Wuppertal Institute for Climate, Environment and Energy

GFA ENVEST

The CDM Project Potential in Sub-Saharan Africa

with Focus on Selected Least Developed Countries

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ABBREVIATIONS AND ACRONYMS

AGR	Associated Gas Recovery
BM	Build Margin
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BRT	Bus Rapid Transport
CDM	Clean Development Mechanism
CDM EB	CDM Executive Board
CDM PoA-DD	CDM PoA Design Document
CER	Certified Emission Reductions
CHP	Combined Heat and Power
CFL	Compact Florescent Lamps
CMP	Conference of the Parties serving as Meeting of the Parties to the UNFCCC
CO_2e	Carbon Dioxide and Equivalences measured in Carbon Dioxide
COP	Conference of the Parties to the UNFCCC
CPA	CDM Programme of Activities
CSP	Concentrated Solar Power Plant
DNA	Designated National Authority
DRC	Democratic Republic of Congo
ERPA	Emission Reduction Purchase Agreement
EU ETS	EU Emission Trading System
fNRB	Fraction of non renewable biomass
GDP	Gross Domestic Product
GEF	Grid Emission Factor
GHG	Greenhouse Gases
GW	Giga Watt Installed Capacity
GWh	Giga Watt Hour
GWP	Global Warming Potential
HFC	Hydrofluorcarbon
IEA	International Energy Agency
kW	Kilowatt
kWp	Kilowatt peak
LDC	Least Developed Country
LFG	Land Fill Gas
LiDAR	Light Detection and Ranging
LoA	Letter of Approval
LUC	Land Use Change
LULUCF	Land Use, Land Use Change and Forestry
MF	Microfinance
MFI	Microfinance Institutions
MHP	Micro Hydro Power
MJ	Mega Joule
MSW	Municipal Solid Waste
MW	Megawatt Installed Capacity
MWh	Megawatt Hour
NAMA	Nationally Appropriate Mitigation Action
NGO	Non Governmental Organization
NPV	Net Present Value
OM	Operational Margin
PCI	Perceived Corruption Index
PDD	CDM Project Design Document
PoA	Programme of Activities
PPP	Public Private Partnership
PV	Photovoltaic
REDD+	Reducing Emission from Deforestation and Forest Degradation
RSA	Republic of South Africa
SFM	Sustainable Forest Management
SHP	Small Hydro Power
SPV	Special Project Vehicle
SSA	Sub-Saharan Africa
SSC	Small Scale
TOE	Tons of Oil Equivalent
TWh	Terawatt Hour
UNFCCC	United Nations Framework Convention on Climate Change
USD	US Dollars

PREFACE

The African continent belongs to the regions that are most vulnerable towards climate change. Least developed countries in sub-Saharan Africa will be hit hardest and have the least capacity to respond. While international carbon markets cannot provide financing for adaptation efforts, they can play a crucial role in attracting carbon finance, providing innovative green technology and fostering access to renewable energy. These technologies are essential for meeting the increasing energy demand in Africa. While Africa is only responsible for approx. 4% of the world's greenhouse gas emissions, vast emission reduction and carbon sequestration potentials exist in the forestry and agricultural sector. However, there are also opportunities for CDM projects in the sectors energy efficiency and renewable energy, which have been widely disregarded by now.

For the past 13 years, the Clean Development Mechanism (CDM) has been successfully utilized to attract investments into emerging markets and developing countries. Yet, the CDM performance in Africa has been very limited so far: Africa's share in registered CDM projects amounts to only 2% of the global CDM pipeline. On the other hand, demand for Certified Emission Reductions (CERs) from African countries currently exceeds supply.

There are, however, encouraging signals at the international level: at its 3rd meeting, the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (COP/MOP) decided to exempt least developed countries from paying the registration fee and share of proceeds at issuance. During the climate negotiations at Copenhagen, Parties agreed to further improve regional distribution of the CDM projects and to develop measures for countries with less than 10 registered CDM projects. In a post-2012 carbon market framework countries that have been underrepresented in the CDM in the past will gain more importance.

The EU supports a variety of initiatives aiming at improved investment climate in Africa. With regard to the CDM, the EU climate and energy package adopted in 2009 foresees special provisions for CERs from LDCs. Even in the absence of an international agreement on climate change, certainty on the acceptance of credits from projects that started in LDCs post-2012 will be provided until 2020 provided that these projects are clearly additional and contribute to sustainable development. The revised EU Emissions Trading Directive and the EU Effort Sharing Decisions both include further provisions to foster CDM project developments in LDCs.

It is against this background that the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) decided to expand the scope of its CDM/JI-Initiative by supporting activities that contribute to the enhancement of CDM in sub-Saharan African least developed countries. Approaches comprise the development of appropriate methodologies, feasibility studies on CDM potentials in respective areas and industries, pilot projects on household energy and programmatic CDM. Promising initiatives funded by the BMU's International Climate Initiative are the Gold Standard Foundation's project on "Innovative Tools to Lower the Entry Barriers and Allow for Scaling-up of Carbon Market Activities in Under-Represented Regions" and the "African Carbon Asset Development Facility" (ACAD), a public-private partnership between BMU, UNEP and the Standard Bank aiming at supporting replicable CDM projects and providing carbon finance training to local financial institutions in sub-Saharan Africa.

Complementing the above-mentioned activities, BMU has initiated a research project on the participation of LDCs in sub-Saharan Africa in the carbon market. It has a twofold objective: first, it shall assist BMU in developing its strategy for climate change mitigation activities in Africa with the additional intention that the results will see a wide uptake from other institutional donors and the private sector. BMU hopes that this may serve as a first building block for practical and operational climate mitigation activities. Second, conclusions with relevance for the international debate on climate change and the post-2012 carbon market will be used for valuable policy advice. Wuppertal Institute and GFA ENVEST with their combined knowledge and expertise in the carbon market, climate negotiations, policy advice, sustainable development and practical CDM experience are fulfilling all expectations for successfully conducting the research. Complementary, a network of experts is involved in the process, ensuring that existing knowledge gained in related BMU project activities will be considered and synergies be used.

This report assesses opportunities and challenges for the CDM in sub-Saharan African least developed countries. It analyses the technical potentials for CDM activities in the region, focusing on 11 Least Developed Countries in the region. Important sectors and specific conditions for CDM in sub-Saharan Africa will be highlighted and discussed. The result is a comprehensive overview displaying various CDM project opportunities in the selected countries. The study is complemented by an analysis of important cross-cutting issues such as the role of Programmes of Activities, innovate financing approaches as well the opportunities of Public Private Partnerships.

Out of these 11 countries, BMU is going to select two countries to be assessed in greater detail. The final aim of the research is to develop recommendations for further BMU engagement in these 2 countries within the ongoing country manager CDM project together with GTZ. Therefore, GTZ experts with experience in the respective countries are participating in the selection process.

The results and findings of the research project will be published and circulated to all project developers, political decision makers, companies, financial institutions and everyone else interested in finding ways of how to best approach the CDM in Africa. I am confident that it will contribute to rising awareness to and help tapping the potentials and opportunities the African continent boasts with regard to CDM projects.

Berlin, January 2011

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EXECUTIVE SUMMARY

Background. The German Federal Ministry for the Environment (BMU) has commissioned a research project identifying options to foster access to carbon finance for Least Developed Countries in sub-Saharan Africa (SSA). Outlying the technical abatement potential of different sectors, this paper is the project's first result. It paper presents an overview of the technical potential for Clean Development Mechanism (CDM) projects of selected countries in SSA, namely Burkina Faso, Democratic Republic Congo (DRC), Ethiopia, Malawi, Mali, Mozambique, Rwanda, Senegal, Tanzania, Uganda, and Zambia. Overall 16 sectors where analysed, comprising a range of energy industry sectors (e.g. hydropower, geothermal power, etc.), energy efficiency, waste and other sectors.

The technical project potential, however, is only one precondition for successful project implementation. Yet an in-depth and empirically sound analysis of non-CDM related barriers (e.g. investment barriers) was not part of this potentials assessment and will be conducted in a later step of the research project.

Results. As laid out above, this paper presents technical project potentials for CDM projects in the study countries. It was found that the total technical abatement potential of all sectors in the study region amounts to 128,6 million CERs per year. The potentials assessment gives an overview on the countries' abatement potentials by sector. The analysis is based on existing literature as available and partly on own calculations. The sector potential findings, expressed in CERs per annum, are presented in the following table.

Table 1 Summary - CDM Potentials by Country and by Sector (in kCERs/yr)

Country	Hydropower	CDM Wind Project Potential (y/n)	Geothermal	Biofuels	Agricultural Residues	Sugar Cane	Forest Residues	Wood Residues	Cooking Stoves	Distribution Losses	End Use EE	Transportation	Municipal Solid Waste	Coal Bed	Mining / Cement	Charcoal	Country Total
Ethiopia	8.175	N	186	396	11.457	40	8.174	722	1.533	50	130	332	142	-	127	538	32.001
Tanzania	5.471	N	857	342	9.629	100	3.433	902	2.097	20	150	176	140	15	125	1.047	24.506
DRC	1.090	N	-	139	5.720	60	6.029	868	2.561	20	240	147	635	19	20	527	18.075
Uganda	-	Y	2.725	118	4.540	60	6.019	1.403	1.546	-	10	93	72	-	51	1.020	17.657
Mozambique	88	N	-	227	4.850	-	1.486	313	679	-	140	135	53	-	38	686	8695
Malawi	-	NA	-	77	4.915	100	460	123	720	-	30	62	34	-	20	670	7.211
Zambia	100	N	-	150	3.454	100	664	199	177	10	140	124	63	37	51	1.204	6.473
Senegal	3.035	Y	-	135	1.220	20	-	-	376	240	160	186	93	-	344	312	6.120
Burkina Faso	173	N	-	49	1.574	-	-	-	409	40	550	59	58	-	-	46	2.959
Mali	528	NA	-	25	1.474	-	-	-	278	20	70	48	60	-	-	123	2.626
Rwanda	187	NA	-	52	484	-	849	221	305	-	-	52	33	-	12	69	2.263
Sector total	18.846		3.768	1.709	49.316	480	27.114	4.752	10.682	400	1.620	1.415	1.383	71	788	6.242	128.586

As illustrated by Table 1, Ethiopia shows the highest total country potential, especially in the sectors energetic use of biomass (agricultural / forest residues), as well as hydropower and cooking stoves. The country's low GEF value in this case does not play a major role, as only hydropower possibly comprises on-grid projects (there are also off-grid potentials for this project type). Ethiopia also has a functioning DNA, which runs an instructive website displaying all relevant information. Moreover, the country also pursues an active climate policy – it has, among other things, submitted a considerable list of National Appropriate Mitigation Actions under the Copenhagen Accord and has announced a national strategy to become carbon neutral by 2025 (Republic of Maldives 2010). However, despite several capacity building activities, only one forestry CDM project has been registered so far.

Tanzania, scoring second, has considerable CDM potential in the sectors agricultural as well as forest residues as well as for hydropower and cook stoves projects. Also, it has the advantage of a higher GEF, which makes grid-connected CDM projects possible. In the rift valley, there are apart from hydropower, favourable potentials for geothermal energy – a very interesting project opportunity, which could be interesting for other LDCs too. Tanzania also has a functioning DNA including a website. On the downside, only one CDM project has been registered so far, a Landfill gas recovery project in Dar Es Salaam.

Yet the other two high-scoring countries, DRC and Uganda, show promising potentials. Their CDM project opportunities are lower than in the first two countries, both stand at about 18 million CERs/year. DRC has a very active DNA the director of which currently chairs the African Group within the UNFCCC negotiations, cp. JIKO Info 03 / 2010 (Wuppertal Institut 2010). Uganda has, among other things, active project developers such as the Uganda Carbon Bureau, which has developed both a Programme of Activities (PoA) for improved cook stoves and the transnational hydro PoA mentioned in the PoA section of this study. Despite its website being offline at the moment, the country has an active DNA as well as a separate authority marketing CDM possibilities (CDM in Africa Network 2010a).

Mozambique features an overall abatement potential of approx. 8.7 million CERs. Major potentials are seen in the agricultural residue sector (4.9 million CERs/yr), forest residues (1.5 million CERs/yr) and in efficient charcoal production (0.7 million CERs/yr).

Malawi offers good abatement potentials in the agricultural sector (4.9 million CERs/yr), in the dissemination of cooking stoves (0.7 million CERs/yr) and in charcoal production (0.7 million CERs/yr).

Despite having a low GEF, Zambia's total emission reduction potential was estimated at 6.5 million CERs/yr). Again, important sectors are agricultural residues (3.5 million CERs/yr) and forest residues (0.7 million CERs/yr), but Zambia also offers excellent opportunities in the charcoal sector (1.2 million CERs/yr, highest in the sector) and some potential in the sugar industry (0.1 million CERs/yr) and in the coal mining industry (0.04 million CERs/yr).

Senegal's overall emission reduction potential was estimated at 6.1 million CERs/yr. Due to its high GEF, most important sectors are hydropower (3.0 million CERs/yr) and agricultural residues (1.2 million CERs/yr). Opportunities are also envisaged in the mining sector (0.3 million CERs/yr), the reduction of distribution losses (0.2 million CERs/yr, highest potential of this sector). Moreover, based on good wind speeds and high GEF, there is a theoretical CDM wind project potential.

Burkina Faso's abatement potential amounts to 3.0 million CERs/yr. Major sectors are agricultural residues (1.6 million CERs/yr) but it also offers excellent opportunities in the End Use Energy Efficiency sector (highest potential from all countries, 0.6 million CERs/yr), cooking stoves (0.4 million CERs/yr) and some hydro power potential (0.2 million CERs/yr).

Though for Mali some sector data is not available, the overall abatement potential of the remaining sectors amounts to 2.6 million CERs/yr. Most important sectors are agricultural residues (1.5 million CERs/yr), hydropower (0.5 million CERs/yr) and the dissemination of efficient cooking stoves (0.3 million CERs/yr).

Despite being by far the smallest country in the study region, Rwanda's abatement potential was estimated to 2.3 million CERs/yr. Major sectors are forest residues (0.9 million CERs/yr), agricultural residues (0.5 million CERs/yr) and hydropower (0.2 million CERs/yr).

1 INTRODUCTION

The German Federal Ministry for the Environment has commissioned a research project, which will investigate options to foster access to carbon finance for Least Developed Countries in Africa. This research will be conducted jointly by Wuppertal Institute and GFA ENVEST. The study focuses on 11 selected LDCs in sub-Saharan Africa: Burkina Faso, Democratic Republic Congo, Ethiopia, Malawi, Mali, Mozambique, Rwanda, Senegal, Tanzania, Uganda and Zambia.

The first phase of the project consists of surveying the potential for CDM projects in sub-Saharan Africa, preliminary investigations into cross-cutting issues as well as a concise barrier analysis. The results of the first two steps are outlined in this paper. It is structured as follows: after a brief explanation of the methodology (chapter 2), the paper begins with an analysis of the CDM performance in Africa, consisting of an overview of the project pipeline and displaying the performance of CDM projects per sector as well as a review of the Kyoto infrastructure and an evaluation of Grid Emissions Factors (chapter 3).

Chapter 4 presents the assessment of the sectoral CDM potentials, grouped along the sectoral scopes used by the CDM Executive Board (CDM EB). A separate sub-chapter evaluates the potential for forest-carbon projects under the emerging avoided deforestation scheme.

In chapter 5 we analyse a set of cross-cutting issues, beginning with CDM Programmes of Activities and their possible role for Carbon Finance in the region. Also, CDM Financing Approaches such as Emission Reduction Purchase Agreements and other schemes are explored which could help easing the heavy burden of up-front financing most projects participants are facing. Further topics analysed include the possible role of Public Private Partnerships and perspectives for combining Microfinancing with the CDM.

Chapter 6 aggregates the sector abatement potentials. Two aggregation steps are conducted: first, the overall emission reduction potentials of each sector for all 11 study countries are evaluated. Second, the overall abatement potentials per country are assessed.

2 METHODOLOGY

This chapter briefly explains the methodology used as well as the scope and the limitations of the study. As a first step, the study team surveyed the current CDM performance in Africa. Using a quantitative approach, we analysed the current CDM pipeline in order to assess Africa's share in the global CDM pipeline and, more important, insights into which sectors are already successful and which ones are underachieving in Africa. This analysis is complemented by an investigation into investment costs as background for the evaluation of Africa's performance in the CDM on a sectoral level.

Moreover, the current state of the art as concerns the region's Designated National Authorities (DNA) was assessed through a literature survey and online research. This is complemented by the evaluation of grid emissions factors for the countries relevant for this study. This was achieved by investigating existing Project Design Documents (PDDs) either registered or undergoing validation. For countries where no such PDDs are available the grid emission factor (GEF) has been calculated by using 2007 data from the International Energy Agency (IEA). Please note that IEA data only allows assessing the total fuel consumption reflected by the Operational Margin (OM). The CO_2 intensity of the recent additions to the grid, reflected by the Build Margin (BM), could not be considered in these cases.

In a second step, we assessed the technical CDM potential of SSA in general with a special focus on the study countries. This step mainly relies on existing literature, complemented by own calculations where appropriate and possible. Concrete, detailed figures on CDM potentials for different countries and sectors of the region are difficult to find. The most relevant study is de Gouvello et al. (2008), prepared for the World Bank. Timilsina et al. (2010) refer to and summarise this work, which identifies 3227 potential CDM Projects in 44 SSA countries. In order to get a detailed picture of the CDM potential of SSA, further major sources such as UNIDO (2009), Econ Pyöry (2010) and a number of other specific studies have been synthesised. However, while many studies mention the great opportunities sub-Saharan countries have as host countries for CDM projects, the advantage of the study of de Gouvello et al. (2008) is that it quantifies the technical potential existing in African countries and hence in SSA countries.

However, the World Bank study has its methodological limitations: while some sectors are analyzed based on detailed data sets, de Gouvello et al. apply a rather general approach for other sectors (e.g. determining the national baseline to be natural gas). This study partially refines de Gouvello's findings (e.g. by factoring in the countries' GEFs) or develops own quantitative assessment approaches (e.g. cooking stoves- or MSW sections).

The result of this step is a concise overview of CDM potential in the selected countries per sector. It should be noted that the results are technical CDM potentials. Limiting factors, such as the absence of feed-in tariffs, underdeveloped (CDM) infrastructure or unreliable or not existing electricity supply could not be considered. These factors can seriously hamper CDM project development but require a detailed assessment, which will be conducted in a subsequent work package.

3 CDM PERFORMANCE IN AFRICA

This chapter analyzes the current status of CDM projects in Africa. Section 3.1 evaluates Africa's share in the CDM pipeline identifying more and less successful sectors. In a second step, an analysis of CDM investment costs is undertaken resulting in the assessment of abatement costs (USD/CER by sector). Finally, abatement costs per Certified Emission Reductions (CER) are combined with Africa's share in the CDM pipeline. This allows for drawing conclusions on the success of less and more capital intensive sectors in Africa.

Section 3.2 evaluates the importance of DNAs before analyzing the availability of DNAs in the study region. Section 3.3 identifies the grid emission factor as a major determinant for a country's CDM potentials. Then the GEF for each country is identified either taken from existing PDDs or calculated based on IEA data.

3.1 Analysis of the CDM Pipeline

3.1.1 Performance of CDM Projects in Africa

On a global scale, the Clean Development Mechanism has been expanding rapidly. To date 2,344 CDM projects have been registered (including CDM projects at validation the number is 5,444) with the CDM EB. These projects (i.e. only registered) will result in 1.85 billion issued CERs by 2012. But these projects not only generate CERs, they have also resulted in a total investment of 72.9 billion USD in low-carbon technology and lead e.g. to a total of 196,989 MW installed capacity (again only registered projects) (all data UNEP Risoe 2010).

Still, in Africa the CDM's performance so far has been very limited. So far there are 44 registered CDM projects in Africa making up for 1.9% of the total number of registered CDM projects. The overall pipeline (i.e. including CDM projects at various registration levels) amounts to 143 projects in Africa, making up for 2.6% of the global CDM project pipeline. Registered CDM projects are expected to generate 55.2 million CERs by 2012 (3.0% of global volume). Considering this assessment on a general level, several conclusions can be drawn:

First and obviously, the CDM in Africa does not perform as well as in other regions. Two constraining factors are commonly mentioned:

- As many regions in Africa are economically (i.e. in Gross Domestic Product, GDP) not as developed as other regions (i.e. China, India, Brazil, Mexico and Malaysia) there are less Greenhouse Gas (GHG) emissions and hence less abatement potential.
- Many African regions face inter alia high interest rates, high corruption, limited access to finance, as well as limited human and technical resources and lack of institutional capacity. These factors are obstacles for CDM investments.

Both factors are surly valid to some extent and will be discussed in more detail in the course of this study.

Second, Africa currently holds 1.9% of total registered projects but will generate 3.0% of total CERs by 2012. This is mainly due to large (in terms of CERs/project) industrial projects in the N_2O abatement sector. Typically, these facilities are operated by multinational companies not being constrained to national access to finance.

Third and most interesting, the share of African CDM projects is currently increasing (Africa holds 1.9% of registered projects but 2.6% of the total project pipeline i.e. including projects under validation. This may be due inter alia to the preferential access of CERs from LDCs into the EU Emission Trading System (EU ETS).

Still, comparing the CDM performance in Africa on a general level does allow for any conclusions on the performance of specific CDM sectors. This analysis is provided in the subsequent section.

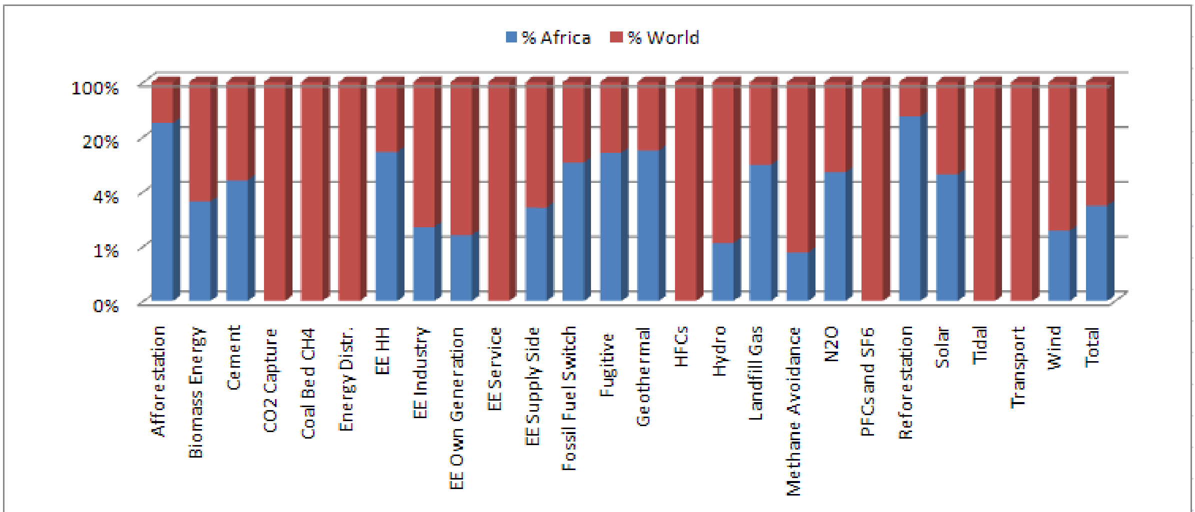
3.1.2 Performance of CDM Projects in Africa by Sector

This section provides the analysis of the CDM in Africa on a sectoral level. This will allow drawing a detailed picture on the CDM performance and will allow for conclusions on financing aspects and abatement potential.

This analysis focuses on the overall project pipeline, i.e. including projects under validation. The analysis is limited to the number of projects and does not outline the CERs per sector. Moreover we follow UNEP RISOE's definition of sectoral scopes grouping CDM activities in 25 categories as this is more detailed and offers a higher explanatory value than the UNFCCC's definition of 15 sectoral scopes.

The below graph illustrates the results of this analysis. For each of the 25 sectors the total number of projects has been set to 100%. Subsequently Africa's share of this 100% was evaluated. Please note that the vertical axis applies a logarithmic scale in order to adequately illustrate Africa's shares in the single digit range. A non logarithmic illustration may be found in Annex III – CDM Pipeline Africa.

Figure 1: Africa's Share in the Current CDM Pipeline



Source: UNEP RISOE 2010 data used for calculations

The following conclusions may be drawn:

- Africa has a significant share in the forestry sector with 36% of reforestation projects and 30% of afforestation projects. This reflects Africa's outstanding potential in the Land Use, Land Use Change and Forestry (LULUCF) sector.
- Second, 13% of all geothermal projects lie in Africa. Due to the high exploration and development costs, such projects are typically not developed by national power companies

but by highly specialized companies. These companies often form Public Private Partnerships (PPPs) with national power companies and have excellent access to international financing sources. That is, similar to N2O projects these projects are not subject to the financing constraints that generally prevail in Africa.

- Third, 13% of fugitive emission reduction projects are in Africa. These are mainly projects in the oil and gas sector. The most important project type is Associated Gas Recovery (AGR) at oil fields currently flaring the associated gas. Oil and Gas companies usually also have good access to finance.
- Moreover, 9% of fossil Land Fill Gas (LFG) projects are located in Africa. Though this sector faces some obstacles (low waste volumes per capita, often unstructured dump sites, bad waste collection infrastructure etc.) this sector's above average performance may be partly explained by the excellent CDM financing impact: due to the high global warming potential of methane the typical project may be financed completely through carbon revenues.
- Several sectors such as Hydrofluorcarbon- (HFC), Perfluorcarbon-, and Sulphur hexafluoride- abatement projects do not exist in Africa. This is due to the fact that the relevant industries are not located in Africa. For example, HFC-23 projects can only be realized in production sites for refrigerant (based on HFC-22, a gas which is being phased out under the Montreal Accord) and in Teflon production sites. Worldwide 19 such production facilities exist, but none is located in Africa.
- Finally, there are important CDM sectors such as Wind (1% of worldwide projects), hydropower (1%), and Biomass (3%) which are underachieving. These sectors may be constrained by limited access to finance, low electrification rates and by low GEFs (please refer to section 3.3), especially in the SADC region.

3.1.3 Investments into CDM Projects by Sector

This section investigates investment costs as background of Africa's performance in the CDM on a sectoral level. First, CDM investment data (UNEP RISOE 2010) from registered CDM projects was evaluated. This data was aggregated to the total investment costs for each project type (second column from the left).

Second, the annual ex-ante estimate of CERs of each project type was multiplied by 10 in order to take an average crediting period of 10 years into account, resulting in the total CER generation for 10 years for each project type (third column).

Dividing the total investment costs by the total volume of CERs gives an approximation of the abatement costs per project type. These findings are presented in Table 2 below, second column from the right.

Finally these calculations are complemented with the Africa's current share in the CDM project pipeline, shown in the first column from the right.

Table 2: Investments into CDM Projects by CDM Sector				
Project Type	Total Investment Costs (in mio. USD)	Total CERs (over 10yr)	Abatement Cost (in USD/CER) (over 10 yr)	Share in Africa (in %)
HFCs	73	816.964.660	0,09	-
N_2O Abatement	468	478.599.719	0,98	7%
Wind	509	392.630.564	1,30	1%
Coal Bed CH_4	555	140.772.760	3,94	0%
LFG	1.392	283.308.151	4,91	9%
CH_4 Avoidance	660	123.415.395	5,35	1%
Fugitive	903	88.306.983	10,22	13%
PFCs and SF_6	363	32.590.810	11,13	0%
Forests	65	4.633.620	13,99	30% / 36%
EE Own Gen.	3.853	234.809.897	16,41	1%
Energy Dist.	12	665.060	17,83	0%
Biomass Energy	3.552	170.385.205	20,85	3%
Geothermal	546	18.347.300	29,76	13%
EE Households	113	3.333.490	33,82	13%
Fossil Fuel Switch	9.267	268.609.620	34,50	9%
Hydro	21.946	625.781.507	35,07	1%
EE Industry	744	16.679.538	44,62	1%
EE Supply Side	2.830	36.837.233	76,84	3%
EE Service	81	587.788	138,22	0%
Transport	437	3.050.130	143,34	0%
CO_2 capture	60	236.880	252,80	0%
Solar	8.167	4.751.340	1.718,82	7%
Calculated based on UNEP RISOE 2010 Data				

The following conclusions are drawn:

- There is a huge span between HFCs offering the lowest abatement costs (0.09USD/CER) and the Solar with the highest abatement costs (1,718 USD/CER), with average costs of 15.11USD/CER (i.e. median).
- Africa's share of projects is higher for those project types were abatement costs lie below the median. Overall the correlation between abatement costs and Africa's share is negative. This means the higher the abatement costs, the lower Africa's share in the project pipeline.
- Fostering the CDM in Africa consequently may require:
    a) Facilitating CDM project proponent's access to finance, and/or
    b) Exploring so far not fully tapped CDM potentials having a comparably low abatement costs through innovative concepts.

3.2 Review of Designated National Authorities

The Kyoto Protocol stipulates that CDM projects have to contribute to the sustainable development of the host country (UNFCCC 1997: Art.12.1). This was further specified in the course of the Marrakesh Accords, where it was agreed that Non-Annex I countries participating in the CDM are to establish Designated National Authorities (DNA), which are mostly integrated in the host countries' environmental ministry.

According to the Marrakesh Accords, the host country needs to confirm that project participation is voluntary (UNFCCC 2001: Art. 28) and “that the project activity assists it in achieving sustainable development” (UNFCCC 2001: Art. 40a). To affirm that these requirements are met, the DNA sends a Letter of Approval (LoA) to the project proponent.

Hence the existence of a DNA is a key element for the development of CDM projects in a host country. Based on the above legal framework, the project consortium has evaluated the existence of DNAs in the selected countries. Details may be found in Annex IV. It was found that all eleven countries have established a DNA. Ethiopia, Rwanda and Senegal have specific DNA websites. Other indicators, such as functioning procedures for project approval in practice or number of staff, could not be assessed within the scope of this study. It is concluded that in principle, there are no formal barriers to the implementation of CDM projects in the selected countries. However, the absence of a DNA website can function as a barrier for investors and can be sign that these DNAs do not actively promote the CDM within the host country.

3.3 Grid Emission Factor Evaluation

The grid emission factor (GEF), defined as the average carbon intensity of a host country’s electricity system, is an important factor determining the impact of carbon finance. More specifically, the GEF outlines how many CERs a renewable energy CDM project may generate for feeding one GWh into the national grid.

To give an example, the Republic of South Africa (RSA) has a GEF of 980tCO_2/GWh. Hence a renewable energy CDM project will receive 980 CERs for feeding one GWh into the electricity grid. By contrast, Zambia’s electricity production is dominated by hydro power. Hence its GEF is close to zero, which means that grid-connected renewable electricity projects will receive hardly any CERs. Consequently the GEF is an important factor delineating the overall opportunities for:

- Grid connected renewable energy projects such as hydro power- and biomass to electricity projects, and
- Demand side energy efficiency projects (i.e. reducing consumption of electricity provided by the national grid) such as Compact Fluorescent Lamp distribution projects/programs.

In order to assess the general feasibility of such CDM projects, we analyzed the GEF for the selected countries. This was achieved by investigating existing PDDs either registered or undergoing validation. For countries where no such PDDs are available the GEF has been calculated by using 2007 data from the International Energy Agency (IEA). Please note that IEA data only allows assessing the total fuel consumption reflected by the Operational Margin (OM). The CO_2 intensity of the recent additions to the grid, reflected by the Build Margin (BM), could not be considered in these cases. The findings are outlined in Table 3 below.

Table 3: Grid Emission Factors for Selected Countries				
Nr.	Country	GEF (in tCO_2/GWh)	Comment	Source
1	Burkina Faso	805.7	Combined Margin	http://www.dnv.com/focus/climate_change/Upload/Felou%20PDD.pdf
2	DRC	2.6	Operational Margin	Calculated based on IEA Data for 2007: 99;7% Hydro and 0,3% Oil
3	Ethiopia	32.7	Operational Margin	Calculated based on IEA Data for 2007: 96;1% Hydro and 3,9% Oil
4	Malawi	N.A.	N.A.	No CDM Projects and no IEA Data available
5	Mali	502.8	Combined Margin	http://www.dnv.com/focus/climate_change/Upload/Felou%20PDD.pdf
6	Mozambique	5.3	Operational Margin	Calculated based on IEA Data for 2007: 99;9% Hydro complemented with Oil and Gas
7	Rwanda	710	Combined Margin	http://cdm.unfccc.int/UserManagement/FileStorage/RM0OY8PHVAUDZE765S1XCL2JFWNGT3
8	Senegal	714	Combined Margin	http://cdm.unfccc.int/UserManagement/FileStorage/7GXSKBDO2JUCY9WQ48F5A13IR60VEZ
9	Tanzania	609.1	Combined Margin	http://cdm.unfccc.int/UserManagement/FileStorage/CQU2J8HTGAXZ3SV49F5NOPYD7KW60I
10	Uganda	693	Combined Margin	http://cdm.unfccc.int/UserManagement/FileStorage/FUYJ930RA8DIXQNVSM7LBP4ZO6GK2W
11	Zambia	5.8	Operational Margin	Calculated based on IEA Data for 2007: 99;4% Hydro complemented with Oil and Coal

The following conclusions are drawn:

- Burkina Faso, Mali, Rwanda, Senegal, Tanzania and Uganda have high GEF values making grid connected CDM projects feasible.
- On the other hand, DRC, Ethiopia, Mozambique and Zambia have low GEF values, so that grid connected CDM projects are currently not feasible. No information is available for Malawi.
- Countries having currently a low value could be supported by refining the GEF calculations according to CDM EB50, Annex 14 by:
    - Calculating separate emission factors for the peak load and base load as well as a coefficient for weighting these (simple adjusted- and dispatch OM). This usually allows for increasing the emission factor of the OM.
    - Integrating recently build transmission lines into the BM or delineating the Project Electricity System in a way that increases the emission factor of the BM.
    - Including off-grid diesel generators into the calculation of the BM and/or OM. This option was only recently included in CDM's tool to calculate the GEF (CDM EB50, Annex 14) and may proof to be specifically useful for SSA.

3.4 Conclusions

The following conclusions may be drawn from section 3:

- The analysis of the CDM pipeline showed that Africa's share in the current CDM pipeline is limited to 1.9% of registered CDM projects and 2.9% of total CDM projects (including validation).
- Most successful CDM sectors in Africa are forestry (36% of reforestation- and 30% of afforestation projects worldwide), geothermal energy (13%) and fugitive emissions (13%).
- Renewable energies such as wind (1%), hydropower (1%) and biomass (3%) involving high investment costs are underrepresented.
- The financial analysis showed that there is a huge span between HFCs offering the lowest abatement costs (0.09USD/CER) and the solar sector with the highest abatement costs (1,718USD/CER), with average costs of 15.11USD/CER (i.e. median).
- Africa's share of projects is higher for those project types where abatement costs lie below the median. Overall the correlation between abatement costs and Africa's share is negative. This means the higher the abatement costs, the lower becomes Africa's share in the CDM project sector.
- It was found that all countries have established DNAs, which allows for the development of CDM projects in the study region.
- GEF analysis showed that Burkina Faso, Mali, Rwanda, Senegal, Tanzania and Uganda have high GEF values making grid connected CDM projects feasible.
- On the other hand, DRC, Ethiopia, Mozambique and Zambia have low GEF values, so that grid connected CDM projects are currently not feasible. No information is available for Malawi.

4 ASSESSMENT OF SECTORAL CDM POTENTIALS

Sub-Saharan Africa is not known for its obvious greenhouse gas abatement potentials: with per capita emissions of 0.8 tons of CO_2 (World Bank 2010a) it is the least GHG emitting region of the world (compared to the USA with 19 tons per capita). However, due to its large population increase and the often very old and inefficient technology used, there is some potential for sustainable development measures in the region. Tapping these potentials can help both abating GHGs as well as improving the livelihoods of the local population.

The total African CDM potential is estimated to more than 3,200 CDM projects, which could add more than 170GW of power – more than twice the current installed generation capacity (World Bank 2009a). Related emission reductions according to this estimation add up to a total of 740.7 million tCO_2/yr. Over 60 % of these emission reductions would be achieved on the supply side (Timilsina et al. 2010).

As the recent World Development Report concludes (World Bank 2010b), different country circumstances require country-tailored approaches. Generally, low-carbon technologies and policies in low-income countries are:

- Expand energy access through grid and off-grid options
- Deploy energy efficiency and renewable energy whenever they are the least cost
- Remove fossil-fuel subsidies
- Adopt cost-recovery pricing
- Leapfrog to distributed generation where grid infrastructure does not exist

In the following, we assess SSA's project potential in general and with a special focus on the selected countries of the region. The presentation is grouped according to the classification of the CDM EB's Sectoral Scopes. However, data was not available for all of the EB's sectoral scopes. Hence, the study focuses on the following sectors:

- Energy Industries (renewable-/non-renewable sources[1]),
- Energy Efficiency Potentials,
- Transport Potentials
- Waste Project Potentials
- Other Potentials (i.e. Mining, Metal / Industrial Production Processes, Cement and Efficient Charcoal Production)

4.1 Energy Industry

With an average of about 0.66 Tons of Oil Equivalent (TOE), Africa has a low per capita energy consumption compared to the global average of 1.8 TOE in 2008. The UN Industrial Development Organization (UNIDO 2009) points out that the gap between energy supply and demand in Africa has actually widened over the past four decades while it has narrowed in other developing countries. Despite considerable general growth rates in the last decade, recent trends indicate that the gap between energy supply and demand will continue to grow. UNIDO concludes that the majority of the population in Africa will continue to lack access to basic energy services, unless drastic interventions are made.

[1] Based on the large significance for SSA LDCs, special focus was put on the analysis of Non-Renewable Biomass as a baseline emission source following the guidance of AMS I.E - Switch from Non-Renewable Biomass for Thermal Applications by the User.

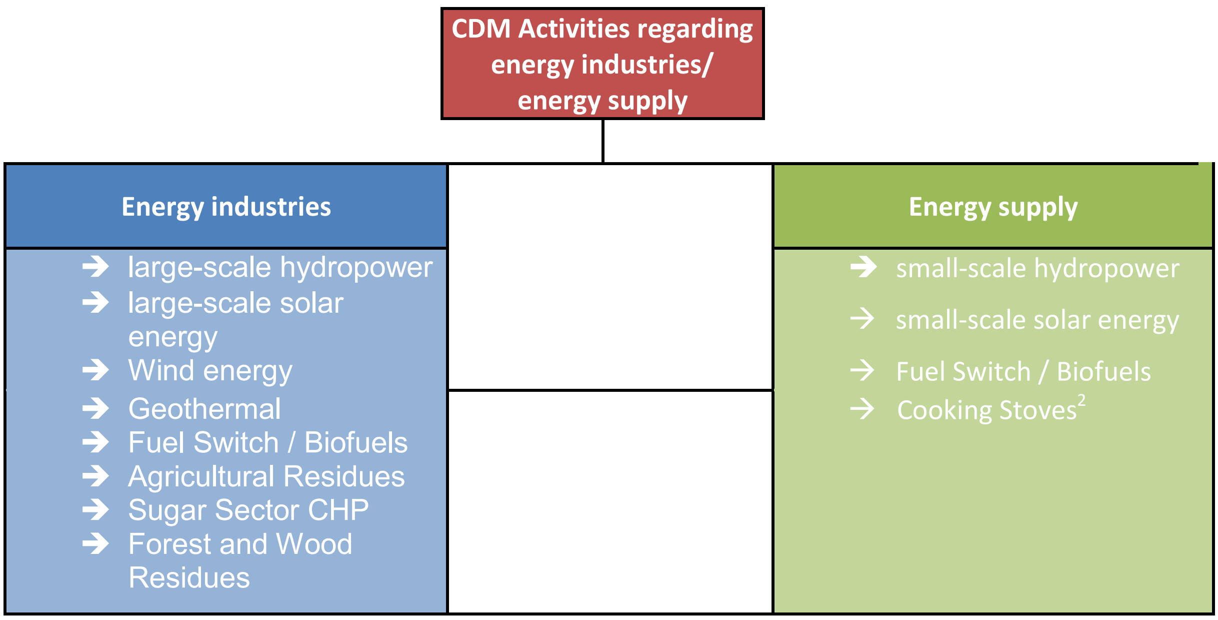
Biomass accounts for 70-90% of primary energy supply in some countries, and as much as 86% of energy consumption. In some countries biomass energy contributes as much as 97% of total energy supply. Variations exist within Africa, with biomass accounting for only 5% of energy consumption in Northern Africa and 15% in South Africa. Due to its dominant role biomass will be considered in several sections below, displaying possible CDM biomass activities such as the use of agricultural residues or biofuel potentials. For example, forest- and wood residues are discussed in a separate section. The call for “drastic interventions” is also based on estimates that sub-saharan Africa needs an annual addition of 4 GW in order to power its economic growth and keep up with the demand for electricity, which is growing at about 5 per cent per year or more in many countries in the region. UNIDO (2009) states that currently only 1 GW is being added annually.

Generally, Africa has a large potential of renewable and non-renewable sources of energy. Regarding renewable energy, several studies report estimates of a potential of 1,750TWh through hydropower and up to 14,000 MW of geothermal energy (UNEP 2008, UNIDO 2009). Africa receives abundant solar radiation through the year. In addition, several recent studies have confirmed large wind energy resources in coastal and some specific inland areas, but these are mainly restricted to the Northern African countries and South Africa (ibid). Small-scale energy systems have high potential but are difficult to quantify in total. There are two types: The first category produces electricity based on photovoltaic- (PV) and wind power, for instance, while the second category produces thermal energy for heating, drying and cooking. (UNIDO 2009).

Currently, the energy reserves and potentials of renewable energies are largely underutilised: Only 7% of the hydropower potential has been exploited (AFDB / OECD 2003). And only 0.6% of the geothermal potential has been utilised (UN 2003).

This study assesses the following project potentials:

Figure 2: CDM Activities in the Energy Industry



2 Though potentially classifying as energy demand activity, cooking stoves projects considering non-renewable biomass are bound to AMS I.E being a Type I Small Scale (SSC) project activity. According to the Marrakesh Accords adopted at Conference of the Parties (COP7 (UNFCCC 2001: Decision 17, §6c) these are classified as renewable energy activities. Hence Cooking stoves are subsequently listed in the renewable energy section.

4.1.1 Hydropower

Large Scale Hydropower

Background. More than 90 percent of the globally unexploited economically feasible hydropower potential (of a total global economically exploitable potential of 6 million gigawatt-hours a year) is concentrated in developing countries, primarily in SSA, South and East Asia, and Latin America. Africa exploits only about 5% of its hydropower potential of just over 1750 TWh (UNIDO 2009, Gaul et al. 2010, World Bank 2010b, recently reported 8%), which is the least exploited hydropower potential in the world (Water for Agriculture and Energy in Africa, 2008). Despite the low percentage use, large-scale hydropower so far provides over 50% of total power supply for 23 countries in Africa (UNIDO 2009).

In order to better illustrate the magnitude of Africa's hydropower potential, the total hydropower potential for Africa is equivalent to the total electricity consumed in France, Germany, United Kingdom and Italy put together (ibid).

For many countries in Africa, regional hydropower trade could provide the least-cost energy supply with zero carbon emissions. The World Development Report concludes that a lack of political will and trust as well as concerns about energy security are serious constraints for such trade. Moreover, greater future climate variability would affect the hydrological cycle and, therefore, could make hydropower supplies unreliable in some regions (AFREPREN/FWD/HBF 2004). In Zambia, for example, in 1992 poor rainfall resulted in a 35% reduction in hydropower generation compared to the previous year. In Kenya, more dramatically, not only the performance but also the estimated hydropower potential has already decreased due to deforestation and reduced precipitation (GTZ as cited in Gaul et al. 2010).

On a more general level, care has to be taken when developing and implementing large hydro dams. Large hydroelectric projects can have adverse environmental and social effects. The EU, for example, restricts the admission of CERs from large hydro projects used for complicance in the European Emissions Trading system: it requires that large hydro projects respect the safeguards established by the World Commission on Dams (DEHSt 2008). Through this measure, the EU attempts to make sure that the respective projects are carried out in a socially equitable, environmentally sustainable and economically viable manner.

SSA Country Potentials. Countries with significant hydropower potential include the DRC, Angola, Cameroon, Egypt, Ethiopia, Gabon, Madagascar, Malawi, Mozambique, Niger and Zambia (Econ Pyöry 2010, UNDP 2009).

The large-scale hydroelectric CDM project potential of five countries - Burkina Faso, Côte d'Ivoire, DRC, Guinea and Mali - could alone achieve emission reductions of about 119.63 million t CO_2e (de Gouvello et al. 2008).

Methodology. The below table shows a summary of overall hydropower potentials as reported by other authors than de Gouvello et al. (2008). Information has primarily been taken from the RECIPES project, a study into the implementation of renewable energy sources ('RES') in emerging and developing countries funded by the European Commission (RECIPES 2006a-l). Other authors (e.g. Sarr / Thomas 2005) refer to both large-scale and small-scale installations. Comparability with de Gouvello et al. is therefore limited. Please note that not for all countries the installed capacity and generation potentials were available.

These sources were combined with:

- The average CDM hydropower size (12.46 MW, calculated based on UNEP RISOE 2010 data) to estimate the potential number of projects,
- The average investment cost per CDM project (calculated based on UNEP RISOE 2010 data).
- For the estimate of emission reductions energy generation was combined with the GEF assessment, outlined in section 3.3.

Table 4: CDM Hydropower Project Potential

Country	Nr. of Potential Projects	Electricity Generation (in GWh/yr)	Installed Capacity (in MW)	Emission Reductions (in kCERs/yr)	Total Investment (in mio USD)
Burkina Faso	6	215	75	173,2	156
DRC	N.A.	419.210	N.A.	1.089,9	N.A.
Ethiopia	N.A.	250.000	N.A.	8.175,0	N.A.
Malawi	N.A.	N.A.	N.A.	N.A.	N.A.
Mali	N.A.	1.050	N.A.	527,9	N.A.
Mozambique	N.A.	16.551	6.298	87,7	13.086
Rwanda	8	263	100	186,6	208
Senegal	N.A.	4.250	N.A.	3.034,5	N.A.
Tanzania	274	8.983	3.418	5.471,2	7.102
Uganda	N.A.	N.A.	N.A.	N.A.	N.A.
Zambia	N.A.	17.233	N.A.	99,9	N.A.

Source: RECIPES 2006a-l, UNEP RISOE 2010 and GEF Calculations from section 3.3;

The following conclusions are drawn:

- First the overall hydropower potential in the region is huge, amounting to 717,000 GWh. However, this potential translates into a comparably small emission reduction potential of 18.85 million CERs/yr as the GEF is low for those countries having the biggest potential.
- DRC, Ethiopia and Mozambique have the largest hydropower potential, but as the GEF is low, CDM project development may not be possible, even if the implementation of these projects would result technically in emission reductions.
- This is followed by Tanzania with 8,983 GWh/yr and Senegal 4,250 GWh/yr, resulting in 5.47 and 3.03 million CERs/yr respectively.

Small Scale Hydropower

Background. Small Hydropower Systems (SHPs, less than 10MW) can supply energy to remote regions and catalyse development in these communities. In comparison to large hydropower systems the smaller systems require significantly lower capital costs. SHP itself can be classified in pico (< 5-10 kW), micro (10-100 kW), mini (100 kW-1 MW), and small (1-10 MW) hydropower systems. SHPs do not only provide electricity for lighting and communication (as solar PV does), but can deliver enough capacity to supply insular mini-grids if it is not fed into public grids and can thus constitute the basis for various forms of productive use of electricity including small industrial applications (Gaul et al. 2010). This allows increased local private sector participation and community involvement. In environmental terms, SHPs are more sustainable than large-scale systems.

In particular micro hydropower systems (MHPs), having an installed capacity from 10 to 100 kW, can provide electricity on a village level (UNIDO 2009). MHPs are already in place in a number of African countries but the total number of plants is limited to not more than about a few hundred MHP plants in SSA countries (Gaul et al. 2010). In comparison, China alone has developed more than 45,000 SHP/MHP plants below 10 MW. During the last decade, some SSA countries have made progress in promoting the application of SHP/MHP potentials more systematically, among them Rwanda, Kenya, Ethiopia and South Africa, exploiting it with a special focus on rural communities. In Rwanda, SHP already contributes a significant portion of the total installed capacity and even MHP starts to contribute as 15 MHP plant are under construction and another 21 are planned (ibid).

SHP/MHP Potential in SSA Countries. Most African countries have a large potential for small hydro systems. The potential, however, is difficult to quantify. Even the existing MHP sites/plants are documented in only a few cases and different sources provide inconsistent information about existing sites/plants (Gaul et al. 2010). With around 0.5% of the global total, Africa has one of the lowest SHP installed capacities despite its great potential for Small Scale Hydropower projects (Water for Agriculture and Energy in Africa: 2008).

According to Econ Pyöry (2010), potentials for small-scale renewables are high in several countries such as Malawi, Zambia and DRC. The European Small Hydro Power Association assessed the market perspectives and considers Uganda and Kenya as countries with promising short-term market perspectives and countries such as Mozambique, Zambia and Rwanda as countries offering good medium-term perspectives (Gaul et al. 2010).

Regarding the assessment of MHP potentials, Gaul et al. (2010) conclude:

- Estimated potentials are mainly based on a rough analysis of water catchment areas and do often not consider the demand side.
- A proxy for the MHP potential of a country is the availability of mechanical hydro mills (upgrading for power generation). Examples from Ethiopia, Mozambique and Tanzania show that it is an advantage that people are already familiar with the use of hydropower (in Ethiopia mechanical water mills were introduced some hundred years ago).

Analysing existing literature such as WEC (2007) and GTZ regional reports (2009) complemented by interviews, Gaul et al. (2010) describe the MHP situation and potential for several SSA countries as follows:

Table 5: MHP Development in Selected SSA Countries

Hydro Power	Ethiopia	Mozambique	Rwanda
Total installed capacity	662 MW	2,136 MW	27 MW
MHP Potential	>600 sites	Unclear	333 sites, 96 MW
Existing MHP plants/installed capacity	Unclear	6 (10-80 kW)	6
MHP plants under construction	5 (7-200 kW)	none	15
MHP plants planned	None	3 (23-600 kW)	21

Source: Gaul et al. 2010

Some additional information has been found for some other SSA countries:

- Ethiopia: there is considerable MHP hydro potential that has CDM potential in an off-grid context as the Ethiopian grid is already very 'clean' (UNDP 2010a). The potential is not been quantified.
- Mozambique: One potential micro-hydro project is included in the list of Project Idea Notes (FUNAE Micro-hydro Bundle, UNDP 2010b).
- Tanzania: a total potential of 234.6 MW for SHP has been estimated of which 4 MW are already exploited (in 2005, Byakola et al. 2009).
- Uganda: Around 30 potential sites for small hydropower CDM projects were identified by the Ugandan Investment Authority. The estimated potential for large and small scale hydro in Uganda is 2000 MW installed capacity. At the moment only 15% are utilized (CDM in Africa Network 2010a).
- Zambia: With 62 MW the SHP capacity installed in Zambia is relative high (Water for Agriculture and Energy in Africa 2008).

CDM Potential. SHP projects have been financed under the CDM in other regions of the world. SSA countries, however, have so far only developed 12 (3 registered) out of the more than 1,400 hydropower projects in the CDM pipeline. All of these projects are large-scale projects ranging from 1.5 to 262 MW installed capacity, none is a SHP/MHP (Gaul et al. 2010). Where projects feed-in generated power into the grid, CDM viability depends on the GEF. As outlined above, Burkina Faso, Mali, Rwanda, Senegal, Tanzania and Uganda have high GEF values making grid connected CDM projects feasible whereas DRC, Ethiopia, Mozambique and Zambia have low GEF values. The viability of SHP/MHP in insular, off-grid installations is independent of the GEF.

4.1.2 Solar Energy

In the following, a distinction is made between large scale and small scale solar energy projects. The differentiation is made from the perspective of the installation level, i.e. energy generation at large plants such as concentrated solar power plants is treated as large scale, whereas small scale solar technology comprises devices in households or at the community / factory level. This covers, in principle, solar photovoltaic (PV) technologies, which convert solar energy into electrical energy; and solar thermal technologies, which use solar energy directly for heating, cooking and drying.

Large Scale Solar Energy

So far, cost constraints have limited the number of large-scale solar energy projects in Africa to a great extent. Feasibility studies have shown that Africa’s desert areas have great potential for concentrated solar thermal power generation, with competitive power production costs around 4-6c/kWh. However, to date, the only solar thermal power system on the continent is operated by South Africa, having an installed capacity of 0.5 MW. Egypt plans to install solar thermal plants of 30 MW by 2010 and 300 MW by 2020 (UNIDO 2009). Several countries in Northern Africa are planning to develop solar thermal plants based on interest from European countries, among them the *Desertec Initiative*, which intends to build a 40 GW Concentrated Solar Power Plant (CSP).

Solar thermal energy technology is becoming increasingly simple so that components can be produced and maintained locally. Also, most technological uncertainties are overcome. On the one hand, therefore, CSP is becoming more attractive for Africa. On the other hand, however, this potential is drastically limited when considering the capital and operating costs to date (AfricaProgressPanel 2009). The potential is further limited for on-grid plants due to the low

GEFs in some SSA countries. As a result, large scale solar power projects are not further considered here.

Small Scale Solar Energy

Background. In SSA, solar energy is used mostly at the household level for lighting, cooking, water heaters and solar architecture houses. At the community level, solar energy is made use of for vaccine refrigeration, water pumping, purification and rural electrification. In the industry sector, small scale solar energy is used for pre-heating boiler water and for power generation, detoxification, municipal water heating, as well as telecommunications (Karekezi / Kithyoma 2003). In general, PV devices have seen widespread promotion throughout the continent. As a consequence, almost every SSA country has a major program to increase dissemination of small-scale solar PV. However, at the end of 2008, the cumulative PV installations of Africa reached 11 MW, while global PV capacity reached 15,200 MW (AfricaProgressPanel 2009). South Africa and Kenya boast the highest documented installed capacities of solar PV systems with over 11,000 and 3,600 kilowatt-peak[3] (kWp) respectively. The distribution of photovoltaic (PV) technology in SSA is distributed as follows: telecommunications (19 percent), PV stations (15 percent), pumping systems (24 percent), solar home systems (37 percent), and community systems with about 5 percent (de Gouvello et al. 2008).

CDM Opportunities. For small-scale solar energy systems, in principle, the same barriers as for large scale projects are relevant: in SSA, solar PV projects have mainly benefited high-income segments of the population so far, due to the high cost of solar PV. Solar PV is not affordable to the majority of the population in SSA, given the high levels of poverty; the same applies for solar thermal applications such as solar water heaters for households (Karekezi / Kithyoma 2003, de Gouvello et al. 2008).

There are, however, promising opportunities for off-grid PV systems in rural areas. In small, decentralized systems, small scale PV systems can be a viable and cost-efficient alternative in order to replace diesel and petrol generators or kerosene used for lighting.

[3] kWP is a term used in solar engineering to measure the nominal power of a PV device under specific illumination conditions. Hence, kWp outlines the nominal power of 1 m^2 PV device with an illumination of 1,000 W/m^2 (defined according to applicable IEC standards). Please note, that radiation in any African country easily can bypass 1000 W/m^2. Hence, the actual power output may exceed the nominal power.

These systems are especially suitable for niche applications in areas such as schools and hospitals, as well as telecommunications purposes in rural areas with no connection to the electricity grid, where in absence of a possible low GEFs CDM project opportunities are possible. Here, CDM revenues can add considerable contributions towards financing such activities, especially in Programmes of Activities. A comparable PoA scheme in Bangladesh involves 2,700 PV systems replacing Kerosene; however, the PoA produces 1,515 CERs per annum only (AfricaProgressPanel 2009).

Table 6: Estimated Solar Insolation	
Country	Radiation (in kWh/m^2/d)
Burkina Faso	5.5
DRC	N.A.
Ethiopia	5.2
Malawi	N.A.
Mali	6.0
Mozambique	N.A.
Rwanda	5.2
Senegal	5.4
Tanzania	4-8
Uganda	5.0
Zambia	5.6
Sources: DFIC 2007a, DFIC 2007b, REEEP 2010a, REEEP 2010b, Sarr / Thomas 2005	

The World Bank considered the development of Solar PV opportunities in 16 sub-Saharan countries (Benin, Burkina Faso, Central African Republic, Chad, Congo, Dem. Rep. Congo, Rep. Côte d'Ivoire, Eritrea, Guinea, Liberia, Madagascar, Mali, Mauritania, Niger, Rwanda, Senegal, Togo). Based on data on population, population density, and electrification rate, they calculated a total emission reduction potential in these 16 countries of 439,000 tCO_2 annually (de Gouvello et al. 2008). However, these calculations are based on several average values and cannot be transferred to single countries.

In sum, potential estimates on small scale solar energy projects in SSA cannot be given. Available data mostly refer to radiation hours per m^2 per day. Concrete figures on GHG abatement or CDM potential were not available in the literature used.

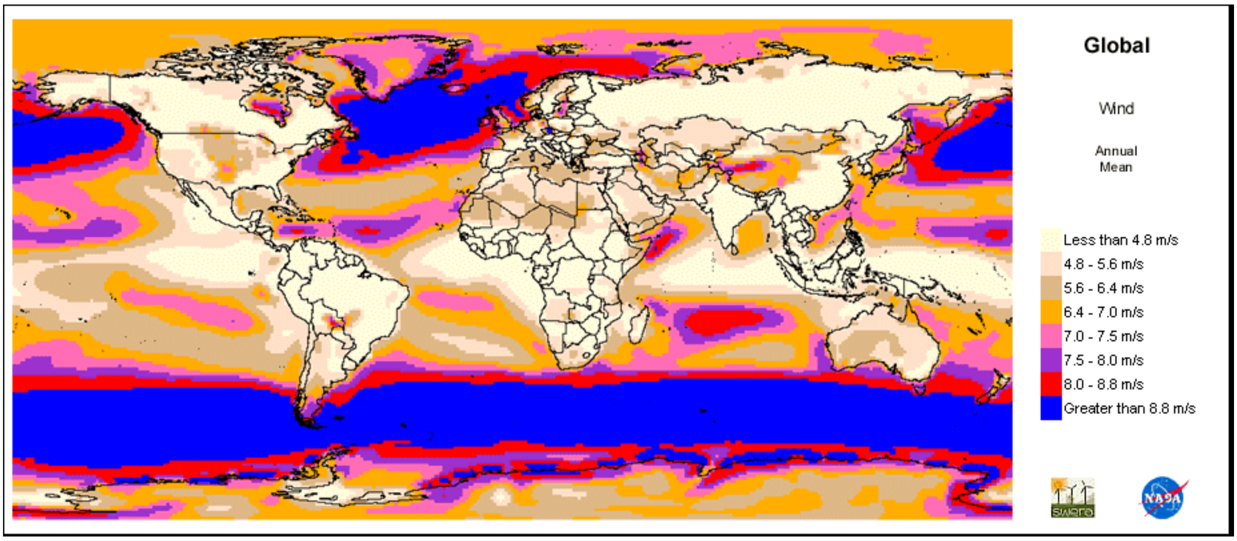
The following conclusions can be drawn:

- Potential estimates on small scale solar energy projects per SSA country are not available. Available data mostly refer to radiation hours per m^2 per day. Concrete country figures on GHG abatement or CDM potential were not available in the literature used for this research.
- The most promising CDM project opportunity is off-grid Solar-PV projects in rural areas. Compared to the mean values of radiation per day in Table 6: Estimated Solar Insolation (see above), it can therefore be assumed that there is potential for Solar-PV projects, e.g. in form of PoAs, in most countries covered by this study. This potential, however, is probably limited to a few niche projects / PoAs. De Gouvello et al. (2008) estimate a reduction potential of 439,000 t CO_2 e/year for the whole of 16 sub-Saharan countries for these kinds of projects / PoAs.
- A comparable conclusion can be drawn for solar-thermal applications, such as solar water heaters.

4.1.3 Wind Energy

Africa is mostly located in the tropical equatorial zones and only in the far South and North overlaps with the wind regime of the temperate westerly winds. While the South and North African coasts therefore dispose of good wind energy potential, low wind speeds prevail in many SSA countries, particularly in land-locked nations. Wind machines are therefore often used for water pumping rather than electricity generation. There is also a low level of technical skills and awareness of the technology's potential (Karekezi / Kithyoma 2003).

Figure 3: Global Annual Wind Speeds



Source: UNEP 2010

In terms of installed capacity, at the beginning of 2008, Africa only had about 476MW of installed wind energy generation capacity compared to global estimate of 93,900MW. Countries developing large-scale wind energy projects so far include Morocco, Egypt, Tunisia, South Africa, and Ethiopia (UNIDO 2009). The available data on wind energy potential per country is patchy. Where available, data is mostly given in terms of wind speeds, sometimes in terms of potential installed capacity. No figures on GHG reduction potential were given in the literature that was surveyed.

Ethiopia. The total theoretical potential is estimated at 10,000 MW. Average wind speeds are low, ranging from 3.5 m/s in the West to 5 m/s in the East, but individual sites with favourable conditions also have higher speeds. GTZ (2007a) has measured speeds up to 9.4 m/s at specific sites.

Senegal. Viable sites are restricted to the coast, where wind speeds of 3.7-6.4 m/s have been measured. However, even these speeds are in the median range so that financial support will be necessary to develop sites. In the country’s interior speeds usually do not exceed 2-3 m/s. While using water energy for water pumping has a long tradition, so far there is not a single large-scale wind energy installation for electricity generation. There are no national targets or support schemes and approval procedures are lengthy.

Tanzania. The average wind speed is low at 2.5-4 m/s. Measurements at some favourable sites have found speeds up to about 5 m/s, which is sufficient to operate a turbine. At this speed the cost of wind electricity is slightly higher than the long-run marginal cost of the interconnected grid (DFIC 2007a).

Uganda. The average wind speed is low at 3-4 m/s. In flat areas, around the Great Lakes and on hillsides speeds may go up to 6 m/s. However, these sites are usually far away from the demand centres (DFIC 2007b).

Other. Karekezi and Kithyoma (2003) as well as Sarr and Thomas (2005) provide some further data on wind speeds for Burkina Faso, Mozambique, and Zambia, which are listed below. Within the time available no data could be found for the DRC, Malawi, Mali, and Rwanda.

Methodology. According to DFIC (2007a) wind speeds of about 5 m/s are necessary to operate a turbine. In practice, the technical wind potential is determined not only by wind speeds, but also by feed-in tariffs and by construction and logistic costs. Hence for the subsequent evaluation, the minimum wind speed is defined as 5.5m/s. Furthermore, as wind blows intermittently it is generally viable only in grid-connected systems, not in isolated applications. CDM viability is therefore directly tied to the applicable GEF.

The following table therefore lists the available data on wind speeds and grid emission factors. The following countries have wind speeds and GEFs that are sufficient to make CDM projects viable: Senegal and Uganda. In Burkina Faso, the DRC, Ethiopia, Mozambique, and Tanzania wind speeds and/or the GEFs are too low. No assessment is possible for Malawi, Mali, and Rwanda.

Table 7: Theoretical CDM Wind Project Potential by Country

Country	Wind Speeds (in m/s)	Wind Project Potential (Y/N)	GEF (t CO_2/GWh)	CDM Project Potential (Y/N)
Burkina Faso	2 -4	N	805.7	N
DRC	NA	NA	2.6	N
Ethiopia	Average 3.5-5, Top up to 9.4	Y	32.7	N
Malawi	NA	NA	NA	NA
Mali	NA	NA	502.8	NA
Mozambique	0.7 - 2.6	N	5.3	N
Rwanda	NA	NA	710	NA
Senegal	Coast 3.7-6.4 Interior 2-3	Y	714	Y
Tanzania	Average 2.5-4, Top up to 5	N	609.1	N
Uganda	Average 3-4, Top up to 6	Y	693	Y
Zambia	Average 2.5	N	5.8	N

Sources: DFIC 2007a, DFIC 2007b, GTZ 2007a, GTZ 2009, Karekezeki / Kithyoma 2003, Sarr 2005

It is concluded that CDM Wind projects may only be realized in Senegal and Uganda, as only those two countries combine sufficiently powerful average wind speeds with a high GEF.

4.1.4 Geothermal Energy

Geothermal energy is an untapped renewable energy source that is abundantly present in many parts of Africa, though estimates vary. According to The Economist (2008) there is a potential of generating up to 14,000 MW from geothermal sources. According to AFREPREN/FWD/HBF (2004) Africa has an estimated geothermal potential of 9,000 MW of which 2,500 MW could be mobilized with current technology.

Generally, less than 1% of the total estimated geothermal potential is exploited (UNIDO 2008) and only few countries such as Kenya have used it commercially. As of today, Kenya has installed up to 127 MW, amounting to about 17% of the national power supply, followed by Ethiopia with a 7 MW installation. Plans to use the potential of geothermal energy in Uganda, Tanzania, Eritrea and other SSA countries are at different stages (UNIDO 2009). However, this power source requires major financial commitments in up-front geological investigations and expensive drilling of geothermal wells (World Bank 2010b).

Methodology. Average investment per MW was calculated from UNEP RISOE data (2010) to be 1.14 million USD per MW installed capacity. Average project size was also calculated based on UNEP RISOE data to be 47.75 MW. Moreover, the average load factor was calculated (92.6%) based on two CDM Geothermal CDM Projects, San Jacinto Tizate geothermal project in Nicaragua and Olkaria III Phase 2 Geothermal Expansion Project in Kenya. Geothermal energy usually involves high exploration costs. Hence the typical size in terms of installed capacity is high. Consequently, geothermal power plants are always connected to the grid and the GEF determines the overall emission reduction potential of this technology.

Ethiopia. While geothermal potential in Kenya is estimated to lie at 2,000 MW, RECIPES (2006c) estimate the potential in Ethiopia to more than 1,000 MW. Other estimates (GTZ 2007a and Woldemariam 2004) come to similar results estimating the potential in Ethiopia at approximately 700 MW. Ethiopian's only geothermal area exploited for electricity generation is Aluto-Langano located on the floor of the Ethiopian Rift Valley.

Mozambique. In Mozambique, at least thirty-eight thermal springs have been identified. The most interesting geothermal area is within the East Africa Rift just north of Metangula where vigorously boiling water is reported on the edge of Lake Nyasa. Several lower temperatures (below 60°C) found in the springs issue from Mesozoic crystalline terrain along and to the west of major faults in the Espungabera-Manica areas, near the border with Zimbabwe. The most promising areas for geothermal energy development are the northern and central provinces of Mozambique where heat-flow values range between 70 and 170 MW/m^2. (RECIPES 2006f). No specific capacity data could be identified.

Tanzania. In contrast, the geothermal resources in Tanzania are fairly small. While in the Northern part of the county there is no evidence of high temperature hydrothermal system, the South has probably three hydrothermal systems. But also in this area temperatures are rather low and several regions are marginal for direct utilization. Therefore, Tanzania's geothermal energy potential amounts only to 150 MW (RECIPES 2006i).

Uganda. Geothermal energy studies in Uganda were already carried out between 1993 and 1994 and three geothermal prospects in the Rift valley along the border of Uganda and the DRC were identified: Katwe, Burango and Kibiro. High subsurface temperatures from 160 to above 200 degree C indicate that potential geothermal systems exist at depth yielding potentials of around 450 MW (Karekezi et al. 2004).

Zambia. In Zambia, there are two major geothermal energy developments currently under consideration. The first one is the Kapisya Geothermal Project, located in Sumbu on the shores of Lake Tanganyika. The second project involves the development of a health resort and the potential construction of a geothermal power plant providing cheap electric power to the local community at Chinyunyu Hot Springs, 50 kilometres east of Lusaka on the Great East Road. This project remains in the planning stages due to lack of funds. (RECIPES 2006k). No quantitative information on project potential was available. Table 8 outlines the geothermal potentials in terms of installed capacity and electricity generation as well as the emission reduction potentials.

Table 8: Geothermal CDM Project Potential

Country	Nr. of Potential Projects	Electricity Generation (in GWh/yr)	Installed Capacity (in MW)	Emission Reductions (in kCERs/yr)	Total Investment (in mio. USD)
Burkina Faso	-	-	-	-	-
DRC	-	-	-	-	-
Ethiopia	16	5.678	700	185,7	798
Malawi	-	-	-	-	-
Mali	-		-	-	-
Mozambique	N.A.	N.A.	N.A.	N.A.	N.A.
Rwanda	-	-	-	-	-
Senegal	-	-	-	-	-
Tanzania	3	1.217	150	857,3	171
Uganda	9	3.650	450	2.725,0	513
Zambia	N.A.	N.A.	N.A.	N.A.	N.A.

Source: UNEP RISOE 2010, RECIPES 2006 (various), GEFs from Section 2.3 and GTZ 2007a

Conclusions:

- For many countries no information or no quantitative information could be identified. Hence the absence of projects from the table above does not necessarily imply that there is no project potential in the respective country.
- Overall geothermal energy offers the potential to install about 1.3 GW in the study region resulting into 10,545 GWh/yr and into 3.77 million CERs/yr involving overall investment costs of approx. 1,482 million USD.
- Uganda offers the highest potential for emission reductions based on geothermal energy with a total installed capacity of 450MW, 3,650 GWh/yr and 2.7 million CERs per year.
- Uganda is followed by Tanzania which has a rather small potential but may profit from its high GEF. Finally Ethiopia has the highest potential in terms of installed capacity (700) but as its GEF is low, this does not result in significant emission reductions.

4.1.5 Fuel Switch / Biofuels

The use of biofuels across Africa has risen considerably. This evolution is also due to rising oil prices. Nevertheless, many biofuels have adverse effects on the environment, food security and land use. Therefore, a plant which can be grown on degraded lands and which does not directly compete with food production is needed to overcome these problems. Jatropha, a plant which is already being used in several sub-Saharan countries, is claimed to offer these advantages (AfricaProgressPanel 2009). According to de Gouvello et al. (2008) bio-diesel production from Jatropha offers robust opportunities for implementing CDM projects in SSA.
It has to be noted, though, that other experts are rather less optimistic about the prospects of Jatropha. Breuer (2009), for example, highlights studies showing that yields on marginal lands are very low unless extensive use is made of irrigation and fertilisers. On non-marginal lands the profits from growing Jatropha cannot compete with yields from other energy plants or non-energy crops. Breuer therefore sees the main potential in multi-purpose uses which have the primary aim of combating desertification. Still for the remainder of this analysis we refer to the available literature for the selected countries being constraint to de Gouvello et al.

The concept according to de Gouvello et al. (2008) envisages the production of 20-percent blends from Jatropha and petro-diesel for use as fuel in existing stocks of diesel vehicles. Up to a biodiesel share of 20 percent no modification of vehicle engines is required. A precondition is to only utilise degraded land for the cultivation in order to minimise leakage and deforestation concerns. On this basis the study posits that Jatropha may be cultivated on 2 percent of the land in each country. Annual emission reductions of almost 11 million tons of CO_2 could be achieved if CDM projects of this type were implemented across sub-Saharan countries (de Gouvello 2008 et al.).

Table 9 shows that Ethiopia with 36 project opportunities and potential emission reductions of 0.40 million tCO_2/yr), Tanzania (28 projects / emission reductions of 0.34 million tCO_2/yr) and Mozambique (25 projects / 0.23 million tCO_2/yr) have the greatest potentials in this area.
While in Burkina Faso, Mali and Rwanda the potential for emission reductions lie below 0.05 million tCO_2/yr, also Zambia (24 projects / 0.15 m tCO_2/yr), DRC (72 projects / 0.14 million tCO_2/yr), Senegal (6 projects / million 1.3 tCO_2/yr) Uganda (6 projects / 1.2 million tCO_2/yr) and Malawi (4 projects / 0.08 million tCO_2/yr) offer opportunities for the achievement of emission reductions through CDM projects of this type.

Table 9: CDM Project Potential based on Biodiesel

Country	No of Potential Projects	Emission Reductions (in kCERs/yr)	Investment Costs (in mio. USD)
Burkina Faso	9	49,1	471
DRC	72	139,0	3896
Ethiopia	36	395,9	1924
Malawi	4	76,8	204
Mali	39	25,2	2130
Mozambique	25	226,7	1347
Rwanda	1	52,2	43
Senegal	6	134,8	337
Tanzania	28	342,0	1522
Uganda	6	118,0	343
Zambia	24	149,5	1273

Source: de Gouvello et al. 2008

4.1.6 Agricultural Residue Potential

Agricultural residues comprise field residues which are left in the fields after crops have been harvested (stalks, stems, leaves and seed pods) and process residues which are by-products in the production process of a useable resource (husks, seeds, bagasse and roots). Despite not being used in the production process of cash crops, these residues offer considerable energy content and may be used for power generation purposes.

Following de Gouvello et al. (2008), this section summarizes the technical potential for the energetic use of agricultural residues in the SSA. Following de Gouvello's methodology, in a first step the volumes of residues are estimated based on annual crop production data (de Gouvello et al. 2008, Table A3.1-4). In a second step, the energy content of these volumes (de Gouvello et al. 2008, Table 3.4.2) was applied to estimate the overall annual electricity generation potential. Finally this was combined with the average size of a CDM project in the agricultural residue sector (10.4 MW) calculated based on data from UNEP RISOE data base.

Box: Atmosfair Biogas Program, Kenya
Atmosfair, Sustainable Energy Strategies, Kenya, Action for Food and Production jointly implement a biogas program in Kenya. Like in many other African countries, biomass is the most important energy resource for the population in Kenya (68% of the total energy consumption by households). In rural areas the consumption of fuel wood is as high as 80%. The project is carried out in the Nairobi River Basin, which is located in the east of Kenya's capital, Nairobi. Thousands of dairy farmers, who each have two to three cows on their property, live in this area. These farmers consume an average of 10kg of fuel wood per day which is mainly used for cooking purposes. The high fuel wood demand is a huge threat to the surrounding forests. If the overexploitation of these resources continues, fuel wood will become scarce in the long run and local biodiversity will be negatively affected. In addition to fuel wood, people in the project area also use kerosene and gas for cooking. In order to reduce the consumption of fuel wood, gas and kerosene the atmosfair project will supply small biogas units (2-3 m^3) to the dairy farmers in the area, which produce regenerative biogas. The biogas units run on cow dung and other agricultural wastes. During the process of biogas generation, slurry is produced as a by-product. Due to its high nutrient content, this by-product can be used as an agricultural fertilizer. During a pilot phase in 2010, twenty biogas units were installed and commissioned. This pilot phase was financed by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. After it is officially registered as a CDM Gold Standard project, atmosfair and Kenyan partner Sustainable Energy Strategies plan to build a total of 5,000 biogas units. Key figures: ▪ GHG savings: 4-5 tons CO_2 per unit and year. ▪ Indian Biogas Technology, locally produced. ▪ Replaces fuel wood, gas and kerosene, avoids deforestation and produces fertile slurry Information kindly provided by atmosfair.

Table 10: Agricultural Residues CDM Potential

Country	Nr. of Potential Projects	Electricity Generation (in GWh/yr)	Installed Capacity (in MW)	Emission Reductions (in kCERs/yr)	Total Investment (mio. USD)
Burkina Faso	30	2.462	312	1.574	437
DRC	109	8.898	1.129	5.720	1.580
Ethiopia	213	17.440	2.212	11.457	3.097
Malawi	91	7.500	951	4.915	1.332
Mali	28	2.319	294	1.474	412
Mozambique	91	7.462	946	4.850	1.325
Rwanda	9	746	95	484	133
Senegal	23	1.896	240	1.220	37
Tanzania	180	14.762	1.872	9.629	2.621
Uganda	85	7.001	888	4.540	1.243
Zambia	64	5.258	667	3.454	934

Source: Average size of CDM projects (in MW) taken from UNEP RISOE 2010, other data taken from de Gouvello et al. 2008.

The following conclusions are drawn:

- Overall there is a huge CDM project potential amounting to 894 projects, 9,606 MW installed capacity and 49.3 million CERs per annum.
- Highest project potential is calculated for Ethiopia with a total of approx. 213 projects, 2.2 GW installed capacity and 11.5 million t annual emission reductions. Major residues are corn cob (5.4 million t/yr with a caloric value of 17.8 MJ/kg), sorghum stems (0.9 million t/yr with 17.0 MJ/kg) and coffee husks (0.1 million t/yr with 18.3 MJ/kg).
- Tanzania offers the second largest potential with a total of approx. 180 project opportunities, 1.8 GW installed capacity and 9.6 million t emission reductions per annum. Major crops are corn cob (6.4 million t), Cassava stems (2.6 million t with 17.0 MJ/kg) and rice husks (0.1 million t with 14.5 MJ/kg).

The following reservations shall be made to the above assessment of project potentials:

- First, in rural areas biomass residues are often used for cooking purposes. Hence the assumption that 100% of biomass residues may be used for electrification will not hold.
- Second, in remote areas it may be too cost intensive to collect field residues and transport them to a centralized electrification station. Road conditions and infrastructure are often poor and transportation may be complicated. Consequently the potential may be constrained to some extent with the feasibility of isolated applications.
- Third, the calculation of the emission reductions is based on natural gas (having the lowest emission factor of all fossil fuels). That is, the analysis always assumes the replacement of natural gas with renewable electricity. In practice it may often be the case that the baseline is determined by electricity provided by the national grid. In this case there would be no potential for projects in DRC, Ethiopia, Mozambique and Zambia as the GEF is too low (cp. section 3.3).

4.1.7 Sugar Sector CHP Project Potentials

In SSA, the sugar factories' heat and electricity needs are usually met through a combination of standalone power and heat plants (fired with bagasse, diesel and/or coal) and grid-connected electricity.
Sugar production processes result in two by-products, bagasse, a fibrous residue which remains after sugar cane is crushed and the syrup is extracted, and cane trash, leaves and plant tops which are usually burned on the field. Enhancing the efficiency through combined heat (CHP) and power cycles allows for covering the mills' energy demand solely through the use of these residues and hence substituting diesel, coal and electricity from the grid.

Following de Gouvello et al. (2008) a review of existing sugar mills in the study region showed that all plants operate at low to medium pressure (15 to 47 bar) with temperatures below 450°C. De Gouvello et al. further note that replacing low pressure plants with high pressure (80 bars and above) plants could increase the efficiency to 110kWh/t sugar cane. A default emission value of 700tCO_2/GWh was applied in the baseline case. Moreover a load factor of 90% was applied (i.e. 7,884 full load hours per year).

Box: Renewable Energy Options in the Sugar Sector

The sugar sector not only offers potential for energy efficiency, but also for large renewable energy projects. In Africa, like in other tropical regions, huge amounts of biomass in the form of sugar cane are processed in sugar production. About 40% of harvested sugar cane ends up as a fibrous by-product with a high calorific value, called bagasse. The economic value of bagasse as fuel is wide known, still in Africa some untapped potential remains.
Besides bagasse, also leaves and plant tops are biomass residues making up for 30- 40% of the total biomass. In case of manual harvest, sugar cane fields are usually burned in order to eliminate these undesired by-products which would just slow down the cutting process. Avoiding sugar cane burning, e.g. switching to mechanical harvest, these residues could be used for power generation. Co-firing up to 10% is feasible without any major negative impact on technical lifetime of power equipment. It is estimated that up to 50% of the total volume of leaves and plant tops may be collected without any negative impacts on soil fertility. Subsequently the potentials for 10,000ha sugar cane are outlined:

- 140,000t harvest residues, 70,000t could be energetically used
- 280,000 MWh thermal energy
- 70,000 MWh (el) based on an efficiency of 25%
- 10 MW electrical installed capacity

Table 11: Sugar Sector CDM Project Potential

Country	Nr. of Potential Projects	Electricity Generation (in GWh/yr)	Added Power (in MW)	CERs (in kCERs/yr)	Investment (in mio. USD)
DRC	1	79,2	15,0	60	22,5
Ethiopia	2	64,7	12,2	40	18,4
Malawi	2	140,7	26,6	100	40,0
Senegal	1	25,5	4,8	20	7,2
Tanzania	5	144,0	27,3	100	40,9
Uganda	3	82,7	15,7	60	23,5
Zambia	1	140,4	26,6	100	39,9

Source: Average size of CDM projects (in MW) taken from UNEP RISOE 2010, other data taken from de Gouvello et al. 2008.

The following conclusions are drawn:

- The above table outlines a considerable project potential in the sugar sector. In total 15 project opportunities in seven countries are identified. Burkina Faso, Mali and Mozambique offer no potential as no mills are located there. The 15 opportunities result in the addition of approx. 128MW capacity, 677 GWh/yr and emission reductions in the range of 480.000CERs/yr. Total investment costs is estimated to 192 million USD.
- Tanzania offers the highest project potential (5 projects, 144.0 GWh/yr and 100,800CERs/yr), followed by Malawi (2 projects, 140.7GWh/yr and 98,500 CERs/yr) and Zambia (1 project, 140.4 GWh/yr and 98,300CERs/yr).

4.1.8 Forest and Wood Residue Project Potentials

Forest and wood residues accumulating in standard logging- and roundwood processing operations may provide an excellent fuel for power generation. The forest sector has huge importance for the study region. The total industrial roundwood production amounts to 17.4 million m^3/yr for all 11 countries (World Bank 2008b). The total sawnwood production amounts to 0.5 million m3/yr (World Bank 2008b). Hence study region offers a wide scope for the electrification of these by-products.

Following de Gouvello et al. (2008), wood residues and forest residues are introduced as sub-categories. Wood residues comprise the by-products of processing roundwood to sawnwood including core wood, wood slabs, bark and saw dust. Forest residues comprise by-products from logging operations including branches, stumps and tree crowns.

Forest residue potential is estimated by analyzing the country's roundwood production data and applying a value of 0.2t residue per m^3 roundwood (de Gouvello et al. 2008). This factor is conservative as it is in the lower range of IPCC default expansion factors for tropical forests (typically used for extrapolating commercial volume to above ground biomass including branches and crown). Subsequently the fraction of collectible forest residues was estimated which finally was applied with a coefficient for its energetic content. For the electrification process, an efficiency ratio of 33% was used (de Gouvello et al. 2008) which is again considered as a conservative estimate for new single cycle power generation facilities.

Investment costs are estimated at 1.4 million USD/MW installed capacity. The average project size of 6.6MW was calculated based on UNEP RISOE 2010 data. Based on our CDM project experience in medium scale sawmills in Central Africa, the renewable power potential oversupplies existing saw mill demands. Hence, following CDM methodology AMS I.D, it is assumed that 50% of the project's electricity output replaces diesel generators (AMS I.D default emission value for diesel generators applied) and 50% are supplied in the regional grid (applying the country's GEF). Table 12 outlines the results of this analysis.

Table 12: Forest Residue CDM Potential							
Country	Nr. of Potential Projects	Roundwood Production (mio. m3)	Forest Residues (mio. t/yr)	Electricity Generation (in GWh/yr)	Installed Capacity (in GW)	kCERs/yr	Total Investment (in mio USD)
Burkina Faso	-	-	-	-	-	-	-
DRC	291	73	15	15.024	1,91	6.029	2.670
Ethiopia	381	96	19	19.633	2,50	8.174	3.490
Malawi	23	6	1	1.150	0,15	460	200
Mali	-	-	-		-	-	-
Mozambique	72	18	4	3.691	0,47	1.486	660
Rwanda	21	6	1	1.124	0,14	849	200
Senegal	-	-	-	-	-	-	-
Tanzania	94	24	5	4.873	0,62	3.433	860
Uganda	155	39	8	8.063	1,02	6.019	1.430
Zambia	32	8	2	1.648	0,21	664	290
Source: UNEP RISOE 2010 was used for calculating average project size, AMS ID was used for default emission value of diesel generator, GEFs are taken from section 2.3, other from de Gouvello et al. 2008							

The following conclusions are drawn:

- The overall emission reduction potential for the forest residue sector is considered as high. There is a total of approx. 1,068 project opportunities in the study region with an emission reduction potential of about 27 million CERs/yr. The total installed capacity amounts to 7 GW and investment costs are estimated to be 9,800 million USD.
- The highest emission reduction potential was found for Ethiopia (8.17 million CERs/yr with 381 project opportunities) followed by DRC (6.03 million CERs/yr with 291 projects). Though Uganda has a far smaller project potential (155 project opportunities) the overall emission reduction potential is also substantial (6.02 million CERs/yr) as Uganda's GEF is significantly higher than the GEF from DRC and Ethiopia.

For the assessment of CDM wood residue potential the same approach was applied as outlined above. Additionally to the above, the sawnwood volume per country was calculated by subtracting paper production and fuel consumption from the total roundwood volumes. From this value, it was assumed that 85% can be recuperated for power generation purposes. The average CDM project size was calculated from UNEP RISOE 2010 data to be 11.78 MW. Table 13 outlines the findings:

Table 13: Sawnwood CDM Potential							
Country	Nr. of Projects	Processed Roundwood (in mio. m^3)	Wood Residues (mio. t/yr)	Electricity Generation (GWh/yr)	Installed Capacity (in GW)	Emission Reductions (in kCERs/yr)	Total Investment (in mio. USD)
Burkina Faso	-	-	-	-	-	-	-
DRC	23	3,7	1,27	2.163	0,27	868	380
Ethiopia	19	2,9	1,02	1.734	0,22	722	310
Malawi	3	0,5	0,18	308	0,04	123	60
Mali	-	-	-		-	-	-
Mozambique	8	1,3	0,46	778	0,10	313	140
Rwanda	3	0,5	0,17	293	0,04	221	50
Senegal	-	-	-	-	-	-	-
Tanzania	14	2,2	0,76	1.280	0,16	902	230
Uganda	20	3,2	1,10	1.880	0,24	1.403	330
Zambia	5	0,8	0,29	494	0,06	199	10
Source: UNEP RISOE 2010 was used for calculating average project size, AMS ID was used for default emission value of diesel generator, GEFs are taken from section 2.3, other from de Gouvello et al. 2008							

The following conclusions are drawn:

- There is a considerable overall emission reduction potential in the wood residue sector with 96 project opportunities, a total of 1.13 GW installed capacity, 4.75 million CERs per annum and a total investment volume of 1.51 billion USD.
- Highest potential is envisaged for Uganda with 1.4 million CERs/yr and for Tanzania with 0.9 million CERs/yr.
- This is followed by DRC with 0.9 million CERs/yr and Ethiopia with 0.7 million CERs/yr. Both countries have similar or higher wood residue potentials but due to lower GEFs the emission reduction potential is lower than in Tanzania and Uganda. Differences to the forest residue sector accrue due to Ethiopia's and DRC's higher share of roundwood export resulting in lower wood residue volumes (See also World Bank 2008b).

4.1.9 Cooking Stoves – Non-Renewable Biomass

Project Types. The most significant share of household energy consumption is used for cooking. The consumption of fuels depends on the calorific value of the fuel, fuel quantity and the efficiency of the stove. Based on these parameters, there are several possibilities for the reduction of fuel consumption, i.e. emission reductions. One possibility is to replace stoves that consume fossil fuels with stoves consuming renewable biomass. This option is only possible if sufficient amounts of renewable biomass are available to the households. Another option is to replace the stoves consuming fossil fuels with solar powered stoves. Apart from replacing fossil fuels, there is also a possibility to replace the stoves with more efficient stoves. In this case, emissions are reduced by lowering the amount of fossil fuel or non-renewable biomass consumption for the equivalent production of energy.

Table 14: Applicable SSC Methodologies

Methodology	Applicability
AMS.I.C "Thermal energy production with or without electricity "	Replacement of (exclusively) fossil-fuelled stoves by biomass stoves
AMS.I.E "Switch from Non-Renewable Biomass for Thermal Applications by the User"	New stoves using exclusively renewable biomass
AMS.II.C "Demand-side energy efficiency activities for specific technologies"	Stove improvement using exclusively fossil fuels
AMS.II.G "Energy Efficiency Measures in Thermal Applications of Non-Renewable Biomass"	Stove improvement using (partly) non-renewable biomass

Source: PoA Blueprint, KfW, 2009

The development of a cooking stove program under the CDM requires the application of an existing and UNFCCC approved methodology. Available small scale (SSC) methodologies for cooking programs are outlined in Table 14. Since the situation in the targeted countries is that households mainly consume biomass for cooking purposes, the introduction of improved cooking stoves with higher efficiency is deemed the most promising project type for reduction of non-renewable biomass consumption and emission reduction. The applicable UNFCCC methodology for this project situation is AMS II.G.

Existing Cooking Stove Programs. The introduction of more efficient cooking stoves has been on the agenda of international donor organizations since the 1970s. Dissemination was implemented either through national initiatives (like in China) or initiatives from international donors and Non Governmental Organizations (NGO). The largest programme implemented was the Chinese National Improved Stove Programme which has started in 1980s and has achieved that 70% of rural households in China operate improved stoves (KfW 2010a). Another success story is the distribution of over one million stoves under the so-called Jiko programme in Kenya. Of special interest for the countries included in this study are the GTZ supported programmes:

- Improved Stoves in Ethiopia
- Improved charcoal stoves in urban and peri-urban Kigali, Rwanda
- Improved Mud Stoves at Madale Youth Centre, Tanzania
- The Rocket Lorena Stove Dissemination in Bushenyi District, Energy Advisory Project/GTZ, Uganda

CDM Stove Projects Overview. Stove projects are slowly increasing their presence in the CDM world. The first two solar cooking projects in India and in Indonesia were registered in 2006. Ever since, three solar cooking projects were registered in China.

Table 15: Existing CDM Stoves Projects		
Development Stage	CDM Projects	CDM PoAs
Registered	7	0
At validation	19	5
Source: UNFCCC 2010		

In Africa, so far two cooking stove CDM projects were registered: the "CDM Lusaka Sustainable Energy Project 1" (Zambia), and the "Efficient Wood Stoves for Nigeria" (please see Table 16). As can be seen from Table 15 a total of 19 stoves CDM projects are currently under validation. Due to their dispersion in time and space, stoves projects are more suitable to be developed as PoA CDM projects than as stand-alone projects. At the moment there are 5 PoA that are in validation targeting introduction of more efficient wood stoves in Latin America.

Table 16: Characteristics of Registered African Cooker CDM Projects		
Project Name	Efficient Wood Stoves for Nigeria	CDM Lusaka Sustainable Energy Project
Country	Nigeria	Zambia
Methodology	AMS II.G	AMS I.E
Registration Date	October 2009	January 2010
Amount of CERs per Stove	2.72 tCO_2	4.66 tCO_2
Average kCERs p.a.	31.3	130.0
Technology Description	The project introduces SAVE80 system, which incorporates cook stoves and heat retaining boxes.	The Save80 Cooking System uses small quantities of renewably harvested sticks and it combines the stove with a heat retaining device.
Source: UNFCCC 2010		

Methodology for CDM Potential Evaluation. The evaluation of the CDM potential of cooking stoves in the study region follows AMS II.G "Energy efficiency measures in thermal applications of non-renewable biomass". Calculations are done on the basis of two main parameters, a) the amount of improved cooking stoves per country and b) the amount of CERs per cooker per year in each country:

- The calculation of the potential of improved cooking stoves that can be introduced in each country was assessed based on following assumptions:
    - Improved cooking stoves fired on firewood are introduced only in the rural areas.
    - An improved cooking stove program may reach 25% of the rural population (subsequently called program outreach).
    - One family/household introduces one improved cooking stove.

- The amount of CERs per stove for each country was evaluated on the basis of the calculations provided in AMS II.G. For the calculation, the following assumptions were made:
    - AMS II.G (version 2) provides for default values of 0.1 for three stone cooking stoves or conventional cooking systems and a default value of 0.2 for all other systems. Even though in rural areas of SSA, 3 stone fires are common practice, an average efficiency of 0.15 was applied for the subsequent analysis, which is considered to be conservative.
    - Efficiency of the improved cooking stoves depends on the applied technology and ranges from 0.2 to 0.8 (assessment of various PDDs published by UNFCCC). Higher efficiency ratios can be achieved by high end cooking devices which are usually not produced in SSA. Such devices have to be imported and face high acquisition costs. Lower efficiency devices can be produced within the countries, have lower acquisition costs and contribute to local development/value added.
      Given the development impacts of local production, this analysis is constraint to the distribution of locally produced cooking stoves. Hence an average efficiency of 0.3 was applied.
    - The assessment of emission reductions per stove not only requires the calculation of biomass consumption, there is also the need to determine the fraction of Non Renewable Biomass (fNRB). As can be seen from Table 40, page 90, the forest cover from all but one study country declines. Only in Rwanda forest areas increase. Hence, it is assumed that fNRB in Rwanda amounts to 25%, in all other countries 50%.
      Please note that this assumption has to be substantiated in the course of CDM project development following the specific guidance of AMS II.G.
    - For each project region, the alternative fossil fuel has to be identified. For this assessment Liquefied Petroleum Gas (LPG) was chosen. As it has the lowest emission factor of all alternative fossil fuel types, this is considered to be a conservative assumption. LPG's emission factor of 63.0 tCO_2/TJ (IPCC default value) was applied.
    - Finally the Net Caloric Value of wood is assumed to be 0.015 TJ per ton wood (IPCC default).
    -

The above outlined assumptions cover all required parameters for the assessment of the CDM potentials. Wherever feasible, IPCC default values were identified. On other occasions conservative assumptions were made. Subsequent sections outline how above parameters were used to assess the countries' potentials.

Amount of Stove Distribution Potentials. The amount of the stove distribution potentials per country was calculated following above outlined methodology using FAO data (2009). Country data was used to calculate the rural population. This was combined with the persons per stove in order to calculate the total amount of stoves in rural areas at a country level. Finally, it was assumed that 25% of rural households can be reached by a cooking stove distribution program allowing for the calculation of the cooking stoves potentials per country.

Table 17: Evaluation of the Stove Distribution Potential						
Country	Population (in 1000)	Rural Rate (in %)	Rural Population (in 1,000)	Persons per Stove	Program Outreach (in %)	Number of Stoves
Burkina Faso	14.358	81%	11.673	8	25%	364.783
DRC	60.643	67%	40.813	8	25%	1.275.398
Ethiopia	81.020	84%	67.814	7	25%	2.421.919
Malawi	13.570	83%	11.263	7	25%	402.254
Mali	11.968	69%	8.258	8	25%	258.060
Mozambique	20.971	65%	13.631	7	25%	486.827
Rwanda	9.464	80%	7.571	7	25%	270.400
Senegal	12.072	58%	7.002	6	25%	291.740
Tanzania	39.458	75%	29.594	7	25%	1.056.911
Uganda	29.898	87%	26.011	8	25%	812.852
Zambia	11.862	65%	7.710	7	25%	275.368
Source: Data was taken from Table 37, page 84 as well as FAO, 2009						

Amount of CERs per Stove. The calculation of CERs per stove requires in a first step the evaluation of biomass use per household. Where biomass use data was available at per capita level, average family size was used to calculate the biomass use per stove/household. Finally fNRB was used to calculate the volume of non renewable biomass per household.

Table 18: Biomass Use per Household						
Country	Biomass Use (t/per capita/yr)	Source	Persons per Stove	Biomass Use (t/stove/yr)	fNRB	fNRB Use (t/stove/yr)
Burkina Faso	0,47	Njiti and Kemcha, (2002)	8	3,80	50%	1,90
DRC	0,85	PDD Nigeria (FAO)	8	6,80	50%	3,40
Ethiopia	N.A.	Environment for Development (2008)	7	2,14	50%	1,07
Malawi	N.A.	GTZ (PROBEC)	7	6,06	50%	3,03
Mali	0,46	Hedon	8	3,65	50%	1,83
Mozambique	0,68	PDD Nigeria (Brouwer/Falcao)	7	4,73	50%	2,36
Rwanda	0,55	PDD Nigeria (FAO)	7	3,82	25%	0,95
Senegal	N.A.	ENDA, 2006	6	4,37	50%	2,18
Tanzania	0,96	PDD Nigeria (FAO)	7	6,72	50%	3,36
Uganda	0,81	PDD Nigeria (FAO)	8	6,44	50%	3,22
Zambia	N.A.	Probec (GTZ)	7	2,18	50%	1,09

In a next step the Net Caloric Value (NCV) of non renewable biomass per stove per year was calculated. LPG was chosen as alternative fossil fuel. Applying the LPG's emission factor results finally in the assessment of CERs per stove at a country level.

Table 19: Evaluation of CERs per Stove					
Country	NRB Use (in ton/stove/yr)	NCV NRB (in TJ/stove)	Alternative Fossil Fuel	Emission Factor (in tCO_2/TJ)	CER per Stove
Burkina Faso	1,90	0,028	LPG	63	0,90
DRC	3,40	0,051	LPG	63	1,61
Ethiopia	1,07	0,016	LPG	63	0,51
Malawi	3,03	0,045	LPG	63	1,43
Mali	1,83	0,027	LPG	63	0,86
Mozambique	2,36	0,035	LPG	63	1,12
Rwanda	0,95	0,014	LPG	63	0,45
Senegal	2,18	0,033	LPG	63	1,03
Tanzania	3,36	0,050	LPG	63	1,59
Uganda	3,22	0,048	LPG	63	1,52
Zambia	1,09	0,016	LPG	63	0,52

Table 20: CDM Cooking Stove Potential			
Country	CER per Stove	Number of Stoves	Emission Reductions (in kCERs/yr)
Burkina Faso	0,90	364.783	327
DRC	1,61	1.275.398	2.049
Ethiopia	0,51	2.421.919	1.226
Malawi	1,43	402.254	576
Mali	0,86	258.060	223
Mozambique	1,12	486.827	543
Rwanda	0,45	270.400	122
Senegal	1,03	291.740	301
Tanzania	1,59	1.056.911	1.678
Uganda	1,52	812.852	1.237
Zambia	0,52	275.368	142

Finally, using the results of Table 17 (i.e. number of cooking stoves that can be distributed under a program per county) and the results of Table 19 (i.e. CERs per stove per country) allows for evaluating the overall emission reductions potentials per country.
It can be seen that DRC features the highest potential due to high value of CERs/stove and due to an overall high volume of stoves. DRC is followed by Tanzania and Uganda having equally high value of CERs/stove but lower distribution potentials.

Costs and benefits Analysis. The CDM and related carbon revenues can significantly improve the economics of cooking stove programs. The following costs were considered:

- **Discounted Stove Costs.** The costs of a locally produced stove amount to 33USD (25€). As these stoves have a lifetime of 3-4 years, an average lifetime of 3.5 years was applied. Moreover it was assumed that the project replaces dysfunctional stoves resulting in the new distribution of new stoves in year 4 and year 8 of a CDM project. Finally the costs for establishing a distribution network are assumed to amount to 30 USD. Discounting the costs of stoves in year 4 and 8 with an interest rate of 15% p.a. and taking the distribution costs (once) into account, results in a total of 101.5 USD per household.

Table 21: CDM Transaction Costs	
Activities	Costs (in USD)
PDD Development, Validation and Registration	100.000 USD
Annual CDM Monitoring and Verification Costs	90.000 USD
Adopted from Blank et al.(2009) and Source: KfW (2010a)	

- **Monitoring Costs.** As outlined in Table 21, the CDM transaction costs comprise PDD development (once) and annual monitoring costs. The programs total transaction costs over 10 years are estimated at 1 million USD.
- **Revenues.** The CERs per country (Table 20) were multiplied with a CER price of 18 USD to calculate the annual carbon revenues. Considering a CDM crediting period of 10 years, the total carbon revenues of a national stove program were calculated.
- **Discounted Revenues.** Finally, an interest rate of 15% p.a. was applied to calculate to discounted carbon revenues.

The findings of above assessments are presented in Table 22. Based on these results the overall profitability (i.e. the projects' Net Present Value (NPV)) of CDM projects was evaluated.

Table 22: Costs, Revenues and NPV of National Cooking Stove CDM Programs

	Revenues		Costs			Profits
Country	Revenues (in mio USD)	Discounted Revenues (in mio USD)	Discounted Stove Costs (in mio USD)	Monitoring Costs (mio USD)	Total Costs (mio USD)	NPV (in mio USD)
Burkina Faso	58,9	29,6	28,3	1	29,3	0,3
DRC	368,8	185,1	98,8	1	99,8	85,3
Ethiopia	220,7	110,8	187,6	1	188,6	-77,8
Malawi	103,7	52,0	31,2	1	32,2	19,9
Mali	40,1	20,1	20,0	1	21,0	-0,9
Mozambique	97,8	49,1	37,7	1	38,7	10,4
Rwanda	21,9	11,0	20,9	1	21,9	-10,9
Senegal	54,2	27,2	22,6	1	23,6	3,6
Tanzania	302,0	151,6	81,9	1	82,9	68,7
Uganda	222,6	111,7	63,0	1	64,0	47,8
Zambia	25,5	12,8	21,3	1	22,3	-9,5

Conclusions: The following conclusions are drawn:

- As can be seen from the table above, in DRC a national stove program would create a net present value of 85.3 million USD. This is due to the fact that DRC has the highest amount of CERs/stove and also the highest amount of stoves to be distributed.
- DRC is followed by Tanzania (68.7 million USD) and by Uganda (47.8 million USD).
- Applying a sensitivity analysis shows that, given above outlined cost- and revenue structure, CDM projects become profitable with 0.89 CERs/stove.

4.2 Energy Efficiency Potentials

4.2.1 Background

African countries have considerable potentials for both increasing energy efficiency on the energy supply side and reducing energy consumption on the demand side without decreasing economic output, lowering the standards of living, or diminishing the quantity and quality of social services provided. Studies by the International Energy Agency show that in Africa energy intensity, i.e. total energy consumed per GDP, is at least twice the global average (IEA 2008a, IEA 2008b). However, energy efficiency continues to be a peripheral issue in the overall energy sector planning and development in Africa. So far, energy efficiency has been vigorously pursued mainly in Northern Africa and South Africa and a few selected countries in

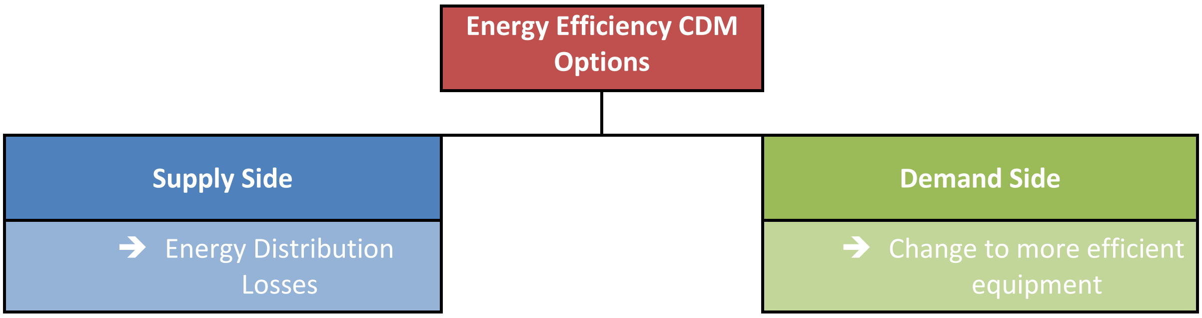
SSA. The adoption of energy efficiency appears to be inhibited by a number of barriers, such as:

- Lack of appreciation of the benefits,
- Initial capital requirements,
- Resistance to change,
- Absence of policy and regulatory frameworks,
- Subsidized energy costs.

A systematic integration of energy efficiency into existing energy generation and use systems, new major infrastructure projects as well as all kinds of small scale applications (e.g. appliances) is needed. This could be achieved through the establishment of policy and regulatory frameworks that promote energy efficiency with appropriate policy instruments to ensure success and effectiveness.
Energy efficiency offers multiple benefits to countries in Africa (UNIDO 2009). Since reducing CO_2 and other greenhouse gas emissions from the burning of fossil fuels is at the heart of current efforts to address the climate change, more efficient technologies can provide 'win-win' options to tackle global environmental and local development challenges. With over 75% of the power generation capacity in Africa based on thermal sources, efficiency improvements in the existing power systems could translate into substantial monetary savings for many countries and increased competitiveness of local industries.

Energy efficiency related CDM project types relevant in SSA comprise activities in business, industry, households and the public sector in most countries. This encompasses a range of measures from improved maintenance, efficiency standards and repair to retrofitting/installing new equipment (electric motors, steam pumps, boilers, lighting, electrical appliances etc.). Subsequently, we look at the following CDM project activities:

Figure 4: CDM Project Options in the Energy Efficiency Sector



4.2.2 Energy Distribution Losses

Northern Africa accounts for 30% and South Africa alone for 45% of the total electricity generated in the African continent. SSA other than South Africa generates about 25% of the total electricity, although about 80% of the continental population resides in this region (UNIDO 2009). The performance of the African power sector has generally been below expectations. In addition to low levels of access to electricity throughout the region, the sector is dogged by erratic and intermittent supply, low capacity utilization and availability, deficient maintenance and high transmission and distribution losses ranging from 15 percent to 45 percent of electricity distributed (Karekezi / Kithyoma 2003, UNIDO 2009) which have to be compared to the international target of 10-12% distribution losses.

CDM Potentials. The potential GHG emission reductions of reducing electricity distribution losses are based on the estimations made by de Gouvello et al. (2008) who analyzed potential projects that could reduce grid-losses in SSA. The study assumed that power losses could be reduced from on average 27 percent to 8 percent. Potential interventions include the use of high-voltage distribution systems, shunt capacitors, and amorphous core transformers.

Conclusions. As shown in Table 23, with emission reductions of 0.24 million tCO_2/yr Senegal has the highest potential for the implementation of this kind of project. Annual emission reductions in the other countries focused on by this study is considerably smaller with the potential in Ethiopia being second at 0.05 million tCO_2.
Nevertheless, taking into account possible emission reductions in other sub-Saharan countries for this project type, also Senegal's potential is rather small. For South Africa, de Gouvello et al. estimate that emissions could be reduced by almost 13 million tCO_2/yr through the implementation of a CDM project aimed at modernising the distribution network.

Table 23: CDM Potential for Sector Grid Losses

Country	No. of Potential Projects	Efficiency Gains (in GWh/yr)	Emission Reductions (in kCERs/yr)
Burkina Faso	1	59	40
DRC	1	1,037	20
Ethiopia	1	440	50
Malawi	1	157	-
Mali	1	88	20
Mozambique	1	2,223	-
Rwanda	1	22	-
Senegal	1	266	240
Tanzania	1	605	20
Uganda	1	370	-
Zambia	1	1,603	10

Source: de Gouvello et al. 2008

4.2.3 End-use Energy Efficiency

There are generally three types of demand-side Energy Efficiency projects (Spalding-Fecher 2006 as cited in Hinostroza et al. 2007): discretionary retrofit, planned replacement and new installations. These types are briefly outlined in the table below:

Table 24: Energy Efficiency Project Types

Type	Definition
Discretionary Retrofit	Decision to prematurely replace existing technology with high-efficiency equipment for the primary purpose of improving energy efficiency
Planned Replacement	Decision to replace existing technology at the end of its useful lifetime (e.g. failure, replacement schedule) with high-efficiency equipment
New Installations	Decision to select high-efficiency equipment over other alternatives at the time of new installations

CDM Potential. Overall, the reduction potential in energy demand is relatively small. De Gouvello et al. (2008) categorize four subsectors of industrial and commercial energy efficiency in their analysis: Improved use of non-lighting electricity for industries, switch to compact fluorescent lamps, improved energy efficiency in household appliances and improved steam system efficiency in industries. Please note that improved cook stoves and building efficiency are not included. As the potential for emission reductions from improved cook stove technology is high throughout Africa, this technology option is addressed separately in section 4.1.9). Table 25 shows the CDM project reduction potentials identified by de Gouvello et al. by country.

Box: Nuru Lighting Project – Rwanda

Nuru Lights, together with Carbon Africa and ACAD, developed a CDM project for the distribution of highly efficient LEDs replacing Kerosene lamps. The Nuru light device consists of one 5 LED lights aggregated in pod and three 850mWh rechargeable and replaceable batteries. When fully charged, the device delivers up to 40h of lighting. The devices will be recharged through a vendor/distribution system of Nuru POWERCylces – making the device completely independent from any electricity system.

- Distribution of 1,230,825 Nuru lights over the next ten years
- Service and recharge provided through 5,500 Nuru POWERCylces
- Displacement of an average 21,500 t Kerosene per year
- 65,636 CERs/yr, (10 year average)

Source: UNFCCC, 2010

The following conclusions are drawn:

- Burkina Faso yields the highest reduction potential of all countries analyzed in terms of energy demand. The highest abatement can be reached in improved steam systems efficiency. Here the reduction potential lies at up to 500,000 tonnes. Another 40,000 tonnes may be reduced through a switch to Compact Fluorescent Lamps (CFLs). The potential of improved use of non lighting electricity for industries is relatively small: solely 10,000 tonnes of CO_2 can be reduced in this sector.
- DR Congo. In DRC steam efficiency systems yield the second highest potential in this sector: reductions of up to 200,000 tonnes are possible. CFLs yield a reduction potential of another 40,000 tonnes of CO_2.
- Ethiopia shows the third highest potential for improved steam efficiency. 100,000 tonnes CO_2 may be abated. Improved use of non-lighting electricity in industry yields a potential of 10,000 tonnes reduction, CFLs may reduce emissions by 20,000 tonnes CO_2.
- Malawi has a very low reduction potential in terms of energy demand. Analysis shows only 30,000 tonnes in improved energy efficiency in household appliances. A switch to CFLs will result in 70,000 tonnes CO_2-reduction in Mali.
- Mozambique may reduce emissions through steam system efficiency by 100,000 tonnes. A further 40,000 tonnes can be abated through improvements in the use of non-lighting electricity for industries in the country.
- For Rwanda, no data was available.

Table 25: CDM Potential for Sector End-use

Country	Emission Reductions (in kCERs/year)	Investments (in mio. USD)
Burkina Faso	550	146
DRC	240	64
Ethiopia	130	35
Malawi	30	8
Mali	70	19
Mozambique	140	37
Rwanda	N.A	N.A.
Senegal	160	42
Tanzania	150	40
Uganda	10	3
Zambia	140	37

Source: de Gouvello et al. 2008, Investments calculated based on UNEP RISOE 2010

- Senegal can potentially reduce emissions by 130,000 tonnes by a switch to CFLs. Improved industrial energy use may result in a reduction of 20,000 tonnes. Higher energy efficiency in household appliances yields another 10,000 tonnes.
- Tanzania will be able to reduce its emissions by about 30,000 tonnes of CO_2 through a switch to CFLs. Improved use of non-lighting electricity for industries may result in 20,000 tonnes. Improved steam system efficiency yields 100,000 tonnes of CO_2-reduction.
- Uganda may reduce its emissions by 10,000 tonnes of CO_2 through improved use of non-lighting electricity for industries.
- Zambia has a reduction potential of 10,000 tonnes both through a switch to CFLs and improved steam efficiency. Improvements in the use of non-lighting electricity for its industries may result in a further 30,000 tonnes.

4.3 Transportation Potentials

Background. The transport sector in SSA is extremely diverse – if two-wheelers are excluded, there are 29.6 vehicles per 1000 people (compared to 816 vehicles in the US). Overland transport is mainly done by private vehicles (in case the road conditions are not too bad). Railway systems were constructed by most of the colonial powers but have been abandoned in many countries so that overland transportation has to rely on roads and airplanes. In the large cities most of the transport is done by an ”informal public transport” with minibuses, pick-up trucks, taxis and non-motorized transport. A proper public transport system as it is known from many developed countries does not exist in most African cities (except for South Africa). Concerning the African waterways, UNECA (2009) states: ”It is estimated that the average productivity in African ports is about 30 percent of international norm.”

The load factor, however, due to the lack of private motorized transport is still much higher than in ”developed” cities so that the energy consumption per capita in the transport sector is much lower in SSA (0.05 ktoe per capita) than in the euro area (0.7 ktoe per capita).
The transport sector is expected to grow rapidly within the next years: Pew (2002) projects an increase of up to 82% by 2020: UNECA (2009) states: ”Given the strong economic growth (...) airline travel is expected to grow in the coming years”. IEA (2008a) projects an increase in CO_2 emissions in Africa from 185 million tonnes in 2006 to 229 Mt in 2020 and 262 Mt in 2030.

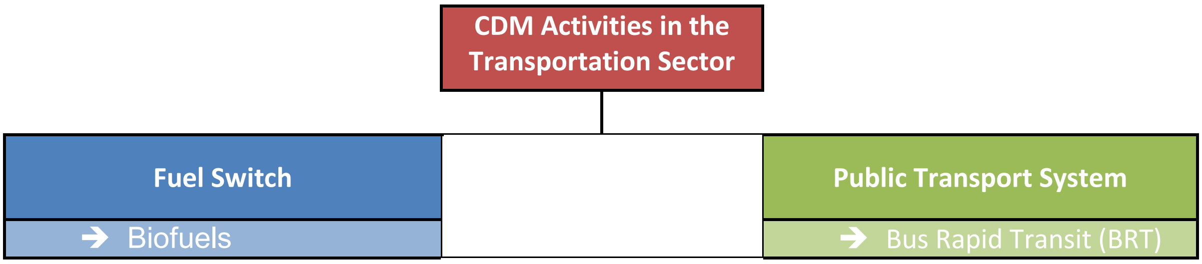
Emission Reduction Potentials in Transportation. ITF (2008), however, sees a possible reduction potential of up to 56% in GHG emissions by 2050. A large potential for CO_2 reduction in the transport sector is seen for biofuels (see section 4.1.5) – IEA (2008a) projects that the use of biofuels in Africa will rise from 0.0 million Mtoe in 2006 to 0.7 Mtoe by 2015 and 1.1 Mtoe by 2030 (p.171) and IPCC (2007) states: ”It is estimated that with 10% ethanol-gasoline blending and 20% biodiesel-diesel blending in southern Africa, a reduction of 2.5 $MtCO_2$ and 9.4 $MtCO_2$ respectively per annum can be realized.” The World Bank (de Gouvello et al. 2008) sees a reduction potential of 10 $MtCO_2$ per year. UNIDO (2009) also analyzes the potential for biofuel measures, which always have to be assessed carefully, especially in Africa, where hunger is still not overcome.

An even bigger potential is seen for modern Bus Rapid Transit systems (BRT) by de Gouvello et al. (2008): 15 MT CO_2 could be saved per year by efficient public transit in African cities. One BRT in Lagos (as well as several in South Africa) has already been implemented. It saved 25,000 tons of CO_2 per year. Several other BRT´s and 3 Metro / Light rail systems are planned (ibid).

There are a number of transport infrastructure projects (e.g. from GTZ, ADB and the World Bank) but only a few transport measures which tend to reduce GHG emissions – one example is the ITDP cycling project. UITP (2010) gives an overview of sustainable transport in African cities and the trans-Africa project has the goal to promote sustainable transport in Africa (UITP 2010). In 2007, the Global Environment Facility started a project to mitigate CO_2 emissions in SSA and Wright (2004) describes a way how to achieve transport and especially car efficiency in developing countries.

CDM Potentials in Transportation. There are currently no CDM projects in the transport sector in SSA and only very few CDM projects in the transport sector worldwide. GTZ (2010b) analyzes the CDM potential for SSA while GTZ (2007b) assesses the potential for CDM projects in the transport sector. At the moment, only one CDM methodology for BRT construction has been introduced, more methodologies (e.g. for biofuels and railway projects) are expected to come. Recently, the CDM EB approved a new methodology for modal shift in cargo transport.

Figure 5: CDM Activities in the Transportation Sector



The Worldbank study (de Gouvello et al. 2008) identifies the following potentials which are presented below:

Table 26: GHG Mitigation Potential for Sector Transport

Country	No of Potential Projects	Emission Reductions (in kCERs/yr)	Investment Needs (in mio. USD)
Burkina Faso	1	59	7,9
DRC	4	147	19,5
Ethiopia	1	332	44,0
Malawi	2	62	8,3
Mali	1	48	6,4
Mozambique	1	135	17,9
Rwanda	1	52	6,9
Senegal	1	186	24,7
Tanzania	1	176	23,4
Uganda	1	93	12,4
Zambia	1	124	16,5

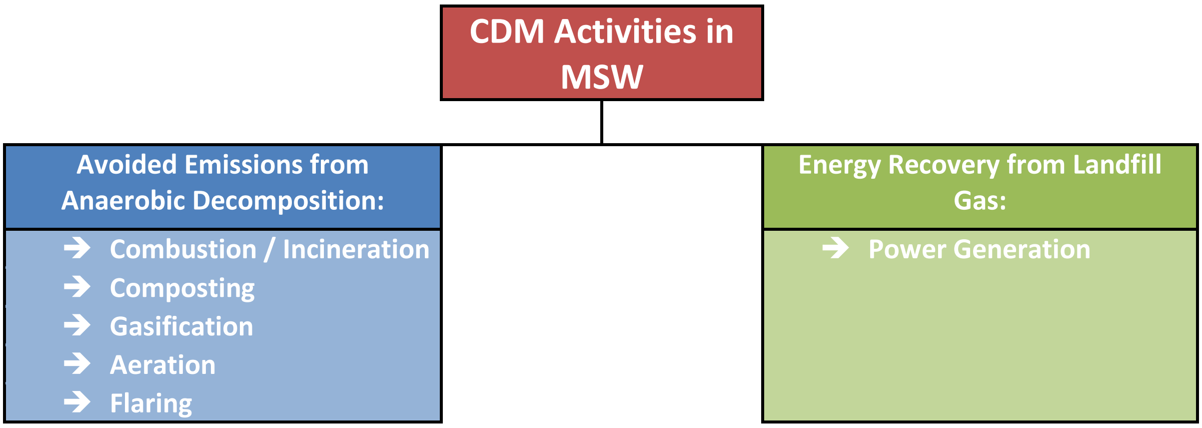
Source: de Gouvello et al. 2008, costs calculated based on UNEP RISOE 2010

4.4 Waste Project Potentials

The potential of CDM-activities in the waste sector is huge worldwide. Even in Europe having rather well-managed landfills and established recycling lines, there is still considerable potential for GHG emission reductions. In developing countries, where there are few recycling activities and landfill management is simpler, the potential for avoiding GHG emissions through CDM-activities is even bigger. In such countries the typical increase in waste quantities originating from higher consumption and increased packaging of food and other products is coupled with increasing urbanisation and subsequent waste disposal problems. The usual CDM waste project in municipal solid waste (MSW) comprises two project elements:

- Avoidance of anaerobic decomposition of organic material, and
- Capture of landfill gas (LFG) to generate renewable heat and/or electricity.

Figure 6: CDM Activities in MSW



The avoidance of anaerobic decomposition leads to the reduction of methane emissions. Methane (CH_4) is a potent GHG, the reduction of 1 t CH_4 leads to the generation of 21 CERs. This leads to a good financing impact of the CDM. If designed wisely, a CDM LFG project can be financed exclusively through carbon revenues.

But LFG projects not only include CH_4 abatement. Whenever technically feasible, such projects should be combined with the energetic use of the LFG. As can be seen in Table 27 below, the LFG projects result in 1,388 MW installed capacity worldwide. Still Africa hosts only 34 MW so far. This large difference might reflect a high rate of unexploited potential in African MSW activities. In contrast to many other sectors, it can be expected that also in African regions significant amounts of waste accrue. However, the potential depends on a by far larger number of factors than merely on waste accrual.

Table 27: Electricity Generation from LFG

Region	Installed Capacity (in MW)	Main Country (in MW)
Asia-Pacific	743	China (502)
Latin America	276	Brazil (113), Mexico (106)
Middle East	335	Israel (225)
Africa	34	South Africa (31)

Source: UNEP RISOE 2010

Methodology. Subsequently we assess the LFG potential in the study region. Determining the CDM potential in the waste sector, the following assumptions are made:

- The technically and financially simplest CDM activity is the installation of a LFG flaring system on a (partially) closed landfill;
- The quantities and composition of waste can be related to the number of inhabitants and to the average GDP per capita within urban areas;
- Only in case of anaerobic managed landfills with depths of at least 5 m the described potential exists; in all other cases it would be lower;

- We focus on urban areas, since managed landfills in these areas will be more frequent, and recollection and transport will be better established;
- Recycling activities of waste pickers are disregarded. Through burning waste or picking, they might reduce the amount of organic waste. However, the above analysis assumes conservative values of waste accrual thus partially compensating the impact of waste pickers.
- Average investment costs per CDM LFG project amount to 8.2 million USD (w/o power) and 11.0 million USD (with power) (UNEP RISOE 2010).
- Only landfills with an annual waste volume of 100,000t/yr have been analyzed. According to our experience, LFG projects are financially not attractive at lower waste levels.
- A capture efficiency of 48% was assumed which is considered as a conservative estimate.
- The Net Present Value of carbon revenues was calculated based on a crediting period of 10 years, a CER of 18 USD/CER and an interest rate of 15% p.a.

In the following the technical potential will be analysed first.

Waste Quantity and Composition. As for African LDCs there is a lack of statistics on total waste amounts on municipal, regional, or national level. Waste intensive industries, especially biodegradable wastes, do not exist in such number to significantly change total waste quantities. Therefore, the estimate is made per inhabitant.

Table 28: Organic Waste Volumes in African Countries, per GDP

GDP (in USD/capita)	Quantity (in kg/capita/d)	Density (in kg/l)	Organic Share (in %)
< 675	≤ 0.5	0.40	62
675 – 8,355	0.5 – 0.8	0.24	42
> 8,355	≥0.8	0.15	n/a
Source: Adapted from Holmes (1993), Cointreau (1982)			

The values provided in the above table are partially confirmed by registered PDDs. A project near the city of Yaoundé in Cameroon shows a quantity of 0.564 kg/head/d and an organic share of 81%. In the light of underperformance of landfill CDM activities it is preferred to take the more conservative values.

Evaluation of CDM Potential. In the following, the potential number of CERs in case of installing a flaring system is expressed. This number might double if a composting activity is established instead. This is because the capture efficiency of a flaring system is typically between 45 - 65%.

Table 29: MSW Emission Reduction Potential					
Country	City	Organic Waste (in tons)	Potential Reductions (in kCERs/yr)	Electricity Output (in GWh/yr)	NPV Carbon Revenues (in mio. USD)
Burkina Faso	Ouagadougou	109,5	58	13.5	5.2
DRC	Kinshasa	877	467	108.9	42.2
	Lubumbashi	157	84	19.6	7.6
	Mbuji-Mayi	157	84	19.6	7.6
Ethiopia	Addis Ababa	266	142	33.0	12.8
Malawi	Lilongwe	64	34	7.8	3.1
Mali	Bamako	115	60	14.0	5.4
Mozambique	Maputo	100,5	53	12.3	4.8
Rwanda	Kigali	64	33	7.9	3.0
Senegal	Dakar*	177	93	21.5	8.4
Tanzania	Dar Es Salaam**	265	140	32.5	12.6
Uganda	Kampala	137	72	16.8	6.5
Zambia	Lusaka	130	63	14.6	5.7
		Total:	1,383		
* Very dry climate, ** registered project					

Based on above analysis 13 project opportunities are identified comprising an overall annual abatement potential of 1.38 million CERs/yr. Moreover, the electricity generation potential is an overall 322.1 GWh/yr. However, to exploit this potential within CDM activities the specific GEFs, that are very different in the above countries, have to be taken into account. In doing so, the realistic electricity generation technical potential within CDM activities would be around 140.0 GWh/yr.

Other measures avoiding methane emissions like waste incineration, composting, or gasification achieve higher rates of methane capture. However, the investment costs are by far higher and their implementation depends on other factors like the existing recollection and transport system or the recycling rate and the kind of recycling system, if any.

Adequate Technical Solutions for LDCs. Apart from the mentioned landfill gas flaring, some other low-cost solutions have been applied in developing countries. The composting of organic shares of waste is an effective means to reduce GHG emissions. In developing countries windrow composting is most popular[4]. In Accra (Ghana), for example, a composting activity for MSW was conducted. However, the process is rather sensitive and a final utilization of the compost is difficult because of missing separation of waste fractions in the households / industries. Dangerous materials like batteries would thus persist throughout the entire composting chain.

Further Potential in the MSW Sector. Apart from the potential described above which could be exploited with single CDM project activities, there is further potential that could be tackled with the CDM programme activities designed for geographically more disperse activities or alternatively within a CDM project bundle, if extent and locations are known from the beginning.

[4] Windrow composting is a method with organic residues stored in small heaps of 3m width and 3m height. These heaps are arranged as a line which allows for efficiently turning over the compost.

Box: Uganda Municipal Composting PoA
The World Bank activity is an innovative MSW composting programme based on the harnessing of carbon finance for addressing the significant environmental challenge associated with solid waste management in growing urban areas. It initially covers 9 cities, with the possibility of expansion. The PoA is coordinated by the Uganda National Environment Management Authority. The project has significant sustainable development benefits, including a positive local health impact and a well-managed dump that can be sustained by the revenues generated from the sale of compost and CERs. Waste amount/city: 25,000 t/a Emission reduction: 8,400 tCO_2e/a Investment: 320,000 EUR Operation: 36,000 EUR/a Profitability: ~ 5%.

In Africa there are 2 PoA in the MSW sector, one of which is currently under validation and one that has been registered. The former is a landfill gas flaring poject in Morocco, the latter a MSW composting activtity in Uganda. PoAs are probably an attractive approach for the sector. The number of participating units in order to achieve a critical size does not exceed manageable dimensions. In case of the Ugandan PoA, for example, there are only 9 cities initially participating. Thus less effort is required to bring together participating activities.

Apart from the CDM PoA approach there are activities in Africa, which analyze the local situation of the waste sector including administration, transport, and recycling. Based on such analyses approaches to address the problems with region specific solutions and actions plants can be developed. Such an initiative, for example, is implemented by KNOTEN WEIMAR in South Africa.

4.5 Other Potentials

4.5.1 Mining

Mining related CDM project types relevant in SSA listed by the CDM EB Meeting 32 in Annex 6 (UNFCCC 2007) are CDM project potentials regarding coalmine methane in coal-rich nations. Figures for overall technical potentials are not available and have to be determined technology/production specifically. According to de Gouvello et al. (2008) significant CDM project potentials in Mining/mineral production exist in the DRC, Tanzania and Zambia (see overview in Table 30).

Following de Gouvello et al., the reduction or use of coal mine methane in mining and mineral production only yields a limited reduction potential. Most countries are not able to reduce their emissions in this sector. Zambia may reduce emissions from mining methane by 37,000 tonnes, Congo by 19,000 and Tanzania by 15,000 tonnes of Carbon Dioxide Equivalents (CO_2e)[5] No potential was identified for the other countries in the study.

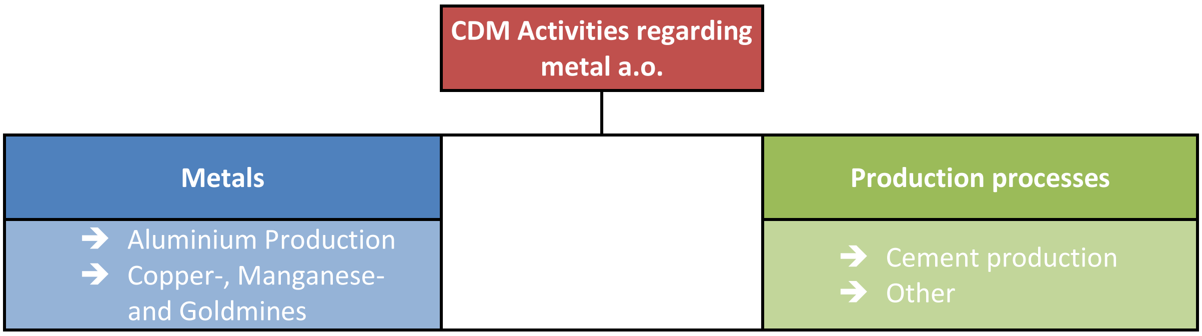
4.5.2 Metal and other Industrial Production Processes

Metal and other industrial production-related CDM project types relevant in SSA listed by the CDM EB Meeting 32 in Annex 6 (UNFCCC 2007) are energy related such as processing and production of metals such as aluminium, copper, manganese and goldmines, as well as the

[5] Different greenhouse gases listed in Annex A to the Kyoto Protocol, such as methane, are characterized by different global warming potentials which are expressed in carbon dioxide equivalents (CO_2e). The carbon dioxide equivalent for a gas is derived by multiplying the tons of a specific gas by the associated global warming potential. Thereby carbon, with a global warming potential (GWP) of one is used as the reference. One ton of e.g. HFC_{23} equals 11 700 tCO_2e. The huge GWP of non CO_2 greenhouse gases is an important factor for the financial viability of emission reduction projects.

production of other materials such as cement. As for the processes mentioned, concrete figures were available for cement only. Therefore, the other project opportunities could not be further assessed.

Figure 7: CDM Options in Manufacturing Industries



4.5.3 Cement

Manufacturing cement is an energy-intensive process that yields a very high potential for reduction of GHGs. CDM projects are therefore possible in multiple stages of the industrial process, as a recent study of the World Bank points out. The study shows four types of projects that offer varying reduction potentials (World Bank 2009a):

- Waste heat recovery in cement plants in Africa could result in a reduction of approximately 5,000 tonnes of CO_2 per year, costing between 15 and 50 USD per tCO_2,
- Alternative fuels could substitute small percentages of fossil fuels in different production stages. Costs vary between 4 USD per tonne through biomass residues and 12 USD/t CO_2 through plantation-based biomass.
- Energy efficiency measures could reduce emissions in various parts of the factories, including pre-heaters, automatic control measures, efficient motors etc. Depending on technologies used, costs vary, but are relatively high.
- Changing the blend or mix of the cement indirectly decreases emissions through reducing high-energy ingredients (mainly clinker). Different mixtures may reduce gross CO_2-emissions by 20 to 45%. Abatement costs vary between ca. 4 and 7 USD/tCO_2.

Projects of the first three kinds are covered elsewhere in this study (see chapters 4.4, 4.1.5, 4.2.3). Therefore, this chapter focuses on the reduction potential gained from changing the cement's blend.

The blending process itself is not highly energy intensive. Large emissions savings can be generated indirectly, as the main bonding component in cement is clinker. Production of clinker is a highly energy-consuming process, resulting in about 0,83 tCO_2 per tonne of conventional cement (World Bank 2009a). Changing the ratio of clinker to additives results in high energy savings through reduction of energy-intensive material. Furthermore, industrial slag and fly ash from other industrial processes may be used as additives, reducing waste that is difficult to dispose of otherwise and lowering the cost of the measure. It has to be noted, though, that the CDM EB has rejected a number of CDM project proposals under methodology ACM0005, mainly because the EB deemed them non-additional.

As there are not many cement factories in the countries this study is concerned with, reduction potentials of blended cement projects are relatively low. Senegal, with two factories, may reduce emisssions by up to 340,000 tonnes of CO_2 per year, whereas the two facilities situated in Uganda yield significantly lower potential reductions: de Gouvello et al. estimate merely 50,000 tCO_2/a in total. Ethiopia and Tanzania also both have significantly lower abatement potentials compared to Senegal (130.000tCO_2/a), although more factories, 4 and 3 respectively, are situated in those countries. This may be due to smaller and/or more modern production facilities.

Total abatement potential in cement manufacture may be significantly higher if one takes into account savings from the above-mentioned measures. The World Bank (2009a) estimates that another 170,000 tCO_2/yr may be abated through energy efficiency measures in Senegal's cement kilns alone. Ethiopia may reduce emissions by another 175,000 tCO_2/yr by installing modern heat recovery systems, and Tanzania's emissions could be reduced by close to 190,000 tCO_2/a with the use of fuel substitution projects.

Table 30: CDM Potential in the Mining and Cement Sector

Country	Coal Bed Methane		Cement	
	Emission Reduction (kCERs/ year)	Investment Cost (in mio. USD)	Emission Reduction (in kCERs/yr)	Investment Cost (in mio. USD)
Burkina Faso			-	
DRC	19	1,0	20	0,9
Ethiopia			127	5,6
Malawi			20	0,9
Mali				
Mozambique			38	1,6
Rwanda			12	0,5
Senegal			344	15,0
Tanzania	15	0,8	125	5,5
Uganda	N.A.	2,0	50	2,3
Zambia	37	N.A.	51	2,2

Source: de Gouvello et al. 2008

4.5.4 Efficient Charcoal Production

Over 90% of the wood extracted from African forests is wood fuel (Seidel 2008). While the majority is directly used as fuel wood, an increasing amount is transformed into charcoal. Across SSA, charcoal is used by low income urban and most rural households. It furthermore serves as fuel for cottage industries. Charcoal is generally harvested in an unsustainable manner from dry woodland. This mostly unregulated tree removal has been identified as the major cause of forest degradation and deforestation in several African countries and is a major cause of concern in areas with high energy demand, especially in the periphery of large urban zones. In economic terms, charcoal production and its trade is a major source of income, especially for poorer households. Despite the importance of charcoal production for the local economy, its contribution to government revenues is limited, as in many countries this sector is not effectively regulated (World Bank 2009b).

Charcoal is produced from wood by a complex carbonization process, occurring at temperatures between 450 to 600 degree C in absence of air. This process produces several GHGs, including CO_2 and CH_4. With the traditional techniques, wood is put into an earth pit, lit and covered with earth. Combustion of part of the wood produces the heat necessary for the carbonization of the remaining wood. While these techniques are cheap and therefore very popular all across the African continent, their efficiency is very low, typically producing only 1 kg of charcoal out of around 10 kg of wood. Besides the low efficiency, also quality inconsistencies and environmental pollution result from this process. In contrast to these traditional techniques, modern low emission systems improve both environmental performance and efficiency, making it possible to produce up to 1 kg of charcoal from 3 to 4 kg of wood (de Gouvello et al. 2008).

Table 31: CDM Potential in Charcoal Production

Country	No of Projects/PoAs	Emission Reduction (kCERs/yr)	Investments (in mio. USD)
Burkina Faso	4 / 1	46	0,5
DRC	42 / 1	527	5,4
Ethiopia	43 / 1	538	5,5
Malawi	54 / 2	670	6,8
Mali	10 / 1	123	1,3
Mozambique	55 / 2	686	7,0
Rwanda	6 / 1	69	0,7
Senegal	25 / 1	312	3,2
Tanzania	84 / 2	1.047	10,6
Uganda	82 / 2	1.020	10,4
Zambia	97 / 2	1.204	12,2

Source: de Gouvello et al. 2008

De Gouvello et al. (2008) conducted a quantitative analysis of the existing potential for CDM projects which substitute inefficient mostly traditional charcoal facilities by introducing high-yield, low emission systems. Their findings indicate that 8 (SSC) CDM projects as well as 2,031 CDM Programme Activities (CPAs, organized under 61 Programs of Activities) could be implemented in SSA, yielding emission reductions of more than 25 million tCO_2e. As these numbers indicate, the charcoal sector offers great possibilities for the implementation of PoAs.

Conclusion. While almost 20% of these emission reductions would be achieved in Sudan, considerable emission reduction potential was also found in the countries this study focuses on. As shown in Table 31, Zambia (97 CPAs/projects and reductions of 1.2 million CO_2e), Tanzania (84 CPAs/projects and reductions of 1.05 million CO_2e) and Uganda (82 CPAs/projects and reductions 1.02 million CO_2e) yield high potential, each reducing emissions by more than 1 million tCO_2e. The emission reduction potential in Mozambique, Malawi, Ethiopia and DRC varies between 690,000 tCO_2e (Mozambique) and 530,000 tCO_2e in (DRC), while fewer opportunities for charcoal CDM projects were found in Senegal, Mali, Rwanda and Burkina Faso (ranging from 310 kCERs/yr to 50 kCERs/yr).

4.6 Reducing Emissions from Deforestation and Forest Degradation

Reduced Emissions from Deforestation in Developing countries (REDD+[6]) activities are aimed at preserving precious tropical forests. Conservation projects aim to manage drivers of deforestation and need to apply complex monitoring schemes. Given the large volume of GHG emissions from land-use change in tropical forests, REDD+ is frequently a top priority on the

[6] In the current political discussion there is a not always consistent use of the terms REDD and REDD+. The authors' understanding is as follows:

- REDD refers to the reduction of emissions from deforestation and degradation without referring to sustainable forest management (SFM), forest conservation, enhancement of sinks and the consideration of biodiversity.
- REDD+ expands above definition to include SFM, conservation and the enhancement of sinks.

As the Copenhagen Accord agreed to the scope of REDD+ at COP15 (UNFCCC 2009) the authors refer to this definition.

current agenda of political discussion about climate change mitigation while bearing a significant climate change mitigation potential in LDCs in Africa.

Currently there are a range of different initiatives fostering REDD+ at a national level. The two most important are the UN-REDD Program, the second is the Forest Climate Project Initiative (FCPF). Both initiatives are briefly outlined below.

4.6.1 The UN-REDD Program

The UN-REDD program supports rainforest nations to prepare for a future REDD+ mechanism under the UNFCCC. It is active in about ten countries in Latin America, Asia and Africa supporting participating governments with capacity building and with the development and implementation of a national REDD+ strategy. UN-REDD offers in particular:

- Technical support in the formulation of measures to reduce deforestation and forest degradation.
- Measures and instruments to measure and monitor GHG emissions.
- Promotion of REDD as a financing instrument for a low-emission development path, support to financing sources.

In the study region, the DRC and Tanzania are participating in the UN-REDD process as pilot countries (please see also Figure 8 below).

4.6.2 Forest Climate Partnership Facility

The World Bank has to be considered as one of the REDD Pioneers. On the one hand the Bank's BioCarbonFund purchases credits from sub-national (i.e. project based) REDD+ programs. On the other hand, it established the Forest Climate Partnership Facility (FCPF) in the context of COP13 and the so-called Bali Roadmap. Similar to UN-REDD, the FCPF shall support selected countries to formulate and establish their REDD+ structures. Therewith, the FCPF inherently envisages REDD+ as a crediting mechanism (i.e. no fund approach).

In September 2010, the FCPF comprised 37 countries from Asia, Africa and Latin America. Moreover, ten donor countries engaged within the framework of the FCPF (FCPF 2010).

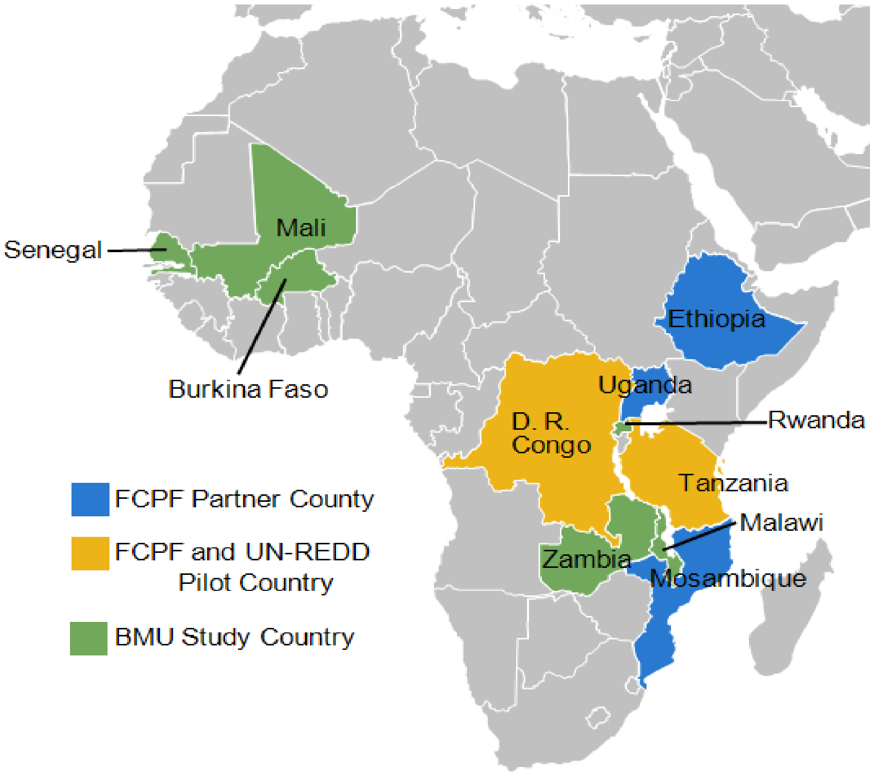
The FCPF offers two financing mechanisms. The first, called *Readiness Mechanism*, offers immediate funding in the amount of 100 million USD (Bousquet et al. 2009) to support the participating countries in the following activities:

- Development of a national REDD+ strategy
- Development of reference scenarios for degradation and deforestation based on historical deforestation, extrapolated into the future.
- Development of a national monitoring, reporting and verification (MRV) system.
-

In a second phase, called *Carbon Finance Mechanism*, the FCPF envisages to purchase emission reductions from national REDD+ programs. This fund is equipped with 200 million USD (Bousquet et al. 2009).

From the study region, the following countries are involved in the FCPF: DRC, Ethiopia, Mozambique, Uganda and DRC and Tanzania. The latter two countries participate not only in the FCPF but also in UN-REDD (please see also Figure 8 below).

Figure 8: UN-REDD and FCPC Partner Countries



Source: Map was compiled based on FCPF (2010) and UN REDD (2010) data.

4.6.3 Evaluation of REDD+ Potential

In order to evaluate the study countries' REDD+ potential, we have analyzed existing FAO data (World Bank 2008b) with respect to forest area, average biomass stock, related average carbon stock and annual deforestation rates. The table below outlines the findings.

Table 32: Evaluation of REDD+ Potential

	Forest Area	Carbon Content	Annual Deforestation	Annual Emissions	Abatement Cost
Country	(in 1000ha)	(in tC/ha)	(2000-2005) (in 1000 ha)	(in $ktCO_2$)	(in US$/$tCO_2$)
Burkina Faso	6.794	44	-24	3.872	N.A.
DRC	133.610	173	-319	202.352	0,7
Ethiopia	13.000	19	-141	9.823	12,2
Malawi	3.402	47	-33	5.687	Na
Mali	12.572	19	-100	6.967	Na
Mozambique	19.262	31	-50	683	18,4
Rwanda	480	92	27	-9.108	N.A.
Senegal	8.673	43	-45	7.095	N.A.
Tanzania	35.257	64	-412	96.683	6,7
Uganda	3.627	38	-86	11.983	N.A.
Zambia	42.452	27	-445	44.055	1,2

Calculated based on data provided by FAO 2009, please refer to ANNEX V – Basic Forestry Data. Abatement costs taken from Bakker et al. 2009.

The following preliminary conclusions as regards technical potentials are drawn:

- As can be seen from the table above, all countries have Land Use Change related emissions but Rwanda. In Rwanda forest areas are increasing (the country including its national parks was largely deforested in the course of the civil war in 1994), hence its annual forestry related emissions are actually negative.
- The actual forestry related emissions are by far the largest in Tanzania (96.7 million tCO_2/yr) and DRC (202 million tCO_2/yr) which are also the countries with the highest forest areas (35 million ha and 133 million ha respectively). Hence, it is concluded that, given the massive deforestation trends, DRC and Tanzania have an excellent REDD+ potential. These countries are followed by Uganda (12.0 million tCO_2/yr), Ethiopia (9.8 million tCO_2/yr), Senegal and Mali (7 million tCO_2/yr each).
- For the other countries REDD+ may be of less importance. First, their historic emissions, expressed as their Reference Emission Levels (REL) are lower. Second REDD+ involves significant initial Readiness (i.e. preparation) costs and it also will result in substantial annual MRV costs. Consequently REDD+ may not be a cost-effective instrument to engage into climate change mitigation for those countries.

A final remark shall be made: Following FAO data, the above analysis is based on forest area change analysis. This data does not allow for taking forest degradation (i.e. the decrease of biomass- and carbon stocks in forests remaining forests) into account. Still in the course of investigations in Peru and Cameroon, we found that forest degradation may play a significant role in terms of overall Land Use Change related emission levels. As this emission source is not considered, the results have to be used with care. The monitoring of degradation is a challenge for REDD+ and innovative concepts such as LiDAR[7] and CLASlite[8] should be tested for their suitability.

Conclusions. The following conclusions are drawn:

- There is a considerable GHG abatement potential through REDD+ activities in SSA. The highest potentials can be found in Tanzania and the DRC, followed by Uganda, Ethiopia, Senegal and Mali.
- In what way and when these potentials can be tapped, however, remains unclear for the time being: this is because REDD+ so far is a building block under the Bali Action Plan, which Parties to the UNFCCC are still negotiating (cp. Arens et al. 2010).
- Even if a decision on the regulatory framework for REDD+ was taken, the question whether and when project-based forestry activities on a sub-national level would be awarded carbon credits, is again wide open. As laid out above, in an initial phase, preparatory tasks such as formulating REDD strategies, developing reference scenarios and establishing MRV systems are required. This will take considerable amount of time and require substantial financial contributions of Annex I countries.

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7 Light Detection and Ranging (LiDAR) is a comparably new approach for measuring forest densities. Similar to RADAR, LiDAR uses laser pulses to measure the distance between the target and the sensor due to the time delay between emission and reflection. If put on a aircraft, LiDAR sensors can be used to determine the canopy structure allowing for a quantification of forest biomass- and carbon stocks. Such flight campaigns and related analysis may be most appropriate to monitor forest degradation.
BMU finances the development of forest carbon map for DRC based on LiDAR technique, This project will assess the opportunities and bottlenecks of using LiDAR for REDD+ and MRV procedures and will be implemented by KfW, WWF, NASA and GFA ENVEST.

8 CLASLite is a software package, developed by the Carnegie Institution which allows for monitoring forest degradation based on Landsat data. As Landsat does not require cost intensive flight campaigns and is available free of charge, it may proof to be a cost effective analysis tool. It is assumed that the program delivers sound results it flat regions, such as the Amazonas, but will work less reliably in mountainous regions.

5 EVALUATION OF CROSS-CUTTING ISSUES

5.1 CDM Programmes of Activities

The CDM Programme of Activities (PoA) is a comparably new instrument for climate change mitigation. It was initially proposed by Christiana Figueres in 2002 as a sectoral CDM which should encourage developing countries to develop country specific emission reduction projects.

From a technical perspective, there is one major difference between CDM PoA and CDM projects (which also may be aggregated in bundles (e.g. CDM EB47, Annex 32): by allowing for the addition of new CDM Programme Activities (CPAs) to already registered CDM PoA Design Documents (CDM PoA DDs), it is feasible to add new facilities/devices to an existing and registered CDM framework. This is neither feasible for CDM bundles nor for normal CDM projects. This small difference offers the flexibility which is needed to develop large emission abatement programs having thousands of small devices.

- As such the programmatic CDM is an instrument to mobilize mitigation activities which are highly dispersed. Consequently the PoA is key to new, so far untapped mitigation potentials (such as e.g. distribution programs for CFLs) and offers huge new potentials for abatement activities in Africa.
- In this regard, PoA is an instrument which allows for bringing the benefits of CDM not only to e.g. HFC- and Adipic Acid facilities (having the largest share of CERs generate so far) but bringing it to a household or a small or medium enterprise level.
- And finally, only the PoA as such and not each of the small reduction activities needs to undergo validation, registration and verification. As the costs associated with these processes (so-called transaction costs) are fairly independent from scale, the PoA significantly reduces transaction costs and thereby enables the mobilization of small and disperse mitigation potentials.

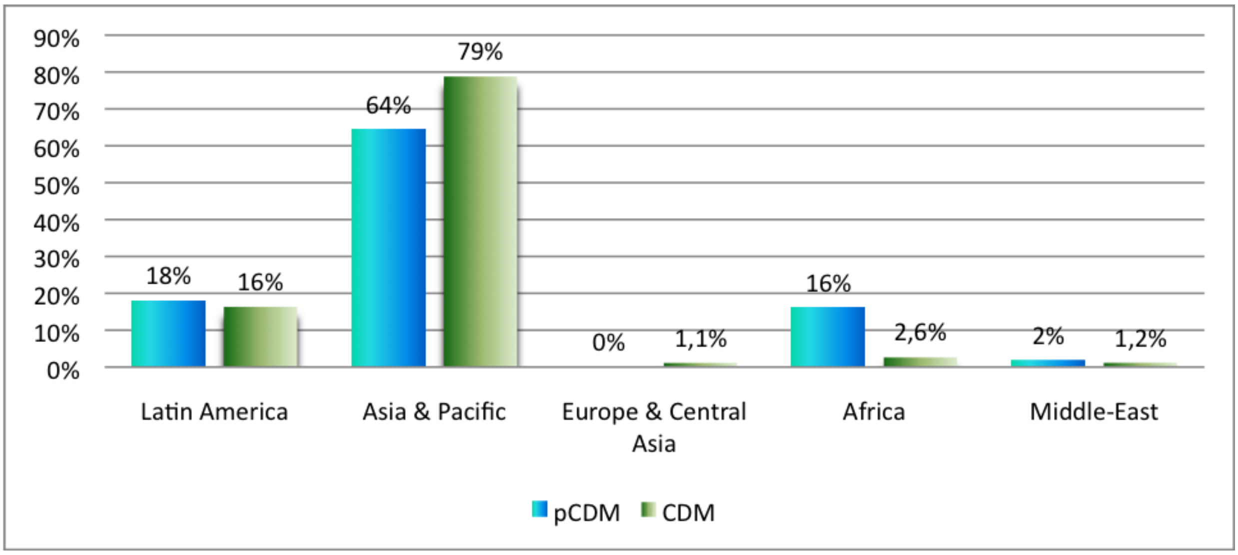
Considering that Africa comprises many regions having a low industrialisation degree, the above outlined advantages play a major role for Africa. The performance of PoAs in Africa so far is analyzed in the subsequent section.

5.1.1 PoA Performance in Africa

The first PoA was submitted in December 2007 to the UNFCCC. However, in the first two years, the PoA rules and procedures were not fully established. In May 2009, the CDM EB finally refined and specified the PoA rules and procedures leading to the breakthrough of CDM PoA (more than 20 submissions in December 2009). Given this positive development, we now can take a step back analyzing the PoA's impact on CDM in Africa.
As can be seen from Table 33, 56 PoAs have been submitted, whereof 16 are located in Africa. This makes up for 16% of the PoA pipeline, which is considered as a huge improvement compared to Africa's 2.6% share in the CDM project pipeline (please see Figure 9 below).

Table 33: Comparison of Regional Distribution of PoA with Projects				
Region	pCDM	CDM	pCDM	CDM
Latin America	18%	16%	10	889
Asia & Pacific	64%	79%	36	4.288
Europe & Central Asia	0%	1,1%	0	61
Africa	16%	2,6%	9	142
Middle-East	2%	1,2%	1	63
Total	100%	100%	56	5.443
Source: UNEP RISOE 2010				

Figure 9: Comparison of Regional Distribution of PoA with Projects



Source: UNEP RISOE, 2010

5.1.2 Requirements and Factors for Bringing forward PoAs

Seed Funding. Until today, the majority of PoAs in the global PoA pipeline are developed by or with support of international financing institutions such as the World Bank or KfW. These prepare CDM programmes in close co-operation with host country organizations, sometimes with support of Annex I country DNAs. However, private sector activities are nearly absent. Apart from a lack of knowledge and familiarity with the CDM requirements, a major obstacle for private sector engagement in the CDM is the financing part (cp. Arens et al. 2010).
For most Programmes of Activities, an incentive is needed to get the programme started. However, most PoA coordinators do not have the financial means for pre-financing this part of the programme – the need for seed money arises.

In fact, not all PoA types require seed funding (cp. KfW 2010a). In *Payment on Delivery* Programmes, revenues of sold CERs are given out to programme participants directly after successful verification of the CPA. Therefore, there is no need for pre-financing. Yet, all other types of PoA, such as grant programmes, loan programmes or supply programmes, the delivery risk for the CER is taken up by the implementing agent, as incentives are set a the beginning of the programme in order to attract programme participants. Here, significant upfront payments are required.

With regard to Africa, this issue becomes even more virulent, as project developers of any type of CDM projects have difficulties finding supportive banks and / or financial institutions. Furthermore, for programmes targeting household appliances such as cooking stoves or refrigerators or Solar Water Heater Programmes, the grant approach is the typical PoA approach (ibid). Thus, the need for seed funding is also a problem of PoAs in the African context.

As a result, the engagement of international carbon buyers, government as well as multilateral institutions is key at this stage of PoA development. In supporting successful Programmes, lighthouse projects should be established which can then serve as blueprints for further activities. Once a significant number of PoAs is established, they will become easier to replicate and, what is more, it will be easier to persuade local / regional financing institutions to engage in CDM projects / programmes.

Dependable PoA Co-ordinators. The need for reliable PoA co-ordinators is a further prerequisite for successful Programmes. The PoA co-ordinator needs sufficient in-house capacity and regional acceptance to guarantee a cost-efficient and effective programme performance through a centralized management structure and the integration of monitoring procedures in the normal business.

The lack of capacities and trained personnel in the whole of Africa has been an ongoing source of complaints for years now. According to practitioners, however, dependable PoA-coordination *can* be found in the region; however, the number and their capacity is limited (KfW 2010b, KfW 2010c, Farmer 2010). It is not so much utilities and other large organisations but rather SMEs specialising in offset projects which are active in this field. One example is Uganda Carbon Bureau, which is preparing a transnational Hydro PoA (see below). Large organisations mostly do not offer the required flexibility for handling CDM PoAs. Yet there are positive experiences with collaboration between KfW and the World Food Programme also (KfW 2010b). Growing capacity is also reflected in networks such as the CDM in Africa Network, which offers a list of Carbon Service Providers from 10 countries (CDM in Africa Network 2010b).

In order to foster this development, measures funded by Annex I donors could focus on a further knowledge exchange between sub-Saharan Africa and other regions as well as between countries in SSA. Another means could be fostering the establishment of local DOEs as well as supporting private project developers, e.g. by supporting PIN and PDD development.

Scope and Size of PoAs. PoAs covering more than one country (transnational PoA) are currently being discussed as a means to tap PoA potentials, cp. the SPEARS example PoA in the box below. The idea is promising as expanding the geographical scope offers the opportunity to significantly increase the number of CPAs added to Programme, thus possibly benefitting from economies of scale. Also, smaller countries such as Rwanda and Burundi with their occasional small projects can benefit from the PoA approach rather than having to wait for a larger CDM project or programme which might never materialize.

The question is whether this approach offers considerable potential to foster PoA development in Africa, which is especially suited for Programmatic CDM.

Box: The SPEARS transnational Hydro PoA
The programme intends to implement renewable energy projects up to 30 MW in Eastern Africa. Five countries are targeted so far: Uganda, Kenya, Tanzania, Rwanda and Burundi. The focus will be – at the beginning - on small hydro power plants. The CPAs will be implemented by the single CPA operators, which will also receive the bulk of the CERs revenues, apart from a small margin for the co-ordinating entity of the programme. The revenues are even more important when considering the low feed-in tariffs of the region and the high capital cost. The programme will be co-ordinated by Uganda Carbon Bureau with its experienced CDM Expert Bill Farmer, and is supported by KfW's PoA Support Centre Germany.

However, few experiences with the transnational PoA approach have been made to date. The CDM EB recently approved a conventional transnational CDM project. The additional requirements for the project developer apparently were comparatively low (KfW 2010b). One difficulty with the SPEARS PoA was to involve the different DNAs. The Tanzanian DNA apparently wanted the co-ordinating entity to have its seat on their territory. Thus, the programme developers currently consider opening local branches in the different countries covered by the PoA (KfW 2010b). Another solution for this problem is to have an operator functioning as coordinator which is organised regionally anyway. This approach is being discussed for plans of the ProBEC initiative, which intends to start a transnational cook stove PoA, the coordinator of which could be a yet to establish SADC Regional Carbon Facility (SRCF). Project Idea Notes describing the PoA to the Designated National Authorities in 4 countries — Malawi, Mozambique, South Africa and Zambia – have been finalised and submitted (ProBec 2010). A private-sector partner is currently being sought to co-develop the cookstove PoA and take it through its final stages of document preparation, validation and eventual registration as a CDM project.

Considering the difficulties "conventional" PoAs are facing anyway (cp. above), one way is to start with an anchor PoA in one country first and start expanding the scope later (KfW 2010c). ProBec, for example, intends to work with an incubation phase, following by a scaling up phase in year four of the PoA's life (ProBec 2010).

On the other hand, the advantages of multi-country PoAs might also make the development of such programmes easier compared to standard PoAs: for example, transnational PoAs can tap regional donor support programmes and have easier access to regional business entities and regional development banks, such as the East African Development Bank in the SPEARS example (Farmer 2010). Also, DNAs in regions covered by groups such as the East African Community or the SADC cooperation can act in a more coordinated and linked matter which will further facilitate project approval.

In order to exploit the potential of this approach, it does not seem advisable to start a theoretical investigation on how this approach could work and what the barriers might be, as the circumstances per country and per technology will differ. It seems therefore more advisable to observe and study on how these first example PoAs such as the SPEARS and the ProBec Programs will fare and then draw conclusions and derive lessons from their performance.

5.1.3 Conclusions

- PoAs are a suitable tool to address the mitigation potentials typical for Africa, which is demonstrated by Africa's high share in the PoA pipeline.
- Still the total number of projects (16) is considered to be moderate. In order to tap the full potential of PoA, combinations with innovative financing concepts should be considered (e.g. contracting and/or microfinance, see chapter 5.4)
- Seed funding initiatives by Annex I countries and multilateral financing institutions will be required for the time being; the engagement of KfW and others in this context is vital and possible synergies with other institutions such as MFI's should be explored, possibly in combination with further BMU engagement in SSA countries in the future
- Dependable PoA coordinators can be found in the region; however, their number and their capacities are limited; additional workshops by KfW this year will support capacitiy building. A (number of) replicable example PoAs and widespread publicity for them would also help developing further capacities
- Transnational PoAs offer ways to tap the potential further; however, experiences with the first example transnational PoAs should be observed carefully.

5.2 CDM Financing Approaches

Following its basic rational (outlined by Figure 17: Steps Prior to Generating Carbon Revenues, Annex VII), the CDM is an ex-post financing instrument for GHG abatement projects.

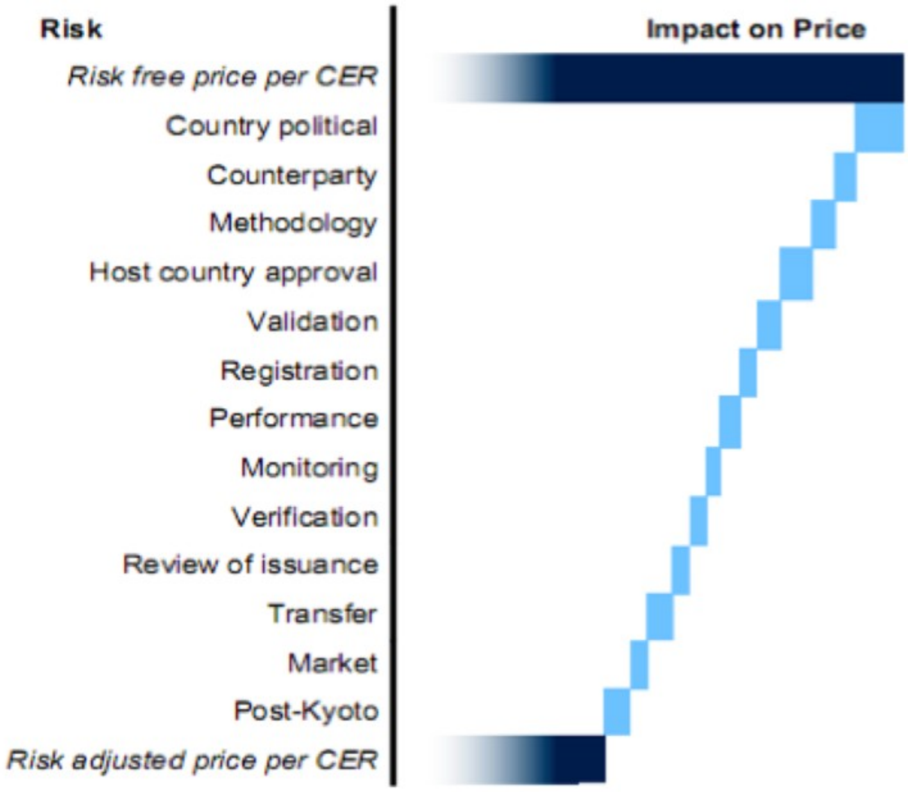
Considering the commonly weak institutional framework for investments in SSA (e.g. high interest rates, high corruption (please refer to Annex VI – PCI 2009 - Africa), limited access to finance, etc.), the ex-post financing character severely limits the impacts that CDM potentially could deliver in SSA.

Most project proponents do not dispose of the financial means for even covering the CDM project development costs. Generally, first inflows from sales of carbon credits can be expected two years after starting the development of a CDM project. Normally, at least one year after the project has been implemented and is up and running needs to be bridged before the first carbon revenues come in. Still there are different options, where the CDM may also be used to provide upfront financing. These options, their advantages and their limitations are briefly discussed below.

5.2.1 Emission Reduction Purchase Agreement

CER prices mainly depend on (a) the risk profile of a CDM project, (b) its development / implementation stage, and (c) whether external financing is needed to start the project.

Figure 10: CDM Project Risks and Their Impact on CER Price



Source: UNEP

Risks. The figure above shows various types of risks that can be attached to a CDM project. Higher CER prices can be expected for projects with

- Low investment risk
  - Project participants with good credit rating
  - Experienced project developers
  - High amount of certificates generated by the project
- Low technology risk
  - Low performance risk (tested technology, high technology quality standard, sufficient technical know-how)
- Low political risk
  - Advanced stage of project development (LoE, LoA, Registration)
  - Low country risk
  -

The same applies for the willingness of an investor to provide equity or a bank to go for a loan agreement.

Development/Implementation Stage. The more advanced the stage of a project is within the circle of project development and implementation, the lower the risk of a failure. Therefore, prices for emission reduction certificates from more advanced projects in general achieve higher prices.

Financing. In case the project owner has sufficient capacities to organize financing project development and implementation on his own, maximum financial returns from selling carbon might be obtained for the project. Any other external funding normally leads to discounted carbon prices.

If the project proponent is free of any obligations against third parties, and is the sole owner of emission reduction certificates, he may choose his best option for maximizing returns from carbon. In principal the following opportunities exist:

Table 34: ERPA and Spot Market Financing Options

Option	When	Pro's and Con's
I. Sell CERs to the spot market (either directly or through tender)	Any time after CERs have been issued	Good option for obtaining highest price, if project owner (= seller) is ready to take over market risk.
II. Sign Emission Reduction Purchase Agreement (ERPA) with carbon buyer	In principle at any time but normally before implementati on of project	Buyer takes over market risk and participates in project risk. This leads to lower CER prices. Seller has price security and eventually a chance to obtain up-front payments from buyer. In case of a financially well-rated buyer, seller may use ERPA as security for debt capital.
III. Mixture of both options, e.g. ERPA on 50% of expected credits and 50% speculating on spot market		Good model for sellers who would like to be on the safe side and still want to speculate on future market development.

In most cases an Emission Reduction Purchase Agreement (ERPA) will be signed between the project owner and a buyer/investor, particularly when it comes to CDM projects, and especially in case of CDM projects in LDC. The most important reason for this is the common need for investment capital. Furthermore, such a financial partnership opens up other opportunities such as

- Joint ventures between partners from industrialized and developing countries that facilitate technology transfer;
- An involvement of a second party with excellent credit rating and/or technological expertise from the start of the project, which again reduces project risks and allows for alternative business models such as contracting agreements.

An ERPA normally is a forward contract on selling CERs from a CDM project. In the contract prices, conditions as well as liabilities, e.g. compensations in case of non-fulfilment of guaranteed delivery, are defined. Fixed or indexed CER prices can be negotiated, as well as guaranteed or non-guaranteed delivery.

Carbon Finance in Africa. African projects are perceived to have high risk profiles. For a project owner from an African CDM country it is generally recommendable to conclude an ERPA that determines a fixed price – or at least an indexed price that is secured through a floor price – and a low percentage of guaranteed delivery CERs. However, depending on the quality and attractiveness of the individual project, other contractual arrangements might be favourable as well.

Normally, the conditions specified in an ERPA are valid until the end of 2012, the end of the 1st Commitment Period of the Kyoto Protocol, and only include a paragraph, which grants the right of first refusal for Post-2012 certificates to the buyer. Regardless of what will happen to a Kyoto follow-up agreement under the UNFCCC, the European Emission Trading Scheme will continue until 2020. Because of the EU ETS regulations for the third trading period up to 2020, projects in African LDC have the chance to conclude ERPAs with longer contract duration, as CERs from these countries do not underlie cap regulations in the EU ETS trading period 2012-2020. LDCs should make best use of this competitive advantage; however, they often require assistance when it comes to project identification and assessment because of lacking capacities within the national DNAs.

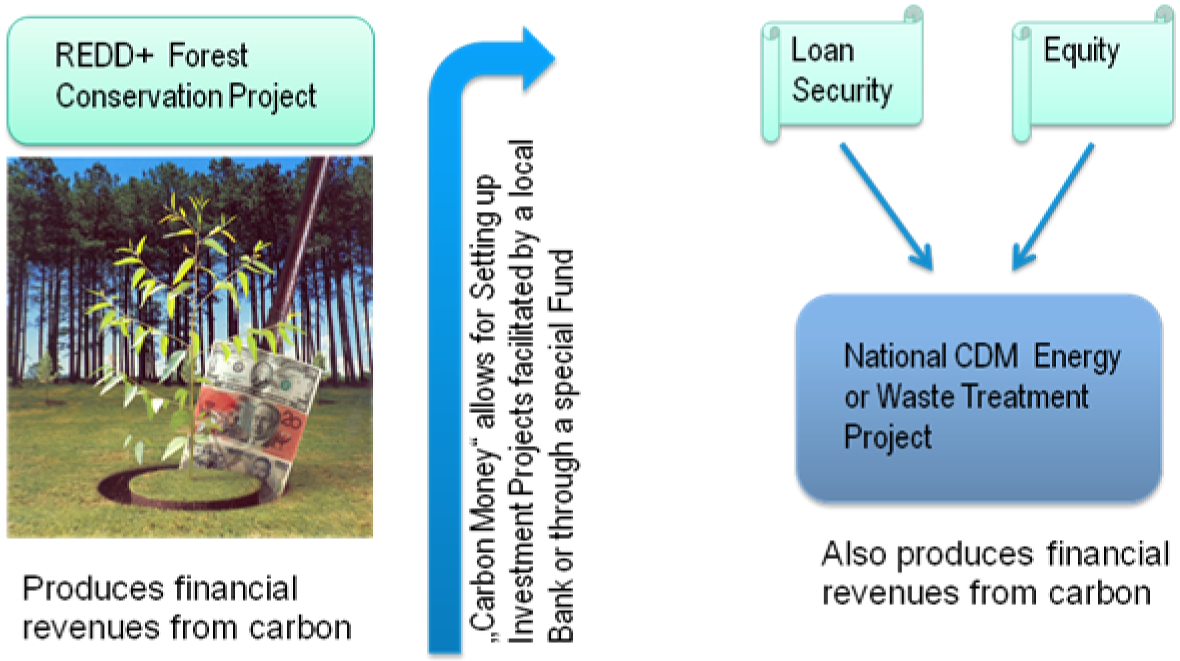
Non-LDC countries have to deal with the Kyoto Post-2012 insecurity. If no follow-up agreement to the Koyto Protocol will be signed, the market for credits that are issued on from 2013 is highly insecure. The currently biggest emission trading market, namely the EU ETS, will stay operational even if there won't be a new treaty under the UN umbrella. However, the amount of emission reduction certificates from the Flexible Mechanisms that can be used by European companies for compliance until 2020 has been severely reduced by the EC. There are still buyers who are willing to take over the political risk and who believe in the future value of CERs, and are willing to sign ERPA's with guaranteed prices also for post-2012 CER vintages. Consequently, prices offered for post-2012 credits are considerably discounted.

When it comes to potential up-front payments, some important aspects should be kept in mind. Some buyers provide such payments, which correspond to a share of ex-ante estimates of CERs multiplied by a negotiated, discounted price. Generally, a maximum of 25% of those emission reductions generated until end of 2012 are taken into account. On the one hand, such an up-front payment might enable a project owner to start project implementation by providing the equity needed for leveraging further debt financing. On the other hand, it needs to be mentioned that the approach is not equally suitable for all CDM project types. It is better applicable for those where CERs have high impacts on IRR, e.g. waste (methane), N_2O or HFC projects. Additionally, very high risk discounts are normally applied. Therefore, as up-front financing is often regarded as one of the only solutions for facilitating CDM projects in Africa, this approach should be taken into consideration with caution, as in the end it could prove to be a bad financial deal for a project proponent.

It is still widely unknown that some banks accept ERPAs as security for providing debt capital. Especially for projects in the SADC region the partnership between the newly established Africa Carbon Asset Development Facility (ACAD) and Standard Bank could provide the means for designing and establishing completely new financing mechanisms for CDM projects, which are tailor-made for African countries.

An example for a "combination project" is provided in the figure below, where a REDD+ forest conservation component provides equity for a combined technical CDM project component. Such an approach could be implemented on large-scale by replicating the concept, or through PoA structures, or through sectoral approaches.

Figure 11: Example - Innovative Carbon Financing Concept



5.2.2 Banks and Investment Funds

A minimum of 20-30% equity – in relation to the overall project cost - is normally a precondition for getting access to bank loans. Lack of capital and no means to attract foreign investment often is the biggest hurdle for African CDM project sponsors.

By setting up investment projects as climate projects under the Kyoto Protocol, financial revenues from producing and selling emission reduction certificates are generated that - from a bank's point of view - might enhance the economics of a project and reduce the bank's financial risk in various ways:

- CER revenues might be directly included in the cash flow of a project, and allow the project owner to use such additional inflow for fulfilling his financial obligations against the bank involved in such a financial transaction.
- Forward sales of CERs might provide the opportunity to the project owner to access capital in form of upfront payments that might be used for contributing sufficient equity.
- Emission reduction purchase agreements concluded with carbon buyers having an excellent financial rating might allow a project owner to use such an ERPA as security for a bank loan.

Development banks play a special role, as they are typically those organisations that could assist the implementation of CDM projects in developing countries through providing grant funding. In general, grants are provided to projects that are commercially marginal, and they do not need to be repaid (provided the stated purpose of the grant funding is achieved). However, in some cases grants may be convertible to loans or equity if the project achieves commercial success (if so, this will be stated in the terms and conditions of the grant). Grants normally only cover a percentage of project costs, other forms of finance are also therefore required.

If a project is financed (even partly) by sources of public funding, this must not result in a diversion of Official Development Assistance (ODA). As stated in the Kyoto Protocol, development aid should not be diverted into the CDM: any public funding from Annex I countries going into CDM projects should not have been taken away from other funding obligations. Where the project is financed by public funds, the project developer is required to provide information to confirm that the public funding of the CDM project has not resulted in any diversion of ODA. In addition, the project developer should be able to demonstrate that the funding of a CDM project is not counted towards the financial obligations of any donor to the country hosting a CDM project.

As said before, setting up an investment project in SSA countries as CDM project might be a means to attract foreign investment and/or enabling technology partnership.

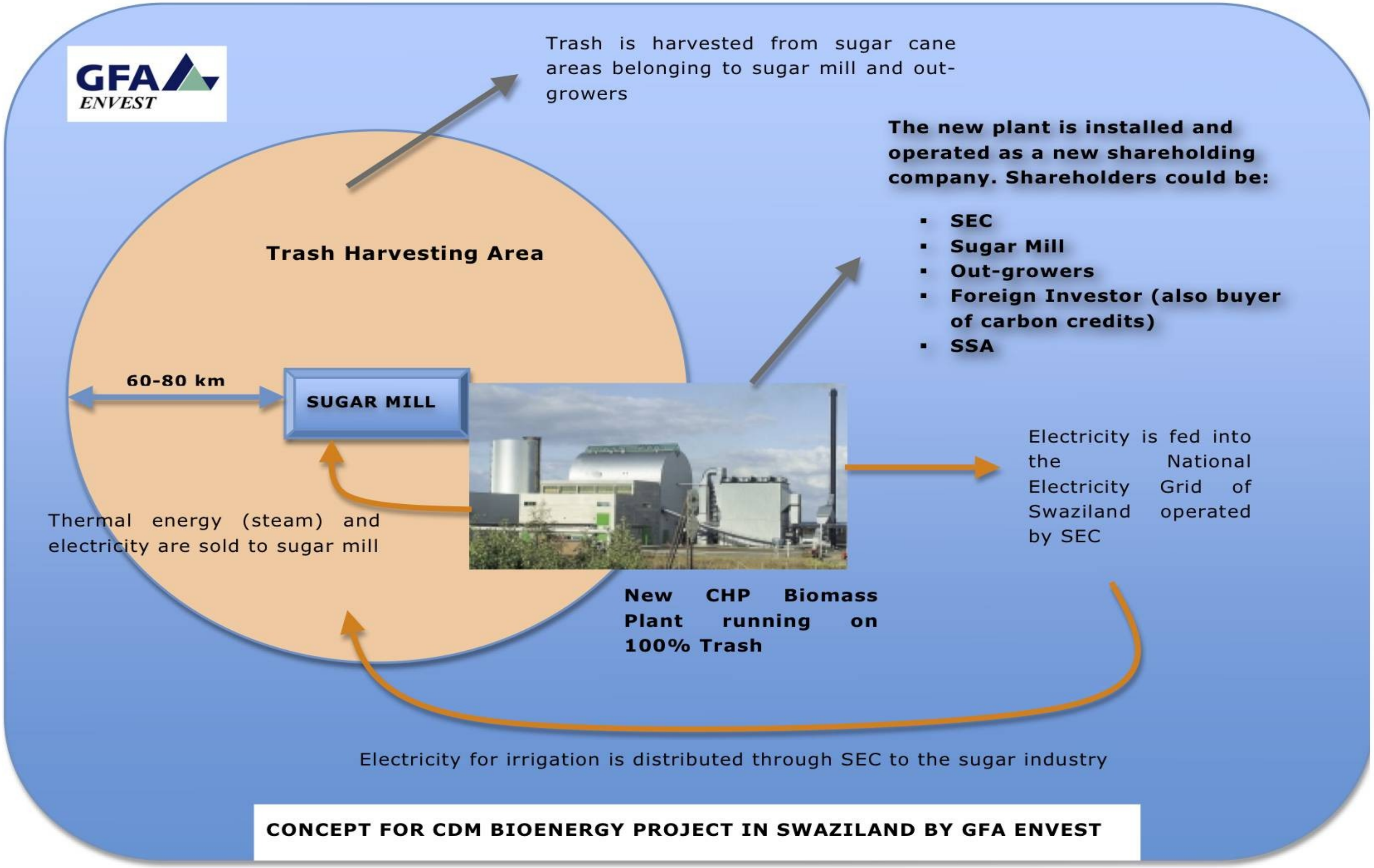
Venture Capital Funds could help finance a project or series of projects by making an equity investment in a CDM project development company. Venture capital is typically invested or ‘ventured’ in the start-up stage of a project or company’s development, and the capital provided is therefore at high risk. In return, venture capital funds require a high rate of return. Typical venture capital investments are usually in the range of US$1−10 million. It would be unusual for a venture capital fund to invest in a single project. Especially in Africa it will be difficult to identify CDM projects that are big enough and deliver the expected high return.

Project developers seeking funding for a CDM project could also be supported by a private equity company. In case a Special Project Vehicle (SPV) will be established for implementing a CDM project, a private equity provider has the opportunity to purchase a proportion of the (non-listed) equity of the company or the SPV, which allows for an investment in such a CDM project. The concept of a CDM project that uses biomass residues from sugar cane production (“trash”) in Swaziland for electricity production might be a good practical example for describing such a project setup. In this project the following potential project participants had been identified:

Table 35: Potential Stakeholders in Financing and Implementing a CDM Sugar Project	
National power generating company and grid operator (SEC)	▪ Could act as buyer of electricity, ▪ Could provide the network infrastructure required to transport power to irrigation systems of mills and growers, ▪ Potential investor (shareholder)
Sugar mills	▪ Providers of biomass fuel (new commodity), ▪ Clients for buying thermal energy (at long-term stable and reliable prices), ▪ Clients for buying electric energy (at long-term stable and reliable prices), ▪ Potential investor (shareholder) ▪ In case of shareholding: providers of new commodity (electricity)
Sugar cane growers (e.g. through a trust fund operated by the Growers Association)	▪ Providers of biomass fuel (new commodity), ▪ Access to electric energy for irrigation (at long-term stable and reliable prices), ▪ Potential investor (shareholder) ▪ In case of shareholding: providers of new commodity (electricity)
External carbon buyer / investor from the power sector	▪ Could act as buyer of carbon credits, ▪ Could provide technical services, ▪ Potential investor (shareholder)
External carbon buyer / investor from the financial sector	▪ Could act as buyer of carbon credits, ▪ Potential investor (shareholder)
National sugar association (SSA)	▪ Potential investor (shareholder)
EC delegation to Swaziland	▪ Could provide financial support to the project in form of a grant

The implementation structure of the project in form of a SPV is shown below.

Figure 12: Project Setup Comprising Several Shareholders and Carbon Buyers for the Establishment of a SPV



5.2.3 Compliance Buyers

Most compliance buyers such as European power generating companies by now excluded SSA – apart from South Africa – due to perceived risks and the low number of CDM projects of sufficient size. Only recently, with growing insecurity regarding the future of CDM projects in BRIC countries and the absence of a political Post-2012 framework, project sponsors start to concentrate on those countries that provide long-term stable conditions for CER delivery, namely LDCs.

In order to tap the CDM potential of host countries offering unfavourable investment conditions, some compliance buyers apply specific financing approaches. One of the most promising concepts is based on providing up-front equity – in order to make a project happen – against long-term delivery of emission reductions at discounted prices.

Under such a contractual agreement the carbon buyer/investor provides equity to a project corresponding to the amount and value of future CERs generated by the project during its operation time. The basis for such an engagement generally is a validated PDD in which the amount of future CERs is conservatively calculated. The buyer/investor is willing to take over any political Post-2012 risk as well as any other risks the CDM project might face during implementation and operation. Of course these risks will be taken into account while determining the future value of the emission reduction certificates, and this will lead to an internal discounted price for the buyer/investor.

The investment sum will be calculated by multiplying the number of expected CERs with the discounted price. The respective amount will be provided as equity to the project. In return the buyer/investor will become the owner of all emission reduction certificates generated by the CDM project during its lifetime. The project operator might use such equity to leverage debt capital for the project.

For hedging the financial risk of such an involvement the buyer/investor becomes a shareholder in the project, or in case a SPV has been established for the project, in a respective company. He will keep his shares as long as all forecasted certificates have arrived on his account. After that he will return his shares to the project owner. I case of non-delivery of CERs, the buyer/investor will participate in other revenues (e.g. electricity or heat sales) according to his shares in the project, and will leave the project only after repayment of the up-front investment.

Compliance buyers are ready to go for such business models, especially in case the CDM project falls within their core business, i.e. typically a power company will invest into a renewable energy project or an energy efficiency project in a power plant, and in case project opportunities of adequate size concerning CER and investment volumes could be found.

5.3 The CDM and Public Private Partnerships

Public Private Partnership (PPP) is a business model which combines government services with private entrepreneurship for the funding and/or operating of projects or programs. PPP usually involves the development of a business model between both parties where the private sector provides a service to the public entity, assumes the financial, technical and operational project risks and in return the public entity contributes mid to long term contracts for the payment of these services or provides in kind contributions (Lewis et al. 1987).

Ever since the early days of the CDM PPP played a significant role for the establishment of emission reduction projects (Benecke et al. 2008). The mayor applications for PPPs in the

CDM are seen in the waste and energy sectors. Different design options for PPPs are used which are outlined subsequently based on generic examples:

- Waste: the private sector invests, conducts landfill rehabilitation and operates the CDM project. The contribution of the municipality is in granting the right to commercialize the CERs. The profits are shared between the municipality and CDM operator.
- Energy: the private sector invests, constructs and operates a biogas facility which supplies its energy to a hospital. The hospital offers a long term energy purchase agreement to limit private investor's project risks.

PPP offers following benefits for CDM project implementation:

- Finance: PPP allows for mobilizing private sector investments in public infrastructure and the provision of public goods. This may be of importance especially for SSA governmental institutions which have limited access to finance or face high interest payments.
- Flexibility: the efficient and profit maximizing operation of a CDM project requires a high degree of flexibility ranging from the purchase of equipment, to the procurement of consultancy services for the development of PDDs, validation services and frequent verification services and finally to the undersigning of contract for the commercialisation of CERs. For all these steps, public institutions are usually bound to time consuming procurement procedures. These procedures pose a substantial barrier to CDM project development in the public sector. A private entity in contrary may manage these processes more flexible.

Still some major constraints are perceived:

- Technical and legal preconditions: the theoretically huge CDM project potential, which is outlined in section 3, is often limited in praxis through missing technical and/or legal preconditions. Some examples of these limitations are
    - Non-existence of feed in tariffs.
    - Technical limitations e.g. to the feed in of electricity due to missing capacity at substations or a lack of electricity infrastructure as a whole.
    - National legislation does not sufficiently specify the ownership of carbon rights (e.g. in Peru it is not clear whether carbon rights from Land Use Change projects are classified as natural resource (and hence state property) or whether they are bound to the land title) or do not allow for the transferral of carbon rights (e.g. Ukraine).
    - Existing contracts (e.g. for the operation of municipal landfills through private enterprises) do not sufficiently specify the ownership of CERs (which may be generated through a CDM LFG project) often leading to a deadlock between of public and private entities on the ownership of the CDM project.
- Other Political Preferences. Some of the sectors qualifying for PPPs such as the waste sector or water distribution are public goods and the population has typically a low willingness to pay for these goods. Consequently public entities establish low and subsidized tariffs for these goods resulting in a very limited potential for PPPs.

5.4 Micro-Financing for CDM

5.4.1 Characteristics of Microfinance and Micro-Energy Lending

Microfinance is generally defined as the provision of financial services for the poor and usually comprises micro-credits as well as savings for micro-entrepreneurs (Robinson 2001). The history of microfinance started in the 1970s when it was realized that international development finance, at that date predominantly huge capital transactions to governmental development banks in developing countries, did not lead to expected trickle-down-effects. The

focus of development aid hence shifted towards financial aid provided directly to target groups and the provision of loans by locally managed NGOs stood out as the most successful approach. Microloans for entrepreneurs and small businesses gained recognition as an efficient development tool and the MF industry grew rapidly (Khawari 2004; Schmidt 2009).
The success of microfinance builds on innovative lending techniques and the utilization of local information flows and consecutive loans in order to overcome informational, institutional and other barriers that limit access to credit (Ahlin / Neville 2008). Most importantly, social sanctions, for example through group lending and loan guarantors, information gathering from neighbours, friends or family members, and formal sanctions, such as the exclusion from future borrowing, serve as a substitute for collateral and the lack of information about poor borrowers (Armendáriz de Aghion / Morduch 2005). Thereby, MF succeeded in lowering information and transaction costs related to loan monitoring and risk management in contrast to the formal banking sector (Demirguc-Kunt / Levine 2008).

Microfinance has engendered great expectations as it provides access to credit for people “living in poverty who are not considered bankable” (Rao / Rao 2010) by the commercial banking sector due to a lack of collateral, steady employment or a verifiable credit history. The prevailing understanding is that the lack of access to credit is a major cause of poverty and that income-generating microloans can contribute to poverty reduction (Demirguc-Kunt / Levine 2008; Khawari 2004). While empirical evidence indicates that the success of microfinance is rather limited compared to these high expectations (Karlan / Morduch 2010; Weiss / Montgomery, 2005), studies have shown that microfinance nevertheless does bear potential to create positive impacts by overcoming financial barriers.

Over the years, the services provided by the microfinance industry have shifted from the exclusive provision of microcredit for entrepreneurs to a broader range of financial services including investments in health and education, savings, money transfers and insurance, acknowledging that financial needs of the poor are not limited to business loans (Armendáriz de Aghion / Morduch 2005; Karlan / Morduch 2010; Khawari 2004). The process of product diversification now even turns to “quality of life loans” (Srinivasan 2007) for housing and other non income-generating goods. More recently, microfinance institutions (MFIs) have also started to focus on the environment, including microloans for energy systems.

Small-scale energy projects in developing countries face substantial barriers. The most important ones include the initial capital costs, as especially renewable energy technologies provide less installed capacity per invested dollar compared to conventional energy technologies. These problems are compounded by high transaction costs due to unfamiliarity and lack of information, subsidies for fossil fuels and environmental externalities of fossil fuel-based technologies that distort the costs to society. Further barriers are the lack of access to credit for project developers and consumers as well as the lack of technical and commercial skills needed for installation, operation and maintenance. Especially in rural areas, imperfect credit markets limit access to modern energy technologies (Beck / Martinot 2004). Another specific rural-market performance barrier is the development of dispersed market structures. Also, the creation of a functioning maintenance infrastructure might be more difficult in rural areas due to a lack of skilled personnel (van der Vleuten et al. 2007).

Micro-energy loans can address especially two of these barriers. Most importantly, loans overcome the barrier of the lack of access to credit for end-users. Additionally, micro-energy loans address the cost barrier of high initial up-front costs of modern energy systems, which often are prohibitive even when fuel savings justify high investment costs (Hosier 2004), by spreading the cost over a longer timeframe. In the literature, it is pointed out that the best approach is to adjust loan instalments to prior energy expenditure for candles, kerosene, diesel, or battery charge, which is though often not possible without additional subsidies

(Martinot et al. 2001; Morris / Kirubi 2009) indicating that microfinance alone will not be able to solve energy poverty on a large scale (OECD/IEA 2010).

But experience with micro-energy lending is still limited and further investigation on how to transfer the microfinance approach to end-consumer energy finance is needed (Legros et al. 2009; UNEP 2007). For an MFI, the provision of energy services requires intensive capacity building, whereas energy companies have a clear expertise in this field. A strong partnership between energy companies and MFIs, as an alternative to an energy company offering credit or an MFI providing energy services, is thus favoured by the literature coming from both the microfinance (for example Morris et al. 2007) and the energy perspective (World Bank 2008a). In summary, microfinance can address the barrier of high up-front cost and end-consumer finance and provides opportunities to promote market-based business models with strong linkages to the private sector. However, additional subsidies are needed in order to build up sustainable market and maintenance infrastructures, support capacity building as well as to finance awareness creation among rural business and potential customers. This is where linking microfinance and the CDM may become mutually beneficial as carbon finance is one opportunity to generate further financial resources.

5.4.2 Microfinance and the CDM

Based on an initiative by Hans-Jürgen Stehr, a former member of the CDM EB, microfinance has for some time now been discussed as a potential means to promote decentralised SSC CDM projects in countries that have so far been bypassed by the CDM. The Danish foreign ministry commissioned a study to analyse the prospects of this approach and together with the EB co-hosted a seminar to discuss the study’s findings and derive recommendations for further steps. The EB integrated the results from this seminar in its 2009 report to the Conference of the Parties serving as Meeting of the Parties to the UNFCCC (CMP). To the best knowledge of the authors, this study (Bahnsen et al. 2009) is the only major research effort so far to analyse synergies between microfinance and the CDM.

Synergies exist in particular in relation to Programmes of Activities (PoAs), as both microfinance and PoAs deal with large but dispersed volumes of small units.

Particular synergies are:
- MFIs are embedded in the communities and meet with millions of households every week. As such, they are a channel to market for financial services, and financed energy services are a natural expansion.
- MFIs possess administration methods suited for widely dispersed applications.
- The CER revenue can enhance the returns of a micro-energy scheme and improve access to loans. Under specific conditions some buyers may also agree to provide a part of the CER revenue up front.
- Project participants may integrate CDM monitoring procedures into the loan monitoring and share infrastructure.

However, there are also important barriers that would need to be overcome, including:
- There is currently a lack of coordination between the energy and microfinance sectors.
- There is also lack of knowledge in both the energy and microfinance sectors of the opportunities the CDM offers.
- There is a need to minimise the number of parties involved in a project in order to decrease transaction costs.
- There may be a risk of overloading MFIs, in particular small MFIs, which needs to be further assessed.
- CDM revenues normally do not seem to exceed 5-10% of project investment costs, which may not even be sufficient to meet the CDM-specific transaction costs.

Bahnsen et al. (2009) derived the following main recommendations to further promote the linking of microfinance and the CDM:

- Projects should be organised as partnerships between MFIs and suppliers/dealers of energy devices.
- Generic Baselines and Standard CER volumes should be developed for individual energy devices in LDCs.
- There is a need to establish demonstration projects to stimulate and test different combinations of microfinance and the CDM. Such demonstration projects should start with targeted capacity building efforts with (M)FIs that already consider CERs as a potential source of financing.
- Parties should establish a CDM project preparation fund for LDCs.
- Annex I countries should commit to sourcing a certain percentage or quota of their CDM projects from LDCs.

The EB took these recommendations on board in its report to CMP 5. CMP 5 decided to request the Subsidiary Body for Scientific and Technological Advice to draft modalities and procedures for the development of standardised baselines. It also decided to establish a loan scheme for pre-financing the development of PDDs, validation and the first verification of projects in countries with less than 10 registered projects. The EB recently finalised modalities and procedures for this loan scheme and submitted it to the CMP for approval. However, the scheme is supposed to be fed from the interest accruing on the CDM Trust Fund and as such will have volume of about 3 million USD only.

The following questions stand out for further analysis:

- A further assessment of the risks of combining microfinance with the CDM (e.g. overloading of MFIs).
- An assessment of how and to what extent CDM funds in combination with microfinance can improve the economic viability of a project.
- Means of reducing PoA transaction costs, for example through reducing the number of parties involved in CDM transactions.

5.5 Conclusions

The different cross-cutting issues dealt with in this chapter all have their own characteristics and vary to a great extent. Therefore, overall conclusions are difficult to derive at this stage.

However, a few general aspects become apparent when reviewing the individual conclusions per sub-chapter:

- Every approach, be it PoAs or financing approaches such as Microfinancing or ERPAs has its own advantages and disadvantages. None of them is a panacea and careful attention needs to be paid when choosing one approach or another
- As circumstances differ from CDM project to CDM project as well as between host countries, every approach needs to be tailored to the actual case in question
- Further research is needed, in most cases not on a theoretical level, but in the form of accompanying research, in deriving lessons learnt from practical tests and / or demonstration projects of these approaches.
- For some aspects, combinations of issues for further research might be useful, such as, for example, Seed Funding for PoAs and Public Private Partnerships
- Other concepts, such as ERPAs, are fully developed and it is just a matter of promoting them in the region, again, possibly per example projects.

6 CONCLUSIONS

In a final step, the sector potentials are aggregated on a country level. The results for the REDD+ potential analysis were excluded from this final step due to the major constraints outlined in the respective chapter.

The quantitative findings are presented in Figure 13 below, outlining the emission reduction potential in kCERs by country. The results are illustrated on a sectoral basis in Figure 14. The overall technical emission reduction potential amounts to 128.6 million CERs/yr.

Figure 13: CDM Potentials by Country (in kCER/yr)

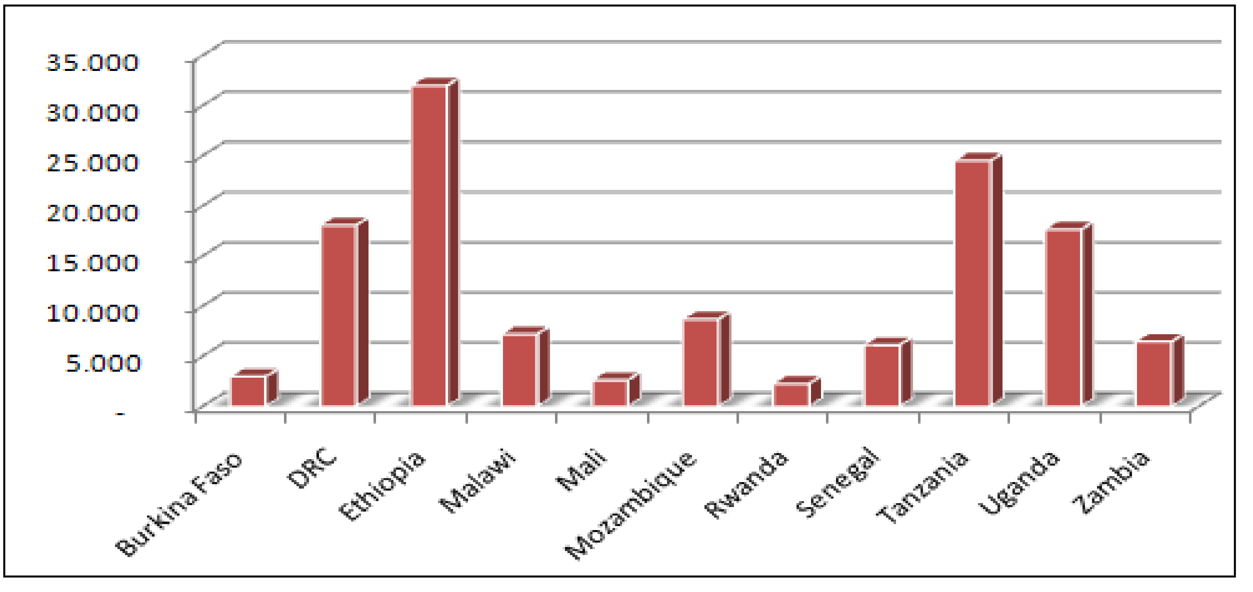
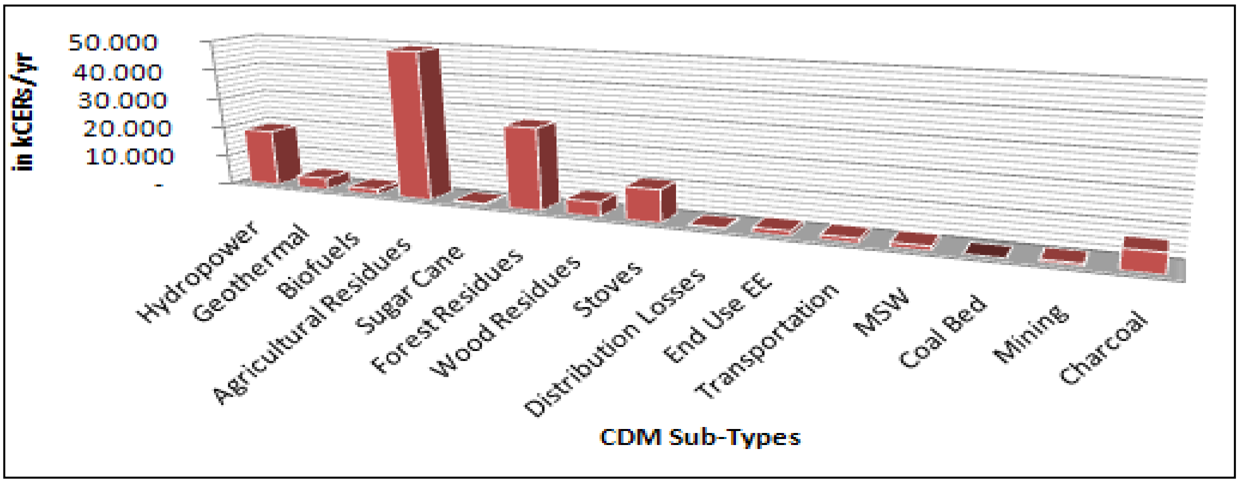


Figure 14: CDM Potentials by Sector (in kCER/yr)



Among all 11 selected countries, Ethiopia offers the largest emission reduction potential amounting to 32.0 million CERs/yr. The most significant sector is the energetic use of agricultural residues with 11.6 million CERs/yr followed by Hydropower (besides the low GEF resulting in 8.2 million CERs/yr), forest residues (8.2 million CERs) and cooking stoves (1.5 million CERs).

Tanzania is second to Ethiopia with an overall abatement potential of 24.5 million CERs/yr. Most dominant sectors are again agricultural residues (9.6 million CERs/yr), Hydropower (5.5 million CERs/yr with a lower technical potential in terms of GWh but higher GEF) followed by forest residues (3.4 million CERs/yr) and cooking stoves (2.1 million CERs/yr).

Third, DRC offers an overall emission reduction potential of 18.1 million CERs/yr. Major abatement sectors are forest residues (6.0 million CERs/yr), agricultural residues (5.7 million CERs/yr) and cooking stoves (2.6 million CERs, highest stove potential in all selected countries). Moreover DRC offers excellent opportunities in the waste sector (0.6 million CERs/yr, highest MSW potential).

Uganda features a total abatement potential of 17.7 million CERs/yr. Besides forest residues (6.0 million CERs/yr) and agricultural residues (4.5 million CERs/yr), its most important sectors are geothermal power (2.7 million CERs/yr highest in the sector), and wood residues (1.4 million CERs/yr due to its high ratio of sawnwood production). Moreover, based on good wind speeds and high GEF, there is a theoretical CDM wind project potential.

Mozambique features an overall abatement potential of approx. 8.7 million CERs. Major potentials are seen in the agricultural residue sector (4.9 million CERs/yr), forest residues (1.5 million CERs/yr) and in efficient charcoal production (0.7 million CERs/yr).

Malawi offers good abatement potentials in the agricultural sector (4.9 million CERs/yr), in the dissemination of cooking stoves (0.7 million CERs/yr) and in charcoal production (0.7 million CERs/yr).

Despite having a low GEF, Zambia’s total emission reduction potential was estimated at 6.5 million CERs/yr). Again, important sectors are agricultural residues (3.5 million CERs/yr) and forest residues (0.7 million CERs/yr), but Zambia also offers excellent opportunities in the charcoal sector (1.2 million CERs/yr, highest in the sector) and some potential in the sugar industry (0.1 million CERs/yr) and in the coal mining industry (0.04 million CERs/yr).

Senegal’s overall emission reduction potential was estimated at 6.1 million CERs/yr. Due to its high GEF, most important sectors are hydropower (3.0 million CERs/yr) and agricultural residues (1.2 million CERs/yr). Opportunities are also envisaged in the mining sector (0.3 million CERs/yr), the reduction of distribution losses (0.2 million CERs/yr, highest potential of this sector). Moreover, based on good wind speeds and high GEF, there is a theoretical CDM wind project potential.

Burkina Faso’s abatement potential amounts to 3.0 million CERs/yr. Major sectors are agricultural residues (1.6 million CERs/yr) but it also offers excellent opportunities in the End Use Energy Efficiency sector (highest potential from all countries, 0.6 million CERs/yr), cooking stoves (0.4 million CERs/yr) and some hydro power potential (0.2 million CERs/yr).

Though for Mali some sector data is not available, the overall abatement potential of the remaining sectors amounts to 2.6 million CERs/yr. Most important sectors are agricultural residues (1.5 million CERs/yr), hydropower (0.5 million CERs/yr) and the dissemination of efficient cooking stoves (0.3 million CERs/yr).

Despite being by far the smallest country in the study region, Rwanda’s abatement potential was estimated to 2.3 million CERs/yr. Major sectors are forest residues (0.9 million CERs/yr), agricultural residues (0.5 million CERs/yr) and hydropower (0.2 million CERs/yr).

The complete overview is presented in the following table.

Table 36: CDM Potential by Country and by Sector (in kCERs/yr)

Country	Hydropower	CDM Wind Project Potential (y/n)	Geothermal	Biofuels	Agricultural Residues	Sugar Cane	Forest Residues	Wood Residues	Cooking Stoves	Distribution Losses	End Use EE	Transportation	Municipal Solid Waste	Coal Bed	Mining / Cement	Charcoal	**Country Total**
Ethiopia	8.175	N	186	396	11.457	40	8.174	722	1.533	50	130	332	142	-	127	538	**32.001**
Tanzania	5.471	N	857	342	9.629	100	3.433	902	2.097	20	150	176	140	15	125	1.047	**24.506**
DRC	1.090	N	-	139	5.720	60	6.029	868	2.561	20	240	147	635	19	20	527	**18.075**
Uganda	-	Y	2.725	118	4.540	60	6.019	1.403	1.546	-	10	93	72	-	51	1.020	**17.657**
Mozambique	88	N	-	227	4.850	-	1.486	313	679	-	140	135	53	-	38	686	**8695**
Malawi	-	NA	-	77	4.915	100	460	123	720	-	30	62	34	-	20	670	**7.211**
Zambia	100	N	-	150	3.454	100	664	199	177	10	140	124	63	37	51	1.204	**6.473**
Senegal	3.035	Y	-	135	1.220	20	-	-	376	240	160	186	93	-	344	312	**6.120**
Burkina Faso	173	N	-	49	1.574	-	-	-	409	40	550	59	58	-	-	46	**2.959**
Mali	528	NA	-	25	1.474	-	-	-	278	20	70	48	60	-	-	123	**2.626**
Rwanda	187	NA	-	52	484	-	849	221	305	-	-	52	33	-	12	69	**2.263**
Sector total	**18.846**		**3.768**	**1.709**	**49.316**	**480**	**27.114**	**4.752**	**10.682**	**400**	**1.620**	**1.415**	**1.383**	**71**	**788**	**6.242**	**128.586**

Source: own compilation; empty cells do not imply non-existing potentials but indicate a lack of data

Putting the Results in Context. When comparing the aggregated data, it should be noted that differing approaches were used when analysing the respective sectors: some data were gathered following a top down approach, combining general national production data with technology-specific coefficients. Other sectors, in contrast, were evaluated pursuing a bottom-up approach, starting with the identification of possible project sites. The quality of the assessments thus differs – some are purely theoretical, others take project site-specific data and minimum project sizes into account. Therefore, the comparability of the data is limited.

In the following, the results of the table above are interpreted for the four countries with the highest reduction potential, complemented by a brief glance at the broader country-specific context.

Ethiopia shows the highest total country potential, especially in the sectors energetic use of biomass (agricultural / forest residues), as well as hydropower and cooking stoves. The country's low GEF value in this case does not play a major role, as only hydropower possibly comprises on-grid projects (there are also off-grid potentials for this project type). Ethiopia also has a functioning DNA, which runs an instructive website displaying all relevant information. Moreover, the country also pursues an active climate policy – it has, among other things, submitted a considerable list of National Appropriate Mitigation Actions under the Copenhagen Accord and has announced a national strategy to become carbon neutral by 2025 (Republic of Maldives 2010). However, despite several capacity building activities, only one forestry CDM project has been registered so far.

Tanzania, scoring second, has considerable CDM potential in the sectors agricultural as well as forest residues as well as for hydropower and cook stoves projects. Also, it has the advantage of a higher GEF, which makes grid-connected CDM projects possible. In the rift valley, there are apart from hydropower, favourable potentials for geothermal energy – a very interesting project opportunity, which could be interesting for other LDCs too. Tanzania also has a functioning DNA including a website. On the downside, only one CDM project has been registered so far, a Landfill gas recovery project in Dar Es Salaam.

Yet also the other two high-scoring countries, **DRC** and **Uganda**, offer considerable technical CDM project potentials. Their potentials are lower than in the first two countries, both stand at about 18 Mio CERs/year. DRC has a very active DNA the director of which currently chairs the African Group within the UNFCCC negotiations (Wuppertal Institute 2010). Uganda has, among other things, active project developers such as the Uganda Carbon Bureau, which is very active and has developed both a PoA for improved cook stoves and the transnational hydro PoA mentioned in the PoA section of this study. Despite its website being offline at the moment, the country has an active DNA as well as a separate authority marketing CDM opportunities (CDM in Africa Network 2010a).

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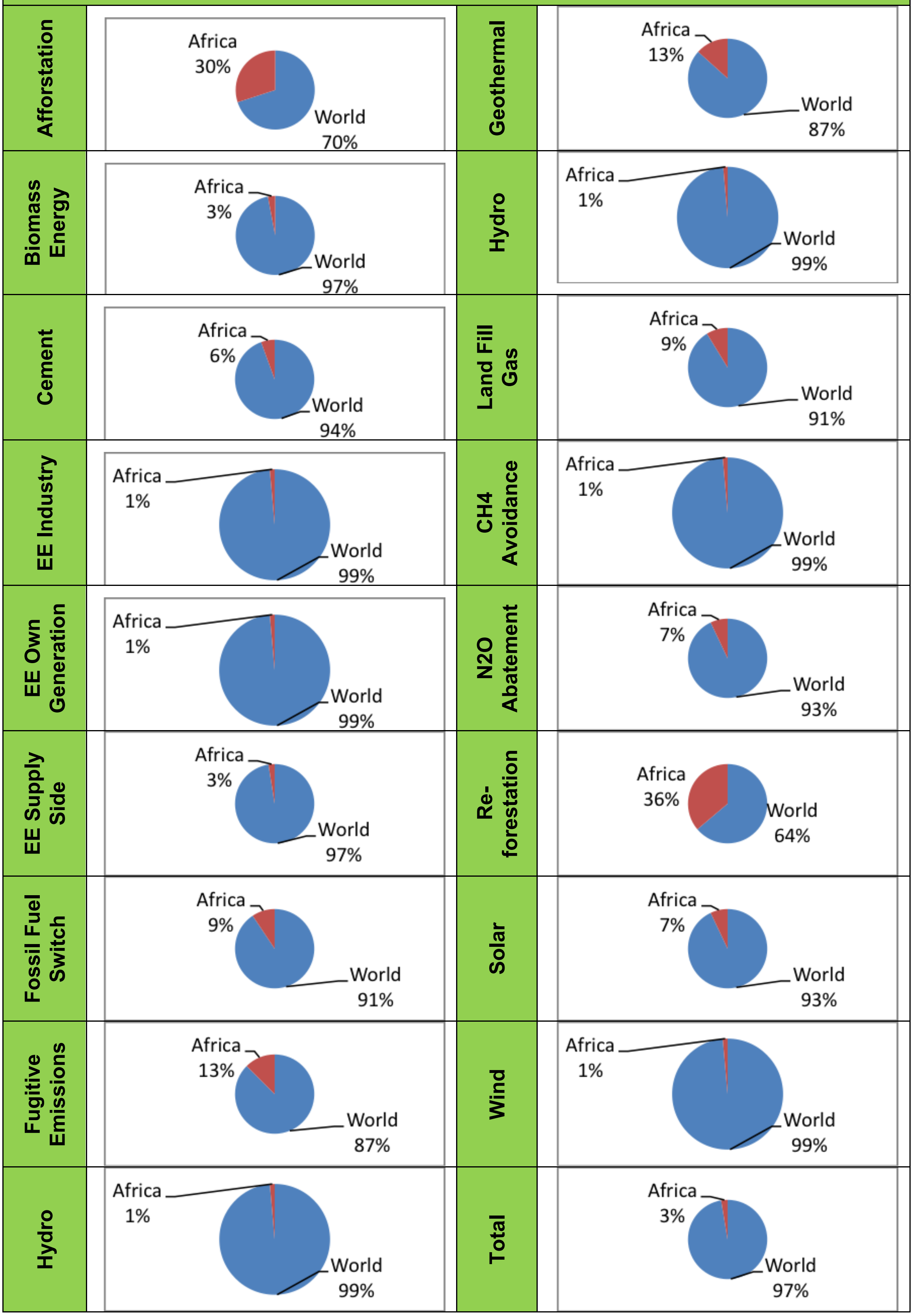
ANNEX I – BASIC COUNTRY DATA

Table 37: Basic Country Data					
	Land area	Population	Rural	GDP per Capita PPP	GDP Annual Growth Rate
Country	(in 1000 ha)	(in 1000)	(in %)	(in USD)	(in %)
Burkina Faso	27.360	14.358	81,3	1.130	6,4
DRC	226.705	60.643	67	281	5,1
Ethiopia	100.000	81.020	84	636	9
Malawi	9.408	13.570	82	700	7,1
Mali	122.019	11.968	69	1.058	5,1
Mozambique	78.638	20.971	65	739	8
Rwanda	2.467	9.464	80	738	5,3
Senegal	19.253	12.072	58	1.585	2,3
Tanzania	88.580	39.458	75	995	5,9
Uganda	19.710	29.898	87	893	5,4
Zambia	74.339	11.696	65	1.259	6,2
Source: FAO 2009					

ANNEX II – CDM PIPELINE ANALYSIS

Figure 15: Africa's Share in the CDM Pipeline



ANNEX III – CDM PIPELINE AFRICA

Table 38: CDM Project Pipeline in Africa

Country	Afforstation	Biomass Energy	Cement	CO_2 Capture	Coal Bed CH_4	Energy Distribution	EE HH	EE Industry	EE Own Generation	EE Service	EE Supply Side	Fossil Fuel Switch	Fugitive
Cameroon	0	1	0	0	0	0	1	0	0	0	0	0	0
Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	0
Congo DR	2	1	0	0	0	0	0	0	0	0	0	0	0
Côte d'Ivoire	0	1	0	0	0	0	0	0	0	0	0	0	0
Egypt	0	1	0	0	0	0	0	0	1	0	2	3	0
Equatorial Guinea													
Ethiopia	0	0	0	0	0	0	0	0	0	0	0	0	0
Ghana	0	0	0	0	0	0	0	0	0	0	0	0	0
Kenya	0	3	1	0	0	0	0	0	0	0	0	0	0
Liberia	0	0	0	0	0	0	0	0	0	0	0	0	0
Madagascar	0	0	0	0	0	0	0	0	0	0	0	0	0
Mali	0	0	0	0	0	0	0	0	0	0	0	0	0
Mauritius	0	0	0	0	0	0	0	0	0	0	0	0	0
Morocco	0	3	0	0	0	0	0	0	0	0	0	0	0
Mozambique	0	0	0	0	0	0	0	0	0	0	0	1	0
Nigeria	0	0	1	0	0	0	1	0	0	0	0	1	4
Rwanda	0	0	0	0	0	0	1	0	0	0	0	0	0
Senegal	0	2	0	0	0	0	0	0	0	0	0	0	0
South Africa	0	5	0	0	0	0	1	2	4	0	0	6	1
Sudan	0	0	0	0	0	0	0	0	0	0	0	0	0
Swaziland	0	1	0	0	0	0	0	0	0	0	0	0	0
Tanzania	0	2	0	0	0	0	0	0	0	0	0	1	0
Tunisia	0	0	0	0	0	0	0	0	0	0	0	0	0
Uganda	1	1	0	0	0	0	0	0	0	0	0	0	0
Zambia	0	0	0	0	0	0	1	0	0	0	0	0	0
Subtotal Africa	3	21	2	0	0	0	5	2	5	0	2	12	5
World	10	703	36	3	69	17	39	142	452	24	80	128	40
% Africa	0,30	0,03	0,06	0,00	0,00	0,00	0,13	0,01	0,01	0,00	0,03	0,09	0,13

Country	Geothermal	HFCs	Hydro	Landfill Gas	Methane Avoidance	N2O	PFCs and SF6	Re-forestation	Solar	Tidal	Transport	Wind	Total
Cameroon	0	0	0	2	0	0	0	0	0	0	0	0	4
Cape Verde	0	0	0	0	0	0	0	0	0	0	0	1	1
Congo DR	0	0	0	1	0	0	0	1	0	0	0	0	5
Côte d'Ivoire	0	0	0	1	0	0	0	0	0	0	0	0	2
Egypt	0	0	0	3	0	1	0	0	0	0	0	4	15
Equatorial Guinea													0
Ethiopia	0	0	0	0	0	0	0	1	0	0	0	0	1
Ghana	0	0	0	0	0	0	0	1	0	0	0	0	1
Kenya	2	0	2	0	0	0	0	8	0	0	0	1	17
Liberia	0	0	0	1	0	0	0	0	0	0	0	0	1
Madagascar	0	0	1	0	0	0	0	0	0	0	0	0	1
Mali	0	0	1	0	0	0	0	0	0	0	0	0	1
Mauritius	0	0	0	1	0	0	0	0	0	0	0	0	1
Morocco	0	0	0	3	1	0	0	0	1	0	0	6	14
Mozambique	0	0	0	0	0	0	0	0	0	0	0	0	1
Nigeria	0	0	1	1	0	0	0	0	0	0	0	0	9
Rwanda	0	0	0	0	0	0	0	0	2	0	0	0	3
Senegal	0	0	0	1	0	0	0	0	0	0	0	0	3
South Africa	0	0	2	8	3	4	0	0	0	0	0	0	36
Sudan	0	0	0	2	0	0	0	0	0	0	0	0	2
Swaziland	0	0	0	0	0	0	0	0	0	0	0	0	1
Tanzania	0	0	1	1	0	0	0	1	0	0	0	0	6
Tunisia	0	0	0	2	0	0	0	0	1	0	0	1	4
Uganda	0	0	5	1	0	0	0	5	0	0	0	0	13
Zambia	0	0	0	0	0	0	0	0	0	0	0	0	1
Subtotal Africa	2	0	13	28	4	5	0	17	4	0	0	13	143
World	15	22	1483	321	601	71	18	47	61	1	32	1029	5444
% Africa	0,13	0,00	0,01	0,09	0,01	0,07	0,00	0,36	0,07	0,00	0,00	0,01	0,03

Source: Data taken from UNEP RISOE 2010

ANNEX IV – INFORMATION ON DNAS

Table 39: DNA Contact Table

Country	Burkina Faso	DRC	Ethiopia	Malawi	Mali
Institution	Secrétariat Permanent du Conseil National pour l'Environnement et le Développement Durable	Ministère de l'Environnement, Conservation de la Nature et Tourisme	Environmental Protection Authority (EPA)	Environmental Affairs Department	Secrétariat Technique Permanent du Cadre Institutionnel de la Gestion des Questions Environmentales
Address	Avenue Bassawarga, Porte No. 392, Côté ouest de l'ex "Camp Fonctionnaire, 6486 Ouagadougou 01	B.P. 12348, Kinshasa 1, Republique Democratique du Congo	P.O.Box 12760, Addis Ababa, Ethiopia	Lingadzi House, City Centre, Private Bag 394, Lilongwe 3, Malawi	BP 2357, Bamako, Mali
Responsible / Email	Mr. B. Isidore Nonga Zongo isidorez@yahoo.com spconedd@fasonet.bf	M. NsialaTosi Bibanda Mpanu-Mpanu andrdcongo@gmail.com	Dessalegn Mesfin epa_ddg@ethionet.et	Dr. Y.M. Ntupanyama, Mrs. S. Najira yntupanyama@yahoo.com	Monsieur Boubacar Sidiki Dembele secretariat.stp@stp.gov.ml
Position	Secrétaire Exécutif de l'Autorité Nationale Designée du Mécanisme pour un Développement Propre (MDP)	Directeur de l'Autorité Nationale Désignée du Mécanisme pour un Développement Propre	Deputy Director General	Environmental Affairs Department	
Phone Nr.	(+226) 50 31 31 66 /	(+243-99) 994 3308	(+251-1)1646 4607	(+265-1) 771 111	(+223) 223 1074
Fax Nr.	(+226-50) 31 64 91	(+243-88) 4 3675	(+251-1)1646 4676	(+265-1) 773 379	(+223) 223 5867

Country	Mozambique	Rwanda	Senegal	Tanzania	Uganda	Zambia
Institution	Ministério para a Coordenação da Acção Ambiental (MICOA)	Rwanda Environment Management Authority (REMA)	Direction de l'Environment et des Etablissements Classés	Division of Environment, Vice-President's Office	Ministry of Water and Environment	Ministry of Tourism, Department of Environment and Natural Resources Management
Address	Av. Acordos de Lusaka nº 2115, P.O. Box nº 2020, Maputo, Mozambique	Kacyiru District, Kigali City, Rwanda	106, Rue Carnot, Dakar, BP 6557 Dakar Etoile	P.O.Box 5380, IBS Building, Dar Es Salaam, United Republic of Tanzania	P. O. Box 20026, Kampala, Uganda	Kwacha House, P. O. Box 34011, Lusaka, Zambia
Responsible / Email	Ms. Marília Telma António Manjate telmanjate@yahoo.com.br	Dr. Rose Mukankomeje / Mr Jean Ntazinda rwandadna@gmail.com	denv@sentoo.sn	Mr. Richard S. MUYUNGI tanzania37@hotmail.com	Hon. Maria Mutagamba minister@mwle.com	Mr. Kenneth Nkowani Kapalakonje@yahoo.com
Position		Director General / Coordinator		Assistant Director	Minister of Water and Environment	Acting Director Environment and Natural Resources Management Department
Phone Nr.	(+258-21)46 584946 6245	(+250) 025 258 0101	(+221) 821 07 25	(+255-222)11-3983	(+256-414) 504 621	(+260-01) 229417
Fax Nr.	(+258-21)46 6495	(+250) 025 258 0017	(+221) 822 62 12	(+255-222)11-3856	(+256-414) 251 797	(+260-01) 229417

ANNEX V – BASIC FORESTRY DATA

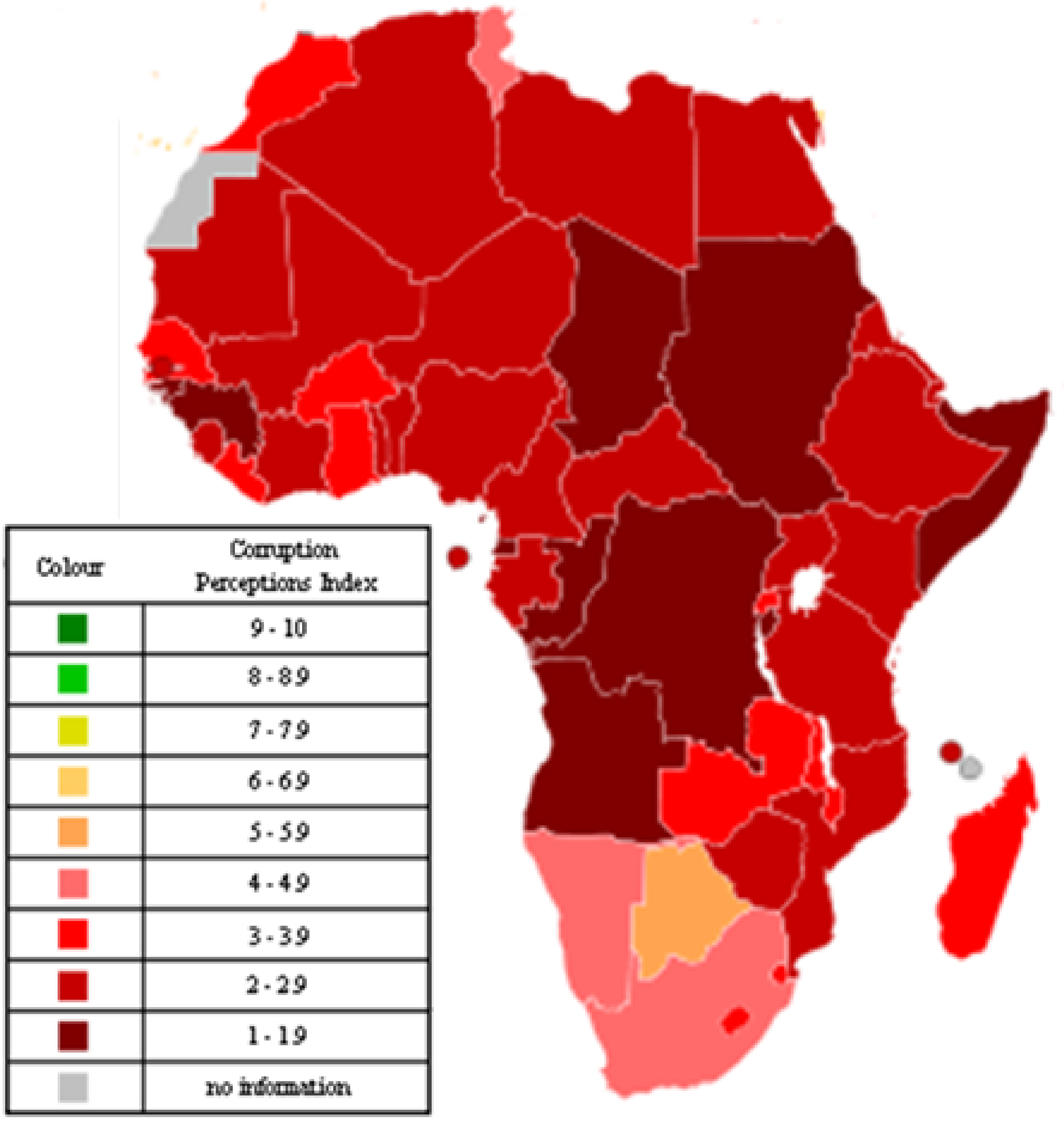
Table 40: Basic Forestry Data							
	Extent of Forest 2005			Annual Change Rates			
Country	Forest Area (in 1000ha)	% of Land Area	Area per 1000 People (in ha)	1990 - 2000		2000 - 2005	
				(in 1000 ha)	(in %)	(in 1000 ha)	(in %)
Burkina Faso	6.794	29,0	473	–24	–0.3	–24	–0,3
DRC	133.610	58,9	2.203	–532	–0.4	–319	–0,2
Ethiopia	13.000	11,9	160	–141	–1.0	–141	–1,1
Malawi	3.402	36,2	251	–33	–0.9	–33	–0,9
Mali	12.572	10,3	1.050	–100	–0.7	–100	–0,8
Mozambique	19.262	24,6	919	–50	–0.3	–50	–0,3
Rwanda	480	19,5	51	3,00	0.8	27	6,9
Senegal	8.673	45,0	718	–45	–0.5	–45	–0,5
Tanzania	35.257	39,9	894	–412	–1.0	–412	–1,1
Uganda	3.627	18,4	121	–87	–1.9	–86	–2,2
Zambia	42.452	57,1	3.630	-445	-0,9	-445	-1,0
Source: FAO 2009							

Table 41: Forest Growing Stock, Biomass and Carbon

	Growing Stock			Biomass		Carbon in Biomass	
Country	Per hectare (in m^3/ha)	Total (in mio. m^3)	Commercial (in %)	Per hectare (in t/ha)	Total (in mio t)	Per hectare (in tC/ha)	Total (in mio. t)
Burkina Faso	35	238	5	88	596	44	298
DRC	231	30833	–	347	46346	173	23173
Ethiopia	22	285	25	39	503	19	252
Malawi	110	373	–	95	322	47	161
Mali	15	191	–	39	484	19	242
Mozambique	26	496	14	63	1213	31	606
Rwanda	183	88	95	183	88	92	44
Senegal	37	324	63	85	741	43	371
Tanzania	36	1264	73	128	4509	64	2254
Uganda	43	156	15	76	276	38	138
Zambia	31	1307	7	54	2312	27	1156
Source: FAO 2009							

ANNEX VI – PCI 2009 - AFRICA

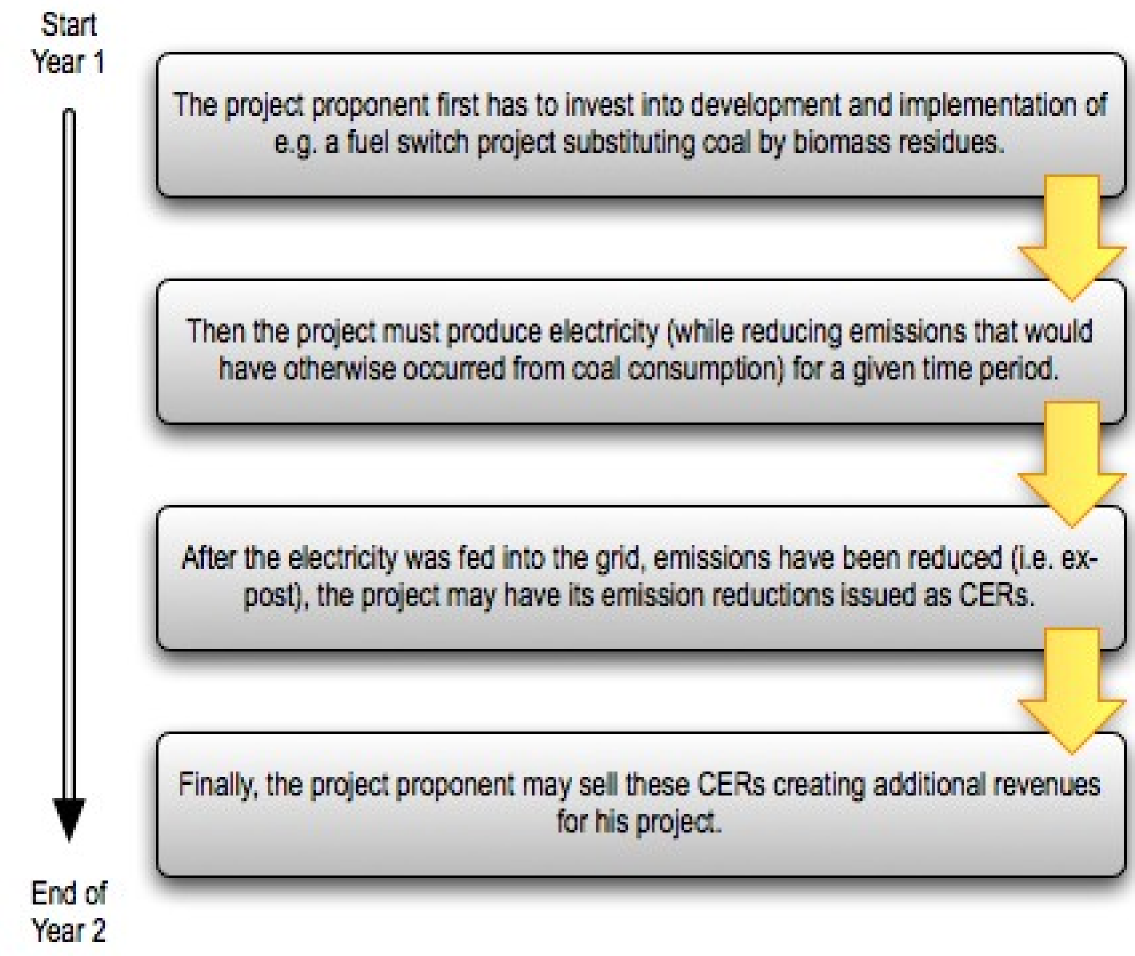
Figure 16: Perceived Corruption Matrix (PCI)- Africa



Source: adapted from Transparency International (2010).

ANNEX VII – STEPS PRIOR CER GENERATION

Figure 17: Steps Prior to Generating Carbon Revenues



The Project

The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has commissioned Wuppertal Institute and GFA Envest a research project on suitable supporting activities that contribute to the enhancement of CDM in sub-Saharan African least developed countries. The main aim of the research is to assist BMU in developing its strategy for climate change mitigation activities on the African continent.

This report assesses opportunities and challenges for the CDM in sub-Saharan Africa countries, focusing on 11 Least Developed Countries. Out of these 11 countries, BMU is going to select two countries to be assessed in greater detail.

The results and findings of the research project will be published and circulated to all project developers, political decision makers, companies, financial institutions and everyone else interested in finding ways of how to best approach the CDM in Africa.

More information on the project can be found at www.jiko-bmu.de/996

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