Standardized Baselines and their Implications for a National Monitoring, Reporting and Verification System

A Case Study for Rural Electrification in Sub-Saharan Africa

Africa at Night

Flashlight Use

PV Electrification

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ABREVIATIONS

AMS	Approved SSC Methodology
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
CAR	Corrective Action Requests
CDM	Clean Development Mechanism
CDM EB	CDM Executive Board
CER	Certified Emission Reduction
CFLs	Compact Fluorescent Lamps
CL	Clarification Request
CM	Combined Margin
CMP	Conference of the Parties serving as Meeting of the Parties to the UNFCCC
DNA	Designated National Authority
DOE	Designated Operational Entity
EC	Electricity Consumption
EF	Emission Factor
GEF	Grid Emission Factor
Gg	Giga gram
GHG	Greenhouse Gas
HH	Household
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
kW	kilo Watt (installed capacity)
kWh	kilo Watt hour
LDC	Least Developed Countries
LF	Load Factor
lmn	Lumen
lmn h	Lumen hours
MSL	Minimum Service Level
MW	Mega Watt (installed capacity)
MWh	Mega Watt hours
MRV	Monitoring Reporting and Verification
NAMA	National Appropriate Mitigation Actions
NCV	Net Caloric Value
NIR	National Inventory Report
NM	New Methodology submitted to the UNFCCC
NMM	New Market Mechanism
PoA	Programme of Activities
PV	Photovoltaic

ODA	Official Development Assistance
QA/QC	Quality Assurance/Quality Control procedures
RSA	Republic of South Africa
SBL	Standardized Baseline
SD	Suppressed Demand
SOP	Standard Operating Procedures
SSA	Sub-Saharan Africa
SSC	Small Scale
SSC WG	Small Scale Working Group
UBA	German Federal Environment Agency
UNFCCC	Unite Nations Framework Convention on Climate Change
USD	US Dollar
W	Watt

1 INTRODUCTION

This study was commissioned by the German Federal Environment Agency (UBA). It complements the study 'Strategies for the Development of Carbon Markets in African Least Developed Countries, commissioned by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and implemented by Perspectives GmbH.

The unequal distribution of the Clean Development Mechanism (CDM) is considered as major shortcoming. The Conference of the Parties (COP) of the UNFCCC notes 'equitable geographic distribution of clean development mechanism among project activities at regional and sub regional levels' (Decision 17/CP.7, Marrakech Accords). Already in 2008, Mr. Rajesh Kumar Sethi, former head of the CDM Executive Board, notes in the context of UNFCCC's press release on the occasion of the registration of the 1,000th CDM project: 'The CDM is operating in close to 50 countries, and is approaching its thousandth registered project with 128 million CERs already issued. Everyone involved can take some pride in those states, but until the potential of the mechanism is realized in the lesser developed countries, especially in Africa, we cannot rest' (UNFCCC, 2008). Ever since much time has passed and still the uptake of the CDM in Africa and other underrepresented regions is fairly limited. Currently 247 CDM projects are registered in Africa, out of a total of 5,133.

The development of Standardized Baselines (SBL) may support the Least Developed Countries in up-scaling their mitigation activities under the CDM. This may hold true as SBL offers the opportunity to include Suppressed Demand in existing methodologies.

Since 2009, the UNFCCC Secretariat engages in putting SBL into operation. The Copenhagen Accords decided that the Subsidiary Board for Technical Advice to the UNFCCC shall develop modalities and procedures for Standardized Baselines. One year later, the COP in Cancun requested the CDM Executive Board to develop Standardized Baselines which are defined as 'a baseline established for a party or a group of parties to facilitate the calculation of emission reductions and removals and/or the determination of additionality for [CDM] project activities, while providing assistance for assuring environmental integrity (Decision 3/CMP.6).

In the meantime the CDM EB provided a range of Guidelines and Procedures for SBL development and the consideration of Suppressed Demand. And as of today, the first SBLs have been developed and are submitted to the Secretariat for review and approval. The below table provides an overview on the current SBL submissions.

Table 1: Current Status of SBLs submitted to UNFCCC				
Reference	Proposal	Submitted by / on	Current Status	Last Update
PSB-0001	Proposed new standardized baselines for charcoal projects	Uganda/16 May 2012	Initial assessment successfully concluded	30 May 2012
PSB-0002	Standardized baselines for clinker production in Ethiopia	Ethiopia/24 Jul 2012	Initial assessment	14. Aug 12
PSB-0003	Standardized baseline on Grid emission factor for the Southern African Power Pool	The Republic of Botswana on behalf of Botswana, DRC, Mozambique, Namibia, Lesotho, RSA, Swaziland, Zambia and Zimbabwe / 21 Aug 2012	Initial assessment successfully concluded	21. Sep 12
PSB-0004	Standardized baseline of energy use in rice mill sector of Cambodia	Cambodia/27 Sep 2012	Initial assessment successfully concluded	10 Dec 2012
Source: UNFCCC, 2013, accessed 3rd February 2013.				

This study investigates opportunities arising from SBL development putting strong emphasis on the consideration of Suppressed Demand. Chapter 3 sketches a possible standardized emission factors for a rural electrification program in Ethiopia. In a step wise approach, national default emission data are derived for rural household lighting, other household electrical appliances and for electricity consumption by other (i.e. non-household) consumers. The study thereby investigates the application of the CDM EB's Guidelines for Suppressed Demand by defining a Minimum Service Level for household lighting, which is based on extensive data on available household lighting technologies and consumption patterns.

Moreover a range of additional issues is explored:

- Based on these findings, chapter 4 conducts an economic evaluation, which assesses the impacts of carbon revenues on a rural electrification program. The question if- and to what extent a CDM program may contribute to the operational costs of a rural electrification program and the capital costs for financing the actual renewable energy interventions.
- If SBL development may allow for the increase of baseline emission factors, how is the environmental integrity ensured? Chapter 5 discusses this question by considering baseline emissions which are based on Suppressed Demand (i.e. not based on historical emissions).
- Are there synergies between the development of SBLs and national GHG inventories? Chapter 6 screens possible synergies between SBL- and MRV development for the aggregation of Tier 2 and Tier 3data and with respect to capacity needs.
- Chapter 7 discusses the need for New Market Mechanisms to have a commonly accepted baseline emission trend. It is explored whether the existing approved methodologies may be adopted on national level as SBL to provide a commonly accepted baseline for new mechanisms.

2 METHODOLOGY

Chapter 3 investigates the potential of Standardized Baseline for rural electrification in Ethiopia. Section 3.1 explores the existing default baseline emission factors provided by the applicable methodology. The following sources of information were used:

- Approved Small Scale (SSC) Methodology (AMS) IL, Electrification of Rural Communities Using Renewable Energy, Version 01, CDM EB66.
- PÖYRY, 2011, Justification Document for Proposed New Baseline Methodology for Electrification of Rural Communities, Final Report. Section 3.2 proposes own standardized baseline emission factors. For this work, it was important to evaluate in detail the development steps of the applicable methodology. As the AMS I.L, as approved by the CDM Executive Board (CDM EB) at the Board's 66th meeting, and the Justification Document show substantial differences for the respective default Emission Factors (EF), we conducted a conference call with the Methodology Panel of the UNFCCC Secretariat. The conference call was held at the 28th September 2012.

The steps for standardization, developed in Section 3.2 strongly build on the current CDM rules and requirements related to Standardized Baselines and Suppressed Demand (SD):

- Decision 3/CMP.6, §44-52;
- Guidelines for the Establishment of Sector-Specific Standardized Baselines, Version 2 approved at EB65, Annex 23.
- Procedure for Submission and Consideration of Standardized Baselines, Version2, EB68, Annex 32).
- Guidelines for Quality Assurance and Quality Control of Data used in the Establishment of Standardized Baselines, Version 1, EB66, Annex 49
- Guidelines for the Consideration of Suppressed Demand in CDM Methodologies (EB62, Annex 6).

The standardization of EFs requires detailed country specific data for the use of baseline technologies. Lighting Africa[1], an initiative by a World Bank/IFC initiative, promotes efficient lighting technologies in selected African countries, including Ethiopia. For this purpose, Lighting Africa conducted extensive baseline studies in Ethiopia on existing lighting technologies an off-grid energy appliances. The related data were used for defining a Minimum Service Level as well as for identifying the baseline technologies for lighting in Ethiopia.

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[1] Lighting Africa is a joint IFC and World Bank program that works towards improving access to better lighting in areas not yet connected to the electricity grid. It aims at catalysing the development of sustainable markets for affordable, modern off-grid lighting solutions for low-income households. General information on the initiative may be found under: www.lightingafrica.org

Chapter 4 evaluates the economic impact of a CDM Programme of Activities on a rural electrification program in Ethiopia. Based on the findings of Chapter 3, the carbon revenues were assessed and compared to the overall capital costs for financing renewable, rural electrification activities.

Chapter 5 evaluates the environmental integrity of SBLs under the consideration of suppressed demand. This analysis evaluates the existing guidelines and procedures with respect to their provisions for quality assurance and quality control. The evaluation is supported by the Consultant's own experience in developing the first SBL to be considered by the CDM EB.

Chapter 6 assesses the synergies between SBLs and national Monitoring, Reporting, and Verification systems. This is done by comparing the capacity needs of national reporting with those required for SBL establishment.

Chapter 7 explores the use of SBLs for New Market Mechanisms. The need of New Market Mechanisms to have a transparent and commonly accepted baseline is evaluated. This need is contrasted with the current accounting of national greenhouse gas inventories. Finally the New Market Mechanism's need for baseline setting is compared to the approach for SBL development.

3 SBL FOR RURAL ELECTRIFICATION

This chapter is driven by the question, whether standardization of default emission factors for rural electrification may provide additional benefits, compared to the -already significant- default emission factors provided in methodology AMS I.L.

Hence, this section covers two technical steps for evaluating the benefits of a possible standardization of AMS I.L: First, the existing emission factors are evaluated (Chapter 3.1) . This is done based on the approved methodology. Second, Chapter 3.2 explores options for the development of alternative emission factors for rural electrification.

3.1 Evaluating the Existing AMS I.L Defaults

Scope of AMS I.L. At its 66th meeting, the CDM Executive Board approved the Small Scale methodology 'AMS I.L – Electrification of Rural Communities Using Renewable Energy[2]'. AMS I.L allows for generating Certified Emission Reductions (CERs) for renewable CDM projects which electrify rural communities that have no access to any electricity distribution system prior to project implementation. The methodology was proposed by Pöyry Management Consulting with support from the UK Department for International Development and the World Bank. It underwent significant changes based on the input from the Small Scale Working Group and the UNFCCC Secretariat before approval.

The methodology applies an innovative approach in two regards:

- First, the methodology is strongly based on the concept of suppressed demand. The baseline scenario is based on a minimum service level, i.e. the energy level required to meet basic human needs. This is in sharp contrast to common baseline scenario approaches which are based on historic data.
- Second, AMS I.L offers a highly standardized approach. It proposes the use of three default emission factors which can be applied without further evidence or reference documents. In this regard, AMS I.L is in line with the Secretariat's efforts to increase the standardization of the CDM (and hence its applicability).

The result is a fairly simple methodological concept which is easily applicable in the context of Least Developed Countries which are often hampered by data availability.

Evaluation of Default Emission Factors. Subsequently, the methodology AMS I.L is evaluated in more detail. It is based on three default Emission Factors (EF) which are linked to different energy services. The exact energy services and the emissions related to them are not explicitly stated in AMS I.L; however, they are well documented in the background documents (Pöyry 2011 and SSC Working Group 34). The default Emissions Factors are as follows:

[2] Please refer to AMS I.L, Version1.

- For the first 55 kWh consumed by a household (HH), an EF of 6.8 tCO_2/MWh is applicable (AMS I.L, Version 1, §9.a). This EF is based on electricity consumption for household lighting services (Pöyry, 2011, p11f).
- It is assumed that further electricity consumed per HH (up to 250kWh per year) is used for other household appliances. For this electricity consumption, a default EF of 1.3 tCO_2/MWh is applicable (AMS I.L, Version 1, §9.b). This EF considers emissions related to the electricity consumption of other household appliances, such as TV, radio, fans, cell phone chargers etc. It is further assumed that the electricity consumption of other household appliances is met by a mini-grid served by a diesel generator (SCC WG34, §5.iii).
  This is in contrast with Pöyry's initial proposal of an EF of 3.4 tCO_2/MWh. This is based on the default EF of a small scale diesel generator (EF: 2.4tCO_2/MWh) and a battery loading efficiency of 75% (Pöyry, 2011, p15). Thereby Pöyry referred to the default EF of a diesel generator with an installed capacity below 15 kW and a load factor of 25% or less (AMS I.F, §13).
- Finally, for any electricity consumption above 250 kWh/yr by households or other electricity consumers (e.g. SMEs), a default EF of 1 tCO_2/MWh is applicable (AMS I.L §9.c). This emission factor is based on the default EF for a diesel generator with an installed capacity of 135-200 kW and a load factor of 50% (cp. SSC WG34, §5.iv).

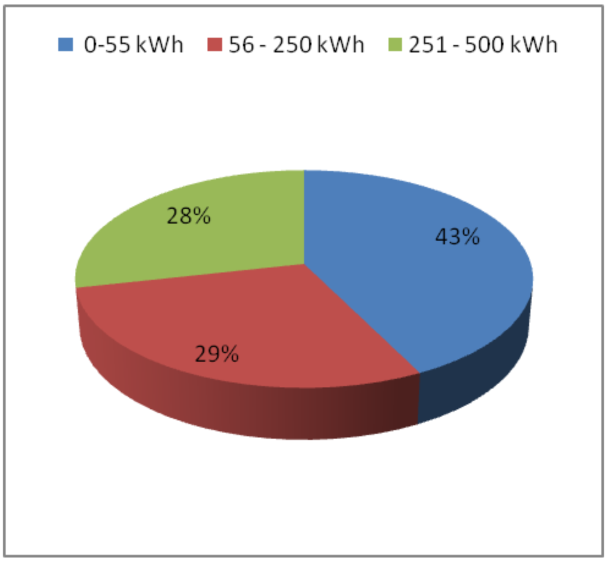
Model Calculation for One Household. Based on these default emission factors, this section presents a model calculation for a single household. This calculation determines the volume of CERs that can be generated by a rural electrification project, based on renewable energy. The calculation is based on the assumption that the household consumes 500 kWh/yr. This value was chosen to allow for the analysis of the different default values of the methodology as presented in Table 2 below, despite the fact that actual average household consumption is still lower in Ethiopia (see Annex III: Ethiopian Electricity Consumption in a Global Context). However, this assumption is still in line with values of electricity consumption in rural households in other developing countries ranging from 228 to 768 kWh/yr/HH as stated in Pöyry, 2011, Table 1, p10.

Table 2: Default Factors of AMS I.L

Baseline Emission Source	Accumulated Electricity Consumption (in kWh per HH/yr)	Emission Factor (in tCO_2/MWh)	Baseline Emissions (in tCO_2/yr)
HH Lighting	0-55 kWh	6.8	0.374
Other HH Appliances	56 - 250 kWh	1.3	0.254
Other Consumers	251 - 500 kWh	1	0.250
	Sub-total (for 500kWh)	N.A.	0.878

Source: Calculated based on AMS I.L, Version 1

Figure 1: Share of Baseline Emissions for 0.5MWh EC



Source: Calculated based on AMS I.L, Version 1.

As can be seen from the table above, the methodological approach laid out by AMS I.L results in 0.374 tCO_2 for the first 55kWh/HH/yr.

The electricity consumption (EC) from 56-250 kWh/HH/yr accounts for 0.254 tCO_2.

Based on above assumption of 500 kWh/HH, the consumption from 251-500 kWh/HH/yr amounts to 0.250 tCO_2. As a result, a rural electrification program may generate 0.878 CERs per HH and year.

The figure to the left shows the contribution of the specific EFs to the overall baseline emissions of one household: Despite making up for only 11% of the total household electricity consumption, the first 55kWh account for 43% of the household's baseline emissions. The categories 56-250 and 251-500 kWh make up for 29% and 28% respectively. Annex II provides a figure comparing the emission factors with their related baseline emissions.

Context Evaluation. In a concluding step, the above findings are evaluated in a broader context. The above determined 0.878 CERs/HH sum up to 1.756 CERs/MWh. As reference the following other baseline emission factors may be used:

- Annex IV provides data on all Grid Emission Factors (GEF) which have been submitted to UNFCCC up to date. This data was aggregated by the Institute for Global Environmental Studies (2012). It shows that the average Combined Margin (CM) amounts to 0.824 tCO_2/MWh.
- Default emission factors for larger diesel sets range from 0.8 to 1.3 tCO_2/MWh (AMS I.F, Version 2, §13).

Comparing baseline emissions determined under AMS I.L (1.756 tCO_2/MWh) with average GEF, the AMS I.L baseline emissions amount to 213% of the average GEF value. The baseline emissions are also considerably higher than the defaults of larger diesel generators. Such high baseline emissions are well justified: The selection of kerosene pressure lamps as baseline technology for lighting, for example, demonstrates the conservativeness of the approach. Despite the fact that this type of lamp is not (yet) commonly used to provide lighting, it was chosen instead of the roughly 10 times less efficient but widely used kerosene wick lamps. Furthermore, off-grid demand is usually covered by small diesel generators, which have usually much higher emission factors than the national grid. Last not least, the AMS I.L baseline emissions already include suppressed demand which is also not included in the GEF value.

Conclusion. AMS I.L, Version 1, offers a high degree of standardization. Moreover, the concept of Suppressed Demand, defined as a minimum energy consumption level, leads to substantial CER volumes per unit renewable energy.

3.2 Standardization of Rural Electrification Defaults for Ethiopia

Chapter 3.1 concludes that AMS I.L features a high degree of standardization combined with substantial emission factors based on Suppressed Demand. Against this background, this Chapter is driven by the question, whether the further standardization of EFs allows to exceed the default EFs provided by AMS I.L. The subsequent approach for standardization is based on an enforced emphasis on suppressed demand for lighting technologies as well as the investigation of load factors for off-grid diesel generators. The sketch for the standardized baseline is developed for the following regional scope:

- The concept for the standardized baseline is development for the Federal Democratic Republic of Ethiopia. The country was chosen by the Federal Environment Agency and the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).
- If national data was not available, regional data covering Sub-Saharan Africa (SSA) or from single SSA countries was used.

Subsequently, we investigate options for increasing the baseline emissions through standardization following the Pöyry's stepwise approach, starting with HH lighting, other HH appliance and concluding with baseline emissions of other consumers.

3.2.1 Household Lighting Baseline Emission Factor

Defining a Minimum Service Level. Following the methodology justification document (Pöyry 2011, p12ff), in a first step a benchmark for a Minimum Service Level (MSL, i.e. in terms of lighting services) is established. The original approach proposed by the methodology justification document was not followed due to a lack of detailed data (SSC WG34, §3.ii). This issue is picked up in below sections based on detailed data sets for Ethiopia.

Pöyry (2011, p13) established a satisfied demand level of two Compact Fluorescent Lamps (CFLs) with a power rating of 15W. This was done in the context of the IEA's definition of a minimum energy service level (IEA, 2010, p19). Pöyry states (2011, p13) that 'the lighting levels of two 15W CFLs is approximately 1,700 -1,800 lumens from the lamp'. Mills (2003, p11) documents an output of 873 Lumen for a 15W CFL. Consequently, the satisfied demand level is determined at 1,746 Lumen per household.

Conclusion. MSL of lighting was defined at 1,746 lumen per household (AMS I.L.)

Determining the Baseline Technology. The Executive Board established Guidelines on the Consideration of Suppressed Demand in CDM Methodologies (CDM EB68, Annex 2). We subsequently follow these to strengthen the applicability of SD. CDM EB68, Annex 2, §13 proposes four steps to identify the appropriate baseline technology under a suppressed demand scenario. These steps are applied based on a detailed market analysis for lighting appliances, conducted by Lighting Africa Lighting Africa, 2008. One of Lighting Africa's focus countries is Ethiopia the current lighting practices of which are analyzed in depth, covering lighting hours, number of lighting devices per household, current lighting technologies etc. The sample size for Ethiopia was 1006.

- **Step 1: Identification of Alternative Technologies.** In a first step, the available lighting technologies are screened. These are:
    - Simple kerosene lamp with no cover;
    - Kerosene lamp with cover;
    - Pressurized Kerosene lamp;
    - Firelight, and
    - Candle.
- **Step 2: Compliance with Local Regulations.** All technologies are in compliance with local regulations.
- **Step 3: Rank Technologies by Decreasing Efficiency**. In this step, efficiency is defined as lumen hours (lmn h) by liter of fuel consumption. The efficiencies of different technologies are presented in the table below. The following methodological approach is applied:
    - Market penetration data was taken from Lighting Africa (2008, p79)[3].
    - Fuel consumption and lumen output-data was taken from Mills (2003) who tested various technologies.

[3] Please note: The survey covers flashlights (8.93%). Lighting Africa (2011, p17) states 'that the low usage of flashlights … reflects the fact that flashlights are mainly used to light the way to the toilet outside or as a backup light and not as a main device to light the living room'. Consequently, flashlights were not included in step 1 above nor considered here. Moreover, the survey showed that 8% of the population used 'Light bulb in a socket'. As the SBL focuses on off-grid electrification, this baseline technology was removed. Finally, please note that he survey collected information on the 'lighting technology applied last night'. There were a few persons using more than one technology. Hence survey results were normalized to 100%.

Table 3: Efficiencies of Different Lighting Technologies					
Type	Pressure Lamp	Lamp with Simple Wick and No Cover	Lamp with Cover	Candles	Firelight
Market Penetration in Ethiopia (in %)	0.00%	70.41%	14.29%	4.08%	11.22%
Fuel Type	Kerosene	Kerosene	Kerosene	Parafine Wax	Un-/Sustainable Firewood
Lumen Output (in lmn)	1300	7.8	45	13	Variable
Fuel Consumption (in l/hour)	0.07906	0.0102	0.0297	0.0025	N.A.
Efficiency (in lmn h/l)	**16,443**	**767**	**1,513**	**4,333**	**N.A.**

- **Step 4: Barrier Test.** None of the above technologies faces barriers related to income, infrastructure, operating skills, or technological barriers.
  EB68, Annex 2, §13.d proposes a penetration threshold of 5% as indication for a technological barrier. Pressure lamps are currently not being used in Ethiopia (i.e. penetration share 0%). However, 9% of households and 12% of businesses consider pressure lamps their preferred type of lighting, indicating that the technology is widely known (Lighting Africa 2008).
- **Step 5: Identification of First Technology to Meet MSL.** Finally, EB68, Annex 2 notes: 'The first alternative ... that is able to meet the MSL under realistic conditions is deemed as the baseline technology'. Of the above mentioned technologies pressurized kerosene lamps are the only alternative that can realistically meet the MSL. To meet a light output of 1746 lmn, 39 units of the second most light emitting technology, kerosene lamps with cover, would be needed. Considering the high fuel costs of alternative technologies and the relatively low lumen output of the alternative technologies and it is deducted that pressure lamps will be the most likely, the 'first' in terms of efficiency (see table above) and only technology to meet the MSL lumen output. Hence pressure lamps are identified as baseline technology.

Conclusion. Pressure lamps are identified as baseline technology.

Determination of the Baseline Emission Factor for Lighting. Moreover, as the baseline technology is identified, it is possible to determine the baseline emission factor. The following methodological steps are applied:

- The Tier 1 Net Caloric Value (NCV) of Kerosene was taken from the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006, page 1.18).
- The Tier 1 EF for Kerosene was taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, page 1.23.
- The density of Kerosene was determined based on Ethiopia's annual average temperature (61°F) and a corresponding density / temperature matrix (www.simetric.co.uk). This amounts to 0.81716 kg/l.
- Combining the above coefficients allows determining the baseline lighting emissions: The emissions amount to 0.16gCO2 per lmn h. Considering that the lamp emits 1300 lumen, this amounts to 0.2 kgCO2/h.At an MSL of 1,746, this corresponds to 273 gCO2/h or 0.5 tCO2/yr (based on five working hours per day, 365 days per year.)
- This finally allows determining the baseline emission factor by dividing the 'Emissions at MSL' with the actual energy consumed for lighting services (i.e. 55 kWh/HH/yr).

Table 4: Pressure Lamp Emission Factor at MSL

Item	Value
Efficiency (in lmn h/l)	16,443
NCV (in TJ/Gg)	43.8
EF (in tCO_2/TJ)	71.90
Density (in Gg/l)	8.172E-07
Emission Factor (in gCO_2/h)	203.45
Emission Factor (in gCO_2/lmn h)	0.16
EF at MSL, i.e. 1746 lumen (in gCO_2/h)	273.25
Emissions at MSL (tCO_2/HH/yr)	0.50
Emission Factor (in tCO_2/MWh)	9.11

Conclusion. The baseline emission factor for lighting amounts to 9.11 tCO_2/MWh which significantly exceeds the volumes determined by AMS I.L, §9.a. This value was derived conservatively by further exploring the options of suppressed demand for lighting based on a detailed data set for Ethiopia.

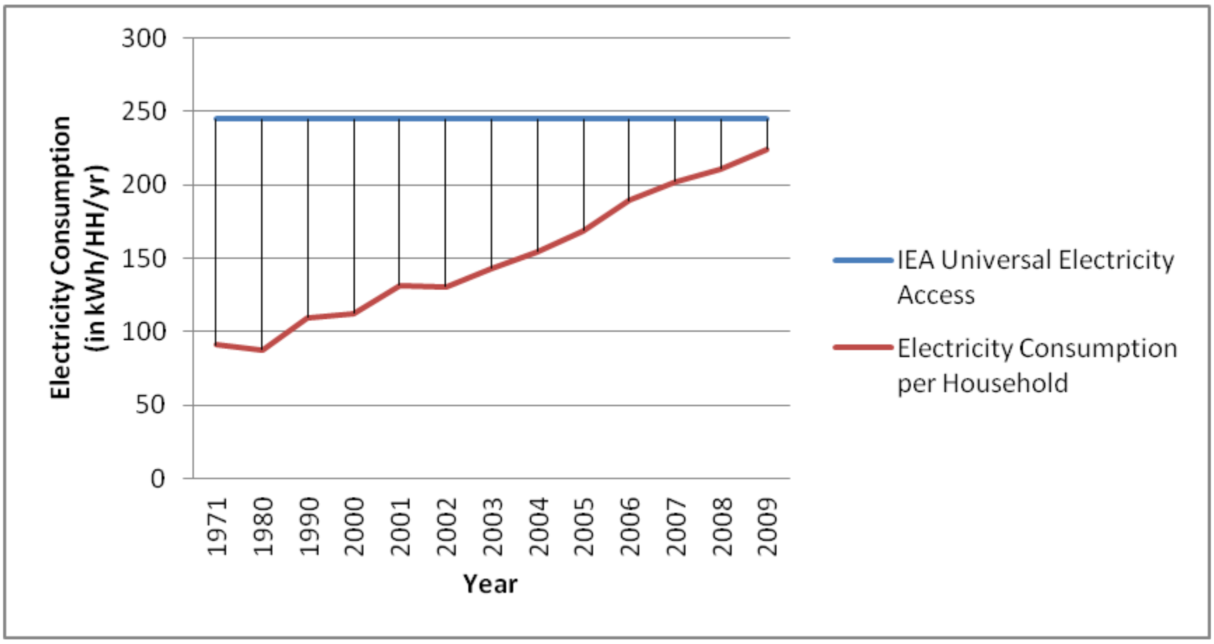
3.2.2 Baseline Emission Factors of other HH Appliances

Electricity Consumption in Ethiopia. Ethiopia is characterized by low electricity consumption patterns per capita. The actual consumption in 2009 amounts to 45.76 kWh/yr and person (IEA Statistics, 2011). Annex III puts the electricity consumption in Ethiopia in a global context: It shows that the electricity consumption per capita (data from 2008) is the lowest from all 30 countries which are compared.

This data was extrapolated at household level. Ethiopia's Central Statistical Agency (2008) reports an average rural household size of 4.9 persons. The below figure illustrates the increase of electricity consumption per household (based on a fixed household size of 4.9 persons). The IEA defines an 'Universal Electricity Access Case' (2009, p.132): 'Basic electricity consumption in rural areas is assumed to be 50 kWh per person per year'.

Considering this electricity consumption volume per person and the rural household size, the minimum electricity consumption level amounts to 245 kWh per HH, per year. This is value is illustrated as the blue line 'IEA Universal Electricity Access' in below graph. The analysis shows that the average electricity consumption level in Ethiopia is below the minimum value defined by the IEA.

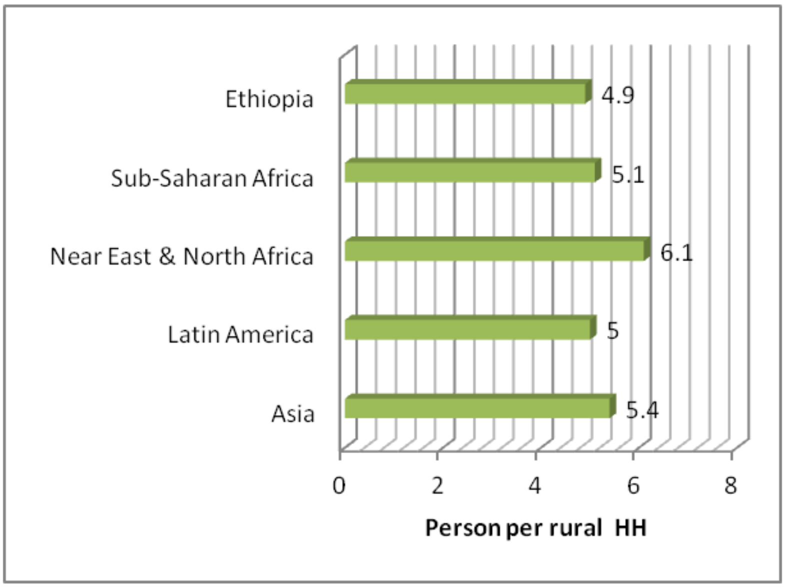
Figure 2: Development of Electricity Consumption in Ethiopia



Source: Based on data from A) IEA Statistics and B) Central Statistical Agency of Ethiopia, 2008

Minimum Service Level for Household Energy Consumption. Against the above context, an MSL for electricity consumption at household level is elaborated. The IEA (2010, p19) defines the minimum electricity consumption level for a rural household at 250kWh/yr. This value was proposed by Pöyry (2011, p10) and adopted in AMS I.L (§9.b). In 2009, the IEA (page 132) defined the 'Universal Electricity Access Case' which specifies a minimum electricity consumption level of 50 kWh per person. Both definitions are consistent, if an average rural household size of five persons is assumed.

Figure 3: Rural HH Size in the Developing World



Source: Based on data from Bongaarts (2001, p25) and Central Statistical Agency of Ethiopia (2008).

This assumption seems reasonable as the average HH level in the developing world ranges in this size. John Bongaarts, Vice President of the 'Population Council', evaluated the average size of rural HH (2001). His findings show values ranging from 5.0 (Latin America) to 6.1 persons (Near East and North Africa). However, for the specific case of Ethiopia, the average, rural household size amounts to 4.9 persons (CSA, 2008). Based on CSA's lower value and based on IEA's 2009 definition, the minimum service level for electricity consumption at rural household level in Ethiopia is defined at 245 kWh per year, per HH, which is considered as conservative.

Determination of the Baseline Emission Factor for HH EC. In a next step, the emission factor for household electricity consumption is evaluated. For electricity consumption at HH level (i.e. up to 250 kWh) AMS I.L determines a default EF of 1.3 tCO_2/MWh (AMS I.L, Version 1, §9.b). It is assumed that this electricity demand is met by a mini-grid served by a diesel generator (SCC WG 34, §5.iii) with an installed capacity in the range of 15-30 kW, with a load factor of 50%. The default emission factors for diesel generators are provided in table below.

Table 5: Default Emission Factors for Diesel Generators

Installed Capacity	Load Factor		
	25%	50%	100%
0-15 kW	2.4	1.3	1.2
15<35 kW	1.9	1.3	1.1
35<135 kW	1.3	1.0	1.0
135>200 kW	0.9	0.8	0.8
200 kW and more	0.8	0.8	0.8

Source: AMS I.F, Version 2, §13

For the determination of the appropriate emission factor, in the following the two determining factors, size and load are discussed. As for the former, we could not identify the average size of diesel generators in rural areas in Ethiopia. This study therefore adopts the size as determined by SSC WG34, §5.iii.

Second, the typical load factor for diesel generators in Sub-Saharan Africa is assessed. As shown by the table above, diesel generators operate more efficiently at full load. Hence the emissions per unit of electricity produced decrease by an increasing load factor.

It is common understanding that any off-power generation system needs to accommodate the peak demand. Consequently, off-grid systems are typically oversized and operate at low load factors. Contreras (2008) evaluated dimensioning parameters for rural electrification by diesel generators in Sub-Saharan Africa (i.e. in Senegal).

In order to adequately dimension the diesel generator for a mini grid, the data on the peak demand and the transport loss factor are required. Based on these, the installed capacity of diesel generators may be determined by the following formula (Contreras, 2008):

$$P_{eng}(kVA) = \frac{1.2}{1000\,x0.9}\; x\; \frac{P_{peak}}{f_1} \quad (2)$$

Whereas

P_{eng}:	Engine capacity in kVA
P_{peak}:	Peak demand in W
f_l:	Transport loss factor

Box: What is a Load Factor?

The load factor (LF) determines the average utilization rate of a power generation unit. It is usually calculated on an annual basis by comparing the maximum output (i.e. at full load) by the actual output.

To give a practical example: A hydropower plant features an installed capacity of 1 MW. In a given year, the electricity output amounts to 2,628 MWh. The maximum output is determined by 1 MW x 24h x 365d equaling 8,760 MWh. The LF is determined by dividing the actual output by the maximum output which results in a load factor of 30%.

$$LF_n = {Actual\ Output_n}/{Maximum\ Output} \quad (1)$$

Whereas:

LF_n:	Load Factor in %
Actual $Output_n$:	Actual electricity generated in year n, in MWh
Maximum Output:	Maximum electricity output of the power plant at full load in any year, in MWh

In a next step, the relation of average demand to the peak demand is evaluated. Here, peak demand is defined in a narrow sense, i.e. as the highest electricity demand in one year, which is usually determined based on hourly- or half-hourly data.

A literature review was conducted to identify appropriate default factors. IEA (2012, p14) notes: 'The power balance challenge for mini-grids in remote communities is increased by load profiles which are often highly variable, with the peak as high as 5 to 10 times the average load'. Elamari et al. come to the identical conclusion (2011, p842): 'This is not an easy task considering that remote communities are characterized by highly variable loads with peak load as high as 5 to 10 times the average load.' Pelland et al. (2011, p2) report on an average to peak ratio of 259% based on a detailed monitoring of one single hybrid system. Moreover Prof. Luis Vargas Díaz from the Universidad de Chile, Facultad de Ingeneria Electrica provided data on a Diesel mini grid in the North of Chile, Huatacondo, where the average to peak ratio amounts to 222%.

Table 6: Determination of the Average to Peak-Demand Ratio	
Source	Value
IEA, 2012	500%-1000%
Pelland, 2011	259%
Elamari, 2011	500%-1000%
Data from Huatacondo, Chile (unpublished)	**222%**
Average to Peak Demand Ratio (Data from 7 Sub-Saharan Countries)	143%

Finally, the load data from eight Sub-Saharan African countries was evaluated. On the one hand, this data is a sound data source, as it is based on full time monitoring of load over one whole year (8,760 data points, or 17,520 in case of half-hourly data). On the other hand, it is assumed that national grids feature fewer fluctuations, as they have a larger number of clients. By contrast, small isolated grids have fewer opportunities to balance high demands. Annex V provides the load duration profiles as the result of the evaluation of the demand in eight Sub-Saharan countries. The mean average to peak ratio amounts to 143%.

In sum, there is a wide range of average to peak demand ratios. Even if the most conservative value is applied (143%), then one household with an average demand of 1 kWh/h (assumed for simplicity, or alternatively 250 kWh / 8760 h) may have an average peak demand of at least 1.43 kW.

Table 7: Technical Transmission Losses	
Item	Value
AMS II.J, §12 (transmission)	10%
ERA Uganda, 2011, p36 (transmission)	15%
AMS I.A, §8 (for rural distribution)	**20%**

The appropriate design of the installed capacity of a diesel mini-grid – as stipulated by formula (2) above – requires the determination of a transmission loss factor, or, in UNFCCC terms, the technical transmission losses. The table at the left provides a review of existing default values.

From all values identified, the value provided by AMS I.A is considered as most appropriate, as it refers to the technical transmission and distribution losses in rural areas. This value is applied for the further analysis. Hence, the transmission loss factor is determined as 1 – 20%, i.e. 0.8.

Table 8: Determination of Installed Capacity	
Item	Value
Average Consumption (in kW)	1.00
Peak Demand (in %)	222%
Transmission Loss Factor	0.80
Installed Capacity (in kW)	**3.70**
Load Factor (in %)	**27%**

Finally, as the input data for formula (2) have been discussed, the installed capacity for a diesel generator can be determined.

Feeding the input data in formula (2) shows that, based on an average consumption of 1 kW, the appropriate installed capacity would amount to 3.70 kW. The corresponding load factor amounts to 27%.

The load factor now allows identifying the appropriate emission factor for diesel mini-grids in Table 5. Based on the above findings, the previously proposed emission factor of 1.3 tCO_2/MWh is considered as inappropriate; merely an emission factor of 1.9 tCO_2/MWh is appropriate.

Note on the Application of Car Batteries and Related Efficiencies. As discussed above, Pöyry considered the use of car batteries which are charged at rural mini-grid diesel systems. Hence, Pöyry (2011, p15) divided the related default emission factor by the charging efficiency (i.e. 75%) thereby increasing the emission factor by 25%. This approach was rejected by the SSC WG34, §5.1.
The use of car batteries was evaluated for Ethiopia, but was found to be inappropriate. Lighting Africa (2008, p70) found that only 1% of traders used car batteries (out of a sample of 400 shops). It is assumed that the penetration ratio at household level is lower. Hence the related efficiency losses were not considered in for the standardization of baseline EFs.

Conclusion. The baseline emission factor for household appliances is determined at 1.9 tCO_2/MWh.

3.2.3 Baseline Emission Factors of other Consumers

For electricity provided to other consumers (i.e. defined as electricity above 250 kWh/yr supplied to a single consumer), AMS I.L determines a standard EF of 1.0 tCO_2/MWh (AMS I.L, §9.c). This is related to the emission factor of mini-diesel grids with an installed capacity of 35- 135 kW and a load factor of 50%.
As elaborated in section 3.2.2, off-grid systems are characterized by low load factors. In analogy to the above, a load factor of 25% seems appropriate. Consequently, a higher emission factor is applied. The corresponding EF amounts to 1.3 tCO_2/MWh (please refer to Table 5 above).

Conclusion. The baseline emission factor for ‘other consumers’ is determined at 1.3 tCO_2/MWh.

3.3 Comparing Default Emissions Factors with Standardized Factors

Chapter 3.1 evaluates the existing EFs as approved by AMS I.L, §9, while chapter 3.2 discusses whether it is appropriate to propose higher EFs for rural electrification activities in Ethiopia. Two findings lead to the proposal of higher emission factors:

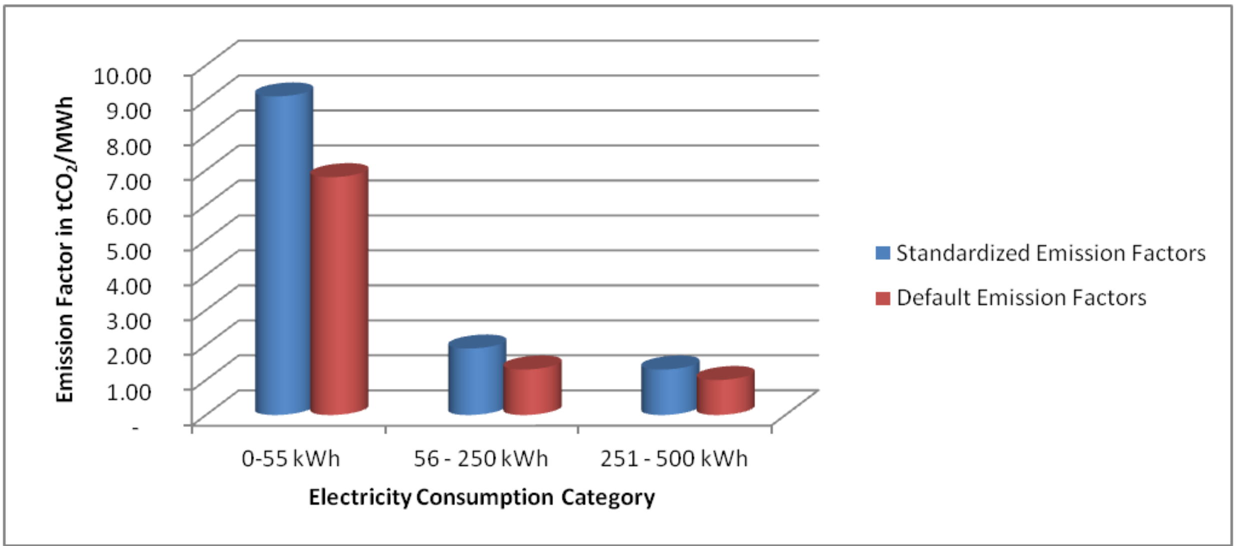
- Strong emphasis on suppressed demand combined with reliable data on current lighting technologies and related emissions lead to the standardization of the EF for household lighting. A standardized EF of 9.1 tCO_2/MWh is proposed for Ethiopia. Compared to AMS I.L, this means an increase of the EF by 25.3%, resulting into an increment of 0.13 CERs per HH.
- Second, the choices of load factors are reviewed. It is found that mini-grid diesel generators are generally operating at a lower load factor than assumed by AMS I.L. As a consequence, the EFs for 'Other Household Appliances' and 'Other Consumers' were increased to 1,9 tCO_2/MWh and 1.3 tCO_2/MWh respectively. This results in an increase of 0.28 CERs per HH and year (assuming that one HH consumes 0.5 MWh/yr).

These findings are presented in below table:

Table 9: Comparison of Default and Standardized Emission Factors

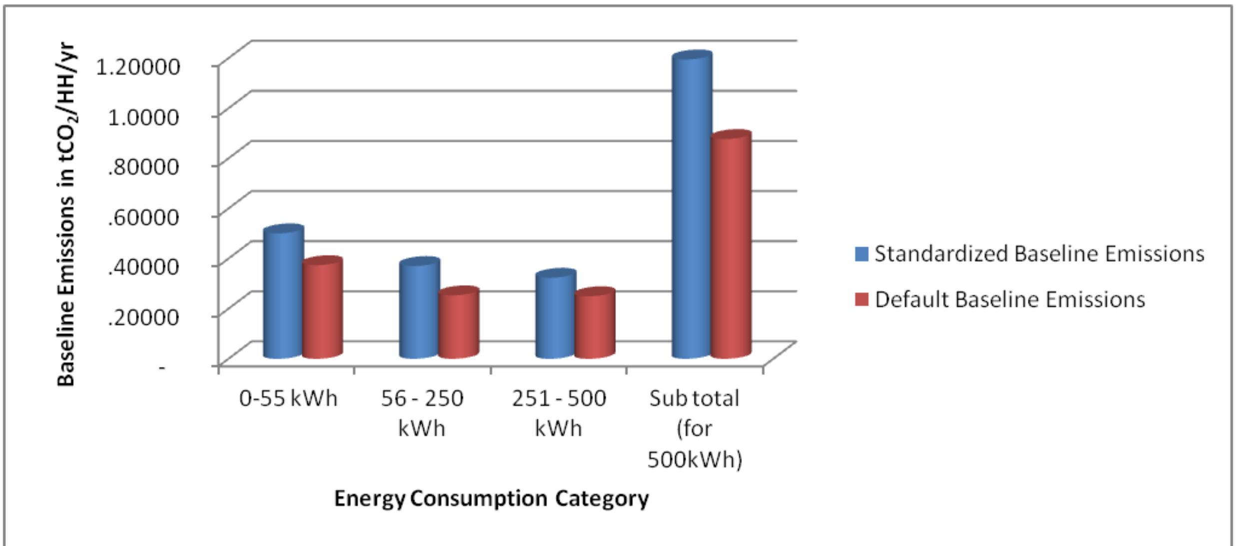
		Default Emission Factors of AMS I.L		Standardized Emission Factors	
Baseline Emission Source	EG per HH/yr	EF (tCO_2/MWh)	Baseline Emissions (tCO_2/yr)	EF (tCO_2/MWh)	Baseline Emissions (tCO_2/yr)
HH Lighting	0 - 55 kWh	6.8	0.374	9.11	0.501
Other HH Appliances	56 - 250 kWh	1.3	0.254	1.9	0.371
Other Consumers	251 - 500 kWh	1	0.250	1.3	0.324
	Sub total (for 500 kWh)		**0.878**		**1.195**

Figure 4: Figure 4: Comparison of Default- and Standardized EFs



The graph above illustrates the comparison of emission factors (i.e. tCO_2/MWh) for different electricity consumption categories.

Figure 5: Comparing Default and Standardized Baseline Emissions



The graph above illustrates the comparison of baseline emission factors per electricity consumption category and the overall total per HH on an annual level. The bars at the right (blue for the standardized approach, red for the default EFs, as specified in AMS I.L) present the aggregated baseline emissions over all three energy consumption categories.

This result demonstrates that the standardization approach developed in Chapter 3.2 allows to significantly increase the baseline emission factor. This leads to a significant increase of CERs per household to be generated by a rural electrification program.

4 ECONOMIC EVALUATION OF CARBON REVENUES

This chapter evaluates the potential carbon revenues for a rural electrification program in Ethiopia. For this purpose, a general cost structure for a rural electrification support program was established. The impact of carbon revenues was assessed against this structure. The following methodology and assumption/input data was applied:

- The average investment costs for PV systems in Africa is determined by calculating the average investments in 1 kW installed capacity in African CDM projects. The average investment costs amount to 3,573 USD/kW, the raw data is provided in Annex VI.
- An exchange rate of 1€ : 0.77 USD is applied (XE, 2012) for determining average investment costs in €. This equals an investment volume of 2.75 mio €/MW and 6.88 mio € per year (see below).
- It is assumed that a rural electrification program in Ethiopia would have an average outreach of 2.5 MW/yr for 10 years. It is assumed that the Rural Electrification Executive Secretariat supports private companies in the implementation of off-grid activities, but the actual electricity generation devices are operated and owned by a private entity.
- Moreover, it is assumed that the private entity invests 20% of equity and receives a loan in the amount of 80% of the investment volume. Hence, the annual loan volume for the whole programme would amount to 5.51 mio €/yr. It is further assumed that such a loan is paid back within 10 years.
- Any electrification project would have to pay interest in the amount of 14.5% p.a. The interest rate was taken from the benchmark for energy investments in Ethiopia, as provided by CDM EB62 (Annex 2, Appendix, § 8).

Findings. Based on above considerations, the capital costs for rural electrification activities are determined. The actual data is provided in Annex VII, Table 16. The discounted capital costs for the total electrification program (25 MW installed capacity, implemented over 10 years) amount to 13.36 mio €.

In a next step, the costs of the rural electrification support program, CDM transaction costs and the related carbon revenues are estimated.

- It is assumed that the personnel and office cost of a rural electrification support program amount to 100,000 €/yr (expert estimate for 2-3 persons, office- and vehicle costs).
- The CDM transaction costs are estimated as follows: CDM Programme of Activity (PoA) development costs amount to 50,000€, Validation and Registration costs amount to 35,000€. The annual verification costs amount to 25,000€ (expert estimate).
- Moreover it assumed that the PoA operates for a crediting period of 28 years (4 times 7 year crediting periods). It shall be noted that the climate finance for Least Development Countries is not determined for that time period. Still, the climate finance contribution from e.g. year 2040 to the discounted revenues is very limited (e.g. 21,985€ for 2040), which is due to Ethiopia's high interest/discount rate.

- Efficiency ratios for solar PV in Africa range between 15% (international default value of AMS-I.L) and 24% (average of values in CDM PV projects submitted to UNFCCC). For the economic analysis it is assumed that the PV off-grid appliances operate at a efficiency ratio of 24%, thus referring to a value based on real-life projects.
- It is assumed that each HH consumes 250 kWh/yr, which is in line with Ethiopia's current average electricity consumption per HH (please refer to Figure 2, page 16).
- Based on the above-mentioned load factor and electricity generation per HH per year, 1 MW installed capacity will generate 5,256 MWh/yr. This may supply 21,000 HH with renewable electricity and would result in 18,322 CERs/yr.

Findings. Based on above considerations, the annual 'Totals' can be calculated. Subsequently, these figures were discounted by above interest rate resulting in the 'Annual Discounted Totals'. The actual figures are presented below for the years 2013 to 2019. For all results (i.e. 2013 to 2040) please refer to Annex VII, Table 17, page 52. The aggregated, discounted net revenues (i.e. over 28 years) amount to 3.35 mio €.

Table 10: Rural Electrification Program Costs, CDM Transaction Costs and Carbon Revenues

Year	2013	2014	2015	2016	2017	2018	2019	…	2040
Personnel Cost (in €)	100,000	100,000	100,000	100,000	100,000	100,000	100,000	…	100,000
CDM Transaction Costs (in €)	110,000	25,000	25,000	25,000	25,000	25,000	25,000	…	25,000
CERs	12,564	25,127	37,691	50,254	62,818	75,381	87,945	…	125,636
Carbon Revenues (in €)	75,381	150,763	226,144	301,526	376,907	452,289	527,670	…	753,815
Totals	- 134,619	25,763	101,144	176,526	251,907	327,289	402,670	…	628,815
Annual Discounted Totals (in €)	**- 117,571**	**19,651**	**67,379**	**102,704**	**128,001**	**145,244**	**156,067**	…	**141,900**

ODA Diversion. Many rural electrification programs are partially financed through Official Development Assistance (ODA). ODA diversion refers to the problem that ODA funding may be used to finance the meeting of industrial countries' emission targets.

- The Decision 17/CP.7 (Preamble) emphasizes 'that public funding for clean development mechanism projects from Parties in Annex I is not to result in the diversion of official development assistance and is to be separate from and not counted towards the financial obligations of Parties included in Annex I'.
- Moreover, decision 3/CMP.1 requires (Annex, Appendix B, paragraph 2.f): 'Information on sources of public funding for the project activity from Parties included in Annex I which shall provide an affirmation that such funding does not result in a diversion of ODA and is separate from and is not counted towards the financial obligations of those Parties'.

Based on these decisions, it is concluded that a project may be financed by ODA, but the Annex-I country shall provide a letter, confirming that the financial contribution is not counted towards the financial obligations of the Party.

Conclusion. The following conclusions are drawn:

- Currently, the CDM is considered as an uncertain financing source. The CER price development is subject to speculations on additional demand from the European Union and a long-term climate policy framework is absent.
- Yet based on our calculations the carbon revenues could be a viable financing source, covering the operative costs of a rural electrification program. After subtracting operative costs, the CDM would result in aggregated, discounted net revenues in the amount of 3.35 mio €.
- Such funding could be used e.g. to reduce interest rate of companies engaging in rural electrification. However, carbon finance will not be sufficient to cover the majority of the capital costs / interest payment. The total capital costs amount to 13.36 mio €. Carbon finance amounts to 3.35 mio. €, making up for 25% the capital costs allowing to substantially reduce the interest rate.

5 EVALUATION OF ENVIRONMENTAL INTEGRITY

This chapter briefly evaluates the environmental integrity of SBLs, i.e. the risk that the application of an SBL leads to an overestimation of emission reductions. This may be the case if the CDM EB approves an SBL featuring e.g. emission factors which are too high. The CDM EB provides three core documents which are subsequently used for further evaluation:

- CDM EB68, Annex 32, Procedure for the Submission and Consideration of Standardized Baselines, Version 2;
- CDM EB66, Annex 49, Guidelines for Quality Assurance and Quality Control of Data used in the Establishment of Standardized Baselines, Version 1; and
- CDM EB65, Annex 23, Guidelines for the Establishment of Sector Specific Standardized Baselines, Version 2.

Moreover, this evaluation is based on GFA's own experience in developing the first SBL which was submitted to the CDM EB for consideration (GEF for Southern African Power Pool). The environmental integrity is evaluated against the above-mentioned regulations.

In a first step, the data for SBL development has to be collected and compiled. The CDM EB defines extensive and demanding Quality Assurance and Quality Control (QA/QC) procedures for data collection. The collected data shall meet the following quality requirements: Relevance, Completeness, Consistency, Currentness, Accuracy, Objectivity, Conservativeness, Security, Transparency and Traceability (CDM EB66, Annex 49, §11.a-k). In the following, key qualities and related procedures are discussed in detail:

- **Completeness**
  For the compilation of the data for SBL development, the Designated National Authority (DNA) shall include all relevant activity data (CDM EB66, Annex 49, §17). A conservative approach for extrapolation of missing data is provided (CDM EB66, Annex 49, §18).
- **Accuracy**
  The DNAs are encouraged to implement measures for avoiding errors. Sources of uncertainties should be identified and reduced as far as practicable (CDM EB66, Annex 49, §19). If sampling approaches are applied, the DNA should determine confidence intervals for the quantification of conservative activity data (CDM EB66, Annex 49, §20).
- **Transparency**
  If applicable, the DNA should invite stakeholders to provide comments on the SBL. The consultation should be done in an open and transparent manner (CDM EB66, Annex 49, §21).

Second, in order to submit a SBL to the Secretariat, the DNA shall require an assessment report from a Designated Operational Entity (DOE) 'on the quality of the data collection, processing and compilation to establish the proposed standardized baseline' (CDM EB68, Annex 2, §7.b). The DOE shall be accredited by the UNFCCC for the validation and verification of CDM Scopes (e.g. 'energy industries – renewable/ non-renewable sources').

In the case of the SBL for the GEF in Sub-Saharan Africa, the contracted DOE assessed the SBL similar to the validation process for a CDM project. The DOE drafted a validation protocol, issued Corrective Action Requests (CAR) and Clarification Requests (CL) which were closed through the amendment of the calculations and/or the SBL document. Once all CARs and CLs were closed, the DOE issued the assessment report (similar to the final validation report).

Finally, once submitted, the Secretariat will engage its own SBL assessment procedures:

- Within 21 days of receipt, the Secretariat shall conduct an 'initial assessment' (specified in CDM EB68, Annex 32, §11-13).
- Thereafter the Secretariat shall select two members of a panel or working group, who shall 'independently assess the proposed standardized baseline', draft a recommendation and inform the CDM EB on the outcome. Afterwards, the CDM EB then will consider the SBL in its next meeting (CDM EB68, Annex 32, §14-27).

The above procedures require substantial efforts to ensure completeness, accuracy and transparency of standardization. Moreover, for many of the required sub-steps, the DNAs need to be actively involved and leading the SBL validation- and approval processes. Finally, SBL-development and –validation will require a highly specialized CDM expertise.

Working experience with DNAs in LDCs (cp, Burian et al. 2011 and Arens and Burian 2012) shows that DNAs are frequently understaffed and the CDM responsible often has to assume a wider range of responsibilities, i.e. the CDM being only one of several tasks. Hence Mersman and Arens conclude (2012, p.12): 'The [SBL] development process, as envisaged right now, lays a heavy burden on countries' Designated National Authorities. Not only are they set as the main authorities in the development of SBLs, and need to approve proposed SBLs that target their country, but they also have the duty to control the quality of the data used for the proposal. As they often only have limited financial and technical capacities, it is unlikely that DNAs will develop many SBLs under the current conditions.' It is concluded that a streamlined support process for SBL development may be key for a broader uptake of SBLs in least developed countries.

Environmental Integrity in the Context of Suppressed Demand. SBLs may be based on the concept of suppressed demand. This will lead to an SBL that overestimates the baseline emissions compared to historical emissions. It implicitly anticipates future demand.

In this context, the CDM EB acknowledges the people's right for a Minimum Service Level, applicable to determine the baseline emissions under consideration of suppressed demand (CDM EB68, Annex 2), which is per se a moral decision.

In the case of rural electrification, the minimum service level for electricity set out in the 'Universal Electricity Access Case' (IEA, 2009, p.132). The baseline emissions are determined by the emissions of the MSL in a conservative manner, as MSL baseline emissions shall be determined by the technology which most efficiently achieves the MSL (CDM EB68, Annex 2, §13, Step 5).

Furthermore, the approach of suppressed demand is not exclusive to rural electrification projects. Virtually all renewable energy projects revert to it. A wind farm constructed as a CDM project will not demonstrate by how much emissions are being reduced in other power plants but emission reductions are calculated simply compared to what would have happened in the absence of the CDM project assuming that the hitherto suppressed demand would have been met by a baseline technology power plant. In the case of rural electrification it is no different. The proposed methodology asks what technology is necessary to provide a minimum service level and uses the emissions of this baseline technology as basis for calculating emission reductions regardless of the extent of use of the baseline technology.

The CDM's purpose is to promote sustainable development in developing countries. The concept of suppressed demand allows the CDM to assist in achieving the most basic development in a more sustainable manner by leapfrogging unsustainable development stages. Environmental integrity is thus ensured by sidelining conventional, unsustainable development at the earliest stage.

Update of SBLs. An inappropriate updating of SBLs may eventually compromise the environmental integrity of the CDM: Assuming that the baseline emissions are determined by the SBL and the real/actual emission trend of the sector decreases (e.g. the emission intensity of the cement sector decreases as several cost effective and hence business as usual efficiency measures are implemented). If the SBL would now have a validity of e.g. three years, whereas project-specific approach is improved on an annual basis, then the application of the SBL would lead to an overestimation of baseline emissions. Hence, in regard to environmental integrity the question is how likely a significant decrease of emissions is within this timeframe.

The most recent version of the SBL Guidelines (CDM EB65, Annex 23) encloses an appendix which suggests a validity of standardization for three years. CDM project development in practice also operates with similar data validity. Many methodologies require the application of 'the most recent data available' at validation (e.g. CDM EB63, Annex 19). Still data availability is often constrained and data collection may be a time consuming and cost intensive process. Hence in 2012 numerous CDM projects were registered which were based on data sets with vintage 2010. It may be concluded that a mandatory updating frequency of three years corresponds to current practice and standardization faces an even more stringent approach than other CDM project development, avoiding adverse impacts of standardization.

Voluntary Character of SBLs. There is an ongoing debate whether the application of a SBL shall be mandatory, once submitted to the UNFCCC Secretariat. Spalding-Fecher and Michaelowa (2013) as well as Schneider et al (2012) argue that 'the proposal of standardized baselines by DNAs is voluntary, but their application [shall] be mandatory once they are approved (Schneider et al., 2012, page 8), as this 'could lead to the worst of both worlds: projects that are eligible under the SBL but ineligible under the project-specific approach, with more credits awarded to projects under the SBL than would otherwise be available under the project specific approach (Spalding-Fecher and Michaelowa, 2013, page 87).

Spalding-Flecher and Michaelowa's conclusion holds true under the implicit but crucial assumption, i.e. that the requirements for standardization are less stringent; hence SBL baseline emissions are higher than those of project specific approaches. Against this background, it seems even more important to argue for the application of the same default stringency levels under SBLs and project-specific approaches (cp. Lambert et al. 2012, p5 and Hayashi and Michaelowa (2012).

For LDCs taking advantages from weaknesses of sector specific-approaches and standardization seems less of a problem. Project development in LDCs may greatly benefit from the consideration of Suppressed Demand and this may be addressed most adequately by standardization. Therefore, project developers will more likely stick to an approved SBL rather than to define a project specific baseline.

Conclusion. Based on the evaluation of the documents for SBL development and the consideration of SD, it is concluded that the existing framework ensures environmental integrity.

- The baseline emissions under Suppressed Demand shall be determined by the most efficient, available technology, not considering the efficiencies of other baseline technologies. This is a very conservative approach.
- The Secretariat provides detailed and very demanding QA/QC procedures for data collection and the establishment of the SBL. Moreover, the SBL documents and underlying data shall be validated by a DOE, and finally is assessed in a two-phase approach by the Secretariat itself. This will ensure the environmental integrity of the SBL.

6 SBL IMPLICATIONS ON NATIONAL MRV SYSTEMS

Measuring, Reporting and Verification (MRV) of greenhouse gas (GHG) emissions allows single countries to meet their emission (reduction) targets. An efficient monitoring will support decision makers through the provision of information on the progress and set-backs in the realization of quantitative emission targets. A bad MRV system on the other hand will provide wrong information on emissions and emission trends of specific sectors. This will result to misleading conclusions on the performance of specific strategies and programs to cope with climate change mitigation.

In the context of the ongoing climate change negotiations, more and more developing countries pledge (absolute or relative) mitigation targets expecting financial support through new climate financing mechanisms (e.g. NAMAs, Green Climate Fund, etc.). Against this background, an efficient MRV system will be of prime importance.

Already in the early days of the UNFCCC, national MRV systems were created and have been improved ever since. The results are submitted to the UNFCCC as ‘National Inventory Reports’ (NIR) or as part of their national communications. National MRV systems are based on the IPCC Guidelines for National Greenhouse Gas Inventories (2006) and may feature different data qualities:

- Tier 1 – Global default values;
- Tier 2 – National default values;
- Tier 3 – Case specific data.

National assessments of GHG emissions are crosschecked by the UNFCCC. National calculations are formalized through Standard Operating Procedures (SOP) and complemented by Quality Assurance/Quality Control procedures (QA/QC).

So far, Ethiopia has submitted only its first national communication. According to the National Meteorological Services Agency (2001, p45), fossil fuel combustion amounts for 88% of national emissions, industrial processes amount to 12%, Land Use Change and Forestry is reported as a sink with 15,063 Gg CO_2.

Standardized Baselines, on the other hand, may also be based on Tier 2 and/or Tier 3 data. However, an SBL’s underlying rationale may be strongly based on the consideration of suppressed demand and/or the involvement of a trend. Both components shall not be reflected in a national MRV system.

Hence, the direct implications of SBLs on MRV system are constrained to the provision of Tier 2 and Tier 3 data, which may be used for the determination of the national GHG emissions.

- Nevertheless, the development of a SBL may require a thorough understanding of relevant institutions which may collect relevant input data on a national level. The development of an SBL may contribute to forging a national network on the collection and aggregation of relevant input data.
- Moreover, SBL development may support the technical understanding of procedures for the implementation of a MRV system: It may strengthen the understanding of methods for the quantification of GHG emissions, approaches for data storage and reporting.

- The materialization of these benefits may be bound to the application of an on hands-on training approach, which inherently involves the Designated National Authority (DNA) and other appropriate institutions in the development of the SBL.

Conclusion. SBL development may contribute to national MRV systems through the provision of Tier 2 and Tier 3 data. The overall direct implication on national MRV systems is limited, as SBLs may be based on Suppressed Demand and/or involve emission trends.

Still, there may be strong indirect implications on capacities for national GHG accounting:

- The SBL development requires collection of data which may be stored/managed by various institutions on national level. SBL development contributes to the development of a national network among institutions which may be relevant for MRV.
- The technical requirements for SBL and MRV development are similar. The increase of technical capacities for SBL development will have a strong positive effect on MRV.

7 THE USE OF SBLS FOR NEW MARKET MECHANISMS

This chapter explores the use of SBLs for New Market Mechanisms (NMM) and (supported or credited) NAMAs. Both NMM and NAMAs that get Annex I support or generate carbon credits (cp. Lütken et al, 2011, p11f) face a common requirement: They need to specify baseline emissions in a transparent and verifiable manner. Raab (2012, p61) notes: 'The greatest challenge when establishing a (sectoral) crediting mechanism is to decide on a crediting threshold'. The baseline may be established by various approaches:

- Absolute Baseline Emissions - defined as tCO_2 emissions per sector per year.
- Relative Baseline Emissions – defined as emissions per output unit (e.g. tCO_2/MWh), or as
- Technology Penetration Baseline – defined by the baseline penetration ratio of a specific technology;

National MRV systems may not allow for appropriately defining such a baseline for at least two reasons:

- First, MRV systems in Non-Annex I countries offer a heterogeneous picture. Some countries have established a transparent accounting system, systematically collecting national data. Others report on an irregular basis and/or reporting is achieved on a fairly general level (cp. UNFCCC, 2012b).
- Second, national MRV systems may be too general to provide sector specific data. The Climate Policy Initiative (CPI) evaluated MRV systems of four countries. CPI concluded (2012, p32ff) that though MRV systems may allow for adequate reporting on actual emissions, the existing framework faces obstacles on reporting of specific mitigation actions/programs.
  To give a practical example: Ethiopia's National Communication reports that 88% of national GHG emissions are emitted by fossil fuel combustion (National Meteorological Services Agency, 2001, p45) and 44% of the emissions from fossil fuel combustion arise from the transport sector (p46). Such information may not allow for adequately defining the baseline emissions for Ethiopia's NAMA in the transport sector (FDRE, 2012b).

This was so far not causing any problems, as national emission reporting in Non-Annex I countries is not directly linked to payments and/or the accounting of credited emission reductions in a future climate regime. But the further operationalization of NMM and supported / credited NAMAs may require a transparent and verifiable approach for the determination of baseline emissions. The Clean Development Mechanism in general and Standardized Baselines specifically may qualify as an important building block in this regard.

The CDM rules, requirements and approved methodologies, and the existing rules for SBL development, validation and approval offer a broad knowledge base for establishing sectoral baselines. The Marrakesh Accords (CP7, Decision 17) operationalized the procedures of the CDM. In the course of the last 10 years, substantial efforts were undertaken to offer quantitative approaches for the determination of baseline emissions and possible emission reductions. So far, this has resulted in the development of 207 approved, active methodologies (i.e. SSC and large scale, UNFCCC, 2012), accompanied by a wide range of tools and guidelines.

This wealth of quantitative approaches is strongly based on the principles of environmental integrity. The Executive Board and its subsidiaries such as the CDM Methodology Panel and the SSC Working Group invested substantial efforts in ensuring that such quantification approaches do not result in the systematical over-estimation of emission reductions.

Box: Ethiopian SBL on the Cement Sector

In its national communication, Ethiopia reports that 12% of national CO_2 emissions arise from 'industrial processes', thereof 98% are emitted by the cement sector (National Meteorological Services Agency, 2001, p45f).

The DNA of Ethiopia has submitted a SBL for the cement sector to the UNFCCC (FDRE, 2012) which may serve as baseline for NMM/Supported NAMA.

A NMM may use this SBL as internationally accepted baseline and cooperate with the Government of Ethiopia in the reduction of emissions in the cement sector. Any emission reduction may be clearly accounted for by comparing actual emissions with the baseline emissions.

A first concept on SBL application under a NMM explores the development of a 'Carbon REFIT', for the Southern African Region (Burian and Arens (2012). The study proposes the development of a feed in tariff which is based on a price for carbon as well as on the baseline emissions as determined by the SBL for the SAPP electricity system. This shows the wide applicability of SBLs as independent and verified benchmark for NMM.

Against this background, SBLs may serve as an appropriate instrument to establish sectoral baselines.

- SBLs shall use the existing framework for the quantification of baseline emissions on a national level. As such SBLs are built on above achievements and apply such quantitative approaches for the development of national or regional baselines.
- By applying SBL procedures, the baseline may include the concept of Suppressed Demand. This may allow for using an internationally renowned approach for adopting e.g. a linear baseline to national circumstances.
- Finally, in order to be accepted as an SBL, a baseline has to successfully pass various QA/QC procedures. The official recognition of the UNFCCC may serve as a viable proof to Annex I countries that their financial contributions are based on high standards for environmental integrity.

It is concluded that SBLs may serve as independent and validated benchmark for NMM development

8 CONCLUSIONS

This study explores the options for standardization and consideration of Suppressed Demand for rural electrification in Ethiopia. The findings show, that the consideration of both concepts not only allows for tailoring the baseline for one specific country, it also increases the baseline emissions rendering CDM projects and/or PoAs with higher CERs volumes and increased financial attractiveness of mitigation activities.

AMS I.L offers a high degree of standardization. Moreover the concept of Suppressed Demand is inherently integrated in the methodological approach. This leads to a volume of 0.878 CERs per HH per year (assuming an electricity consumption of 500 kWh/yr/HH). It is concluded that AMS I.L offers significant emission factors compared to e.g. the average GEF values.

Still it was found that the approach may be subject to further standardization. We have put further emphasis on suppressed demand and defined a MSL at 1,746 lumen per HH. Using the available data on lighting technologies in Ethiopia allows for developing a standardized EF for HH lighting in the amount of 9.1 tCO_2/MWh. Moreover we investigated the typical load factor for off-grid diesel generators. It was concluded that the underlying assumptions by the SSC WG are too conservative. Adopting higher values results in EFs 1.9 tCO_2/MWh and 1.3 tCO_2/MWh for HH electricity consumption and the electricity consumption by 'other consumers. This approach for standardization increases the baseline emissions by 26.5% (assuming an electricity consumption of 500 kWh/yr/HH).

The economic evaluation of carbon revenues demonstrates that a CDM program may substantially contribute to financing rural electrification activities. After the subtraction of CDM transaction costs and the costs of a rural electrification support program, the discounted net carbon revenues are estimated at 3.35 mio €. This may significantly contribute to the capital costs of rural electrification activities (approx. 25%) allowing for offering e.g. reduced interest rates. Sill it is important to note that the carbon market currently faces low price levels and that the future climate political framework for LDCs is not yet fully determined which involves significant uncertainties.

The review of the current procedures for the development and approval of SBLs demonstrates that various quality checks have to be accomplished prior to SBL approval by the CDM EB. It is included that the existing provisions and procedures avoid the systematical overestimation of baseline emissions. On the other hand these regulations may pose a substantial barrier to DNAs for the development of SBLs. It seems questionable whether DNAs facing limited financial- and personnel capacities will engage in SBL development without further support from Annex-I countries. This seems implausible especially for Least Developed Countries. LDCs on the one hand may face the strongest limitations in terms of capacities. On the other hand, such countries would also benefit most from the consideration of Suppressed Demand under a SBL.

The investigation of synergies between SBL development and national MRV procedures concludes that SBL related data may not be applicable for MRV systems, as they may involve an emission trend and/or baseline emissions based on suppressed demand. Still in terms of capacity requirements, there are significant synergies. SBL development may enhance local knowledge on how to aggregate Tier 2 and Tier 3 data. But such benefits are bound to the involvement of the DNA, who is in charge for SBL development, in the compilation of national GHG emission reports.

The baseline setting of NMM and NAMAs is still fairly undefined. On the other hand, since the Marrakesh Accords substantial efforts were undertaken to offer quantitative approaches for the determination of baseline emissions and possible emission reductions. So far this resulted in the development of 207 CDM EB-approved methodologies. SBL development may allow for using this wealth of quantitative approaches by defining national baselines, which are approved by the CDM EB and hence commonly accepted. SBLs may be an important building block for NMM and supported/credited NAMAs.

Due to the increase of knowledge concerning emissions accounting and implementation of climate projects on a sectoral bases the development of SBLs in developing countries should be strongly facilitated. However, the current lack of demand of CER won't foster the development of SBLs and thus the development has to be advocated and supported by donors form Annex I countries.

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ANNEX I: ELECTRICITY ACESS IN AFRICA

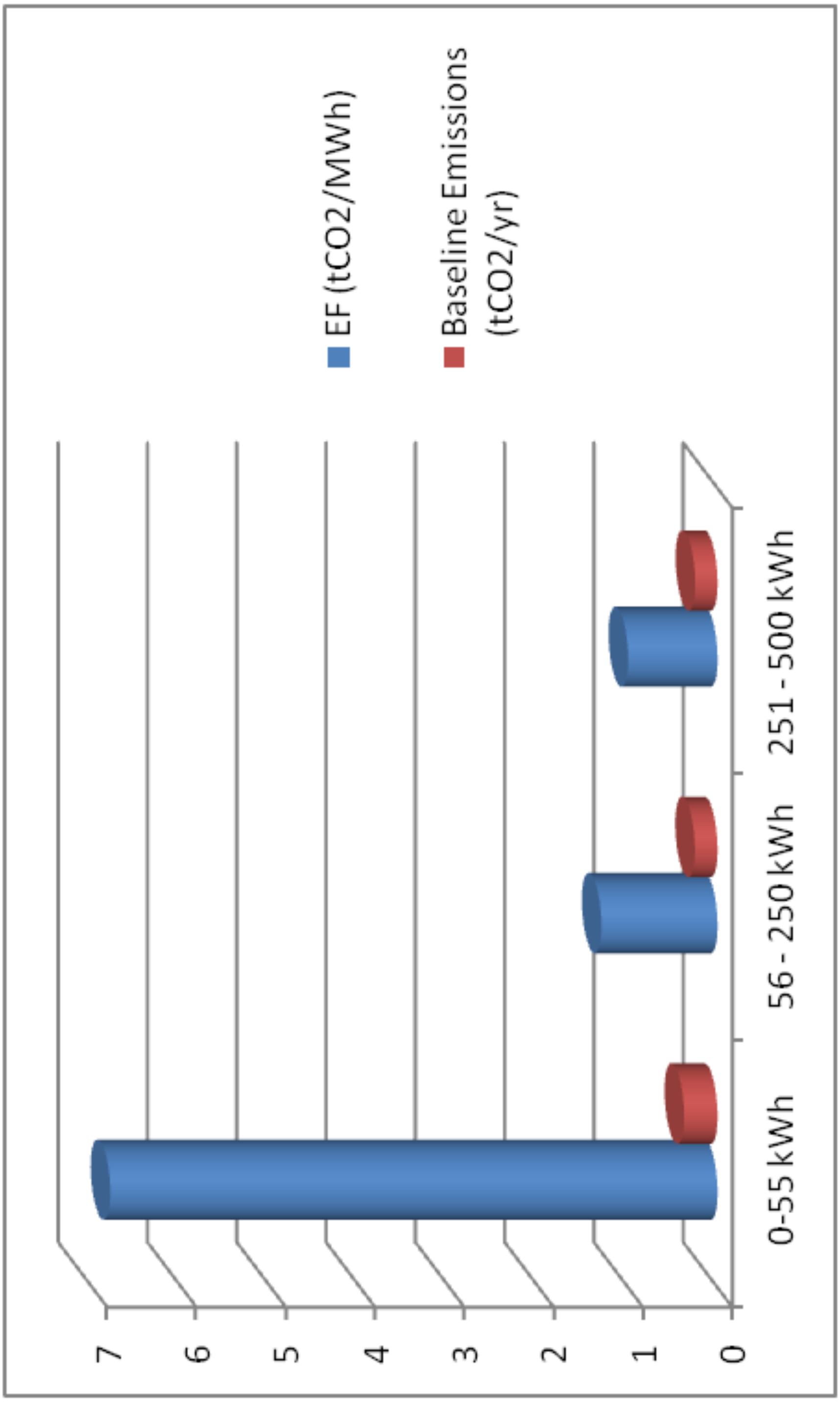
Table 11: Electricity Access in 2009 - Africa

Country	Electrification Rate (in %)	Population without Electricity (in mio)
Angola	26.2	13.7
Benin	24.8	6.7
Botswana	45.4	1.1
Burkina Faso	14.6	12.6
Cameroon	48.7	10.0
Congo	37.1	2.3
Cote d'Ivoire	47.3	11.1
DR Congo	11.1	58.7
Eritrea	32.0	3.4
Ethiopia	17.0	68.7
Gabon	36.7	0.9
Ghana	60.5	9.4
Kenya	16.1	33.4
Lesotho	16.0	1.7
Madagascar	19.0	15.9
Malawi	9.0	12.7
Mauritius	99.4	0.0
Mozambique	11.7	20.2
Namibia	34.0	1.4
Nigeria	50.6	76.4
Senegal	42.0	7.3
South Africa	75.0	12.3
Sudan	35.9	27.1
Tanzania	13.9	37.7
Togo	20.0	5.3
Uganda	9.0	28.1
Zambia	18.8	10.5
Zimbabwe	41.5	7.3
Other Africa	17.0	89.1
Sub-Saharan Africa	30.5	585.2
Algeria	99.3	0.2
Egypt	99.6	0.3
Libya	99.8	0.0
Morocco	97.0	1.0
Tunisia	99.5	0.1
North Africa	99.0	1.6
Africa	41.8	586.8

Source: IEA, World Energy Outlook 2011

ANNEX II: EF AND BASELINE EMISSIONS BASED ON AMS I.L

Figure 6: Emission Factors and Baseline Emissions based on AMS I.L



Source: Developed based on AMS I.L, Version 1.

ANNEX III: ETHIOPIAN ELECTRICITY CONSUMPTION IN A GLOBAL CONTEXT

Table 12: Electricity Consumption in Ethiopia in a Global Context

Country	Population (in mio)	GDP (in billion USD)	GDP/c in USD	Electricity Consumption (GWh/yr)	Electricity Consumption (kWh/c/d)	Rank
Ethiopia	**85**	**$70**	**$824**	**3,777**	**0.12**	**30**
DR Congo	69	$21	$304	6,939	0.28	29
Nigeria	149	$336	$2,255	21,110	0.39	28
Bangladesh	156	$226	$1,449	35,893	0.63	27
Pakistan	176	$431	$2,449	91,626	1.43	26
Indonesia	240	$917	$3,821	149,437	1.7	24
Philippines	98	$318	$3,425	60,819	1.7	25
India	1166	$3,304	$2,834	860,723	2.02	23
Vietnam	87	$242	$2,782	76,269	2.4	22
Egypt	83	$445	$5,361	130,144	4.29	21
Thailand	66	$549	$8,318	149,034	6.18	20
Mexico	111	$1,567	$14,117	257,812	6.36	19
Brazil	199	$1,998	$10,040	505,083	6.95	18
China	1339	$7,992	$5,969	3,444,108	7.04	17
Turkey	77	$904	$11,740	198,085	7.04	16
World	**6784**	**$70,048**	**$10,325**	**20,279,640**	**8.18**	—
Iran	66	$844	$12,788	211,972	8.79	15
Italy	58	$1,827	$31,500	359,161	16.95	14
UK	61	$2,236	$36,656	400,390	17.97	13
EU*	**541**	**$16,221**	**$29,983**	**3,635,604**	**18.4**	—
Saudi Arabia	29	$578	$19,931	204,200	19.28	12
Netherlands	17	$674	$39,647	123,496	19.89	11
Russia	140	$2,271	$16,221	1,022,726	20	10
Spain	41	$1,402	$34,195	303,179	20.25	9
Germany	82	$2,925	$35,671	617,132	20.61	8
France	64	$2,133	$33,328	526,862	22.54	7
Japan	127	$4,340	$34,173	1,083,142	23.35	6
Korea	49	$1,338	$27,306	443,888	24.8	5
Taiwan	23	$714	$31,043	238,458	28.39	4
Australia	21	$803	$38,238	257,247	33.54	3
USA	307	$14,440	$47,036	4,401,698	39.25	2
Canada	33	$1,303	$39,485	620,684	51.5	1

Sources: Population and GDP data are from CIA World Factbook 2009, Electricity data are from IEA/OECD 2008

ANNEX IV: NON-ANNEX I GRID EMISSION FACTOR

Table 13: IGES Grid Emission Factor Data

Region	Host Party	Num. of use of CM EF	Combined Margin EF (Average)	Combined Margin EF (Maximum)	Combined Margin EF (Minimum)	Operating Margin EF (Average)	Operating Margin EF (Maximum)	Operating Margin EF (Minimum)	Build Margin EF (Average)	Build Margin EF (Maximum)	Build Margin EF (Minimum)
Asia	China	2191	0.9186	1.2526	0.6080	1.0786	1.2910	0.5123	0.6920	1.2783	0.3157
	India	657	0.8788	1.1360	0.4180	1.0036	1.2610	0.1210	0.6899	1.0760	0.1763
	Viet Nam	133	0.5659	0.6448	0.4960	0.6446	0.7880	0.5925	0.4862	0.6111	0.3420
	Thailand	60	0.5372	0.9058	0.4480	0.5604	1.0086	0.4520	0.5072	0.6551	0.3760
	Republic of Korea	60	0.6185	0.8300	0.5215	0.7121	0.7850	0.6780	0.4354	0.7088	0.3258
	Philippines	41	0.4945	0.6550	0.1990	0.6311	0.8157	0.1960	0.3512	0.6328	0.2020
	Indonesia	26	0.7566	0.9010	0.5200	0.8581	1.2400	0.3200	0.6552	0.9370	0.4000
	Malaysia	26	0.6626	0.8510	0.0410	0.6159	0.8370	0.0380	0.6954	0.9000	0.0440
	Sri Lanka	6	0.7257	0.8496	0.6151	0.7746	0.8719	0.6336	0.6768	0.8273	0.5817
	Pakistan	6	0.4810	0.4902	0.4659	0.6633	0.7240	0.6045	0.2987	0.3759	0.2420
	PNG	5	0.6686	0.6790	0.6660	0.7176	0.7220	0.7040	0.6202	0.6530	0.6120
	Bangladesh	3	0.6476	0.6910	0.6200	0.6436	0.6704	0.6260	0.6519	0.7116	0.6150
	Lao PDR	2	0.5406	0.5764	0.5048	0.6091	0.6465	0.5716	0.4723	0.5064	0.4381
	Cambodia	1	0.6981	0.6981	0.6981	0.6379	0.6379	0.6379	0.7584	0.7584	0.7584
	Mongolia	1	1.0610	1.0610	1.0610	1.1210	1.1210	1.1210	0.8850	0.8850	0.8850
	Bhutan ;	1	1.0040	1.0040	1.0040	1.1600	1.1600	1.1600	0.8500	0.8500	0.8500

Asia		**3221**	**0.8724**	**1.2526**	**0.0410**	**1.0162**	**1.2910**	**0.0380**	**0.6690**	**1.2783**	**-**
Latin America	Brazil	144	0.3030	0.9421	0.0745	0.4768	0.9581	0.0794	0.1234	1.0160	0.0311
	Mexico	73	0.5357	0.6515	0.4000	0.6623	0.7389	0.5746	0.3882	0.4807	0.3000
	Chile	43	0.5290	0.7740	0.3920	0.6841	0.8758	0.5170	0.3701	0.5207	0.2010
	Peru	25	0.5367	0.6845	0.2240	0.6746	0.7736	0.1782	0.3914	0.5692	0.2320
	Honduras	22	0.6894	0.8000	0.5938	0.6930	0.7700	0.5900	0.6773	0.9100	0.5589
	Argentina	19	0.4763	0.7170	0.4170	0.5489	0.7923	0.4835	0.4069	0.6950	0.3350
	Colombia	16	0.3688	0.4441	0.3062	0.4829	0.5764	0.3620	0.2495	0.3206	0.0360
	Ecuador	13	0.6521	0.7194	0.5603	0.7455	0.8748	0.6260	0.5763	0.6070	0.5390
	Guatemala	11	0.7081	0.8370	0.5778	0.7893	0.8740	0.6679	0.6369	0.8800	0.4570
	Panama	11	0.6178	0.7710	0.4060	0.7556	0.9000	0.2200	0.5068	0.6980	0.3504
	Costa Rica	7	0.2795	0.4884	0.0600	0.4335	0.9692	0.0300	0.0566	0.1000	0.0060
	Uruguay	7	0.6344	0.9140	0.2590	0.5780	0.7790	0.3380	0.6188	0.7330	0.1810
	El Salvador	6	0.6868	0.7170	0.6130	0.7051	0.7370	0.5760	0.6683	0.7175	0.6490
	Nicaragua	7	0.7041	0.7540	0.6300	0.7615	0.8570	0.6900	0.6280	0.6902	0.5523
	Dominican Republic	5	0.6699	0.7500	0.5316	0.7711	0.8450	0.6193	0.4619	0.4957	0.4220
	Bolivia	3	0.5770	0.6100	0.5400	0.7003	0.7310	0.6400	0.4603	0.6000	0.3490
	Cuba	2	0.8735	0.9060	0.8410	0.8706	0.9332	0.8080	0.8765	0.8780	0.8750
	Jamaica	2	0.7832	0.8340	0.7324	0.8325	0.8930	0.7720	0.6947	0.7760	0.6134
	Guyana	1	0.9483	0.9483	0.9483	0.9483	0.9483	0.9483	-	-	-
Latin America		**417**	**0.4734**	**0.9483**	**0.0600**	**0.6018**	**0.9692**	**0.0300**	**0.3335**	**1.0160**	**0.0060**
Africa/Middle and Near East	Israel	14	0.7549	1.0340	0.4810	0.8131	0.9380	0.7450	0.6378	0.9710	0.3855
	Egypt	6	0.5437	0.5810	0.5150	0.5783	0.6850	0.5440	0.4845	0.5590	0.4280
	Morocco	6	0.7119	0.7520	0.6352	0.7204	0.7430	0.6506	0.6567	0.7610	0.5892
	South Africa	6	1.0310	1.2215	0.9300	1.0071	1.1950	0.9080	1.0545	1.2480	0.9510
	Kenya	5	0.6016	0.6545	0.5299	0.7496	0.8761	0.6612	0.4194	0.4329	0.3987

	Iran	4	0.6126	0.7081	0.3262	0.6884	0.7004	0.6525	0.5369	0.7158	-
	Uganda	4	0.6343	0.6673	0.5890	0.6288	0.7010	0.5685	0.6393	0.6772	0.6050
	UAE	3	1.0207	1.3000	0.8810	0.9380	0.9380	0.9380	0.7080	0.7080	0.7080
	Jordan	3	0.5839	0.6160	0.5228	0.6455	0.6745	0.6011	0.5222	0.5710	0.4444
	Côte d`Ivoire	2	0.7080	0.7291	0.6868	0.7885	0.8642	0.7127	0.6274	0.6608	0.5940
	Madagascar	2	0.5520	0.5560	0.5480	0.4975	0.5180	0.4770	0.6070	0.6350	0.5790
	Mauritius	2	0.9753	0.9835	0.9670	0.9771	1.0252	0.9290	0.9318	1.0050	0.8585
	Senegal	2	0.6826	0.6891	0.6761	0.7067	0.7123	0.7011	0.6354	0.6510	0.6198
	Nigeria	1	0.6300	0.6300	0.6300	0.6700	0.6700	0.6700	0.5800	0.5800	0.5800
	Rwanda	1	0.6540	0.6540	0.6540	0.6606	0.6606	0.6606	0.6474	0.6474	0.6474
	Ghana	1	0.5485	0.5485	0.5485	0.2442	0.2442	0.2442	0.8528	0.8528	0.8528
	Mali, Mauritania, Senegal	1	0.5822	0.5822	0.5822	0.5178	0.5178	0.5178	0.6466	0.6466	0.6466
Africa/Middle and Near East		**63**	**0.7198**	**1.3000**	**0.3262**	**0.7398**	**1.1950**	**0.2442**	**0.6531**	**1.2480**	**-**
Others	Cyprus	5	0.8015	0.8180	0.7700	0.8296	0.8457	0.7990	0.7172	0.7352	0.6830
	Armenia	3	0.4360	0.4370	0.4339	0.5145	0.5350	0.4735	0.3970	0.3980	0.3949
	Serbia	3	1.1229	1.1230	1.1226	1.1668	1.1668	1.1668	0.9911	0.9918	0.9897
	Fiji	2	0.6400	0.6560	0.6240	0.6535	0.6600	0.6470	0.6260	0.6500	0.6020
	Albania	1	0.4631	0.4631	0.4631	0.0529	0.0529	0.0529	0.5999	0.5999	0.5999
	Azerbaijan	1	0.6170	0.6170	0.6170	0.6460	0.6460	0.6460	0.5290	0.5290	0.5290
	Macedonia	1	0.8880	0.8880	0.8880	0.7720	0.7720	0.7720	1.0040	1.0040	1.0040
	Georgia	1	0.0928	0.0928	0.0928	-	-	-	-	-	-
Others		**17**	**0.7074**	**1.1230**	**0.0928**	**0.7481**	**1.1668**	**0.0529**	**0.6959**	**1.0040**	**0.3949**
Total		**3718**	**0.8244**	**1.3000**	**0.0410**	**0.9648**	**1.2910**	**0.0300**	**0.6317**	**1.2783**	**-**

Source: Data withdrawn at the 19th September from the Institute of Global Environmental Studies (2012), adopted by GFA ENVEST.

ANNEX V: LOAD DURATION CURVES FROM SELECTED AFRICAN COUNTRIES

In absence of appropriate published data, the Consultant developed a determined the ratio between average demand and peak demand. This was done for eight countries in SSA. The evaluation is based on the annual hourly or half-hourly load data of the respective countries. Please note, Lesotho Power Corporation and Botswana Power Corporation report load data in half –hourly intervals.

Dividing the peak demand by the average demand results in the 'Average- to Peak Demand Ratio' which was used in Section 3.2.2 to determine the appropriate size of diesel GENSETs. The below table presents the results of this evaluation. Please note, that Mozambique's electricity demand is determined to some extent by the MOZAL aluminum smelter, which is the second largest one in Africa. MOZAL operates at full load through the year which impacts the Average- to Peak Demand Ratio. Due to this bias, it was decided not to consider the results for Mozambique in the further evaluation.

Table 14: Determination of the Average- to Peak-Demand Ratio

	Botswana	Lesotho	Mozambique	Republic of South Africa (RSA)	Swaziland	Tanzania	Zambia	Zimbabwe
Installed Capacity	132.00	72.00	2,187.00	44,111.00	70.10		1,687.00	1,905.00
Peak Demand	389.00	121.44	1,186.64	36,513.00	199.83	508.65	1,153.20	2,066.00
Average Demand	267.72	66.86	1,157.31	27,983.28	126.02	369.86	802.21	1,402.27
Average- to Peak-Demand Ratio	1.45	1.82	1.03	1.30	1.59	1.38	1.44	1.47

Source: Calculations are based on hourly/half-hourly data provided by Botswana Power Corporation, Lesotho Electricity Corporation, Electricidade de Moçambique, ESKOM (RSA), Swaziland Electricity Corporation, TANESCO (Tanzania), ZESCO (Zambia) and ZESA (Zambia).

Figure 7: Botswana Load Duration Curve

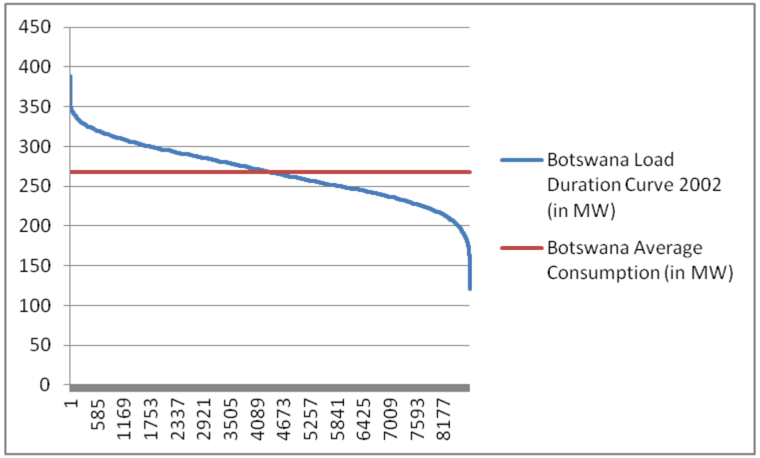


Figure 8: Lesotho Load Duration Curve

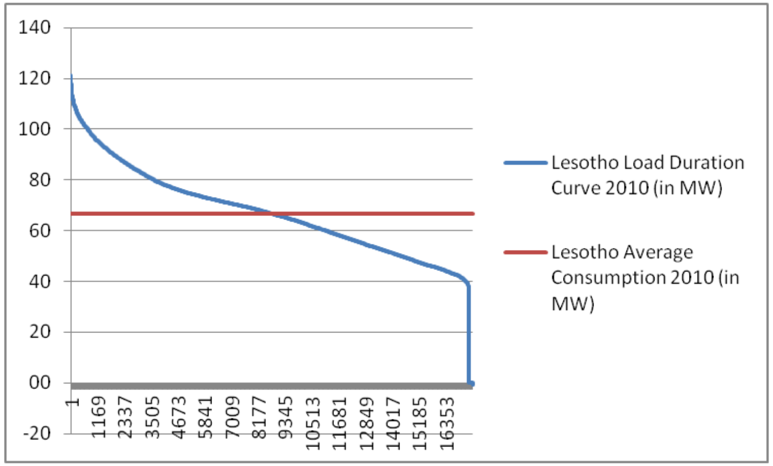


Figure 9: Mozambique Load Duration Curve

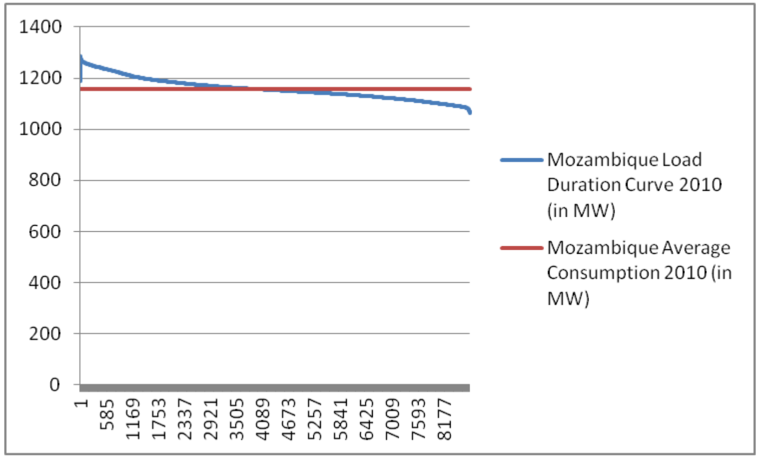


Figure 10: RSA Load Duration Curve

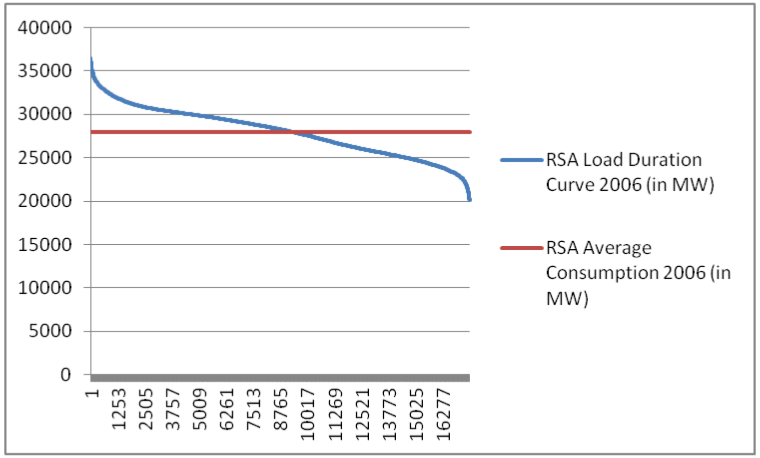


Figure 11: Swaziland Load Duration Curve

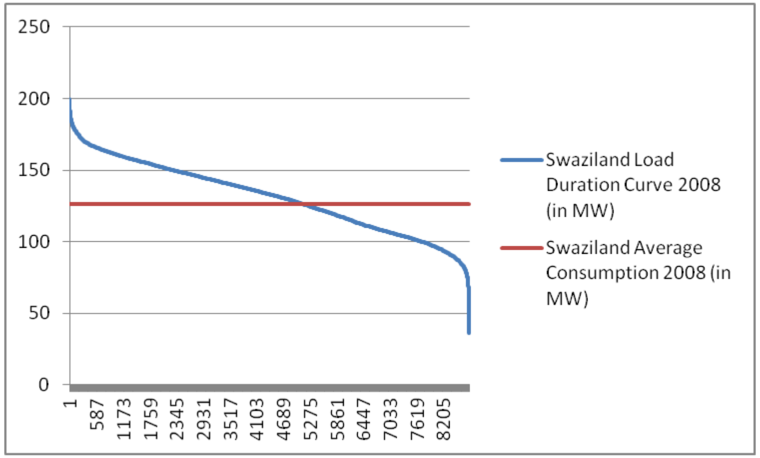


Figure 12: Tanzania Load Duration Curve

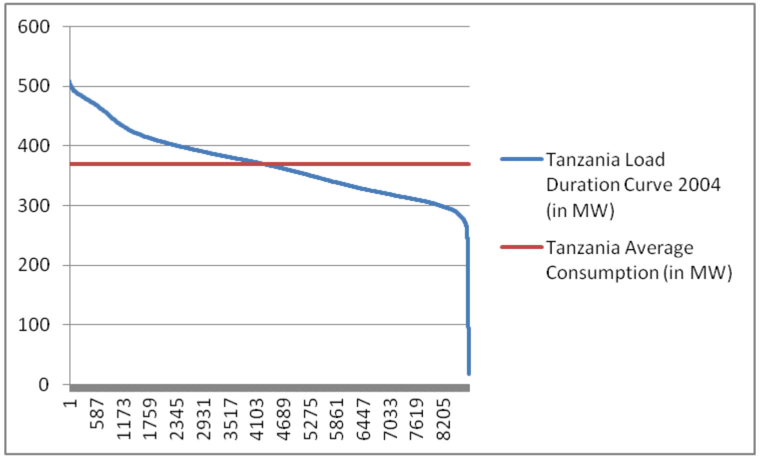


Figure 13: Zambia Load Duration Curve

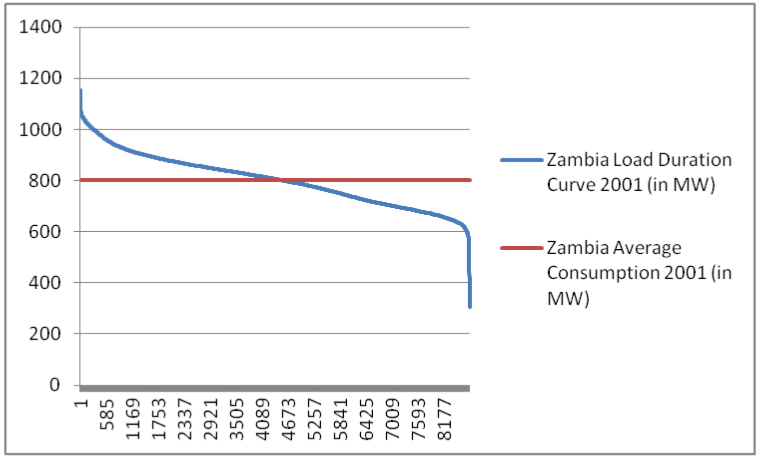
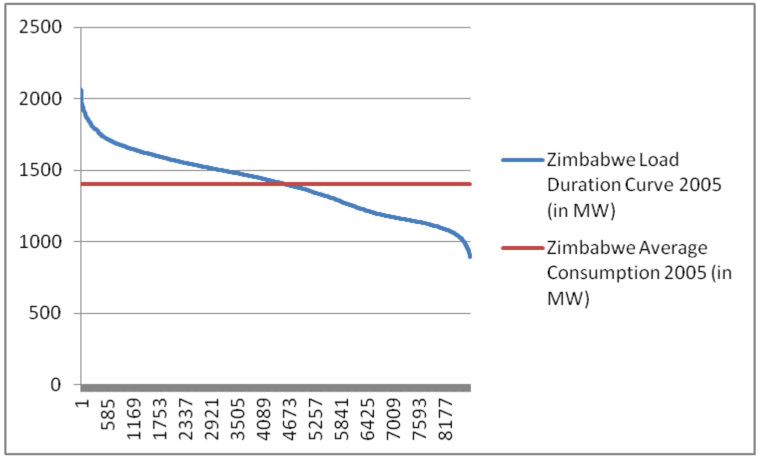


Figure 14: Zimbabwe Load Duration Curve



ANNEX VI: INVESTMENT COSTS IN AFRICAN CDM PV PROJECTS

The below table presents all African Photovoltaic (PV) CDM projects (i.e. registered and under validation as provided by UNEP Risoe (2012). The column at the very right provides data on the investments per kW installed capacity. The average investment costs per kW amount to 3,573.45 USD.

Table 15: Investment Costs in African CDM PV Projects

ID	Title	Region	Host country	Status	Type	Sub-type	Methodology	1st period $ktCO_2e/yr$	MWel	GEF tCO_2e/MWh	Invest-ment MUS$	Invest-ment $US\$/tCO_2$	Invest-ment US$/kW
07241	Tough Stuff Solar Panel and Lamp Sales	Africa	Madagascar	At Validation	Solar	Solar PV	AMS-I.A.	8.17	-				
00250	Photovoltaic kits to light up rural households	Africa	Morocco	Registered	Solar	Solar PV	AMS-I.A.	38.64	7.70				
08329	Prieska Grid Connected 20 MW Solar Park	Africa	South Africa	At Validation	Solar	Solar PV	ACM2	38.08	20.00		72.61	1,906.68	3,630.41
09046	Karoo Renewable Energy Facility	Africa	South Africa	At Validation	Solar	Solar PV	ACM2	91.79	50.00	0.97	201.83	2,199.00	4,036.70
09257	De Aar Grid Connected 10 MW Solar Park	Africa	South Africa	At Validation	Solar	Solar PV	AMS-I.D.	19.04	10.00	0.99	40.00	2,100.73	4,000.00
09275	Kathu Grid Connected 100 MW Solar Park	Africa	South Africa	At Validation	Solar	Solar PV	ACM2	190.41	100.00	0.99	296.08	1,555.01	2,960.85
10670	Langa Energy Photovaltaic Solar Energy Facility	Africa	South Africa	At Validation	Solar	Solar PV	ACM2	134.31	75.00	0.96	242.95	1,808.85	3,239.28

Source: Data from UNEP Risoe CDM Pipeline (UNEP, 2012)

ANNEX VII: FOR RURAL ELECTRIFICATION PROGRAMME COSTS

Annex VII prepares the input data for the economic evaluation of a CDM PoA for rural electrification. Table 16 determines the capital costs for rural electrification activities. The calculation is based on the input which are discussed in chapter 4 in detail (2.5 MW new installed capacity per year, investment costs of 3,5735 USD/kW, equity finance ratio of 20% and annual interest of 14.5%). Based on these input data, the ‘Remain Loan’ specifies the dept at the end of 2013 of the facilities installed at the beginning of 2013 (i.e. after the debt retirement of the year 1). The same is repeated for all new facilities installed within 10 years time. ‘Annual Capital Costs’ then specifies the total capital costs which were subsequently discounted. The total discounted capital costs amount to 13.36 mio €.

Table 16: Calculation of the Capital Costs for Rural Electrification

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	…	2040
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	…	28
Remaining Loan (in €)	1,982,793	1,762,483	1,542,172	1,321,862	1,101,552	881,241	660,931	440,621	220,310	0						
1	287,505	255,560	223,615	191,670	159,725	127,780	95,835	63,890	31,945	0						
2		287,505	255,560	223,615	191,670	159,725	127,780	95,835	63,890	31,945						
3			287,505	255,560	223,615	191,670	159,725	127,780	95,835	63,890	31,945					
4				287,505	255,560	223,615	191,670	159,725	127,780	95,835	63,890	31,945				
5					287,505	255,560	223,615	191,670	159,725	127,780	95,835	63,890	31,945			
6						287,505	255,560	223,615	191,670	159,725	127,780	95,835	63,890	31,945		
7							287,505	255,560	223,615	191,670	159,725	127,780	95,835	63,890	…	
8								287,505	255,560	223,615	191,670	159,725	127,780	95,835	…	
9									287,505	255,560	223,615	191,670	159,725	127,780	…	
10										287,505	255,560	223,615	191,670	159,725	…	
Annual Capital Costs (in €)	287,505	543,065	766,680	958,350	1,118,075	1,245,855	1,341,690	1,405,580	1,437,525	1,437,525	1,150,020	894,460	670,845	479,175	…	
Discounted Capital Costs (in €)	251,096	414,229	510,737	557,574	568,124	552,885	520,012	475,786	424,978	371,159	259,325	176,155	115,385	71,981	…	

Table 17 determines the expenditures and revenues of a rural electrification program under the CDM. The input data are discussed in Chapter 4 in detail. Based on the input data, an annual balance is developed. Subsequently, the balance discounted in order to make the results comparable to the capital costs determined above. The total discounted balance amounts to 3.53 mio €.

Table 17: Rural Electrification Program Costs, CDM Transaction Costs and Carbon Revenues

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	...	2040
Personnel Cost	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	...	100,000
CDM Transaction Costs (in €)	110,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	...	25,000
CERs	12,564	25,127	37,691	50,254	62,818	75,381	87,945	100,509	113,072	125,636	125,636	125,636	125,636	125,636	...	125,636
Carbon Revenues	75,381	150,763	226,144	301,526	376,907	452,289	527,670	603,052	678,433	753,815	753,815	753,815	753,815	753,815	...	753,815
Balance	- 134,619	25,763	101,144	176,526	251,907	327,289	402,670	478,052	553,433	628,815	628,815	628,815	628,815	628,815	...	628,815
Annual Discounted Balance (in €)	-117,571	19,651	67,379	102,704	128,001	145,244	156,067	161,820	163,612	162,356	141,795	123,839	108,156	82,497	...	14,190