Carbon Financing for Renewable Energy Projects in Zimbabwe – A Case of Chipendeke Micro-Hydro Scheme

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Abstract: ***The purpose of the research was to determine the availability of alternative carbon revenue for renewable energy schemes in Zimbabwe taking Chipendeke Micro Hydro Scheme as a case study for the research. The research was based on how the Micro hydro power projects can benefit from the financing in terms of improved revenue provision as a source of income, it came up with the a comparison between carbon financed scheme and a non carbon financed scheme and explained how carbon finance affects the payback period of the project After analysis of the different carbon finance options available a design package of the carbon finance was done and it came up with the mechanism of carbon finance to be used, cost of project with and without carbon finance, how the carbon revenue would be used and the responsible parties for application and receipt of the funding.***

Keyword: Carbon financing, Micro hydro scheme, Carbon credit, Joint Implementation

1. Introduction

There is clear evidence of changes in the composition of the greenhouse gases in the lower atmosphere, with CO2 in particular steadily increasing to its present level of about 390 ppm. It has increased by one third in the last 200 years, and half of that in the last 30 years. Ice core samples show that both carbon dioxide and methane levels are higher than at any time in the past 650,000 years [1].

Estimates of the individual contribution of particular gases to the greenhouse effect or simply their Global Warming Potential (GWP), are broadly agreed (relative to carbon dioxide = 1). Such estimates depend on the physical behavior of each kind of molecule and its lifetime in the atmosphere, as well as the gas's concentration.

A carbon credit is a generic term for any tradable certificate or permit representing the right to emit one tonne of carbon or carbon dioxide equivalent (tCO2e).Carbon credits and carbon markets are a component of national and international attempts to mitigate the growth in concentrations of greenhouse gases (GHGs). One carbon credit is equal to one ton of carbon dioxide, or in some markets, carbon dioxide equivalent gases. Carbon trading is an application of an emissions trading approach. Greenhouse gas emissions are capped and then markets are used to allocate the emissions among the group of regulated sources. The goal is to allow market mechanisms to drive industrial and commercial processes in the direction of low emissions or less carbon intensive approaches than those used when there is no cost to emitting carbon dioxide and other GHGs into the atmosphere. Since GHG mitigation projects generate credits, this approach can be used to finance carbon reduction schemes between trading partners around the world.

There are also many companies that sell carbon credits to commercial and individual customers who are interested in lowering their carbon footprint on a voluntary basis. These carbon off-settings purchase the credits from an investment fund or a carbon development company that has aggregated the credits from individual projects. The quality of the credits is based in part on the validation process and sophistication of the fund or development company that acted as the sponsor to the carbon project.. This is reflected in their price; voluntary units typically have less value than the units sold through the rigorously validated Clean Development Mechanism [2, 3].

There are two types of carbon trading schemes: cap-and-trade and carbon offsets. The Kyoto Protocol requires signatory nations to reduce their greenhouse gas emissions to five percent below their 1990 levels by 2012 [4]. Emissions trading are one of the means authorized by the Kyoto Protocol for accomplishing this goal. The UNFCCC negotiations in Durban, South Africa extended the protocol to 2015 [5].

2. Case Study-Chipendeke Micro-hydropower Scheme

2.1 Project background

Practical Action is implementing a regional energy project funded by the European Union Energy facility that intends to improve access to modern energy services to isolated poor rural communities in the mountainous regions of Malawi, Mozambique and Zimbabwe. Chipendeke is a beneficiary under the facility. The project will harness the dropping water potential energy of the mountain regions to generate hydro power for application to benefit the community both at household and institutional level. Through trying out different models of implementation the project intends to influence the execution of a diversified mode of rural electrification in the region. By installing 15 micro hydro power systems the facility is targeting to reach to 45,000 poor rural people in the region providing them with energy services. The plant has a capacity to generate 28KW of electricity.

2.2 Baseline Selection

In Carbon Financing projects one of the fundamental considerations is the baseline chosen for the particular project. A baseline is the practical alternative that might have been implemented in place of the project under consideration. In the case of Chipendeke Micro Hydro scheme, diesel electricity generation has been chosen as a baseline. The choice of diesel was arrived at since it is the practical option for the plant of such small output. The purpose of the base line is to determine the amount of emissions that was going to be released to the atmosphere in the event that power was being generated from diesel.

2.3 Calculation and emission factors

The RET Screen International Clean Energy Project Analysis Software is a unique decision support tool developed with the contribution of numerous experts from government, industry, and academia. The software, provided free-of-charge, can be used worldwide to evaluate the energy production and savings, life-cycle costs, emission reductions, financial viability and risk for various types of energy efficient and renewable energy technologies (RETs). The software also includes product, cost and climate databases, and a detailed online user manual. Other tools include: a case study based on a college/university-level training course; an engineering electronic textbook; and an extensive Website. All of these tools are available free-of-charge in English and French, with many of the tools available in other languages. The emission factors for the purposes of the project were obtained from RET screen.

2.4 Coal and Green house Gases

Zimbabwe has a lot of coal reserves and it is currently resuscitating almost all the thermal plants that are dormant. Besides there are plans to build a big thermal power plant in Gokwe so besides the existing thermal plants that are currently running, more and more of investment in energy is in the direction of fossil fuels. Power generation from coal is responsible for more than 50% of greenhouse gas emissions which interfere with the climate system thereby causing climate change. Carbon finance is an incentive for investing in low carbon economy as a way to reduce the traditional way of generating power from fossil fuels

2.5 Trading scheme selection and justifications

There are many trading schemes available for trading the carbon credits as explained in the previous chapters. The selection of a particular trading scheme is informed by various reasons. Some of the reasons are financial and others are to do with the availability and functionality of the local Designated National Authority (DNAs). The Kyoto protocol has a long and tedious process that has to be followed before the certified emission reductions certificate can be issued. The process also involves a lot of costs and for a small project like Chipendeke scheme with a capacity of 28KW the costs incurred will far much exceed the benefits to be realized from trading the savings. Besides it also depends on the availability of the DNA. For now the document for the local DNA has been sent to the Attorney General office and is waiting to be finalized. In that case the Clean Development Mechanism (CDM) is therefore not any option for now as there is no operating framework for Zimbabwe.

Therefore for this scheme the credits are going to be sold on the voluntary market where the process of verifying the emission reductions is not as expensive as the one for the CDM. The main disadvantage of the voluntary market is that the prices are low. The Kyoto protocol also implement the Joint lmplementation (JI), but the JI is irrelevant in this case given that it involves projects carried in developed counties alone and it does not involve developing counties. JI is not an option also for this case

2.6 Emission quantification from a coal generating plant

Harare Power station

Harare power station generates electricity from coal and the coal in obtained from Hwange.

Table 3.1: Daily Coal analysis at ZESA Harare Power Station

Day	*Moisture %*	*Ash %*	*Volatile Matter%*	*Fixed Carbon %*	*CV MJ/KG*	*Sulphur %*	*Coal in Ash %*
1	1.4	10.3	22.4.	65.9	28,265	1.52	7.95
2	1.4	11.9	22.4	64.1	28.466	1.56	11.95
3	0.84	13.8	22.84	62.50	27.088	2.3	5.5
4	0.9	12.4	23.25	63.43	27.997	2.0	9.05
5	0.96	13.86	2151	62.43	27.8643	0.143	10.3
6	1.93	12.71	23.0	61.21	29.1769	1.32	10
7	1.70	8.7	22.49	63.1	29.2594	2.35	10.85
8	7.7	18.8	18.4	65.2	29.9374	1.1	10.86
9	2.3	14.9	23.9	55	28,0704	1.0	16.85
10	0.4	13.31	23.5	62.57	28,0222	1.8	9.65
11	o.23	13.39	24.1	65.63	27,1921	2.1	2.8
12	0.9	14.09	20.08	65.63	29,847	1.33	17.1
13	1.11	14.86	19.27	65.06	29.156	0.29	10.9
14	1.42	11.18	18.82	64.49	29.015	2.56	6.85
15	1.56	15.1	19.18	67.41	30.165	1.26	2.25
Daily Average	1.65	13.32	21.68	63.38		1.3	9.51

Source-Harare Power Station (ZESA)

It will be considered as a baseline for the quantification of CO_2 emissions for our thermal generating plants. But for the purposes of trading under the CDM indexes obtained from the national communications to the United Nations Framework Convention on Climate Change (UNFCCC) will have to be used.

2.6.1 Emissions Calculations

CO_2 calculation
Assuming X tons of coal are consumed every day
Now from the table above and taking daily average
Fixed Carbon = 63.38%
Ash = 13.32%
From table 3.1 again it can be established that in the ash there is some residual carbon implying that not all the fixed carbon is burnt.

Carbon in ash is 9.51 from table 3.1

Therefore contaminated ash denoted by Y in this case can be found by the following equation

Y=0.332X +0.0951Y
Y=0, 1332X/0.9048
Therefore Y= 0.14472X

But Carbon content in the ash after combustion is 9.51% of Y given by
C_{res} = 0.0951*0.1447X

where C_{res} is the residual carbon
C_{res} =0.014X

Given that the daily consumption of coal at the station is 250t:

The total burnt Carbon becomes, in terms of X
Subtracting unburnt carbon from fixed carbon
This becomes 0.6338X - 0.014X =0.6198X

Now substituting the Value of X which is the daily coal consumption and in this case it is 250t and we can obtain the burnt carbon per day and the burnt sulphur per day.
Burnt carbon per day is given by
0.6198*250t=154.95t

From the combustion equation $C0_2$ emitted can be calculated assuming that there is complete combustion.
$C + O_2 = CO_2$

From the stoichiometric ratios of complete combustion of coal and given that there is 154.95t of carbon burnt per day. The amount of CO_2 produced can be calculated.

CO_2 produced assuming complete combustion:
154.95*44 t/12= 568.15t.

Therefore 568.15 tones of CO_2 are produced every day.

The Electricity generation for the day is on average 18MW.

From this the specific CO_2 per each kWh produced can be calculated.
568.15*103/(18*103*24) kg/kWh
= 1.315kgCO_2/kWh

Calculating Sulphur Oxides

Sulphur content = 250*0.00139
Therefore burnt sulphur is 3.475t assuming that all the sulphur is converted in the combustion process.
Combustion of sulphur gives SO_2 and SO_3
$S + O_2 = SO_2$
$2S + 3O_2 = 2SO_3$
Now because the Sulphur oxides are different they are given as a range
SO_X emissions per day are from 6.95t SO_2 to 8.69t SO_3
SO_2 emissions per kilowatt hour can be determined in the similar manner

SO_2/ kWh = 6950/432000=0.16KgSO_2/kWh

2.6.2 Carbon dioxide Savings for Chipendeke Micro Hydro Scheme

To find the carbon dioxide savings for the scheme for a certain period just multiply the quantity of electricity generated and the calculated emissions per kilowatt. Now for Chippendale the plant is generating 28 kW. Assuming the plant is operating 300 days a year, taking into account downtimes because of repairs and planned maintenance. Electricity generated a year is:

28*24*300KWh=201 600KWh

From above 1.315kg of CO_2 are emitted per each kilowatt-hour generated from coal.

Therefore the CO_2 avoided by using hydropower is:

1.315kgCO_2/KWh*201600kWh =265 104kgCO_2

Now I Carbon Credit is equivalent to 1 tone of CO_2

Therefore for this purpose Chipendeke has 265 Credits per year.

It is these 265 Credits that are going to be traded per year on the compliance market for the lifespan of the project.

2.7 Choosing of a Suitable Baseline

If the country was getting its electricity only from coal them the above calculated carbon credits were going to be used for the purposes of trading. In Zimbabwe part of the electricity is Hydro and part is from coal. Therefore if the grid emissions were to be used, then the factor has to be the average of the two taking into consideration the percentage contribution of each source to the total emission. In choosing the baseline, the chosen alternative has to be a practical alternative given the prevailing conditions .Because the plant is too small, the only feasible alternative is the stand alone Diesel Generator. For this purpose emission factors for diesel generator taken from Ret screen are going to be used.

2.8 Quantifying the emissions for the Chosen baseline

Having chosen the suitable baseline it is therefore necessary to choose standard emission factors from the Ret screen. A conversion factor of 3.2 kg CO_2 per kg of diesel has been used (following revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories). Taking the above conversion factor of 3.2kgCO_2/kWh and the total kWh of electricity produced for Chipendeke in a year, the total credits can be calculated by simple multiplication. For a generator running for 24 hours, the conversion factor of 1.3Kg CO_2 EQ/kWh is chosen from Ret screen. Total CO_2 emissions = Emission Factor*kWhs produced Now kWhs for Chipendeke Micro Hydro Scheme are given as follows 28*24*300kWh=201 600kWh

Total CO_2 Emissions =201600*1.3kg of CO_2 eq
This gives 262080kg CO_2.

3. Economic Analysis

Table 3.1 shows comparisons of pay back periods and cumulative profits for the project without carbon finance and for the project with carbon revenue.

Table 3.1: Payback periods for the two schemes

	Payback Period
Project Without Carbon Finance	Between the 10th and 11th year
Project with Carbon Finance	Between the 8th and the 9th year

Table 3.2: Cumulative undistributed funds at the end of project

	Cumulative Undistributed profits
Project Without Carbon Finance	$296,507.06
Project with Carbon Finance	$ 389,286.50

4. Discussion

From the above results it was established that carbon financing has the potential of improving project sustainability from renewable energy projects.

From table 3.1 the payback period for the project without carbon revenue is between the 10th and the 11th year while the one after including carbon revenue is between the 8th and the 9th year. It is clear that the contribution of carbon revenue has reduced the payback period for the project. Normally the projects of such a nature have a long payback period given that the communities may not be used to paying the bills especially during the first years of project.

From the table 3.2 it is clear that the addition of carbon revenue results in more undistributed profits at the end of the project. Because of the relatively large amount of undistributed funds brought about by carbon trading it is the possible to continue with the project after the life of the initial equipment. In the event of a major fault which requires large sums of money it is possible to continue with the project since some funds are contributed from carbon revenue.

5. Recommendations

The following recommendations have been made to some of the respective major stakeholders;

5.1 Chipendeke Power Company

Since carbon financing provide an additional revenue stream, the project can benefit a lot from carbon trading if it is registered. It is strongly recommended that the project registers for the voluntary carbon trading schemes which will provide an enabling framework for it to be registered under Clean Development Mechanism (CDM). It is therefore necessary for the company to facilitate registration of the project under Voluntary Carbon Market since it cannot benefit from CDM.

5.2 Government

Lack of knowledge on the benefits of carbon financing and the absence of enabling policy framework has been identified as some of the major hindrances to implementation of CDM projects in Zimbabwe. As a result of these observations it is recommend ted that the government creates a conducive environment that allows for increased investments in the renewable energy sector. This can be done by coming up with policy conditions that favor the creation of Public Private Partnership (PPPs) in the renewable energy sector. The first commitment period of the Kyoto protocol is almost coming to an end without even one project being registered under CDM because the country does not have a functional Designated National Authority (DNA). It is recommended that the government establish the DNA to enable projects to benefit from carbon finance under the mandatory CDM scheme.

5.3 Project Developers

From the research it is evident that carbon trading has financial benefits in renewable energy schemes; the design of these schemes must be done with the concept of carbon trading as a background in order to maximize the reduction of carbon dioxide emissions. It is therefore recommended to project designers to put in consideration the revenue from carbon trading when designing projects.

Renewable energy project developers like Practical action should make it a point that they have within their project team some people are knowledgeable about carbon finance so that their project can benefit from such additional funding. This reduces the burden of continually supporting the same project even beyond the project funding. This will create stability of the project and reduces continued reliance on the funding partners.

5.4 Universities in Zimbabwe

Lack of technical capacity on carbon finance has been identified during the project as one of the reasons non registration of renewable energy projects for carbon finance. It is therefore strongly recommended that the Universities take a lead in coordination trainings on CDM. One of the major drawbacks is the absence of technocrats on the part of the team that leads climate change programme. The universities are recommended to work closely with the industry and the community in consultations so as to know the challenges facing the industry which need research. The department of Mechanical Engineering should consider including Carbon financing as an optional course for its Renewable Energy Programme. The Universities should take a leading role in promoting CDM in the country.

5.5 Business Community

The business community is recommended to come up with local carbon markets to enable local buyers and sellers to transact locally. Creation of a local carbon trading markets is beneficial in that even the local companies who want to offset their emissions will be able to do that without much hustles. From the research most active carbon markets are international markets like Chicago Climate Exchange. It is further recommended that the business community put in place training opportunities on carbon financing to their employees as this is beneficial to all. It is recommended that the business community actively participate in the climate change negotiations to ensure that their issues are not overlooked when major decisions are being made. The business community should also work with institutions of high learning to fund innovations with regards to low carbon technologies like energy efficiency and renewable energy technologies.

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