable energy auctions in Peru. Available at:
http://www2.osinerg.gob.pe/EnergiasRenovables/contenido/ResultadoSubastas.html

OSNG b, 2011. Subasta de energías renovables. Presentation by Riquel Mitma on behalf of OSINERGMIN on November 2011. Available at:
http://www.minag.gob.pe/portal/download/pdf/especiales/bioenergia/seminario_biodigestores/osinerg_biod.pdf

Painter, J., 2008. Deglaciation in the Andes. Human Development Report 2007/2008. UNDP. Available at:
http://hdr.undp.org/en/reports/global/hdr2007-8/papers/Painter_James.pdf

PCF, 2012. Peru Carbon Fund Website. Available at:
http://perucarbonfund.com/somos.php?lang=en

Pearson, B., 2007. Market Failure: Why the Clean Development Mechanism won't promote clean development. Journal of Cleaner Production 15 (2007).

PNUD a, 2002. Informe sobre Desarrollo Humano 2002 (pg. 42). United Nations Development Program (UNDP), 2002.

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

Qori, 2010. Q'ori Q'oncha carbon project: Efficient Stoves in Peru. Video available at:
http://www.youtube.com/watch?v=4h1iDYT6V_Q

Rydén, M., 2008. Hydrogen production from fossil fuels with carbon dioxide capture, using chemical-looping technologies. Doctoral Thesis. Division of Energy technology, Chalmers University of Technology, Sweden, 2008.

Shujinga Q., 2012. The Analysis on Barriers of Low Carbon Technology Transfer. Energy Procedia 14 (2012) 1398-1403.

Standing, A., 2012. "Corruption and REDD+". Report for U4 - Anticorruption Research Centre. Available at:
http://www.redd-monitor.org/2012/05/22/corruption-and-redd-it-is-highly-unlikely-that-we-will-find-a-country-where-forms-of-corruption-linked-to-redd-are-non-existent/

UNFCCC, 2012. United Nations Framework Convention on Climate Change (UNFCCC) website. Available at:
http://unfccc.int/essential_background/items/6031.php

UNFCCC b, 2012. CDM projects ratification status. Available at:
http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php

Unnikrishnan S., Singh A., 2010. Energy recovery in solid waste management through CDM in India and other countries. Resources, Conservation and Recycling 54 (2010) 630–640.

VCS a, 2011. Project Description: Joven Forestal VCS, Version 2. Voluntary Carbon Standard (VCS).

VCS, 2012. Voluntary Carbon Standard (VCS) Projects Database. Available at: https://vcsprojectdatabase2.apx.com/myModule/Interactive.asp?Tab=Projects&a=1&t=1

Winkelman, A., Moore, M., 2010. Explaining the differential distribution of Clean Development Mechanism projects across host countries. Energy Policy Journal 39 (2011).

WroGre b, 2011. Blog "The wrong kind of green" - Indigenous Groups Reject REDD: A False Solution that Breads a New Form of Climate Racism. Available at: http://wrongkindofgreen.org/2011/11/26/indigenous-groups-reject-redd-a-false-solution-that-breads-a-new-form-of-climate-racism/

WroGre, 2010. Blog "The wrong kind of green" - Grenoxx NGO sells first tons of REDD project. Available at: http://thewrongkindofgreen.wordpress.com/2010/05/14/greenoxx-ngo-sells-first-tons-of-redd-project/