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Evolution of carbon markets: CDM and VER as tools for supporting NGOs' energy projects in developing countries

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Abstract

This thesis gives an overview of the global carbon market from its history and economic background and investigates about the better entry options for NGOs which access carbon finance to overcome some economic barriers in particular when developing energy projects. Then, it analyses four case studies of NGOs' energy projects in developing countries as Ethiopia and Malawi based on different technologies: improved cook stoves, PV, biogas and hydro. The thesis compares the Clean Development Mechanism and Gold Standard methodologies for voluntary carbon market applied to the case studies and estimates the amount of emission reductions. Then it evaluates the potential impact of carbon revenue on total project cost with certification fees for different price scenarios. The results demonstrate that the application of a different methodology does result in a different number of carbon credits because of the date and version of the method.

The estimation of impact of carbon revenue highlights the advantage for NGOs of accessing carbon finance through the dissemination of improved cook stoves or biogas digesters. However, also the other technologies can obtain some small but useful revenue. Only PV is disadvantaged for high project costs. Another important answer is found : which is the right market for NGOs? The voluntary market, it has a great potential for not-profit organizations because of smallest transaction costs and assurance to meet sustainable development requirements applying certification process like the Gold Standard, instead of CDM. Finally, carbon finance can support NGOs' projects to both improve energy access in developing countries and fight climate change.

Keywords: carbon credit, NGO, carbon market, CDM, VER, Gold Standard, carbon revenue, energy projects, developing countries

Italian Abstract

Questa tesi fa una panoramica del mercato globale del carbonio a partire dalle sue origini e dalle teorie economiche su cui si fonda e cerca di capire quale sia il modo migliore per le ONG per ottenere i carbon credit e superare le barriere economiche che si incontrano in particolare nei progetti energetici.. L'analisi viene fatta su quattro casi studio relativi a progetti di ONG italiane nei Paesi in Via di Sviluppo basati su diverse tecnologie: stufe migliorate e fotovoltaico in Malawi e biogas e idroelettrico in Etiopia. La tesi confronta inoltre le metodologie legate al Meccanismo di Sviluppo Pulito e quelle del Gold Standard per il mercato volontario applicandole ai casi studio e stimando il quantitativo di emissioni ridotte. Inoltre, si valuta il potenziale impatto dei guadagni dovuti alla vendita dei carbon credit sul costo totale del progetto comprensivo delle spese di certificazione per prezzi di vendita differenti. I risultati dimostrano che l'applicazione di diverse metodologie da risultati differenti nel numero di carbon credits in quanto i metodi dipendono dalla versione e dalla data in cui sono state sviluppate. La stima dell'impatto delle entrate evidenzia il grande vantaggio di accedere al mercato dei crediti del carbonio per le ONG che distribuiscono stufe migliorate o installano impianti a biogas. Comunque, anche le altre tecnologie analizzate possono ottenere piccoli ma utili contributi. Solo il fotovoltaico risulta sfavorito per gli elevati costi progettuali. Un'altra importante risposta è stata trovata inerente a quale sia il giusto mercato per le ONG: il mercato volontario ha un grande potenziale per il settore no profit per i minori costi di certificazione e per la certezza di promuovere lo sviluppo sostenibile attraverso processi di enti terzi quali Gold Standard, invece che il Meccanismo di Sviluppo pulito. In conclusione, ottenere i carbon credits si traduce in un supporto ai progetti delle ONG volti a migliorare l'accesso all'energia e combattere i cambiamenti climatici.

Parole chiave: meccanismo dei crediti del carbonio, meccanismo di sviluppo pulito, ONG, energia

Synthesis in Italian

Il Programma per lo Sviluppo delle Nazioni Unite (UNDP) ha posto come primo tra gli Obiettivi del Millennio lo sradicamento della povertà estrema e della fame nel mondo. Il primo passo per conseguire tale obiettivo è stato identificato nella necessità di aumentare e migliorare l'accesso all'energia elettrica e a sistemi energetici moderni e puliti per provvedere a soddisfare i bisogni primari dell'uomo. Infatti, è un dato allarmante come al giorno d'oggi 1,3 miliardi di persone vivano senza accesso all'elettricità localizzate principalmente nelle aree rurali dei Paesi in Via di Sviluppo. Inoltre 2,6 miliardi basano la loro sussistenza sull'utilizzo di biomassa attraverso sistemi inefficienti per riscaldarsi e cucinare, col principale effetto di una elevata incidenza di morti per intossicamento e malattie respiratorie.

Un altro problema che affligge tutto il mondo e, in particolare, i PVS in quanto più vulnerabili, è quello relativo ai cambiamenti climatici e ad uno scenario futuro che, secondo molti scienziati, sarà sempre peggiore per quanto concerne il riscaldamento globale e i fenomeni naturali catastrofici sempre più frequenti. Anche questo problema è legato all'energia, in quanto costituisce la fonte principale di emissioni di gas a effetto serra dato l'ampio utilizzo di combustibili fossili. Dai report dell'IPCC e della World Bank si evince che i Paesi industrializzati stanno effettivamente diminuendo le proprie emissioni di CO_2 (in parte la flessione è legata anche alla crisi economica mondiale), mentre nei PVS, che comprendono anche le economie cavalcanti Cina e India, se ne registra, invece, un aumento notevole. A livello globale, in ogni caso, le emissioni di CO_2 sono raddoppiate rispetto ai valori del 1970.

L'impatto dei cambiamenti climatici, altre ai fenomeni naturali, è stato tradotto in termini economici da Stern, un economista inglese della World Bank, che con il report del 2006 ha stimato che senza agire si perderà nei prossimi anni fino al 20% del GDP globale per far fronte agli effetti del clima. Per cercare di raggiungere gli obiettivi e risolvere i problemi, in particolare focalizzandosi sui PVS, sono necessari investimenti. Proprio quest'ultimo punto accomuna ancor di più i due temi sopra citati e già interconnessi: accesso all'energia e cambiamenti climatici.

Per cercare di risolverli, gli sforzi della comunità internazionale hanno portato alla creazione dei mercati dei crediti del carbonio. I crediti del carbonio o carbon crediti sono strumenti finanziari che possono essere scambiati, acquistati e venduti. Ciascuno di essi rappresenta una tonnellata di CO_2 equivalente ridotta. Equivalente indica che oltre alla CO_2 anche altri gas a effetto serra possono essere oggetto dei progetti e tramite un fattore, il GWP, Global Warming Potential, vengono convertite in tonnellate di CO_2e. I carbon credit 'muoiono' nel momento in cui servono a compensare le emissioni e quindi non possono

essere più scambiati, altrimenti vengono anche acquistati da broker e per speculazioni possono essere venduti più volte.
I mercati si suddividono in due segmenti: mercato regolato e mercato volontario. La differenza principale tra questi sistemi è che nel mercato regolato è il Paese a definire, per esempio, in linea con il Protocollo di Kyoto, le regole e quali settori e aziende siano soggetti a ridurre le proprie emissioni di CO_2, mentre nell'altro segmento la domanda è dettata da chi volontariamente decide di ridurre l'impatto sul clima compensando le proprie emissioni per ragioni di coscienza ambientalista, piuttosto che di marketing e responsabilità sociale. I crediti generati nel mercato volontario prendono il nome di VERs (Verified o Voluntary Emission Reductions). Inoltre, l'altra grande differenza sta nelle dimensioni in termine di valore e tonnellate di CO_2 scambiate, in quanto il mercato volontario risulta circa la centesima frazione di quello regolato.
Il mercato regolato si basa su un tetto che i soggetti coinvolti non devono superare altrimenti nel caso in cui, solitamente alla fine di ogni anno, si è emesso di più rispetto a quanto concesso, è necessario acquistare dei crediti. Dall'altro lato vi sarà un soggetto che avrà ridotto le proprie emissioni perciò potrà vendere sul mercato il disavanzo di crediti ricevuti. Accanto a questo meccanismo di compravendita, con il protocollo di Kyoto sono stati creati due sistemi Joint Implementation e Clean Development Mechanism che si basano su progetti di riduzioni in Paesi differenti da quelli del promotore. In particolare, JI si sviluppa nei paesi ex-URSS mentre CDM ha per oggetto progetti nei PVS. Questo secondo approccio risulta interessante perché può essere il modo per finanziare contemporaneamente l'accesso all'energia e combattere i cambiamenti climatici. I crediti generati tramite il CDM sono chiamati CERs (Certified Emission Reductions).
Il mercato volontario si fonda sui soli progetti, ed è questa la piattaforma che più interessa alle Organizzazioni Non Governative. Le ONG ricoprono ruoli diversi nel mercato del carbonio: alcune fungono da intermediari coi partner locali nei PVS per conto di chi sviluppa un progetto; altre esercitano pressioni politiche per ottenere regolamenti volti a garantire il minor impatto ambientale possibile dei progetti; altre ancora si dedicano al monitoraggio dei progetti che vengono effettuati; infine, altre sono parte attiva e promotrici di progetti energetici nei Paesi in Via di Sviluppo. Quest'ultimo ruolo è quello analizzato nella tesi con l'obiettivo di individuare quale sia il mercato più adatto alle ONG, quali gli strumenti attraverso i quali le ONG possono accedere ai crediti del carbonio e valutare per quattro casi studio relativi a progetti energetici reali sviluppati senza carbon credit quale possa essere attualmente l'impatto delle entrate generate dalla vendita di questi strumenti finanziari.

Obiettivi

Gli obiettivi della tesi sono i seguenti:

- ✓ Descrivere la struttura e lo sviluppo del mercato dei crediti del carbonio valutando in particolare le possibilità di accesso da parte delle ONG
- ✓ Confrontare i principali meccanismi di certificazioni, quali il Meccanismo di Sviluppo Pulito, Gold Standard e Voluntary Carbon Standard.
- ✓ Definire il ruolo delle ONG e i principali progetti sviluppati con accesso ai carbon credit
- ✓ Analizzare alcuni casi studio relativi a progetti energetici applicando differenti metodologie (CDM and GS VER) per stimare le emissioni ridotte e l'impatto delle entrate generate dalla vendita dei carbon credit sul costo totale del progetto.

Nel Primo Capitolo della tesi, si descrive la nascita ed evoluzione storica del mercato dei carbon credit sia regolato che volontario a partire dalla prima teoria economica di Coase che consisteva nel dare un valore e un diritto di proprietà alle esternalità secondo il noto principio 'chi inquina paga'. Inoltre si descrivono i principali sistemi sui quali si basa attualmente il mercato globale delle emissioni e le modalità con cui si generano i crediti del carbonio:

- ✓ Cap-and-trade, il più comune sistema su cui è fondato il mercato regolato e che consiste nell'assegnazione da parte del Governo di permessi di emissioni ad aziende inquinanti (principalmente società energetiche, acciaierie, industrie cartarie o comunque aziende energivore e, di recente, anche compagnie aeree) fino ad un tetto massimo che alla fine dell'anno di riferimento viene confrontato con le effettive emissioni monitorate. A questo punto, chi ha emesso più di quanto concesso dovrà necessariamente acquistare dei crediti per il quantitativo di tCO2e in surplus da chi invece è stato al di sotto della soglia di riferimento. Ecco che in questo modo nascono domanda e offerta nel mercato.
- ✓ Baseline-and-credit attraverso il quale tramite un progetto si valutano le emissioni che sarebbero occorse senza il progetto stesso per verificare quali benefici e quindi quante tCO_2e sono state ridotte con la sua realizzazione.

Successivamente si entra nel dettaglio del Protocollo di Kyoto, che ha posto degli obiettivi di riduzione delle emissioni ai firmatari e definito tre meccanismi flessibili per dare possibilità ai soggetti coinvolti di ridurre effettivamente il proprio impatto ambientale. Emission trading è basato sull'assegnazione dei permessi di emissione, mentre Joint Implementation e Clean Development Mechanism consistono nella realizzazione di progetti di riduzione delle emissioni al di fuori del proprio Paese. Ci si focalizzerà prevalentemente sul CDM, ampiamente analizzato nel capitolo seguente. Alla fine di questa sezione vengono anche definiti gli attori in gioco nella creazione, acquisto, vendita e dismissione dei carbon credit.

Il Secondo Capitolo, analizza lo stato attuale e l'andamento dei mercati che possono interessare le ONG. In particolare, per CDM e mercato volontario si fa una fotografia dei quantitativi di crediti scambiati, di chi vende e chi compra e dove sono localizzati. Inoltre si descrive brevemente il processo di sviluppo del progetto per accedere ai carbon credit con particolare attenzione al tema della addizionalità: difatti, un progetto può acquisire crediti solo e solo se senza i carbon credit non sarebbe stato implementato per problemi relativi al superamento delle barriere economiche, istituzionali o tecnologiche nei PVS. Per il mercato volontario si introducono gli Standard di certificazione, che sono nati per dare credibilità a questo segmento che non in origine non era controllato come avviene per il CDM e gli altri meccanismi sotto l'egida delle Nazioni Unite. Poi viene presentato in particolare il Gold Standard, ente terzo che, sostenuto dalle ONG, è specializzato nei progetti energetici e garantisce il raggiungimento dei requisiti dello Sviluppo Sostenibile tramite appositi indicatori. Infine viene accennato un altro ente certificatore, VCS, Voluntary Carbon Standard, specializzato nei progetti forestali e viene fatto un paragone prima tra i diversi standard del mercato volontario e poi tra CDM e mercato volontario in termini di prezzi, dimensioni e procedure.

Il Terzo Capitolo descrive inizialmente il contesto problematico dei PVS e i vari programmi di sviluppo sponsorizzati dalle Istituzioni Internazionali, quali la World Bank, inerenti a migliorare l'accesso all'energia. Successivamente, ci si focalizza sui principali progetti sviluppati dalle ONG che hanno accesso al mercato dei carbon credit. Essi si suddividono in progetti energetici e forestali. Tra quelli energetici vengono descritte le tecnologie principali adoperate: le stufe migliorate, il fotovoltaico con i kit per gli abitanti dei villaggi rurali, il solare termico e altre applicazioni che sfruttano l'energia del sole, l'eolico, gli impianti a biogas, l'idroelettrico e il biodiesel ottenuto da jatropha. Per quanto riguarda i progetti forestali, che al momento costituiscono una gran parte dei progetti sviluppati dalle ONG nel mercato volontario per la semplicità di realizzazione, nonostante lo scetticismo e alcune problematiche nella certificazione, si descrivono in generale l'afforestamento, il rimboschimento e la deforestazione.

Nel Quarto Capitolo, si analizzano nel dettaglio quattro casi studio:

1) COOPI-STOVES Malawi
   Progetto sviluppato dalla ONG italiana COOPI in Malawi consiste nella distribuzione di 1600 stufe migliorate del tipo Mbaula con un'efficienza del 21% a 9000 beneficiari diretti che in questo modo potranno

migliorare la qualità della vita sostituendo l'utilizzo di sistemi tradizionali e inefficienti, quali le tre pietre per riscaldarsi e cucinare.

2) COOPI-PV Malawi
   Progetto costituito da diverse componenti alimentate da pannelli fotovoltaici e, in piccola parte, da sistemi ibridi PV-eolico per 14508 beneficiari con l'obiettivo di fornire:
   - ✓ Illuminazione per 1300 famiglie (1300 unità solari)
   - ✓ Pompe elettriche per l'acqua per 75 famiglie e pompe per irrigazione per 800-1200 famiglie
   - ✓ Energia elettrica per 25 piccole imprese
   - ✓ Energia elettrica per 6 scuole e 3000 studenti con 6 unità solari (2000 kWh/y/scuola)
3) LVIA-BIOGAS Etiopia
   Progetto di una ONG italiana, LVIA, che consiste nell'installazione di 1400 impianti biogas per un totale di 8400 beneficiari. Le famiglie avranno 1 m^3 di biogas al giorno da utilizzare per scaldarsi e cucinare e per illuminare attraverso le lampade a biogas. Oltre a questo aspetto si installeranno 200 latrine migliorando le condizioni igieniche delle famiglie stesse.
4) LVIA-HYDRO Etiopia
   Progetto 10 impianti (5 pico-idro e 5 mini-idro) per un totale di 18500 beneficiari e 100 kW di potenza. Ogni famiglia avrà a disposizione 25 W di potenza elettrica, costituiti da 10W per una lampada e 15W per una presa da utilizzare per altre utenze. Oltre alle utenze domestiche, l'energia sarà utilizzata per le attività commerciali e i servizi pubblici.

A questo punto si entra nel merito della valutazione del possibile accesso di questi progetti al mercato volontario dei carbon credit.

Scelta dello standard

Tra gli enti certificatori esistenti, la scelta è ricaduta sul Gold Standard in quanto specializzato nei progetti energetici e, oltre ad essere stato fondato dalle ONG stesse come detto prima, nella sua procedura coinvolge gli stakeholder locali e certifica soltanto progetti che portano dei benefici aggiuntivi. In realtà, quest'ultimo punto, legato allo sviluppo sostenibile, rientra anche nello scopo dei CDM, ma negli anni si è visto come la tendenza delle società coinvolte nei progetti si sia focalizzata più sull'incremento del numero dei carbon credit (e relative tonnellate di CO_2 ridotte) che ai benefici per le comunità locali. Proprio per questo motivo, Gold Standard cerca di dare maggiori garanzie in merito. Gold Standard da la possibilità di sviluppare i progetti sia secondo il CDM che secondo metodologie per l'acquisizione dei VER.

Scelta delle metodologie

Per la presentazione di un progetto che possa accedere ai carbon credit è necessario seguire determinate metodologie che descrivono equazioni, ipotesi ed eventuali valori di default legati ai report IPCC al fine di:

- ✓ Definire lo scenario di 'baseline' ;
- ✓ Determinare la riduzione delle emissioni;
- ✓ Definire le regole per il monitoraggio.

Esistono diverse metodologie definite dalle commissioni dell'UNFCCC per quanto riguarda il CDM e altre ancora definite dal Gold Standard.

Le metodologie sono in continua evoluzione e vengono revisionate dalle commissioni dell'UNFCCC (per i CDM) e dal Gold Standard o altri enti (per i VER) perciò discrepanze nei valori si possono verificare proprio per le differenze tra due metodologie e tra due versioni della stessa metodologia. Per esempio, uno stesso progetto, seguendo la stessa metodologia ma con un una versione più aggiornata darà risultati differenti. Ovviamente, nel momento in cui si deve presentare la documentazione per l'accesso ai carbon credit bisogna fare riferimento alla versione più aggiornata.

Definizione dello scenario di baseline

Ogni metodologia definisce l'area del progetto e quali componenti utilizzare per la definizione della baseline. Solitamente il CDM si basa sullo scenario costituito da combustibili fossili. La metodologia per i GS VER rispecchia invece i dati reali della zona di interesse o ottenuti tramite interviste su un campione dei beneficiari.

Nel nostro caso, i combustibili utilizzati nello scenario di baseline dai dati COOPI e LVIA sono:

- ✓ Stufe migliorate – 4500 kg/year a famiglia
- ✓ PV – 63000 kWh/year da diesel
- ✓ Biogas – Legna da ardere: 4.116 ton/year; kerosene: 25.2 ton/year
- ✓ Idroelettrico - kerosene: 88 ton/year;

Dove mancano i dati, alcune metodologie consentono l'utilizzo di valori di default dell'IPCC per il Paese considerato.

Determinazione delle emissioni ridotte ex-ante

Generalmente, per tutte le metodologie le emissioni vengono calcolate attraverso la seguente formula:

$$ER_y = BE_y - PE_y - LE_y$$

ER_y sono le emissioni ridotte annuali

BE_y sono le emissioni di baseline annuali, quindi senza il progetto
PE_y sono quelle del progetto annuali
LE_y sono quelle di leakage annuali, dovute per esempio a eventuali tecnologie importate.

Essendo nella fase ex-ante e non avendo quindi dei dati di monitoraggio PE si considera nulla. In ogni caso, per le energie rinnovabili è sempre così.
Solo per le stufe migliorate, si potrebbe considerare che per questioni culturali e di tradizione le famiglie possano rifiutare l'utilizzo delle stufe per continuare a sfruttare le 'tre pietre' e lo stesso eventualmente per una certa riluttanza nei confronti dei sistemi a biogas. Questo aspetto è stato escluso dall'analisi.
Lo stesso avviene per LE perché le tecnologie utilizzate si trovano in loco, si cerca di produrle in loco o comunque si trovano a non molta distanza dai luoghi di installazione.
Vi sono altre ipotesi 'forti' per quanto riguarda biogas e stufe migliorate, in quanto la vita utile porterebbe a ridurre il numero degli impianti operativi nell'arco della durata del progetto. Si assume quindi idealmente che le stufe e gli impianti biogas siano subito sostituiti da altri e che quindi il numero rimanga costante nel tempo.
Altra ipotesi, è che non vi siano perdite di rendimento degli impianti e, infine, che il numero di beneficiari non vari durante tutta la durata del progetto.
Vi sono equazioni specifiche per ogni metodologia ma generalmente il calcolo delle emissioni si basa sui fattori di emissione (espressi in tCO_2/kg combustibile) definiti per il combustibile che viene sostituito o ridotto nel consumo.

Scelta del prezzo

Per dare un valore alle entrate, sono stati individuati i prezzi di riferimento contenuti nel report "State and trend of the voluntary carbon markets" di Bloomberg New Energy Finance.
In particolare:
- prezzo per tipo di progetto
- prezzi per ubicazione del progetto
- prezzo per dimensione del progetto

Per ricavare i prezzi del Gold Standard CDM rispetto al Gold Standard VER si è fatto il rapporto tra i prezzi medi di questi due tipi di certificazioni con un risultato del 30% in più per il prezzo dei crediti da CDM.
La valutazione economica è stata effettuata utilizzando i prezzi della prima parte della tabella, con i valori relativi ai prezzi massimi, minimi e medi avuti nel

mercato. E successivamente si è valutato anche un unico prezzo medio intorno uguale a 9 EUR/tCO_2e per i VER e 11,7 EUR/tCO_2e per i CDM.

Budget e Costi di transazione

Dai dati di COOPI e LVIA relativi ai progetti si è ricavato il costo di ciascuna tecnologia. I budget si riferiscono ad una coppia di tecnologie (per COOPI comprende sia stufe che PV, mentre per LVIA sia biogas che idroelettrico) quindi per quanto riguarda la componente relativa alle spese per le risorse umane, viaggi e altri costi, si è suddivisa la quota in proporzione ai costi delle sole tecnologie e alle tempistiche di implementazione di ciascuna tecnologia . A questo punto, ottenuto il costo del sistema totale è necessario aggiungere il costo per la certificazione.
Dalla letteratura e dai progetti esistenti si evince che generalmente i costi per progetti di piccola scala sono costituiti dalle seguenti componenti:

- ✓ tariffa dello standard, in percentuale rispetto all'ammontare dei crediti ricevuti
- ✓ tariffa per lo studio di pre-fattibilità, solo per il primo anno
- ✓ costo della certificazione, solo per il primo anno
- ✓ costo per le verifiche annuali

Anche in questo caso i CDM hanno tariffe di certificazione maggiori rispetto ai VER.

Carbon credit e Valutazione economica

Per tutti i casi studio si è scelto un periodo creditizio di 7 anni. Le possibilità sono due generalmente: 10 anni senza rinnovo oppure 7 anni con la possibilità di due rinnovi. La scelta è basata sul fatto che analizzando i progetti energetici che hanno accesso ai carbon credit solitamente fanno riferimento ai 7 anni (tranne che per le stufe migliorate, che solitamente si basano sui 10 anni senza rinnovo). Per omogeneità si è considerata sempre la stessa tempistica, 7 anni.
Per la valutazione economica, si sono seguiti i seguenti passi:

1. Calcolato l'ammontare delle emissioni in tCO_2e (che corrisponde al numero dei crediti) seguendo la metodologia di riferimento (CDM o GS VER) si è moltiplicato ciascun valore per i diversi scenari di prezzo di riferimento per quella tipologia di progetto.
2. Successivamente è stata calcolata la percentuale delle entrate rispetto ai costi totali calcolati prima, ottenendo valori differenti per ogni scenario di prezzo.

Tutti i costi ed entrate non sono state attualizzate perché ritenuto di poco interesse per il settore no-profit e per il fatto che si sta sviluppando una valutazione economica di massima ex-ante.

I risultati ottenuti per quanto riguarda le emissioni, evidenziano una disparità tra il calcolo effettuato con la metodologia CDM e quella GS VER. La metodologia CDM risulta in ogni situazione più conservativa. Le differenze tra CDM e GS VER variano del 40% per le stufe migliorate, del 31% circa per PV e idroelettrico, in quanto usano le stesse metodologie, e del 17% per il biogas. Analizzando in dettaglio le equazioni, si evince che le differenze per le stufe migliorate sono dovute alla considerazione delle emissioni date dai gas diversi dalla CO_2 per il solo calcolo dei VERs. Per quanto riguarda le metodologie utilizzate per PV e idroelettrico, il valore delle emissioni per CDM e VER risulta differente proprio per i differenti fattori di emissione utilizzati (Ad esempio, per il diesel: 0,8 $kgCO_2/kWh$ nel CDM contro 1,3 $kgCO_2/kWh$ per i VERs).
Infine, per il biogas, i VERs considerano anche le emissioni dovute alla gestione del letame proveniente dagli animali che con l'impianto vengono in parte recuperate.

Per quanto concerne l'impatto sul costo totale per i diversi scenari, le stufe migliorate risultano notevolmente favorite con valori che superano il 200%, nel caso del CDM e il 400% per i VERs. Il biogas raggiunge anch'esso percentuali elevate che variano tra 20% e 280% per i diversi scenari di prezzo per entrambe le metodologie. L'idroelettrico ottiene al massimo il 13% con il CDM e il 15 % con i VERs. Per ultimo, sfavorito per i costi elevati, il PV non supera il 2,7 % per i CDM e il 3,1 per i VERs.

Al fine di valutare la validità dell'analisi, per un confronto qualitativo si è riportata la stima effettuata dal Green Markets International per il solo mercato volontario e risulta in linea con i valori medi ricavati a parte per l'idroelettrico che nei casi studio raggiunge decisamente una percentuale inferiore.

Conclusioni

Il mercato dei crediti del carbonio può essere fonte di fondi per supportare le ONG e promuovere progetti basati sulle energie rinnovabili.
Il mercato di riferimento per i progetti implementati dalle ONG è il mercato volontario in quanto sia a livello di procedura che per costi risulta meno oneroso.
Per quanto riguarda il Gold Standard, esso presenta metodologie alternative semplificate rispetto a quelle del CDM e da la garanzia di rispettare i requisiti dello Sviluppo Sostenibile, cosa che trova un punto d'incontro con la mission delle ONG stesse.
Dal calcolo delle emissioni, risulta che metodologie diverse danno risultati differenti perché utilizzano generalmente coefficienti di emissione per un

determinato combustibile definiti in tempi diversi oppure non includono emissioni di sola CO_2.
Per quanto riguarda la valutazione economica, visto le variabili in gioco, per esempio il prezzo stesso, non si può dire in assoluto quale sia la metodologia migliore da seguire per una determinata tipologia di progetto ma di certo si vede come le stufe migliorate siano nettamente favorite rispetto al PV. Essi affrontano problemi differenti, ma bisognerebbe valutare se effettivamente le stufe migliorate hanno o meno un impatto sempre positivo. Anche il biogas risulta favorito ottenendo un elevato ammontare di crediti.
Considerato l'interesse della politica, del marketing e anche dei comuni cittadini per le tematiche ambientali, questo mercato è destinato a crescere e può portare investimenti notevoli per progetti concreti in ambito energetico sviluppati dalle ONG.

Content

List of Acronyms and Abbreviations

A/R	Afforestation and Reforestation
ACP	African, Caribbean and Pacific
AES	Applied Energy Services
AFOLU	Agriculture Forestry and Other Land Use
AMS	Approved Methodology for Small scale
CAR	Climate Action Reserve
CARE	Cooperative for Assistance and Relief Everywhere
CCB	Climate Community and Biodiversity
CCT	Control Cooking Test
CCX	Chicago Climate Exchange
CDM	Clean Development Mechanism
CERs	Certified Emission Reductions
CFU	Carbon Finance Unit
COOPI	Cooperazione Internazionale
COP	Conference Of Parties
DNA	Designated National Authority
DOE	Designated Operational Entity
E4All	Energy for All
EB	Executive Board
EPA	Environmental Protection Agency
ERUs	Emission Reduction Units
ESCOM	Electricity Supply Corporation of Malawi
ET	Emissions Trading
EU ETS	European Emission Trading System
EUA	European Allowances
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GS	Gold Standard
GS-CERs	Gold Standard Certified Emission Reductions
GS-VERs	Gold Standard Verified Emission Reductions
GWP	Global Warming Potential
HAWT	Horizontal Axis Wind Turbines

HIV/AIDS	Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome
HRT	Hydraulic Retention Time
ICRC	International Committee of the Red Cross
ICS	Improved Cook Stoves
IEA	International Energy Agency
IETA	International Emissions Trading Association
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
JI	Joint Implementation
KPT	Kitchen Performance Test
KVIC	Khadi and Village Commission
lCERs	long-term CERs
LITA	Likoma Island Tours Association
LPG	Liquid Petroleum Gas
LSC	Local Stakeholder Consultation
LULUCF	Land Use, Land-Use Change and Forestry
LVIA	Lay Volunteers International Association
MDG	Millennium Development Goals
MSL	Minimum Service Level
NGOs	Non-Governmental Organizations
NRC	Natural Resources Committees
NZ	New Zealand
OECD	Organization for Economic Cooperation and Development
OTC	Over-The-Counter
PCU	Power Conditioning Unit
PDD	Project Design Document
PDN	Power Distribution Network
PM	Particulate Matter
REDD	Reduce Emissions from Deforestation and forest Degradation
RGGI	Regional Greenhouse Gas Initiative
RMU	Removal Unit
SE4All	Sustainable Energy for All
SHS	Solar Home Systems
SPV	Solar Photovoltaic
SW	Small Wind

tCERs	temporary CERs
TCG	The Climate Group
TEG	Thermoelectric Generator
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Program
UNFCCC	United Nations Framework Convention on Climate Change
VAWT	Vertical Axis Wind Turbines
VCM	Voluntary Carbon Market
VCS	Voluntary Carbon Standard
VCUs	Voluntary Carbon Units
VERs	Voluntary Emission Reduction units
VFA	Volatile Fatty Acids
WBT	Water Boiling Test
WCI	Western Climate Initiative
WEF	World Economic Forum
WEO	World Energy Outlook
WHO	World Health Organization
WMO	World Meteorological Organization
WWF	World Wildlife Foundation
YMCA	Young Men's Christian Association

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Introduction

As we begin the 21st century, the governments and the international community face two challenges which will define our future: the battle against poverty and the prospect of climate change crisis. These are two of the eight Millennium Development Goals defined by the United Nations (the 1st and the 7th MDGs).

According to the UNDP and the WHO, the global aspirations embodied in the MDGs will not become a reality without massive increases in the quantity and quality of energy services. Modern energy services are crucial to human well-being and to a country's economic development. Access to modern energy is essential for the provision of clean water, sanitation and healthcare and for the provision of reliable and efficient lighting, heating, cooking, mechanical power, transport and telecommunications services. Also, improved household energy technologies for the very poor can prevent the almost 2 millions deaths a year attributable to indoor air pollution from solid fuel use.

It is an alarming fact that today billions of people lack access to the most basic energy services: as World Energy Outlook 2013 shows nearly 1.3 billion people are without access to electricity and more than 2.6 billion people rely on the traditional use of biomass for cooking (Table 1).

	Without access to electricity		Traditional use of biomass for cooking*	
	Population	Share of population	Population	Share of population
Developing countries	**1 257**	**23%**	**2 642**	**49%**
Africa	**600**	**57%**	**696**	**67%**
Sub-Saharan Africa	599	68%	695	79%
Nigeria	84	52%	122	75%
South Africa	8	15%	6	13%
North Africa	1	1%	1	1%
Developing Asia	**615**	**17%**	**1 869**	**51%**
India**	306	25%	818	66%
Pakistan	55	31%	112	63%
Indonesia	66	27%	103	42%
China	3	0%	446	33%
Latin America	**24**	**5%**	**68**	**15%**
Brazil	1	1%	12	6%
Middle East	**19**	**9%**	**9**	**4%**
World***	**1 258**	**18%**	**2 642**	**38%**

** Based on World Health Organization (WHO) and IEA databases. **Includes OECD countries and Eastern Europe/Eurasia*

Table 1: People without access to modern energy services by region

These people are mainly in either developing Asia or sub-Saharan Africa and in rural areas.

At the same time, energy is the greatest contributor of greenhouse gas (GHG) emissions worldwide and low income countries are among the most vulnerable to climate change, underlying the importance of clean energy for increasing energy access. The great part of climate scientists agree that human activities are responsible for the process of climate change. While our planet does release and absorb carbon naturally in a continuous cycle, the burning of fossil fuels, large scale deforestation and other human activities have all led to the release of more carbon dioxide and other GHG that can be naturally absorbed and recycled by the world's oceans and forests. As a result of the increasing concentration of GHG in the atmosphere, average global temperatures are steadily rising. New records set in 2012 confirm a worsening situation: these include the lowest summer ice coverage in the Arctic and highest temperatures in Australia since records began. In relation to IPCC Report 2013 current global emissions of GHG could put us on a pathway towards a world that is 3.5 to 4 degrees Celsius warmer by the end of the century. A great increase in temperature would threaten our current economic model with unprecedented and unpredictable impacts on human life and ecosystems into the long-term future.

At the global scale, the key greenhouse gases emitted by human activities are:

- Carbon dioxide (CO_2) – (77% of global GHG)
  Fossil fuel use is the primary source of CO_2. The way in which people use land is also an important source of CO_2, especially when it involves deforestation. Land can also remove CO_2 from the atmosphere through reforestation, improvement of soils and other activities.
- Methane (CH_4) – (14%)
  Agricultural activities, waste management and energy use all contribute to CH_4 emissions.
- Nitrous oxide (N_2O) – (8%)
  Agricultural activities, such as fertilizer use, are the primary source of N_2O emissions.
- Fluorinated gases (F-gases) – (1%)
  Industrial processes, refrigeration, and the use of a variety of consumer products contribute to emissions of F-gases, which include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). [1]

In terms of anthropogenic emissions, carbon dioxide is the primary source. According to the 'Trend in global CO_2 emissions' of the European Commission's Joint Research Centre, the six largest emitting countries/regions in 2012 were: China (29%), the United States (15%), the European Union

(11%), India (6%), the Russian Federation (5%) and Japan (4%). Remarkable trends were seen in the top three emitting countries/regions, which account for 55% of total global CO_2 emissions (Figure 1). Carbon cuts in the industrialized world weren't enough to offset rising emissions in fast-growing economies in developing world. [2]

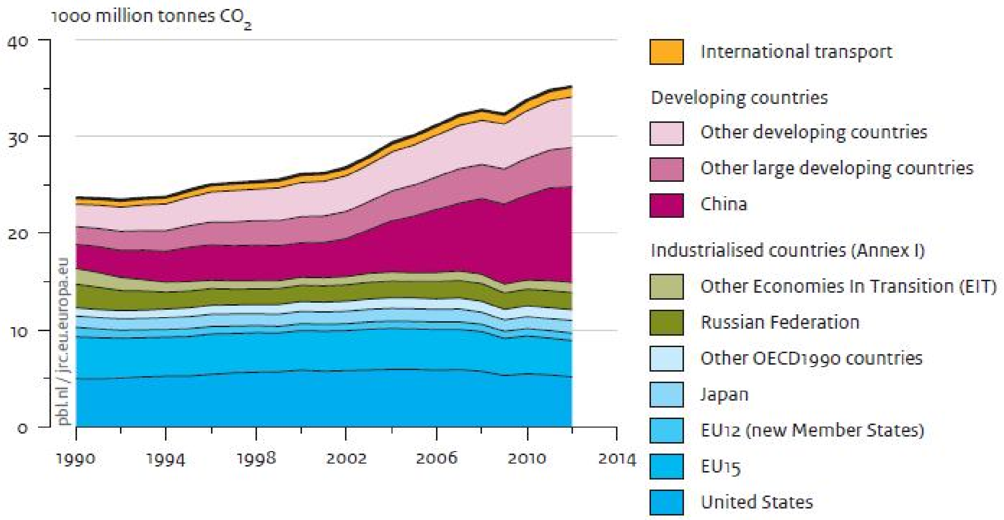


Figure 1: Global CO_2 emissions per region from fossil-fuel use and cement production

On a global scale, the amount of energy from carbon-free or low-carbon sources continued to grow in 2012. Compared to 1990 levels, renewable energy was up by 733 per cent in 2012. The amount of power which came from low carbon sources was up 41 per cent on 1990 levels. But as a share of the total amount of energy we use, renewables and low carbon are still way behind carbon-rich fossil fuels like coal, oil and gas.

The impact of climate change

Globally, emissions have almost doubled since 1970 and there are a number of signs that the world's climate is changing and that these changes will intensify over the coming years (e.g. droughts, storms and hurricanes are occurring more frequently), but these are not the only effects. In 2006, the Stern Review of the Economics of Climate Change translated the effects into economic terms. It predicts that global warming will lead to a 20 per cent loss of the world's economic production (Figure 2) as measured by Gross Domestic Product (GDP) and that the poorest countries will be the worst affected. This is in part because of their heightened exposure; many developing countries are located in drought and flood prone areas and heavily rely on activities such as agriculture and fishing which are sensitive to climate variation. In addition, many developing countries lack capacity and resources to adapt to any changes in the climate.

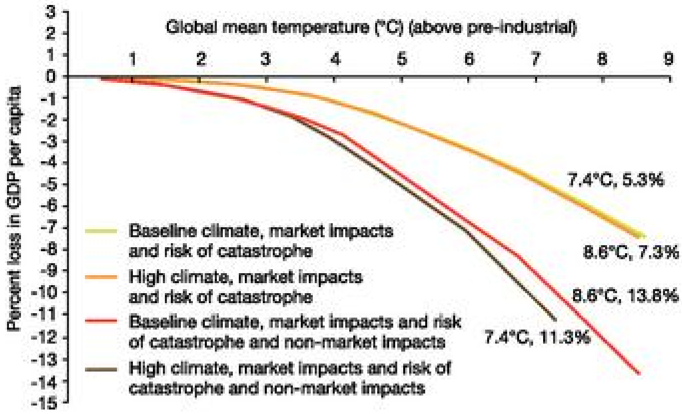


Figure 2: Impact of climate change on GDP

Now, there is widespread agreement that the costs of significantly reducing GHG emissions today are lower than the future financial costs that will be incurred as a result of climate change. For this reason, it is essential to reduce emissions. The goal is to peak global emissions in the next decade and decline to roughly 80% below 1990 levels by the year 2050.

Perhaps one would expect that enormous potential cost of climate change would be motivation enough to rapidly reduce GHG emissions. However, the large emissions reductions needed to mitigate climate change would require individuals and organizations to lower their own carbon footprints by improving energy efficiency, relying on lower-emission products and changing consumption patterns. This, in turn, would require us to change our lifestyles and restructure our economy.

Unfortunately, without strong economic incentives such changes are not likely to happen any time soon. This transition can only be achieved by far-reaching national and international climate policies. At the same time, voluntary individual and corporate climate action can be essential for creating the public awareness and constituency needed for policy change.

The role of carbon credits

Finance is the key to realizing emission reductions needed to bridge the emissions gap. So, two kind of carbon markets have been created as tools to fight climate change: compliance or regulated market and the voluntary carbon market (VCM).

Compliance markets are created and regulated by mandatory regional, national and international carbon reduction regimes. They are dominated by the

European Union's allowance-based Emissions Trading Scheme and the Kyoto agreement's project-based Clean Development Mechanism (CDM).

Voluntary carbon markets function outside of the compliance markets and enable companies and individuals to purchase carbon offsets on a voluntary basis. The big difference is that the voluntary market is based only on project-based transactions because it doesn't operate under a universal cap.

Carbon offsetting is an increasingly popular means of taking action. By paying someone else to reduce GHG emissions elsewhere, the purchaser of a carbon offset aims to compensate for their own emissions. Individuals seek to offset their travel emissions and companies claim climate neutrality by buying large quantities of carbon offsets to neutralize their carbon footprint or that of their products. This is possible because climate change is a non-localized problem; greenhouse gases spread evenly throughout the atmosphere, so reducing them anywhere contributes to overall climate protection.

GHG emissions reductions are traded in the form of carbon credits, financial instruments which represent the reduction of GHG equal to 1 metric ton of carbon dioxide equivalent (tCO_2e). Specific rules are used to make sure that emissions reduction projects meet strict environmental integrity standards. Carbon offset should be additional, real, verified, should avoid double counting and address permanence and leakage.

The most important currently available carbon offset standards are the CDM, the Gold Standard (GS) and the Voluntary Carbon Standard (VCS). They differ from project eligibility and project cycle, but, particularly CDM and GS, accept energy projects and can contribute to improve energy access and to a developing country's sustainable development objectives through:

- Transfer of technology and financial resources;
- Sustainable ways of energy production;
- Increasing energy efficiency and conservation;
- Poverty alleviation through income and employment generation;
- Local environmental side benefits

Hence, the market for project-based emission reductions has been an important catalyst for low-carbon investment in developing countries providing an additional source of revenue for sustainable energy projects.

The non-profit sector: NGOs

In this context, Non-Governmental Organizations active in environmental protection and poverty alleviation have become increasingly active in the carbon markets. Many of these NGOs develop projects directly or support communities and organizations that are trying to develop a project that will generate carbon credits and deliver additional benefits, such as access to energy. They may hire consultants to certify the project, subsidize equipment, pre-finance projects and sell carbon credits. They also play a role in influencing public opinion on climate change and thereby stimulate demand for credits on the voluntary market.

NGOs have two carbon market entry options: CDM and VCM. Usually, NGOs projects are more suitable for the voluntary market for a number of reasons but particularly because they are small scale projects and there are less transaction costs. Development organizations such as the World Bank tend not to be as involved on the operational level, but rather offer to NGOs investment capital at attractive rates or for free to carbon credit projects.

Finally, for NGOs small scale sustainable energy project in rural areas accessing finance is very important to overcome key barriers and is one of the major constraints to expansion. However, not all are aware of basic criteria that will allow their projects to qualify for carbon finance and the impact of carbon revenue on their investment plan.

Purpose of the thesis and outline

The main objectives of the thesis are:

- ✓ provide an overview of the global carbon market from their origins in global efforts to address climate change and explain the Kyoto Protocol mechanisms and the role of the voluntary carbon market, more interesting for NGOs.

- ✓ describe and compare the most important currently available carbon offset standards such as:
  - Clean Development Mechanism (CDM)
  - Gold Standard (GS)
  - Voluntary Carbon Standard (VCS)

- ✓ show the role of NGOs in the carbon market and describe the main types of project developed

- ✓ analyze some case studies based on sustainable energy project realized by NGOs in developing countries and seek to evaluate the impact of revenue from selling carbon credits on investment plan. This could be an important indication on how much of the financial needs of the project must be covered through other sources like loans and equity.

The overall goal is to conclude whether carbon finance can be a suitable tool for financing renewable energy project in developing countries.

In order to reach specific goals and objectives, a series of chapters is planned as summarized below.

Chapter 1 describes the milestones of the carbon market history and introduces the fundamental elements behind the theory and practice of emissions trading in context of other policies to address climate change. This section defines also carbon credits and how cap-and-trade and baseline-and-credit systems are employed to mitigate climate change. Then, it describes the specific framework for market-based management of the global atmosphere created through the UNFCCC and the Kyoto Protocol Finally, this chapter shows the carbon market structure with compliance and voluntary segment and explains the supply chain and the main actors involved.

Chapter 2 describes the state and trend of both compliance/regulated market and voluntary carbon market. In particular, this section focuses on the main important ways for NGOs to securing carbon finance: the most important alternatives for NGOs are the CDM and the Voluntary Market with Gold Standard and Voluntary Carbon Standard. In this section, the criticity of additionality of a project and the sustainable development tool are explained. Finally, a comparison of CDM and Voluntary market is done in order to answer what is the better market for NGOs.

Chapter 3 introduces in brief the important role of Development Cooperation and the main problems of the developing countries, such as the energy access. Then, this section shows the main types of projects developed by the NGOs in energy and forestry field giving the most important objectives and a list of them.

Chapter 4 analyzes four case studies: two COOPI projects (Cookstoves and PV in Malawi) and two LVIA projects (Biogas and Hydro in Ethiopia). This section estimates the carbon credit accounting applying CDM and Gold Standard VER methodologies to each project, compares the results, evaluates the possible carbon revenue from the energy projects developed by NGOs for different price scenarios and evaluates also the impact on total costs.

Chapter 1

1 A background to the carbon trading

1.1 Origins of the carbon markets

Over the last years, a worldwide GHG emissions market has evolved, based on a theory for creating property rights for nature, proposed by Coase in 1960. The term "carbon markets" refers to the buying and selling of emissions credits that have been either distributed by a regulatory body or generated by GHG emissions reduction projects.

Date	Event
1960	Coase proposed a theory based on creating property rights for nature
1977	Dyson had an innovative idea: carbon offset
1980	US environmental movements
1983	The United States Environmental Protection Agency (EPA) acknowledged that climate change could have a serious destructive effect
1988	UNEP and the World Meteorological Organization (WMO) establish the Intergovernmental Panel on Climate Change (IPCC)
1989	First voluntary carbon offset: a U.S.-based company promised to plant millions of trees in Guatemala in exchange for permission to construct a large new coal burning power station.
1990	US Clean Air Act, the first mandatory emissions trading scheme
1992	The UN Framework Convention on Climate Change (UNFCCC) is agreed to at the Rio Earth Summit
1994	The UNFCCC enters into force
1995	The IPCC Second Assessment Report concludes that there is evidence suggesting a discernible human influence on the global climate
1997	Adoption of the Kyoto Protocol to the UN Climate Convention
2001	The IPCC finds stronger connection between human activities and the global climate system
2005	The Kyoto Protocol came in force on 16 February. Birth of global carbon market

Table 2: Major milestones in the carbon market

In the past, economists have already been alerted about the invisible development costs (social) related to the indiscriminate use of natural resources (public goods) and, therefore, related to the externality problem. Externalities exist when the actions of one part affect the utility or production possibility of another part outside an exchange relationship and emerge because there is an obscure definition of private property rights. [3]

Pigou

In 1920, Standard Welfare Economics of Professor Pigou suggested that a better approach would be to impose a unitary tax on the polluting activity. Economists argued that the outcomes of the traditional regulatory command-and-control approach could be achieved at a lower cost to society and with a smaller government bureaucracy through a tax. This would therefore cause polluters to internalize the externality by imposing extra costs on production.

Coase

In 1960, in contrast with Pigou's theory, Ronald Coase, from the University of Chicago, reframed pollution control as a problem of property rights. Coase suggested that this regulatory system could be improved by making these rights more transparent and transferable. The role of government in this approach involved setting the appropriate standard for protection, allocating the initial rights and then stepping back to let the market decide over time where and how the pollution rights would be used between different firms. If the transaction costs are low and the property rights are well defined and being able to be traded, there is an incentive to the rearrangement (exchange) of these rights to increase the economic efficiency and to solve the problem of externality. This general principle is called as the Coase Theorem. [4]

Dyson

The beginnings of the carbon offset idea can be traced back at least as far as 1977, when the British physicist Freeman Dyson speculated that large-scale planting of trees or swamp plants could be a cheap means of soaking up excess carbon dioxide in the atmosphere. That, Dyson figured, would buy time during which ways of phasing out hydrocarbon use could be found. [5]

IPCC

At the end of the 1980s climate change takes part in the political agenda caused by the scientific evidence of anthropogenic influence on the climate system and the public growing interest in environmental issues.

In 1988, United Nations Environmental Program (UNEP) and the World Meteorological Organization (WMO) established the Intergovernmental Panel on Climate Change (IPCC). The IPCC, consisting of hundreds of leading scientists and experts on global warming, was tasked with assessing the state of scientific knowledge concerning climate change, evaluating its potential environmental and socio-economic impacts and formulating realistic policy advice.

AES Corp

Voluntary carbon markets pre-date all regulated carbon markets. The world's first carbon offset deal was brokered in 1989 when Applied Energy Services Corp, an American electricity company, invested in an agro-forestry project in Guatemala. Since trees use and store carbon as they grow (an example of carbon sequestration), AES reasoned it could offset the GHG emitted during electricity production paying farmers in Guatemala to plant 50 million pine and eucalyptus trees on their land. AES, like other companies, hoped to reduced its carbon footprint for philanthropic and marketing reasons, not because it was forced to do so by legislation or global treaty. The deal was voluntary and made the beginning of a voluntary carbon market. [6]

Clean Air Act

In 1990, the United States established the first mandatory emission trading scheme by the Clean Air Act. The reason of this document was the problem of tackling acid rain and not the climate change. The system provided penalties for infringement. The success of this experiment and socially acceptable costs for American firms inspired the negotiators of the future Kyoto Protocol.

IPCC First assessment report

In 1990 the IPCC published its first assessment report, concluding that the growing accumulation of human-made greenhouse gases in the atmosphere would "*enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface*" by the next century, unless measures were adopted to limit emissions. [4]

UNFCCC

In response to warnings from the IPCC, the United Nations General Assembly declared global warming a "*common concern of mankind*" and held the first major global environmental conference, the Earth Summit in Rio de Janeiro in 1992. This United Nations Conference on Environment and Development saw the creation of the United Nations Framework Convention on Climate Change, which entered into force on 21 March 1994. The Convention

has been ratified by over 190 countries, affording it one of the broadest memberships of any international agreement. The main objective of the Convention is to stabilize the concentrations of GHG in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Scientists have recommended trying to keep global temperature rise to below 2 degrees Celsius from pre-industrial levels, which they estimate equates to keeping atmospheric carbon dioxide concentration roughly below 500 parts per million. To achieve this objective, all countries have a general commitment to address climate change, adapt to its effects and report their actions to implement the convention.
The Convention divided countries into two groups:

- Annex I Parties, the industrialized countries who have historically contributed the most to climate change;
- non-Annex I Parties, which include primarily the developing countries.

The principles of equity and of "*common but differentiated responsibilities*" require Annex I parties to take the lead in changing emissions trends. Annex I Parties that are also members of OECD are included in Annex II and have an obligation to provide new and additional financial resources to developing countries to help them fight climate change. [4]

Kyoto Protocol

UNFCCC set out the principles for a legally binding international agreement to reduce GHG emissions and resulted in the Kyoto Protocol in 1997 which was signed by most of the world's countries. The Kyoto Protocol set maximum emissions targets for industrialized countries and introduced three mechanisms that would enable them to meet their targets: Emissions Trading, the Clean Development Mechanism and Joint Implementation. Emissions Trading formalized the creation of the carbon credit as a tradable commodity on international financial exchanges. The Clean Development Mechanism and the Joint Implementation set rules for the generation of carbon credits through approved projects implemented in developed and developing countries. Together, these three mechanisms led to what is now called the carbon market.

Meanwhile 2005 marked the birth of a global carbon market with the launch of the European Emission Trading System (EU ETS) and the Kyoto Protocol entering into force.

Stern Review

After decades of debate, there is now a clear scientific consensus that climate change is occurring and that human activities are a major contributory factor.

Furthermore, in October 2006, Sir Nicholas Stern shows clearly by his report that it is a serious economic threat, not just a scientific concern. In his comprehensive report for the U.K. government, the economist at the World Bank describes climate change as ‘‘*the greatest market failure the world has seen*’’. Unabated climate change could cost as much as 20 percent of global GDP, but acting promptly to avoid the worst impacts of global warming, however, could limited the cost to around 1 percent of GDP.

A variety of responses are required, including education and awareness raising, improvements in energy efficiency, and measures to stimulate the deployment of low-carbon technologies, but the most important answer is a key policy requirement: carbon pricing, assigning a cost to emissions of greenhouse gases through taxation, regulation and/or emissions trading. [7]

1.2 The systems to create carbon commodities

In order to understand the carbon markets, it is important to recognize the differences between two fundamentally different types of systems that create carbon commodities like allowances and offsets. The first, cap-and-trade system, creates allowances. The second, baseline-and-credit system (also sometimes called project-based system), creates offsets. Cap-and-trade systems exist almost exclusively in the compliance market. Baseline-and-credit systems exist both in the compliance and in the voluntary market.

1.2.1 Cap-and-trade

Under a cap-and-trade system, an overall cap is set to achieve emissions reductions. Each of the participants within a cap-and-trade system (usually countries, regions or industries) is allocated a certain number of allowances based on an emissions reduction target. After the distribution of the allowances between players involved in the scheme, they can choose to conduct abatement of emissions or buy additional allowances. At the end of each period, usually one calendar year, each emitter must surrender one allowance per unit of emissions they release to the atmosphere. If a facility emits less than the amount of allowances it holds, it may sell its surplus allowances to other emitters (Figure 3). Conversely, if a facility does not hold enough allowances to cover its emissions for the period, it must buy allowances from the market. This is known as the trade portion of cap-and-trade. [8]

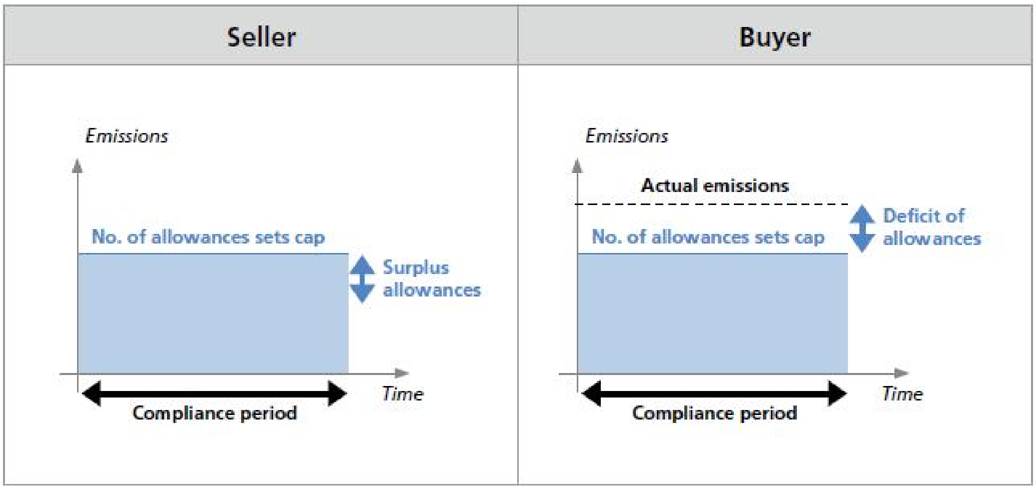


Figure 3: How Cap-and-trade systems work

In a cap-and-trade system the cap constitutes a finite supply of allowances, set by regulation and political negotiation. These allowances are then neither created nor removed, but merely traded among participants. This finite supply creates a scarcity and drives the demand and price for allowances. A cap-and-trade system aims to internalize the costs of emissions and thus drives actors to seek cost-effective means to reduce their emissions. The challenge in a cap-and-trade program is to determine the appropriate level at which to set the cap, which should be stringent enough to induce the desired level and rate of change, while minimizing overall economic costs. Cap-and-trade systems often allow for a certain number of offsets to come from emissions reductions that are generated by projects that are not covered under the cap (from baseline-and-credit systems). In other words, under a cap-and-trade system, offsets do not lead to emissions reductions beyond the target set by the cap but only cause a geographical shift in where the emissions reduction occurs. The EU ETS is an example of a cap-and-trade scheme.

Example of cap-and-trade system

To illustrate a cap-and-trade system, let's take an example of two firms: Company A and company B (Figure 4). Company A emits 12 million tons, while company B emits 15 million tons. Each company was allocated allowances to emit ten million tons under the government’s overall cap. Company B finds it too expensive to reduce its GHG emissions to this amount. Company A invests in a new technology that allows it to reduce emissions significantly, not only to the ten million ton level, but by an additional five million tons. It only has to surrender five million allowances to the government, and can thus sell the remaining allowances to Company B. Overall, the same total reduction in GHG emissions has occurred as in a command-and-control scenario where the government simply required that both companies emit no more than ten million tons, but with the cap-and-trade scenario, the net cost of this total reduction was lower, as Company A was able to reduce emissions more cheaply.

Figure 4: Example of Cap-and-trade with offset

If the cap-and-trade system also involves emission reduction offset credits from projects that occur outside of capped sectors, Company B has another option for complying with the emission limit. It can offset its excess emissions by purchasing credits from projects that have reduced emissions elsewhere. The inclusion of offsets takes advantage of the same concept used in trade between companies, and incorporates the principle that a ton of CO_2-equivalent GHG emissions has the same effect anywhere in the world.

1.2.2 Baseline-and-credit

The baseline-and-credit scheme (Figure 5) involves establishing a baseline level of emissions for a sector or a project or a company. Under this scheme there isn't a cap, but players are encouraged to reduce their emissions below the baseline (usually called as Business As Usual scenario) with each new project implemented to generated emissions credits that can then be traded. Emission reductions are calculated by comparing baseline emissions (occurred in the absence of the project) and proposed project emissions. These credits can then be used by buyers to comply with a regulatory emission target, to offset an emitting activity or to be a carbon neutral organization with zero net emissions.

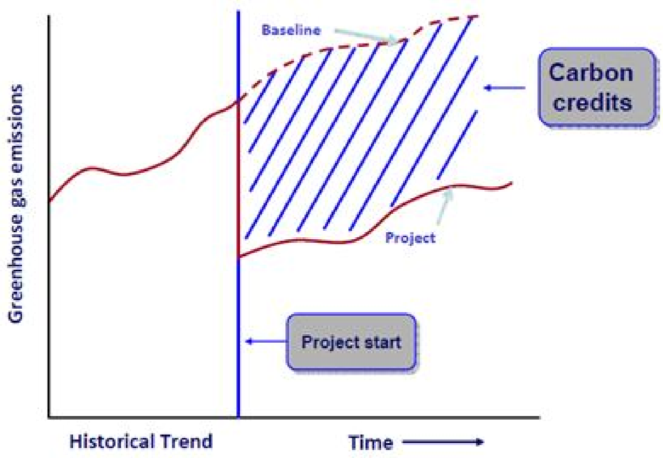


Figure 5: Baseline-and-credit system

In a baseline-and-credit system a carbon offset buyer can only legitimately claim to offset his emissions if the emissions reductions come from a project that would not have happened anyway. These scheme is the basis for White Certificate that governments are using to improve energy efficiency measures.

Example of baseline-and-credit

To illustrate a baseline-and-credit system, let's take an example of a project developer that voluntarily decides to replace a diesel electric plants serving isolated grids with a mini-hydro. Projects are typically eligible for baseline-and-credit if they reduce emissions, compared to the status quo, in developing countries with no emissions trading scheme in place. All projects must follow an approved methodology for defining the baseline, evaluating the project emissions and emissions reductions and defining the monitoring procedure. For all these steps, project developer applies for registration with an authorized body. In the case considered, the baseline scenario (Figure 6) is set on the alternative to the project, that is the continued use of isolated thermal diesel generating units for electricity generation.

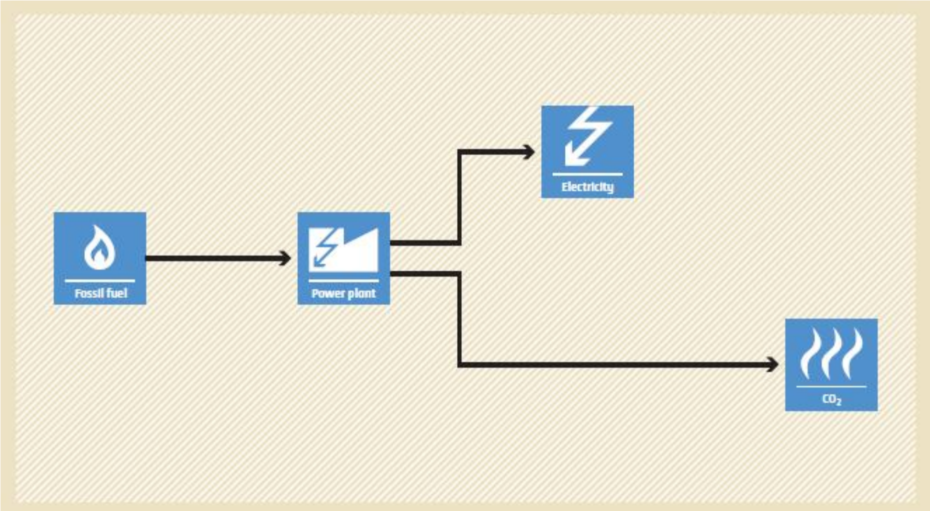


Figure 6: Baseline scenario

Baselines are generally intensity-based and is defined as the kWh produced by the renewable generating unit multiplied by an emission factor (measured in $kgCO_2/kWh$). The annual energy production from mini-hydro project is evaluated in kWh per annum and will replace an equivalent capacity from diesel.

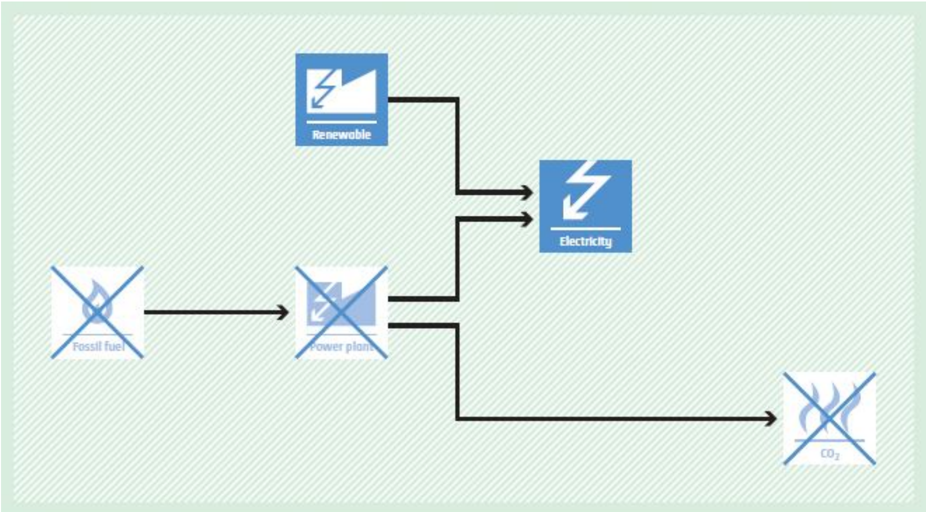


Figure 7: Project scenario

The amount of emission reductions is the difference between the two scenarios and is estimated over the crediting period. At the end of, or at a discrete point during, the project's actual emissions are compared to the assigned benchmark of emissions for the project-based activity. Project developers, then, receive carbon credits based on those emissions reductions that have been verified and certified by an authorized body. If no reductions result from the project, no certificates are exchanged. In other words, project developers incur no obligation to surrender certificates if project-related emissions exceed the assigned benchmark of emissions. As mentioned above in the cap-and trade example, if a scheme allows the use of project-based activities, carbon credits that result from a project can be used to offset emissions obligations. Alternatively, some environmentalists can decide to offset their emissions purchasing voluntarily these carbon credits.

1.2.3 Cap-and-trade versus Carbon tax

There are a number of policies needed to cut greenhouse gas emissions applying the ‘polluter pays principle’, the commonly accepted practice in which who produce pollution should bear the costs of managing it to prevent damage to human health or the environment. However, this principle can be mainly implemented either through the cap-and-trade scheme (a quantity instrument described above) and a carbon tax (known as a price instrument). The section below describes the differences between these two policies using the most basic of all environmental economic models.

The diagram in Figure 8 illustrates the increasing marginal abatement costs of two firms. One has an old dirty plant with high abatement costs (in blue) that goes right to left with abatement. The other firm has a newer plant that has lower abatement costs (in green) that goes left to right with abatement. The width of the horizontal axis is the abatement that must be achieved to reduce overall emissions to the efficient level. The intersection of the two marginal abatement costs is where economic efficiency is achieved. This is known as the "*equimarginal principle*". The total costs of achieving the efficient abatement/emissions level is

$$C + G + K$$

The efficient emissions level, e*, shows that the low abatement cost firm should reduce more emissions than the high abatement cost firm.

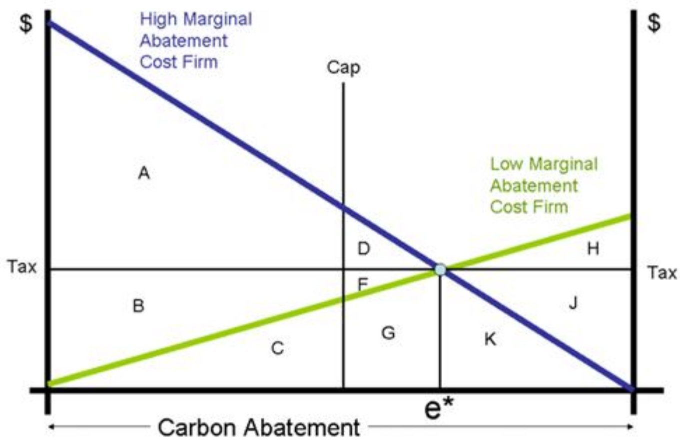


Figure 8: Cap-and-trade vs Carbon tax

Carbon Tax

One way to achieve this level of abatement is to set a tax where the marginal abatement costs are equal, assuming that we have this information, represented by the horizontal tax line. The polluting firms will notice that it is cheaper to abate carbon emissions as long as the marginal abatement cost is lower than the tax. The high cost firm will abate to e* (right to left) and suffer abatement costs of K and pay a tax bill to the government equal to **B + C + F + G**

The low cost firm will abate to e* (left to right) and suffer abatement costs of **C + G** and pay a tax bill to the government equal to **J + K**
Results:

- The efficient abatement level is achieved: e*
- The abatement cost to the polluting firms is minimized, C + G + K
- Government revenue is equal to B + C + F + G + J + K

Carbon Cap-and-Trade

Another way to achieve this level of abatement is to set a carbon cap by issuing carbon permits to polluting firms. Each permit gives the firm the right to emit one unit of carbon. If we don't have the political will to go ahead and give more permits to the high cost firm (in order to achieve efficiency) we can do it fairly by giving each firm the same amount of permits (represented by the vertical cap line).

The abatement cost to the low abatement cost firm is equal to area C. The abatement cost to the high abatement cost firm is **D + F + G + K**.

At some point the high cost firm might rather have a permit than pay those high costs. If it recognizes that its marginal abatement cost is higher than the marginal abatement cost of the low cost firm it could propose a trade.

In effect, the blue line over area D, F and G is a demand curve for permits and the green line is a supply curve for permits. Anywhere in between the blue and green line is a permit price that is mutually agreeable between both firms. A competitive permit market will result in a permit price equivalent to the efficient carbon tax. Trading reduces overall abatement costs by area **D + F**.

Results:

- The efficient abatement level is achieved: e*
- The abatement cost to the polluting firms is minimized C + G + K

In terms of the market failure, the negative carbon externality, both a carbon tax and carbon cap-and-trade will achieve the same level of increased efficiency by achieving the optimal abatement level at the minimum cost. The only difference is the distributional implications. The cost to the firm is lower for carbon cap-and-trade.

This is one of the reasons why the carbon market of emission rights is more politically attractive to establish a quantifiable, legally enforceable limit on emissions which will ensure that essential climate change targets are met at the lowest possible cost.

1.3 UNFCCC and the Kyoto Protocol

As we can see in Table 2, the United Nations Framework Convention on Climate Change (UNFCCC), which took effect in March 1994, represents the first international action to address the problem of global warming. It encouraged developed countries (called Annex 1 countries in the convention) to reduce their emissions of greenhouse gases to in effect to stabilize their emissions. Kyoto Protocol was adopted in 1997 but only enforced in February 2005 after ratification by the required number of industrialized countries. The Convention established the Conference of Parties (COP) as its supreme body with the responsibility to oversee the progress toward the aim of the Convention.

The Kyoto Protocol has two key features:

- Legally-binding emission reduction commitments
- Flexibility mechanisms.

Under the Kyoto Protocol, developed countries commit to reducing their annual emissions of greenhouse gases by an average of 5.2 per cent below 1990 levels over the five year period from 2008 to 2012. The target is averaged over five years to take account of year-to-year fluctuations in emissions. The requirements are stricter for developed countries for two main reasons: they have greater financial resources and their accumulated emissions, produced by industry over the last century or more, greatly exceeds the emissions of developing countries.

1.3.1 Flexibility mechanisms

A distinctive feature of the Kyoto Protocol is the concept of flexibility mechanisms. These aim to help developed countries meet their emission reduction commitments in the most efficient way possible. The mechanisms allow for trading of emission reductions between countries, so that polluters with high emission reduction costs can pay others with lower costs to cut back more. In this way the total cost of emission reductions is reduced. This flexibility is possible because a unit emission of greenhouse gas has the same impact regardless of the country where it is emitted.

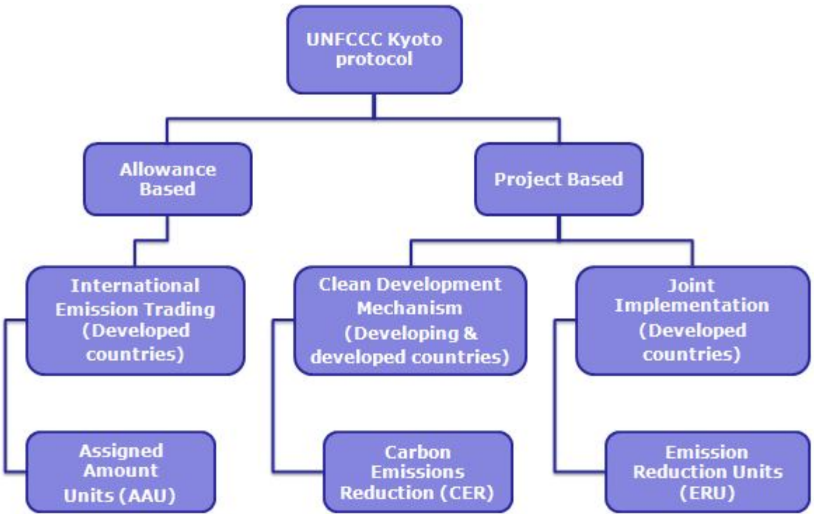


Figure 9: Flexible mechanisms under Kyoto Protocol

The flexible mechanisms (Figure 9) work in two main ways:

- **Emissions trading** (ET) - developed countries that reduce their emissions of greenhouse gases to levels below their assigned amount can sell these excess emission reductions to others. Conversely, they can buy emission reductions from other countries to meet their target. This mechanism has led to the establishment of regional and national emission trading systems, the largest being the European Union's Emissions Trading System (EU ETS).
- **Investment in projects** - developed countries can meet part of their emission reduction requirements by investing in emission reduction projects in other countries through the following:

- **Clean Development Mechanism** (CDM) - developed countries can invest in projects in developing countries (non-Annex I) to generate Certified Emission Reductions (CERs).
- **Joint Implementation** (JI) - developed countries can invest in projects in other developed countries to generate Emission Reduction Units (ERUs).

This mechanisms are the basis for the regulated international compliance carbon market described in Chapter 2. The mechanisms (Figure 10) give countries and private sector companies the opportunity to reduce emissions anywhere in the world wherever the cost is lowest and they can then count these reductions towards their own targets. Any such reduction, however, should be supplementary to domestic actions in the Annex I countries. Through emission reduction projects, the mechanisms could stimulate international investment and provide the essential resources for cleaner economic growth in all parts of the world. The CDM, in particular, aims to assist developing countries in achieving sustainable development by promoting environmentally friendly investment from industrialized country governments and businesses.

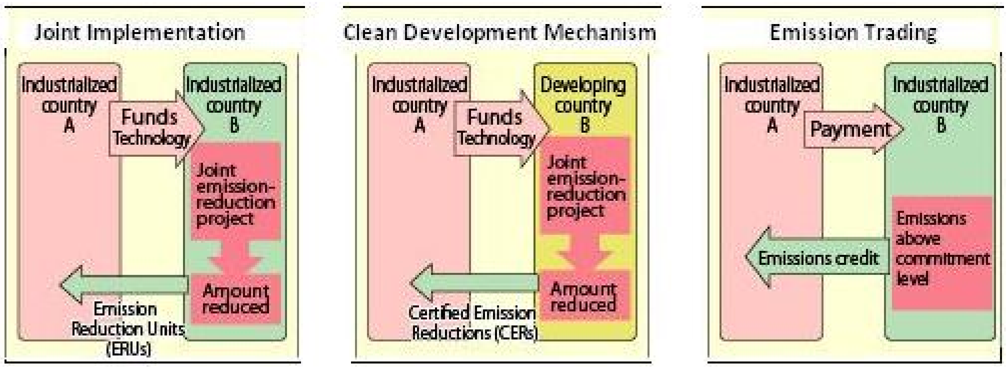


Figure 10: Flexibility Mechanisms Scheme

The Protocol also allows the countries the option of deciding which gases and activities will form part of their national emissions reduction strategy. Some activities by land use, land-use change and forestry (LULUCF), such as afforestation and reforestation, that absorb carbon dioxide from the atmosphere and generate Removal Unit (RMU), are also covered. To meet their Kyoto obligations, countries have established (or are establishing) national or regional emissions trading. For example, in January 2005 the European Union launched the EU ETS to achieve the GHG emission reductions targets required by the Kyoto Protocol. The EU ETS involves all of the EU member states and allows limited trading via the three Kyoto mechanisms described above through a Linking Directive. Outside of Europe, regulated emissions trading schemes have not developed so quickly. Trading will take place electronically, requiring the establishment of an International Transaction Log, which became operational in 2007.

The targets cover six main greenhouse gases:

- ✓ Carbon dioxide (CO_2)
- ✓ Methane (CH_4)
- ✓ Nitrous oxide (N_2O)
- ✓ Sulphur hexafluoride (SF_6)
- ✓ Hydrofluorocarbons (HFCs)
- ✓ Perfluorocarbons (PFCs)

In order to compare the impact of different GHG (Table 3), emissions of these gases are converted to carbon dioxide equivalents (CO_2e) using the global warming potential (GWP). GWP is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the gas in question to that of the same mass of carbon dioxide, whose GWP is by definition 1.

Species	Chemical formula	GWP	Species	Chemical formula	GWP
CO_2	CO_2	1	HFC-23	CHF_3	11,700
Methane *	CH_4	25	HFC-236fa	$C_3H_2F_6$	6,300
Nitrous oxide	N_2O	310	HFC-143a	$C_2H_3F_3$	3,800
Perfluoroethane	C_2F_6	9,200	HFC-134a	CH_2FCF_3	1,300
Perfluoropentane	C_5F_{12}	7,500	HFC-134	$C_2H_2F_4$	1,000
Perfluorohexane	C_6F_{14}	7,400	HFC-32	CH_2F_2	650
Sulphur hexafluoride	SF_6	23,900	HFC-41	CH_3F	150
Nitrogen trifluoride	NF_3	17,200			

Table 3: GHG and Global Warming Potential

For example, 1 unit of methane is considered equivalent to 25 units of carbon dioxide equivalent. [9]

1.3.2 Actual status of Kyoto Protocol

Currently, there are 192 Parties (191 States and 1 regional economic integration organization, the European Union) to the Kyoto Protocol to the UNFCCC (Figure 11). On 8 December 2012, was adopted the Doha Amendment to the Kyoto Protocol which includes:

- New commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020;
- A revised list of greenhouse gases to be reported on by Parties in the second commitment period;
- Amendments to several articles of the Kyoto Protocol which specifically referenced issues pertaining to the first commitment period and which needed to be updated for the second commitment period.

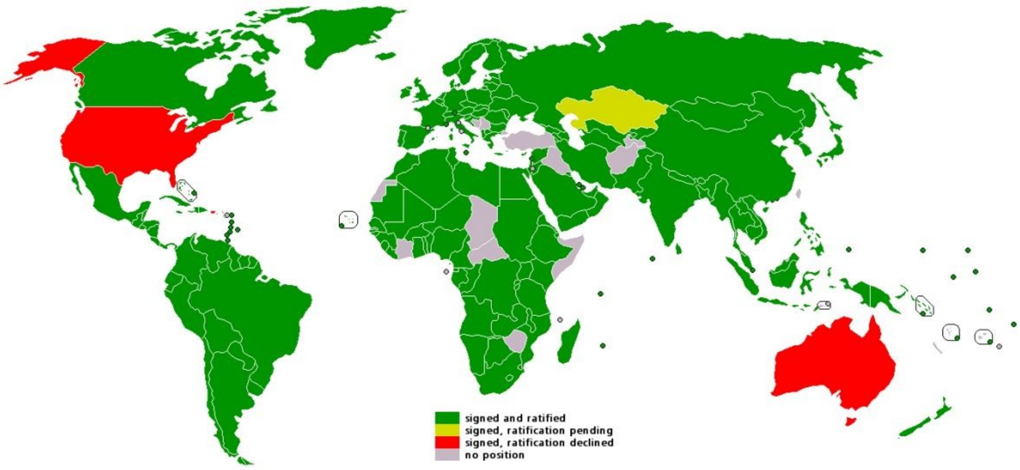


Figure 11: Kyoto Protocol map

During the first commitment period, 37 industrialized countries and the European Community committed to reduce GHG emissions to an average of five percent against 1990 levels. During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first.

1.4 Global carbon market structure

Despite the global label, GHG market is actually composed of a variety of different markets. Two different categories are: compliance (mandatory or regulated) and voluntary (or retail) carbon market. The carbon market has experienced strong growth in trade volumes since the mid 2000s (Figure 12). Global carbon markets are now valued at $176 billion, with $22 billion of this figure linked to investment in a wide range of GHG emission reduction and removals projects in developing countries. Thousands of projects now exist, ranging from large-scale industrial gas capture to household-level renewable energy or forestry.

Figure 12: Global Carbon Markets (Source:World Bank)

1.4.1 The compliance and voluntary segments

Compliance segment

Driven by regulation, the compliance market is currently dominated by the Kyoto project based scheme, the CDM, and by the allowance-based EU ETS. Other important schemes include JI and non-Kyoto markets including New South Wales and the United States Regional Greenhouse Gas Initiative. Annex I parties bound by caps under the Kyoto Protocol are key participants. Some carbon credits generated for sale in the compliance market, known as CERs or ERUs, can also be sold in the voluntary market.

Voluntary segment

Although compliance markets provide by far the greatest volumes, some voluntary schemes are making meaningful progress, notably the Chicago Climate Exchange (CCX) in force until 2010. A project based retail market has also emerged through which parties not bound by specific caps or regulations can voluntarily .offset. carbon emissions by investing in emission reductions projects. Businesses create substantial demand, primarily for strategic reasons. Further demand is generated by green conferences and institutions including governments, and individuals altruistically choosing to offset travel or energy use. Carbon credits generated for sale in the voluntary market are known as Voluntary Emission Reduction units (VERs). Voluntary market is explained in detail in Chapter 2.3.

While on the global scale the voluntary market remains small in comparison to the compliance market, it is growing rapidly and now represents an important stimulus for development of carbon reduction projects around the world.

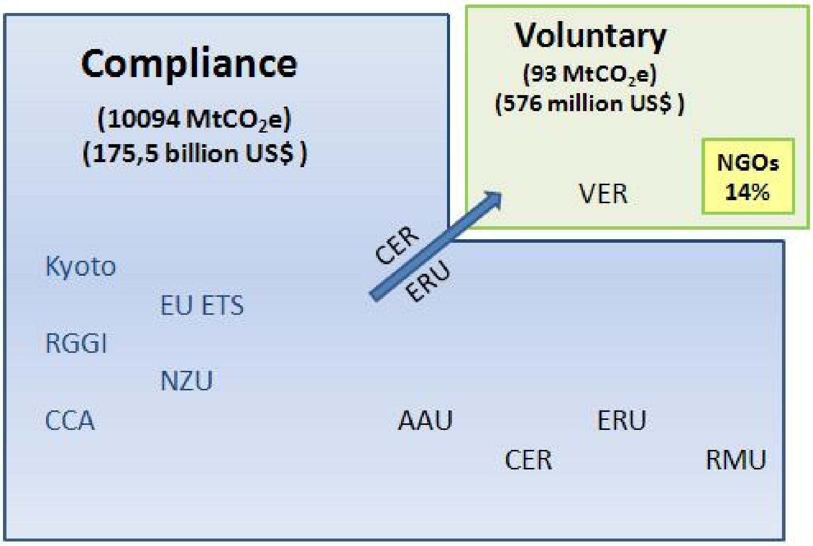


Figure 13: Global carbon market scheme

Trading volumes in the voluntary market are much smaller (Figure 13) because demand is created only by voluntary buyers (corporations, institutions and individuals) to buy offsets whereas in a compliance market, demand is created by a regulatory instrument. Because there is lower demand and because VERs cannot be used in compliance markets, VERs tend to be cheaper than those credits sold in the compliance market.

NGO projects are more suitable for the voluntary market for a number of reasons but particularly because of scale, transaction cost, choice of technology and timelines. In fact, NGOs have the 14% of the voluntary market share. CERs from CDM are also attractive for NGO because this flexible mechanism has been developed with the aim of tackling global climate change while at the same time contributing to sustainable development in host countries. Chapter 2.2 explains in detail the power of CDM.

Project based and Allowance based transactions

As shown in Figure 9 for Kyoto Protocol, carbon credits can be accrued through two different types of transactions: project based and allowance based. This is also valid for all types of carbon markets. In project-based transactions, emissions credits or offsets are the result of emissions reduction achieved by a specific carbon offset project, such as renewable energy, energy efficiency, destruction of various industrial gases and carbon sequestration underground or in soils and forests. Allowance-based transactions involve the trading of issued allowances or permits created and allocated by regulators under a cap-and-trade regime.

1.4.2 Features of an offset

In order to substitute an emissions reduction with an offset credit, it is critically important that each offset represent a real reduction of emissions. Specific rules are used to make sure that emissions reduction projects meet strict environmental integrity standards. Minimum parameters for ensuring offset credibility include the following:

- ✓ Additional: Reductions are surplus offsets that would not have occurred under business as usual scenario
- ✓ Real: Offsets are sourced from tangible physical projects with evidence that they have or will imminently occur;
- ✓ Measurable: Reductions are objectively quantifiable by peer-reviewed methodologies within acceptable standard margins of error;
- ✓ Permanence: Reduction streams are unlikely to be reversed and will continue throughout the life of the project;
- ✓ Leakage: The increase in GHG that occurs outside the boundary of the project and that is directly attributable to project activities must be considered,
- ✓ Verifiable: Performance is monitored by an independent third-party verifier with appropriate local and sector expertise;
- ✓ Enforceable: Offsets are backed by legal instruments that define offsets' creation, provide for transparency and ensure exclusive ownership;
- ✓ Synchronous: Offset flows are matched to emission flow time periods with rigorous and conservative accounting that designates boundaries and baseline calculations.
- ✓ No harming: offset projects should not cause or contribute to any adverse effects on human health or the environment and should instead seek to provide environmental co-benefits whenever possible. Some offset standards even require that a project provide co-benefits, such as jobs for the local population, in order to gain a seal of quality.

In addition to these project criteria, offsets should need to meet standards for delivery. That is, they should be tracked and registered to avoid double counting, clearly demonstrate ownership and, upon their application, be verifiably retired.

1.4.3 A look at the supply chain

Institutions, organizations and individuals acquire offsets in a number of ways, but simplified model of the carbon market supply chain typically includes the following elements (Figure 14).

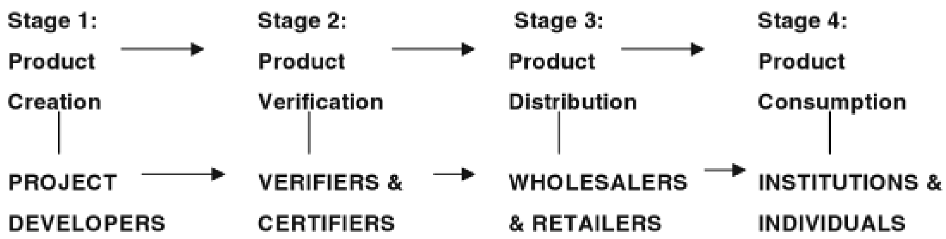


Figure 14: Semplified carbon market supply chain

1) Product creation
   A project or project idea is generated by a project developer.
2) Project validation and credit verification
   Credit verification occurs when a third party verifiers confirm that emission reductions have occurred and carbon credit can be created and registered in a database. To increase credibility, in the voluntary carbon market there are a lot of certification standard.
3) Product distribution
   Once credits have been verified and certified, middlemen often step in either as buyers interested in purchasing credits for on-sale, or as facilitators interested in arranging transactions between buyers and sellers on a fee-for-service basis (generally referred to as brokers).
4) Product consumption
   Companies, NGOs, government agencies and individuals may purchase carbon credits in order to offset the emissions generated by their facilities and employees in the course of doing business, such as emissions from transport, energy use, manufacturing etc.

1.4.4 Actors involved in the carbon finance

Even though the parties involved differ from project to project some general categories and types of stakeholders are:

- Project Owner

The operator and owner of the physical installation where the emission reduction project takes place can be any private person, company or other organization.

- Project Developers
  A person or organization with the intention to develop an emission reduction project could be the project owner, a consultant or specialized services provider. In practice, project developers include NGOs interested in combating climate change and/or contributing to sustainable development, private companies or public sector agencies.
- Project Funders
  Banks, private equity firms, private investors, non-profit organizations and other organizations may lend or invest equity to fund a project. Some of the standards have rules to what kind of funding, aside from the offset revenue, are acceptable for an offset project.
- Stakeholders
  Stakeholders are individuals and organizations that are directly or indirectly affected by the emission reduction project. Stakeholders include the parties interested in developing a specific project (e.g. owner, developer, funder, local population, host community), parties affected by the project (e.g. local population, host community environmental and human rights advocates) and national and international authorities.
- Third Party Auditors
  The CDM and many of the voluntary offset standards require a third-party auditor to validate and verify a project's climate saving potential and achieved emission reductions.
- Standards Organization
  In the absence of national and international legislation, standard organizations define a set of rules and criteria for voluntary emission reduction credits.
- Registries
  Issued credits need to be registered in a database and once use by the client they need to be retired, which means they are removed from the registry. The certification body is usually associated with one particular registry.
- Brokers and Exchanges
  In the wholesale market, emission offset buyers and sellers can have a transaction facilitated by brokers or exchanges. Exchanges are usually preferred for frequent trades or large volumes of products with standardized contracts or products, while brokers typically arrange transactions for non-standardized products, occasionally traded and often in small volumes.
- Trader

Professional emission reduction traders purchase and sell emission reductions by taking advantage of market price distortions and arbitrage possibilities.

- Offset Providers

  Offset providers act as aggregators and retailers between project developers and buyers. They provide a convenient way for consumers and businesses to access a portfolio of project offsets.
- Final buyers or end buyers

  Individuals and organizations purchase carbon offsets for counterbalancing GHG emissions. Therefore, the final buyer has no interest in reselling the offset but will prompt the retirement of the underlying carbon offset.

The initial offset contract between a project developer and an end user or other intermediary is referred to as the primary market. The secondary market consists of transactions between retailers and retailers, or retailers and offset end buyers.

NGOs can play a lot of the roles above but this thesis focuses on the project developer side.

Chapter 2

2 The carbon markets targeted by NGOs

The Non-Governmental-Organizations have two options to entry carbon markets: the Clean Development Mechanism and the Voluntary Carbon Market. In this regard, this chapter gives an overview of the compliance market with a detailed focus on the CDM. Then, it describes the Voluntary Carbon Market with the certification standards more interesting for NGOs, such as Gold Standard and Voluntary Carbon Standard.

2.1 Overview of the compliance markets

Since the signing of the Kyoto Protocol in 1997, several compliance or regulated cap-and-trade carbon markets have emerged around the world.

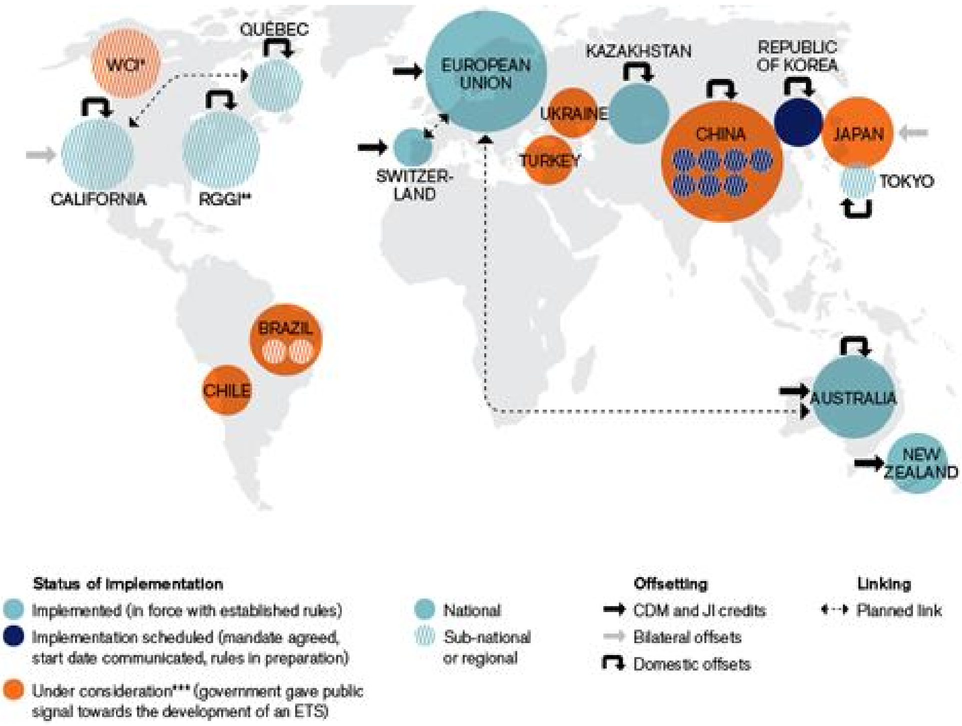


Figure 15: Carbon markets in the world

As we can see on Figure 15, regional, national and sub-national carbon pricing initiatives are proliferating because policy makers are facing the challenge of finding the most efficient systems to limit global warming pollution. There are some compliance markets already implemented in Europe, Australia and US, other scheduled in Korea and others are still under consideration in China and Latin America.

To understand the different weight of compliance markets, Table 4 shows in columns the volume in $MtCO_2e$ and the value in US million dollars of the credits transacted in 2010 and 2011. The rows of the table represents the list of all the existing compliance markets.

The first thing worth noting in is that roughly 82% of all credits traded are European Allowances (EUA) from EU ETS. Instead, credits produced through carbon credit projects account for a much smaller slice of the market. Project based credits include those produced through the CDM.

Transaction Volumes and Values, Global Carbon Market, 2010 and 2011

	Volume ($MtCO_2e$)		Value (US$ million)	
Markets	2010	2011	2010	2011
EU ETS [EUA]	6,789	7,853	133,598	147,848
Primary CDM	265	291	3,206	3,320
Secondary CDM	1,275	1,822	20,637	23,250
Kyoto [AAU]	62	47	626	318
RGGI	210	120	458	249
RMU	-	4	-	12
NZU	7	27	101	351
CCA	-	4	-	63
Other Allowances	94	26	151	40
Total Regulated Markets	8,702	10,094	158,777	175,451

Source: Ecosystem Marketplace and the World Bank's State and Trends of the Carbon Markets 2012. Note: Totals may not add up due to rounding.

Table 4: Volumes and values in compliance market

Secondly, trade volumes should not be equated with end-user demand, even for credits associated with projects, because many credits have been traded more than once. For example, CERs generated through the CDM are differentiated as primary and secondary CERs in the available data. Primary CERs are those credits that are sold for the first time, whereas secondary CERs are those sold any number of times after the first trade. Data from 2011 shows that trade in secondary CERs was six times greater than trade in primary CERs, suggesting that each CER is traded seven times on average (the first sale as a primary CER and six times thereafter). Speculative trade is one reason for this.

As shown in Figure 15 and in Table 4 there are different existing carbon markets that form the global compliance market. This fragmentation is presented below, with a brief description of the main markets, from the European to the Swiss Emission Trading Scheme.

❖ *European Union Emissions Trading Scheme (EU ETS)*

The European Union Emissions Trading System, also known as the European Union Emissions Trading Scheme, was the first large emissions trading scheme in the world, and remains the biggest. It was launched in 2005 to combat climate change and is a major pillar of EU climate policy. As of 2013, the EU ETS covers more than 11,000 factories, power stations, and other installations with a net heat excess of 20 MW in 31 countries (all 28 EU member states plus Iceland, Norway, and Liechtenstein). The installations regulated by the EU ETS are collectively responsible for close to half of the EU's emissions of CO_2 and 40% of its total GHG emissions. The EU ETS reduced emissions by between 2% and 5% relative to what emissions would have been otherwise. The declining cap during the compliance period guarantees further emissions reductions (Figure 16).

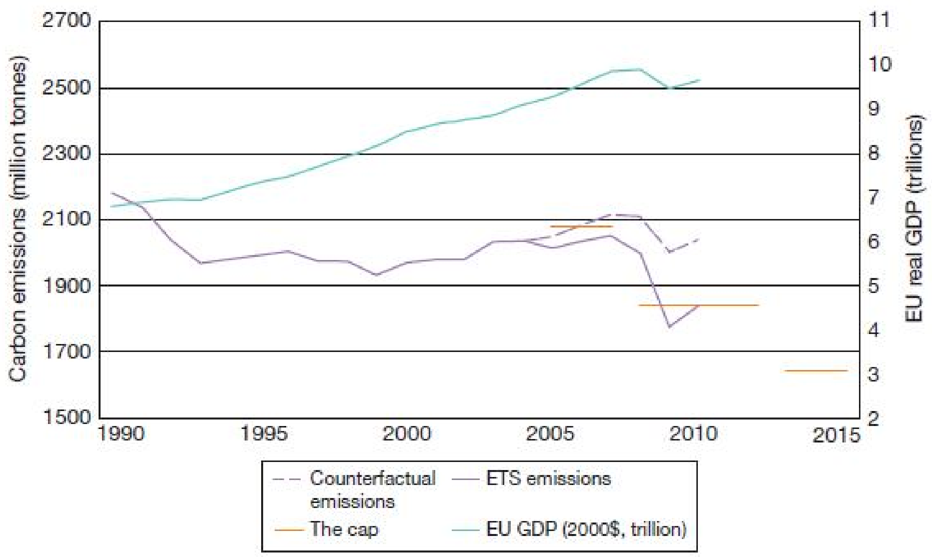


Figure 16: Emissions decreases within the EU ETS (Source: World Bank)

The ETS development consists in these phases:

- 2005-2007: first trading period used for ‘learning by doing’.
  EU ETS successfully established as the world’s biggest carbon market. However, the number of allowances, based on estimated needs, turns out

to be excessive; consequently the price of first period allowances falls to zero in 2007.

- 2008-2012: second trading period.
  Iceland, Norway and Liechtenstein join (1.1.2008). The number of allowances is reduced by 6.5% for the period, but the economic downturn cuts emissions, and thus demand, by even more. This leads to a surplus of unused allowances and credits which weighs on the carbon price. Aviation brought into the system (1.1.2012).
- 2013-2020: third trading period.
  Major reform takes effect. Biggest changes are the introduction of an Euwide cap on emissions (reduced by 1.74% each year) and a progressive shift towards auctioning of allowances in place of cost-free allocation. Croatia joins.
- 2021-2028: fourth trading period to be defined.

❖ *Regional Greenhouse Gas Initiative (RGGI)*

RGGI is a multi-state regional cap-and-trade program for the power sector in the Northeast United States. The RGGI cap-and-trade program is proposed to start in 2009 and lead to a stabilization of emissions at current levels (an average of 2002-2004 levels) by 2015, followed by a 10% reduction in emissions between 2015 and 2020. Some of the program reductions will be achieved outside the electricity sector through emissions offset projects. Offsets serve as the primary cost containment mechanism in RGGI; if allowance prices rise above trigger prices, the ability for regulated sources to use offsets increases.

❖ *Western Climate Initiative (WCI)*

The WCI is a collaboration of 5 Western US stated and British Columbia launched in early 2007. The initiative set a goal of reducing GHG emissions by 15% from 2005 levels by 2020 and requires partners to develop a market-based, multi-sector mechanism to help achieve that goal, and participate in a cross-border GHG registry.

❖ Australia ETS

Australia's trading scheme will be linked with the EU ETS from 2015, and the EU hopes to link up the ETS with compatible systems around the world to form the backbone of a global carbon market.

❖ New Zealand ETS

The New Zealand (NZ) ETS began in 2008 as a scheme covering only the forestry sector. In July 2010, it was amended and expanded to cover also stationary energy, fishing, industrial processes and the liquid fossil fuels sectors.

The NZ Government had planned for its ETS to cover all sectors of the economy by 2015.

❖ Swiss ETS

Swiss companies with installed energy capacities above 20MW or GHG emissions above 25.000 tonnes per year are required to participate in the Swiss ETS. Medium-sized firms can choose between paying a carbon tax and participating in the ETS. Both the carbon tax and the voluntary ETS were introduced in 2008. The ETS became mandatory for large firms on 28 February 2013.

Actually, in Asia and Latin America some emission trading systems with a great potential are under consideration.

2.2 Clean Development Mechanism

As we describe in Chapter 2, the CDM allows a developed country to implement a project that reduces GHG emissions or, subject to constraints, removes greenhouse gases by carbon sequestration in the territory of a developing country. The resulting CERs can then be used by the industrialized party to help meet its emission reduction target.

2.2.1 CDM market overview

Administration

The CDM is supervised by the UN Executive Board (EB), which itself operates under the authority of the Parties. The EB is composed of 10 members, including one representative from each of the five official UN regions (Africa, Asia, Latin America and the Caribbean, Central Eastern Europe and OECD), one from the small island developing states and two each from developed and developing Parties. The EB accredits independent organizations, known as operational entities (DOE), that validate proposed CDM projects, verify the resulting emission reductions, and certify those emission reductions as CERs. The EB approves new CDM methodologies submitted by stakeholders. Another key task of the EB is the maintenance of a CDM registry, which will issue new CERs, manage an account for CERs levied for adaptation and administration expenses and maintain a CER account for each developing Party hosting a CDM project.

Participation

In order to participate in CDM, all Parties (developed and developing countries) must meet three basic requirements:

- voluntary participation,
- establishment of the National CDM Authority,
- ratification of the Kyoto Protocol.

Industrialized countries moreover must meet additional requirements such as the following:

- establishment of the assigned amount under Article 3 of the Protocol
- national system for the estimation of greenhouse gases
- national registry
- annual inventory
- accounting system for the sale and purchase of emission reductions.

Supply of CDM credits to the compliance market

There has been substantial growth in CDM projects since 2005 (Figure 17). In 2012, there are 7167 projects in the CDM pipeline which have the potential to generate 2.7 billion CERs, excluding those projects withdrawn by the owners, rejected by the CDM EB, or those projects of which the design was approved but could not validate emission reductions afterwards.

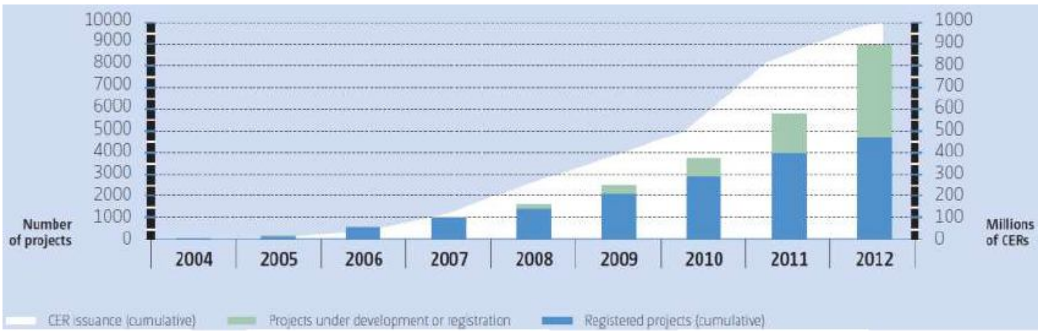


Figure 17: Projects and issuance of CERs
" CDM Executive Board Annual Report 2012 " – UNFCCC

Geographical distribution of projects

China is currently the main supplier of CERs accounting for half of the global project activities (Figure 18). The contribution from Africa remains at only 7%, although both transaction volumes and the number of projects under development are growing steadily in a number of African countries, such as South Africa, Egypt, Kenya and Morocco.

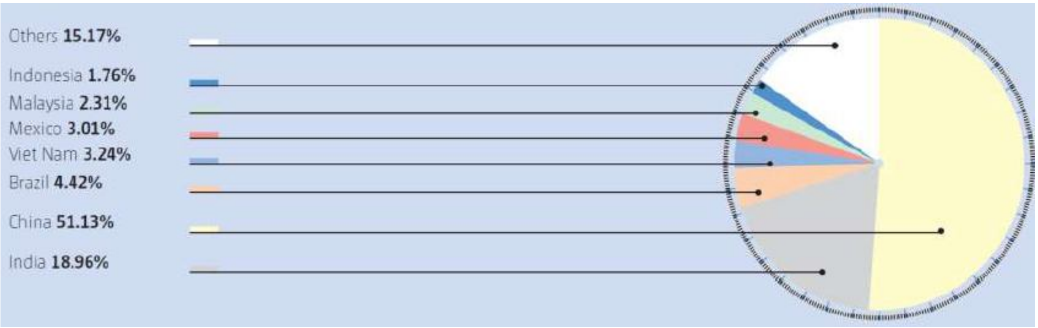


Figure 18: Registered project activities by host party.

More than 90 per cent of the total issued credits (1.030.436.008 CERs) come from five countries (China, India, South Korea, Brazil and Mexico) because these countries are among those that face the least difficulty in attracting foreign capital (Figure 19). Only 4 % of credits come from Africa and among them most are from South Africa or the Maghreb countries.

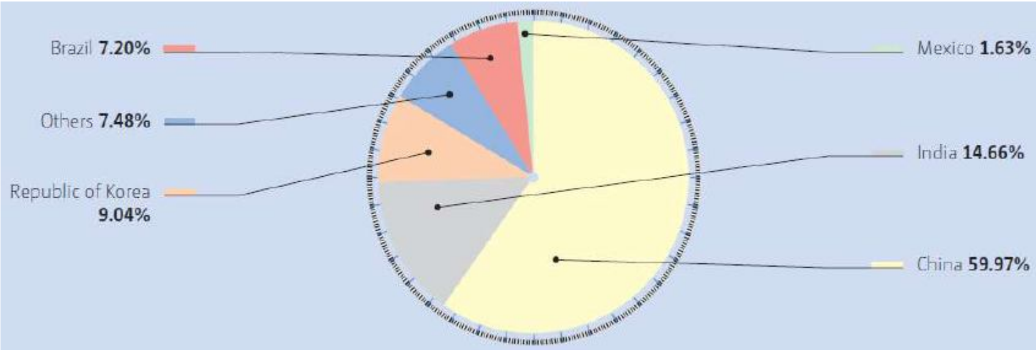


Figure 19: CERs issued, by host Party

Investors

The profile of market players changed significantly over time. Before 2004 public funds or multilateral agencies were the only players in the carbon market. The prototype carbon fund of the World Bank and the Dutch and Japanese investments programs represented most of the investments in CDM projects. Since 2005 and the launch of EU ETS, there was an explosion of private investments, including banks in search of capital gains for their clients in a new and growing sector. In 2012, the main investor parties are UK and North Ireland, Switzerland, Netherlands and Japan (Figure 20).

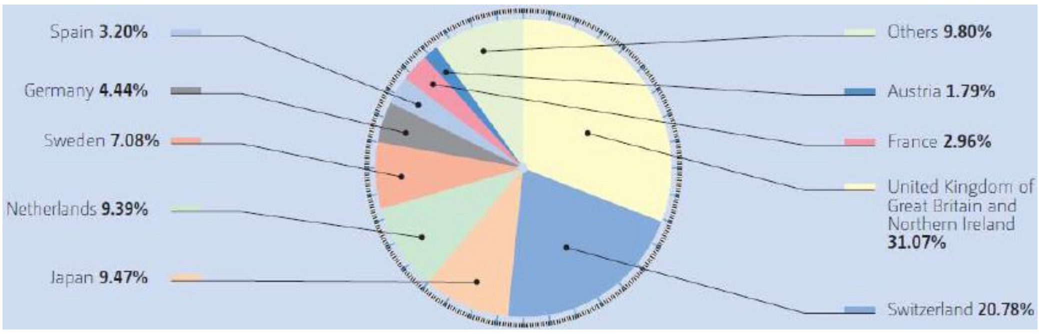


Figure 20: Investor parties

Project Types and Scale

In general, CDM project activities may be classified into main areas, namely GHG emissions reduction and CO_2 sequestration.
The CDM projects involving emission reduction are further classified into three types of CDM projects:

- ✓ Type I: renewable energy projects cover those involving electricity generation by the user for its own use or for an electricity grid, mechanical and thermal energy generation for the user.
- ✓ Type II: energy efficiency improvement projects include supply side efficiency improvements in energy generation, transmission and distribution; demand-side energy efficiency programs cover specific technologies and energy efficiency and fuel switching measures for buildings, industrial facilities and agricultural facilities/activities.
- ✓ Type III: include solid waste and wastewater treatment, methane recovery, destruction of more serious greenhouse gases like N_2O and emission reductions by low-greenhouse gas emitting vehicles,

In 2012 the majority of projects developed (Figure 21) are in the energy field (small hydropower, wind farms, etc.) and in the waste sector (waste recycling, recovery of CH_4, etc.).

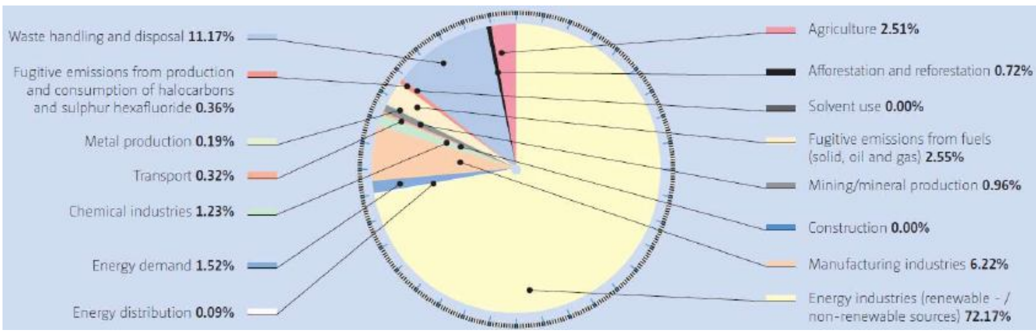


Figure 21: Distribution of registered project activities by scope

CDM projects are also classified as small scale or normal sized projects based on the targeted GHG emissions reduction.
Small scale projects are those frequently developed by NGOs. In the Marrakesh agreements, three type of small scale CDM projects were defined:

- Renewable energy project activities with a maximum output capacity equivalent of up to 15 MW
- Energy efficiency improvement project activities that reduce energy consumption on the supply and/or demand side, by up to the equivalent of 15 GWh per year
- Other project activities that both reduce anthropogenic emissions by sources and directly emit less than 15,000 tonnes of CO_2 annually.

The crediting period for all CDM projects above can be either:

- ✓ Seven years with the option of up to two renewals of seven years each if the project baseline is still valid or has been updated;
- ✓ Ten years with no renewal option

Afforestation and reforestation projects (A/R) are different from the others because they do not reduce GHG emissions but only remove them for a certain period of time. Therefore, A/R rules are the sequent:

- ✓ Non permanence
  CO_2 when sequestered in trees could be released back into the atmosphere if the tree dies (e.g. in a forest fire). To address this problem two different type of CERs were created, namely temporary (tCERs) and long-term (lCERs). The feature of tCERs and lCERs is that are only valid for a certain period and they have to be replaced with other permanent offsets at some point.
- ✓ Longer crediting period for A/R projects
  Project developer may choose between a crediting period of 20 years thet may be renewed twice (60 years maximum) or a period of 30 years with no renewal.

2.2.2 Criteria of eligibility for CDM

The Kyoto Protocol stipulates several criteria that CDM projects must satisfy. Two critical criteria could be classified as additionality and sustainable development.

Additionality

Article 12 of the Protocol states that projects must result in *"reductions in emissions that are additional to any that would occur in the absence of the* *project activity"*. The CDM projects must lead to real, measurable, and long-term benefits related to the mitigation of climate change. Additionality is demonstrated through a specific tool (Figure 22).

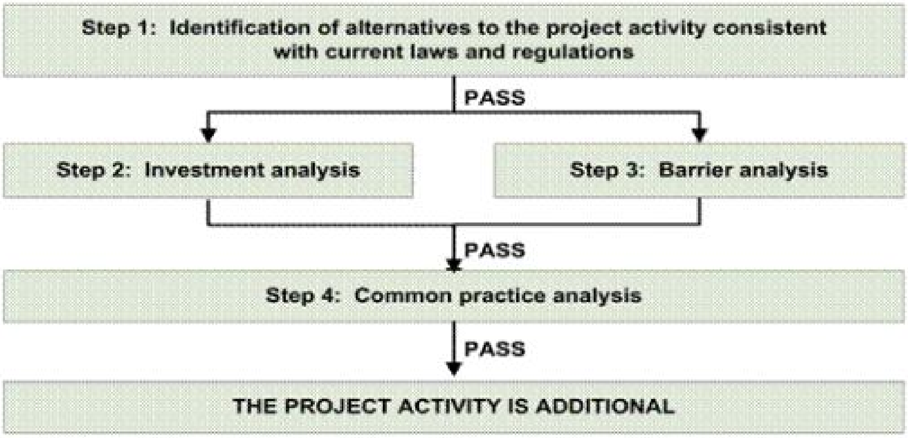


Figure 22: UNFCCC Additionality Tool

Step 1 involves the identification of realistic and credible alternatives to the project scenario and ensuring compliance with all mandatory laws and regulations.

Step 2 or **Step 3** can be choosen by the project developer.

Step 2 - Investment barrier
Revenue from the carbon offsets must be a primary driver for project implementation. An investment barrier for a carbon offset project activity exists if a financially more viable alternative to the project would otherwise have led to higher GHG emissions.

Step 3 - Barrier Analysis
Project implementation must require the ability to exceed implementation barriers, such as local resistance, lack of know-how and institutional barriers. Other barriers include in this step are investment, technology or prevailing practice barriers.

Investment barriers:

- ✓ similar activities have only been implemented with grants or other non-commercial finance terms and are undertaken in the relevant country/region;

- ✓ no private capital is available from domestic or international capital markets due to real or perceived risks associated with investment in the host Party (e.g. demonstrated by a poor credit rating in that country).

A technology barrier exists if a less technologically advanced alternative to the project activity involves lower risks due to the performance uncertainty or low market share of the new technology adopted for the project and so would have led to higher emissions.

Prevailing practice barriers or existing regulatory or policy requirements would have led to implementation of a technology with higher emissions.

Step 4 complements steps 1, 2 and 3 with an analysis of the extent to which the proposed project type has already diffused in the relevant sector and region. This step is a credibility check, in that if similar activities are widely observed and commonly carried out, it calls into question the claim that the proposed project activity is financially/economically unattractive or faces barriers.

Sustainable development

The CDM tries also to stimulate the sustainable development in developing countries. Article 12.2 of the Kyoto Protocol, explicitly states that *"The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development…"*.

Sustainable development is the need to balance the satisfaction of near-term interests of the present with the protection of the interests of future generations, including their interests in a safe and healthy environment as expressed by the 1987 UN World Commission on Environment and Development.
Like Additionality, there is also a SD tool that comprises a series of five steps each with a set of questions.

Step 1 consists in a selection of language, project name and type.

Step 2 - Sustainable development co-benefits
It is the key issue and must be completed to specify the SD co-benefit or impact based on criteria that may be broadly categorized as (Figure 23):

- ➢ Environmental criteria
  The project reduces GHG emissions and the use of fossil fuels, conserves local resources, reduces pressure on the local environments, provides health and other environmental benefits and meets energy and environmental policies.
- ➢ Social criteria
  The project improves the quality of life, alleviates poverty and improves equity.

- Economic criteria
  The project provides financial returns to local entities, results in positive impact on balance of payments and transfers new technology.

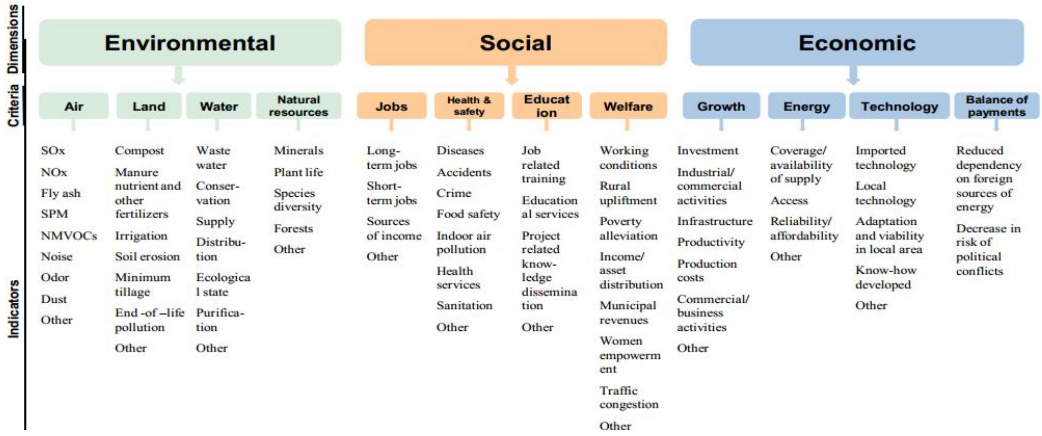


Figure 23: SD tool

Step 3 – No harm safeguards
The project developers declare the level of risk of negative impact of the project activity for six no harm safeguard principles that have been adapted from the UN MDGs, such as human rights, good labor practice, environmental protection, anti-corruption, land rights and other related impacts.

Step 4 – Stakeholder engagement
Project developers declare if and how interested or affected parties have been consulted in making the declaration, confirm if compliant with any relevant laws, regulations or voluntary commitments, and indicate a willingness for third party verification.

Step 5 requires the persons using the SD tool to identify themselves.

Once completed, the SD tool produces a SD declaration report, which forms part of the project's documentation.

2.2.3 CDM project cycle

The CDM system has highly developed mechanisms for ensuring that projects comply with the Kyoto Protocol criteria and for continuously quantifying their emissions reductions. The CDM project cycle has a lot of steps (
Figure 24).

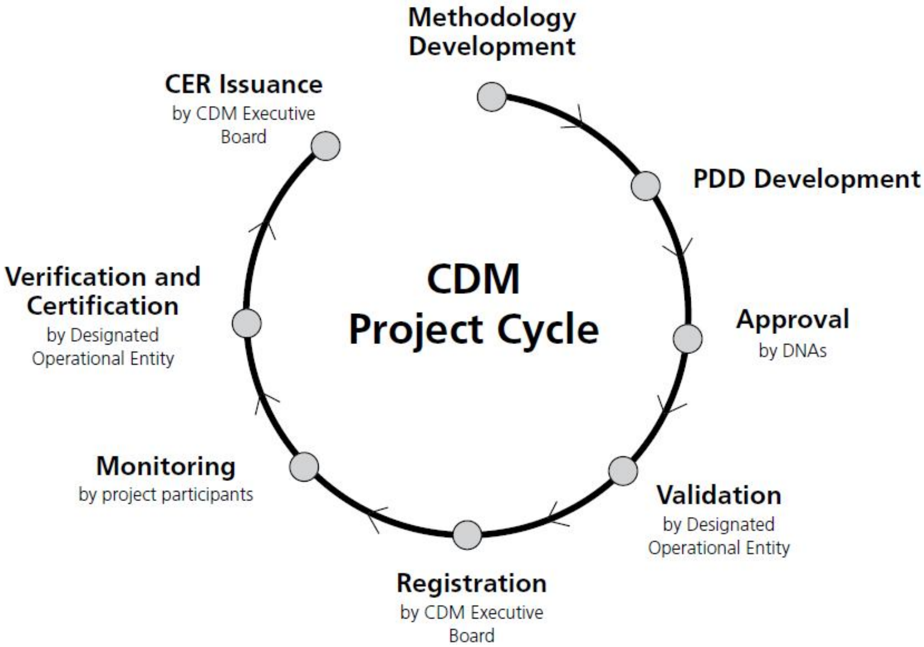


Figure 24: CDM project cycle

1) The project cycle starts with the choice of an existent methodology or with the submission of a new baseline and monitoring methodology if no methodology approved by the EB exists for the project type. Approved methodologies can be revised at any time but the revisions do not apply to projects that have been registered earlier as long as their crediting period is not renewed.
2) The Project Design stage includes also developing a project concept and stakeholder consultations. All of these elements are documented in the CDM Project Design Document (PDD).
3) A project idea note is prepared and submitted for endorsement to the Designated National Authority (DNA).
4) A validation is the process of independent evaluation of a project by an accredited third-party auditor called Designated Operational Entities (DOEs). This step involves also a 30-day public comment period.
5) Registration is the formal acceptance by the CDM-Executive Board.
6) Project developers are required to maintain records measuring the emission reductions achieved during a project’s operation phase.
7) The monitoring report then is evaluated and approved by a DOE. To minimize conflict of interest under the CDM, the validating auditor cannot also conduct project verification. Verification is done at time intervals freely chosen by the project developer or owner, usually determined by

consideration for cost-saving and frequent sales revenues. The verification report is submitted to the CDM EB for certification and issuance of CERs.

8) After the mandatory fees are paid to the UNFCCC Secretariat, the issued CERs are transferred to the CDM registry account of the relevant project participant. The certificates are recorded in an international registry system, with unique serial numbers, that makes each CER traceable to the project through which it was generated.

When a customer purchases a CDM offset, the money goes to the company that developed the project, thus financing the emission reductions created in the project. These certificates are evidence that the provider generated the emission reductions paid for by the customer. The certificates are cancelled (by the customer or the provider) in the registry, which means that the emission reductions are irrevocably assigned to the customer and cannot be reused.

Emission reductions from CDM projects can be used by companies within the EU emissions trading system or by states with obligations under the Kyoto Protocol in the compliance market, but the customer may be also a company that seeks to offset on a voluntary basis.

2.3 Voluntary Carbon Market

The Voluntary Carbon Market (VCM) functions outside of the compliance market and enables companies and individuals to offset their carbon emissions on a purely voluntary basis by purchasing carbon credits generated from projects that either reduce GHG emissions or capture carbon from the atmosphere. In other words, they are not subject to legislation that requires them to reduce or offset their GHG emissions, like AES Corporation in 1989. In the voluntary market, organizations and even individuals typically assess their own carbon footprint themselves, attempt to reduce their emissions by saving energy and then offset additional emissions either by buying carbon credits from projects that reduce emissions elsewhere, or by directly investing in these projects.

VCM can be seen as a preparation for future participation in a regulated cap-and-trade system as companies and authorities gain experience with emission reductions and carbon market mechanisms. On the positive side, voluntary markets can serve as a testing field for new procedures, methodologies and technologies that may later be included in regulatory schemes. Voluntary markets allow for experimentation and innovation because projects can be implemented with fewer transaction costs than CDM or other compliance market projects. Voluntary markets also serve as a niche for micro projects that are too small to warrant the administrative burden of CDM or for projects currently not covered under compliance schemes.

2.3.1 Voluntary market overview

Demand in the voluntary market

The VCM is very small compared to the compliance market. In 2012, 101 $MtCO_2e$ were traded on the voluntary market (about 1% of the total) compared to 175451 $MtCO_2e$ on the compliance market. The VCM however is a significant component of the overall carbon market: voluntary actions sends an important message on the need for action, expressed through the rapid growth of the market (Figure 25).

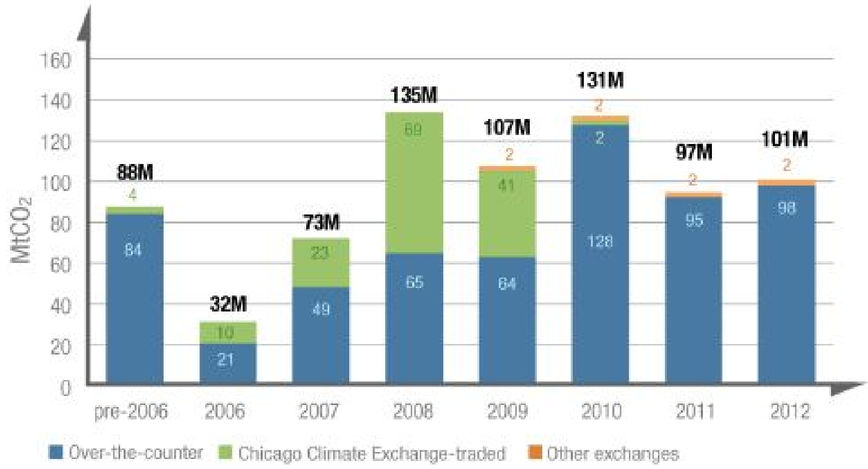


Figure 25: Historical demand in Voluntary Carbon Markets

As can be seen in the graph above, the VCM was affected by the global recession in 2009.

The trade volume is calculated from two main sources: over-the-counter (OTC) trade and the Chicago Climate Exchange (CCX).

The majority of voluntary offset buyers obtain offsets through decentralized over-the-counter (OTC) transactions. These are bilateral contracts between producers and buyers that define the terms of payment and offset delivery.

The CCX was a cap-and-trade system that organizations joined voluntarily, making legally binding commitments to track and reduce their GHG emissions. The exchange was launched as a pilot program and completed its final trades in 2010. Today, CCX continues to administer a voluntary offset program and registry.

Geographical origins

The geographical origins are also wider than in the mandatory compliance market (Figure 26). Voluntary carbon offsets are not a standardized commodity, but are instead a product market where preferences, prices, and projects vary greatly by region.

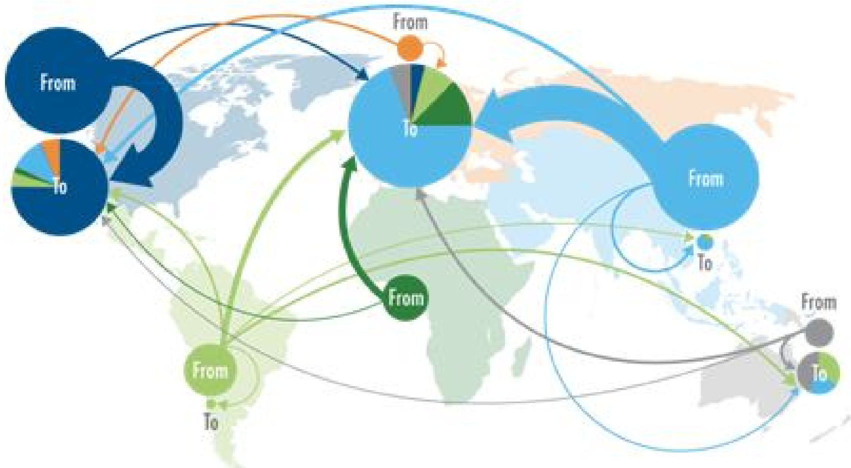


Figure 26: Flow of Transacted Volumes, 2012

In contrast to CDM projects that can only be implemented in non-Annex I countries, VCM projects can take place in any country of the world. For voluntary market projects, China and India are the major supplier countries. US has also a large transaction volume (

Figure 27). This can be explained by the fact that the US lacks a large compliance market, so companies developing projects look to the voluntary market. It can also be attributed to the fact that the US is not a signatory to the Kyoto Protocol, and so US-based projects are not eligible to participate in CDM or JI mechanism. Latin America, Oceania and Africa have a 10% share of the transaction volume. Turkey claimed a relatively significant 3 percent of the market, which can be attributed to the fact that it is ineligible to participate in the CDM, meaning that the voluntary markets remain its main niche.

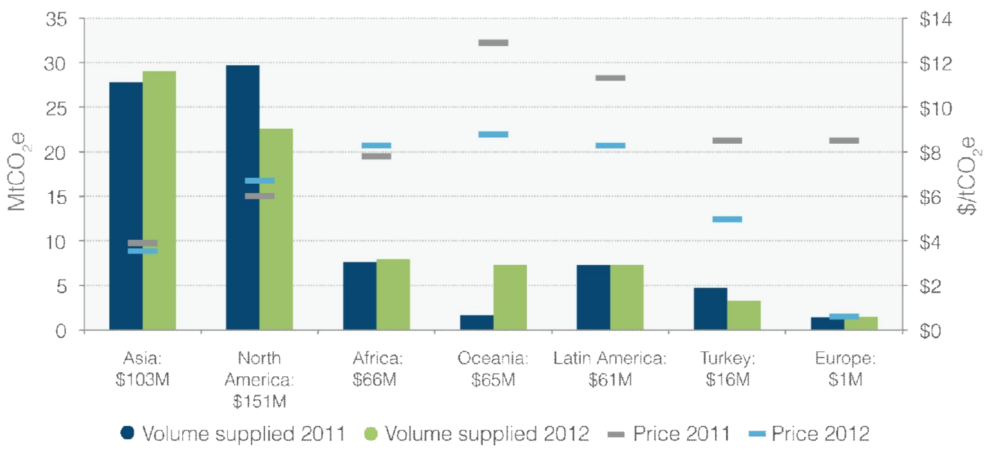


Figure 27: Volume and Average Price by Project Region

The major buyer countries are Europe and North America (Figure 28). While the main motivation for buyers in the compliance market is being able to comply with the law regulating GHG in the cheapest way possible, voluntary buyers, on the other hand, have a variety of motivations. Among these are personal idealism, corporate social responsibility, marketing and PR purposes. Some companies also participate in the voluntary market because they see it as a good way of preparing for future entrance into the compliance market and their actions now may be of benefit later.

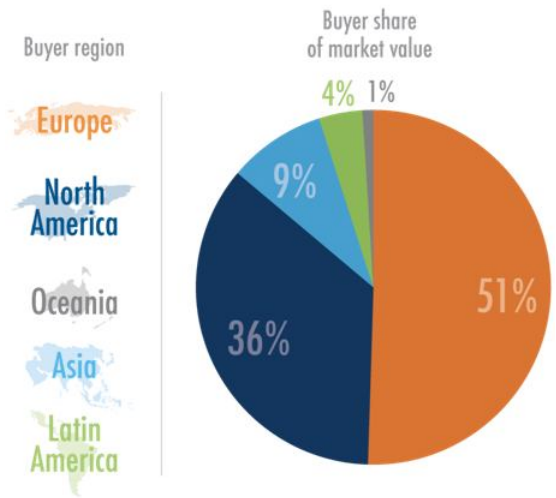


Figure 28: Market share by Buyer region

For buyers on the voluntary market, the social or environmental story behind the carbon credit is often as important as the GHG emission reduction itself that the carbon credit represents. This is particularly true for those companies using carbon credits for marketing and PR purposes.

Types of projects

A feature of voluntary offsetting projects is that they are often small scale and they are primarily of five types:

- Renewable energy
- Energy efficiency
- Forestry
- Methane capture
- Destruction of fluorinated gases
- Waste management

In 2012, offsets developed from renewable energy projects were the most popular with 34% of all transacted offsets and 26 $MtCO_{2e}$ (Figure 29)

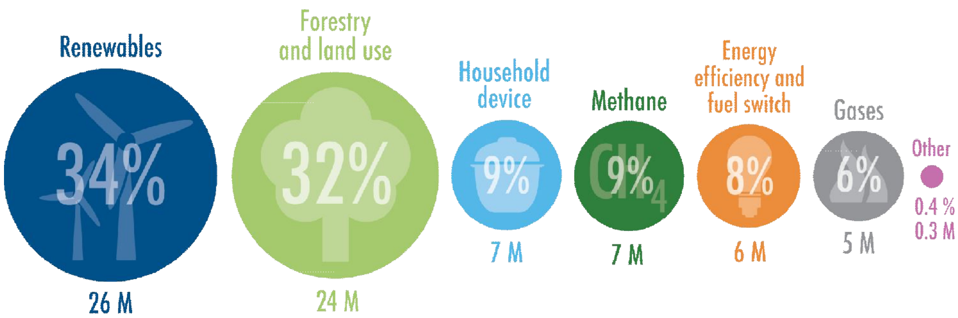


Figure 29: Volume by Project Category, 2012 ($MtCO_2e$ and % Share)

Forestry and land-use activities were the source of another 24 $MtCO_{2e}$, 32% of all volume. Household Device tracked significant growth both in the number of projects and demand (9% of all transacted volume) for offsets generated from the distribution of clean cookstoves and water filtration devices in developing world. These projects have so far delivered at least 4 million cookstoves or other clean household devices to developing country households with the aid of carbon revenues.

Looking at specific project types within each of these categories (Figure 30), wind energy offsets is the most popular of renewable energy projects (20% of market share). Another 7% of market share comes from large hydropower projects.

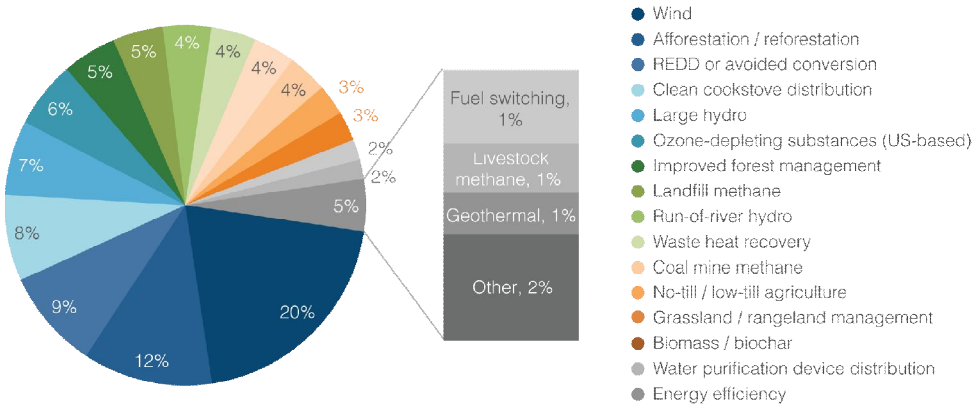


Figure 30: Market share by project type

Across all sequestration approaches, afforestation/reforestation (A/R) remained the second most popular activity in the voluntary offset market, as the source for 12% of transacted offsets. Credits from projects that reduce emissions from deforestation and forest degradation (REDD) reach 9% of market share.

2.3.2 Certification standards

The lack of uniformity, transparency and registration in the voluntary markets has created a great deal of criticism from some environmentalists who claim that they are only a business rather than an engine of actual environmental progress. Previously the voluntary market was poorly regulated which gave rise to considerable adverse publicity.

Over the last few years a number of robust standards have emerged, that give assurance to purchasers that credits are valid, are not double counted and contribute to sustainable development. Their emergence is a reflection of the offset industry's response to offset quality concerns by offset buyers and the general public, as well as sign of the maturation of the voluntary offset market. Most standards operate on a not-for-profit basis and cover their costs from charges applied to registration and credit issuance.

Third-party verification is required for CDM projects and not obligatory in the VCM, but there has however been increasing demand for certified credits in voluntary market.

Carbon offset standards have three core components:

1. Accounting and quantification procedures aim to ensure that offsets are real, additional and permanent and provide the methods for quantifying the number of offsets a project can generate. They specify the tests used to determine additionality and procedures to address uncertainty and leakage. They provide the methodologies for

quantifying the baseline and project emissions, the difference between the two being the number of credits awarded to a project. Accounting rules may also include definitions of accepted project types and methodologies for validating project activities.

2. Monitoring, verification and certification procedures aim to ensure that offset projects perform as reported and follow the conditions specified in approved project documentation. Verification and certification rules are used to quantify the actual carbon savings that can enter the market once the project is up and running.
3. Registration and enforcement systems aim to ensure that contractual standard clearly identify ownership of the emission reductions and also define who bears the risk in case of project failure. Registries are vital in creating credible, fungible offset commodity. A serial number is assigned to each verified offset. In this manner, registries reduce the risk of double counting, that is, to have multiple stakeholders take credit for the same offset. [10]

The first type of standard is the CDM defined in Chapter 2.2 and the other most important offset standard are:

- Gold Standard (GS)
  Created by consortium of NGOs for energy projects, currently represents best practice since it requires the project to prove that it is contributing to sustainable development and will not have any adverse socio-economic or environmental impacts. This requires more rigorous monitoring which, in turn means extra expense and a need for greater staff capacity. Carbon credits attract a premium price because of this assurance. Since 2013, GS handle also forestry and land use projects.
- Voluntary Carbon Standard (VCS) or Verified Carbon Standard
  It is emerging as a market leader in the voluntary carbon market. It handles all types of projects, but specially forestry and land use projects and has slightly less demanding monitoring requirements with this difference normally being reflected in the price per tonne being offered.
- Chicago Climate Exchange (CCX)
  Standard for offset projects accepted into the voluntary GHG emissions cap-and-trade scheme based in North America.
- Plan Vivo
  It is a system for developing community-based payments for ecosystem services, projects and programs with an emphasis on building capacity, long-term carbon benefits from community forestry and land use projects, diversifying livelihoods and protecting biodiversity.
- Climate Action Reserve (CAR)

The CAR is a Californian standard for forestry, landfill gas and urban forestry projects on the US carbon market.

- The Climate, Community & Biodiversity Standard (CCB)
  Created by consortium of NGOs and private sector for land-based sinks projects.
- Panda Standard
  It is the first voluntary carbon standard designed specifically for China. It will provide transparency and credibility in the nascent Chinese carbon market and will advance the People's Republic of China government's poverty alleviation objectives by encouraging investment into China's rural economy.
- VER+
  It is a carbon offset standard and closely follows the Kyoto Protocol's project-based mechanisms (CDM and JI). The VER+ standard was developed by TÜV SÜD, a Designated Operational Entity for the validation and verification of CDM projects. It was designed for project developers who have projects that cannot be implemented under CDM.
- ISO 14064
  It is an offset protocol, voluntary and is deliberately policy neutral. The ISO 14064 standard consists of three parts. The first part (ISO 14064-1) specifies requirements for designing and developing organization or entity-level GHG inventories. The second part (ISO 14064-2) details requirements for quantifying, monitoring and reporting emission reductions and removal enhancements from GHG projects. The third part (ISO 14064-3) provides requirements and guidance for the conducting of GHG information validation and verification.
- Social Carbon
  It was developed by the Instituto Ecologica (Brazil) in 1998, but it is not a full offset standard. It is a methodology that focuses on enhancing co-benefits such as biodiversity and active participation of local communities. It is usually used in conjunction with another standard, such as VCS or CDM.
- American Carbon Registry
  Founded in 1997 as the first private voluntary GHG registry by the environmental non-profit ERT, was relaunched as ACR in 2009. It accepts all project types.

For many voluntary buyers, a carbon offset's contribution to social and sustainable development is as important as its climate benefits. Some carbon standards, like Gold Standard, Plan Vivo, Social Carbon and CCB, require that their projects measure up to both climate and additional social and environmental indicators that are certified simultaneously. On the other hand, purely carbon accounting standards like the VCS do not require additional co-benefits certification.

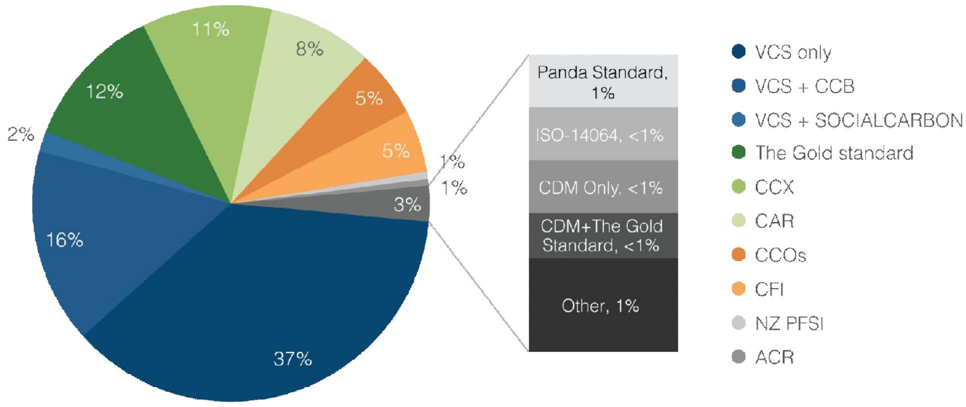


Figure 31: Market Share by Project Standard, 2012

The percentage of credits sold that uses this particular standard is an important indicator of the level of acceptance of the standards amongst buyers and intermediaries. Market share is also an indication of the likelihood of any given standard being able to survive. Within the VCM, co-benefit standards accounted for approximately 30 per cent of the market (Figure 31).

The VCM has provided a useful testing ground for co-benefit standards and guidelines. It has facilitated and encouraged innovation to occur in the CDM compliance market. It has also allowed for some co-benefits to be recognized within compliance markets by building on the CDM methodologies.

A study of NetBalance Foundation illustrates the continuum of international standards and guidelines, with levels of quantification and measurement plotted against the levels of co-benefits. Different standards take very different approaches to the requirements of projects (Figure 32). [11]

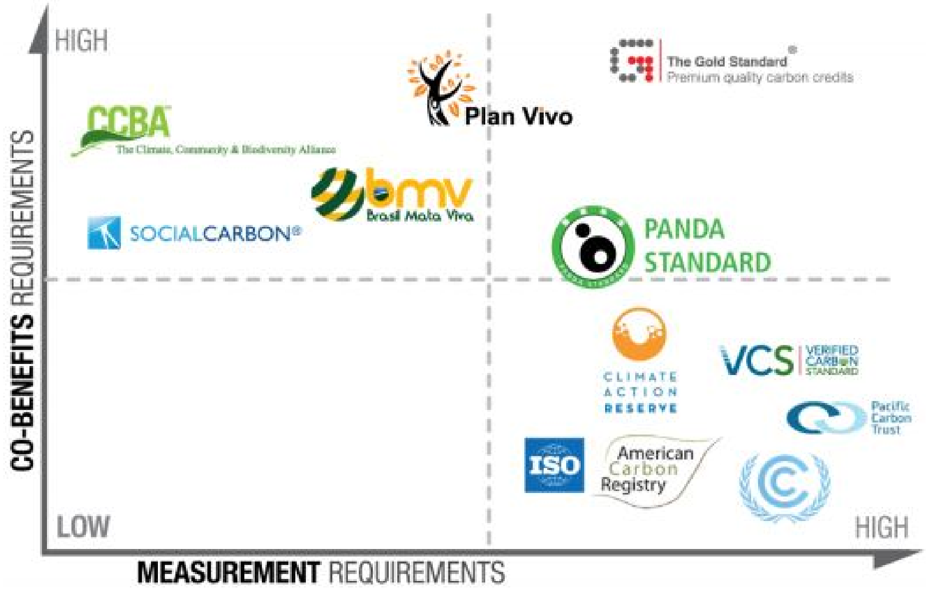


Figure 32: Standards mapping quantification versus Level of co-benefits

The Gold Standard is seen as the leader in terms of measuring co-benefits and so is the most important for NGOs whose objective is to improve people livelihood in developing countries.

2.3.3 Gold Standard – GS

As described in Chapter 2.2 the standard set up by the CDM EB for CDM address additionality, but do not set any guidelines for sustainable development. This is the added value of the Gold Standard and for this reason is widely considered to be the highest standard in the world for carbon offsets.

The GS requires social and environmental benefits of its carbon offset projects and has a very well developed stakeholder process that involved NGOs and local communities in developing countries. The GS can be applied to voluntary offset projects as well as to CDM projects in compliance market.

The objectives of the GS are to:

- ✓ Help boost investment in additional sustainable energy projects
- ✓ Ensure significant and lasting contributions to sustainable development
- ✓ Provide assurance that investments have environmental integrity
- ✓ Increase public support for renewable energy and energy efficiency

History of Standard

The GS was developed in 2003 under the leadership of the World Wildlife Foundation (WWF), Helio International and SouthSouthNorth in order to ensure that emission reduction projects are real and provide social, economic and environmental benefits. GS is based on a non-profit foundation under Swiss Law funded by public and private donors. The GS CER was launched in 2003 and GS VER was launched in 2006. The GS presently is endorsed by 85 NGOs, such as the Italian Legambiente.

All GS activities are subject to safeguards based upon principles used by the UNDP MDG Carbon facility.
These are:

- ✓ Safeguards regarding the livelihoods of communities in and around the project
  1 No human rights abuses
  2 No involuntary resettlement
  3 No damage on critical cultural heritage
- ✓ Safeguards regarding the employees of the project
  4 Freedom of association
  5 No forced labour
  6 No child labour
  7 No discrimination
  8 Safe working environment
- ✓ Safeguards regarding corruption
  9 No corruption
- ✓ Safeguards regarding environmental aspects of the project
  10 Precautionary with environmental challenges
  11 No significant conversion or degradation of critical natural habitats

Project Type

The GS is currently available for projects in the following scopes:

- ✓ Renewable energy – the generation and delivery of energy from non-fossil and non-depletable energy sources, such as solar, biomass, biogas, wind, geothermal and hydro.
- ✓ End-use energy efficiency – the reduction in the amount of energy required to produce goods or services (e.g. energy efficient cookstoves or water filters).
- ✓ Waste handling and disposal – that deliver an energy service (e.g. electricity generation from land fill recovered methane) or a usable product with sustainable development benefits (e.g. composting).
- ✓ Land-use and forestry – reforestation/afforestation, climate smart agriculture and improved forest management.

Project Size

The GS does not have any project size minimum and the classification for GS VERs is:

- ✓ micro-scale (<5,000 tonnes CO_2 per year)
- ✓ small-scale (5,000-60,000 tonnes CO_2 per year)
- ✓ large-scale (>60,000 tonnes CO_2 per year).

For GS CERs, the same size limits as for the CDM apply.

Additionality requirements

Both GS CERs and GS VERs requires the application of the latest UNFCCC additionality tool as described in Chapter 2.1.

2.3.4 Gold Standard project cycle

The process is very similar to that of the CDM. However, there are some fundamental differences (Figure 33). The GS insists that developers take a holistic approach to project design and implementation. In this context, GS remains the only certification standard that requires all projects to adhere to the strictest standards on additionality and positively contribute to sustainable development by making a net-positive impact to the economic, environmental and social welfare of the local communities.

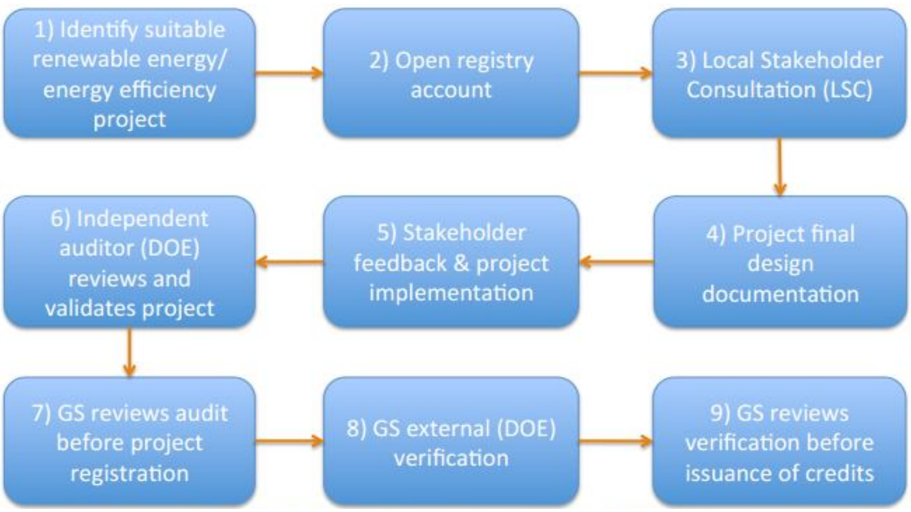


Figure 33: GS certification process

1) The first step includes an eligible project identification.

2) Then, project developers open an account on The Gold Standard Registry, a web-based software application that serves as the tracking tool and administration tool for both GS CER and VER projects.
3) Project developers start writing the GS Passport, which is the document that presents all required information using a fixed template and start planning the Local Stakeholder Consultation (LSC) process, assessing the potential environmental and socials impacts of the project with relevant stakeholders including NGOs, policymakers and local residents.
   The consultation sessions takes place in two rounds. The first round is a face-to-face meeting to introduce and explain the project to the local community and collect feedback, comments and concerns. The second round is a follow-up from the first consultation; it does not have to include a physical meeting if everyone has access to, and is able to read, the documentation.
4) Developers write up the Project Design Document (PDD), which provides information focusing on the project design and the application of the selected baseline and monitoring methodology to calculate emission reductions. It is the primary means to communicate about the emission reductions for the host country approval (if required), validation and registration process.
5) Project developers carry out the Stakeholder Feedback Round in order to show stakeholders how their comments from the first consultation were taken into account.
6) Then, developers contact an independent UN-accredited auditor (e.g. DOE) to review and to validate the project activity.
7) Following the project validation, the validated PDD, Passport and other relevant project documents plus the validation report must be uploaded into the registry. The GS Secretariat, the Technical Advisory Committee, and The GS NGO Supporters then conduct a final document review before the project becomes registered.
8) An independent UN-accredited auditor verifies the project’s emission reductions and sustainable development monitoring activities.
9) The GS Secretariat conducts a final document review before the project may issue credits.

GS issues a corresponding amount of emission reduction certificates, known as GS-CERs (Gold Standard Certified Emission Reductions) and GS-VERs (Gold Standard Verified Emission Reductions), depending on whether they were issued in the CDM or voluntary market. GS credits are uniquely numbered and transparently listed in one central registry that allows direct access to all project and audit documentation. This, like the CDM registry, not only ensures traceability of the project but also provides the platform for retiring the credits (cancelling the certificate once it has been assigned to an end-user).

2.3.5 Voluntary Carbon Standard – VCS

The Voluntary Carbon Standard is a full-fledged carbon offset standard. It focuses on GHG reduction attributes only and does not require projects to have additional environmental or social benefits. The VCS 2007 is broadly supported by the carbon offset industry (project developers, large offset buyers, verifiers, projects consultants). VCS approved carbon offsets are registered and traded as Voluntary Carbon Units (VCUs).

History of Standard

The first VCS version was published jointly in March 2006 by The Climate Group (TCG), the International Emissions Trading Association (IETA) and the World Economic Forum Global Greenhouse Register (WEF). The VCS 2007 was launched in November 2007 following a 19-member Steering Committee review of comments received on earlier draft versions. The Steering Committee was made up of members from NGOs, DOEs, industry associations, project developers and large offset buyers. The World Business Council for Sustainable Development joined in 2007 as a founding partner of the VCS 2007.The VCS will be updated yearly for the first two years and every two years after that.

Project Type

Projects, activities or methodologies can be developed under any of these sectoral scopes:

- ✓ Energy (renewable/non-renewable), Energy distribution, Energy demand
- ✓ Manufacturing industries, Chemical industry, Construction, Transport, Mining/Mineral production, Metal production
- ✓ Fugitive emissions from fuels (solid, oil and gas), Fugitive emissions from Industrial gases
- ✓ Solvents use
- ✓ Waste handling and disposal, Agriculture Forestry and Other Land Use (AFOLU), Livestock and manure management

VCS is among the most widely used AFOLU standard.

Project Size

There is no upper or lower limit on project size.VCS does however classify projects into 3 categories based on their size:

- Micro projects: under 5,000 tCO_2e per year
- Projects: 5,000–1,000,000 tCO_2e per year
- Mega projects: greater than 1,000,000 tCO_2e per year

The rules on validation and verification vary to some degree for projects that fall in the micro or mega categories.

2.4 Comparison regulated vs voluntary

At this point, it is important to describe the main differences between the two markets, Compliance with CDM and Voluntary Market.Table 5 shows volume, value and average price of CERs and VERs transacted in 2012. It also presents which are the different administration bodies, geographic scopes, trading platforms and price setters.

	Clean Development Mechanism			Voluntary Carbon Offsets		
	Volume ($MtCO_2e$)	Value ($ Million)	Avg. Price ($\$/tCO_2e$)	Volume ($MtCO_2e$)	Value ($ Million)	Avg. Price ($\$/tCO_2e$)
Primary Markets	339 Mt	$1,047 M	$3.1/t	20 Mt	$86 M	$5/t
Secondary Markets	1,686 Mt	$5,451 M	$3.2/t	22 Mt	$87 M	$4.2/t
TOTAL 2012	2,025 Mt	$6,498 M	$3.2/t	42 Mt	$172 M	$4.5/t
Rulemaking Body	UNFCCC/ Executive Board (CDM EB)			Independent third-party standards guide projects; no central regulatory body		
Geographic Scope	Non-Annex I Countries			Global		
Trading Platform	Exchange or Over-the-Counter			Over-the-Counter		
Price Setter(s)	Kyoto Compliance Markets			Voluntary Buyers		

Table 5: Comparison CDM versus VCM, 2012

By comparing CDM and VCM emerge different features that are illustrated below, regarding in detail the market size, the time to receive credits, the technology used, the size of projects, the prices of credits, the process of host country approval and the sustainable development impact.

Market size

As mentioned in Chapter 2.2, the compliance market is 100 times greater than the voluntary market in terms of $MtCO_2$ transacted volumes. Figure 34 shows the daily average volume of the two markets.

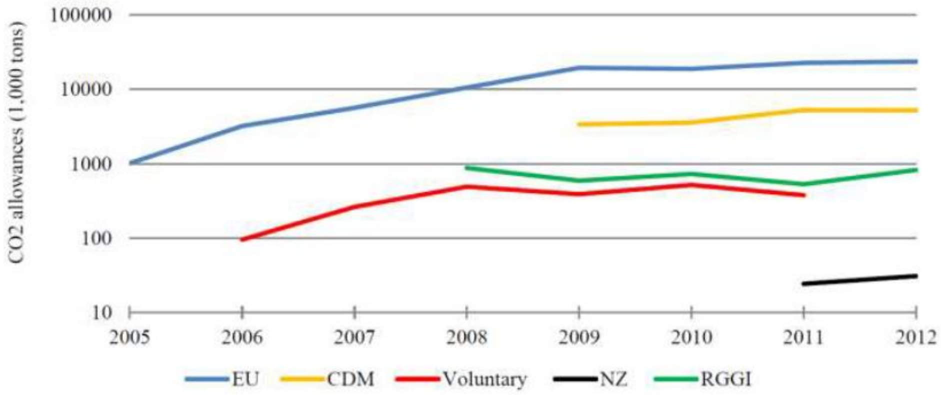


Figure 34: Volume of CO_2 Allowance Trades (Daily Average)

Time

The process of meeting the requirements for a voluntary project is usually shorter than developing a CDM project. Creating VERs will have the advantage of a simplified development phase, reduced monitoring and evaluation requirements (which will however depend on the VER standard used), and the project does not need final UN approval either. Thus, the process to receive credits can often be much quicker.

Technology used

For many technologies, approved carbon credit methodologies can be difficult and especially stringent under the CDM or they can be rejected. In such cases their development through the voluntary market using one of the several existing standards might be more feasible. A strong advantage of the voluntary market is the possibility to use methodologies that are not currently permitted under the CDM system, but which still have the potential to verify GHG emissions and create marketable carbon credits.

In CDM projects most of technology is imported from industrialized countries, instead in most VCM projects technology is developed locally.

Project size

The carbon revenues from a project should overcome the money put into the setup for accessing carbon finance. CDM projects require going through a rigorous registration process and obtaining UN approval and they involve considerable transaction costs and resource needs. Thus, projects should not be too small. Costs for validation, registration and verification in the voluntary market are lower than under the CDM, although with a recent tightening up of quality measures these costs have risen towards the levels of the CDM. Projects that are too small to justify the costs and rigorous processes associated with CDM approval are usually developed under voluntary standards.

Prices

The main advantage of the CDM over voluntary standards is its perceived robustness and stringency, which reflects well in the price of these carbon credits. These qualities derive from the important supervisory role of the UN and the validation and verification companies, the Designated Operational Entities (DOEs). CERs can also be used to meet regulatory requirements by European firms regulated by the EU ETS, which makes them more precious. Although this characteristics , these years CDM price is decreasing (Figure 35).

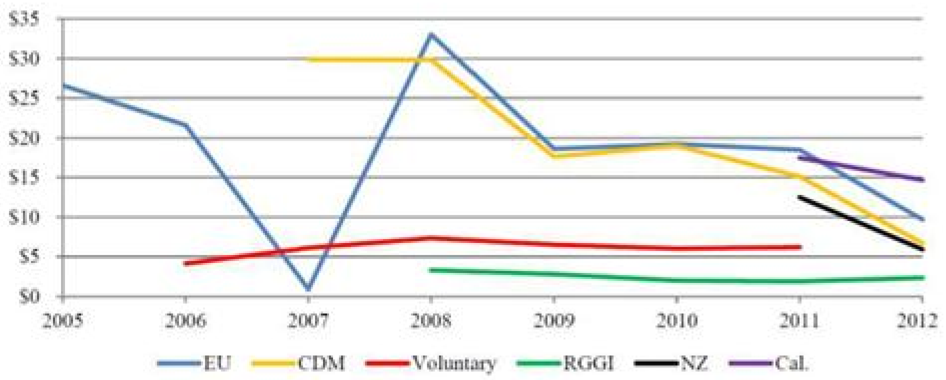


Figure 35: CO_2 Prices (Annual Average Price per Mt CO_2, Nominal US$)

Host country approval process

Specially in developing world, some host country approval offices can be slow and inefficient adding more time in developing a CDM project. A voluntary market process might be faster, but some governments advise project developers to follow the CDM process because of its perceived better quality.

Sustainable Development

Within the VCM there are clearly many projects offering strong sustainable development benefits, including projects for agroforestry, efficient stoves and lighting, and community-based renewable energy. Many of these projects are located in developing countries and are vital for the voluntary market because retailers believe in the presence of additional attributes.

Despite its twin stated objectives of cost-efficient emission reductions and sustainable development, in an analysis of the CDM portfolio Dr. Sutter, a Swiss carbon expert, suggests that there is a trade-off between the two objectives, with the cost efficiency strongly favored over SD. This is demonstrated by the great volume of HFC projects, usual large scale industrial project with few or no additional attributes.

Chapter 3

3 NGOs and carbon credits

The main problems facing developing countries can be summarized as follows: poverty, hunger, education, gender equality, child mortality, maternal health, illnesses, HIV/AIDS and other diseases, social and cultural exclusion, war, lack of preventable health care services, dependence on agriculture, access to clean drinking water, pollution and access to electricity. Improvements in all these areas are indicated by improved living standards, increased economic opportunity, reduced GHG emissions and more judicious and efficient use of natural resources.

The UN Millennium Development Goals are designed to be a long-term commitment to poverty alleviation and act on all aspects of rural livelihoods including education, health care and agriculture. Many factors contribute to development, but access to energy is often seen as central to development in all sectors and without improvements in the quality and quantity of energy supply, none of the MDGs can be met.

Work on poverty reduction and energy access strategies involves many individuals and organizations. Apart from officials and international organizations, participants include private-sector companie and NGOs both in developing countries and in industrialized countries. NGOs carry out development projects together with their developing country partners, improve people’s knowledge about development and globalization issues and influence the formulation of development policy. NGO work broadens and deepens the interaction between people in developed countries and the developing countries and the people living in them.

3.1 Energy situation in developing countries

The 2013 edition of the World Energy Outlook (WEO) by IEA assesses two indicators of energy poverty at the household level: the lack of access to electricity and the reliance on the traditional use of biomass for cooking.

Access to electricity

Today, 1.3 billion people are without access to electricity. Developing Asia and sub-Saharan Africa account, together, for more than 95% of those without modern energy access (Figure 36). The population without access to electricity in sub-Saharan Africa (600 million people) is now almost equal to that of developing Asia (615 million people) and, if current trends continue, will overtake it in the near future. Across developing countries, the average electrification rate is 77%, increasing to around 91% in urban areas but only around 65% in rural areas.

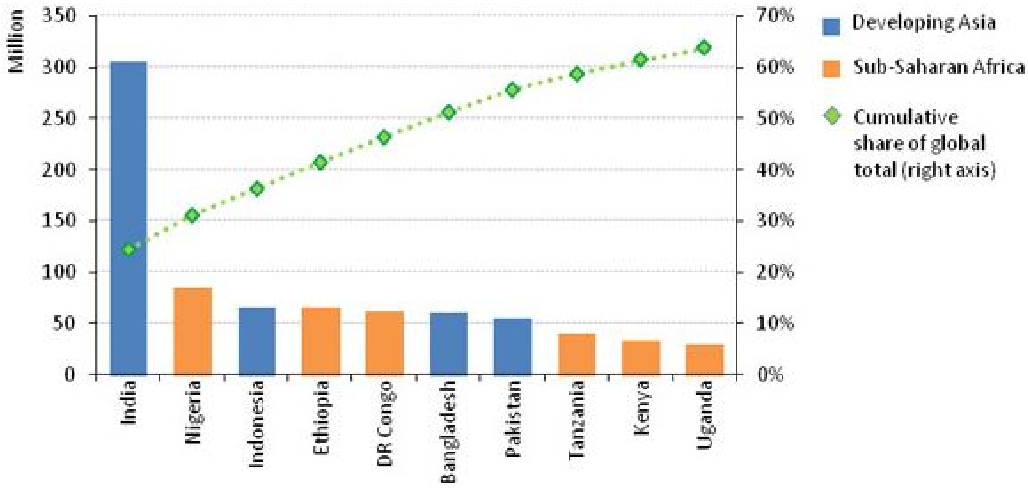


Figure 36: Countries with the largest population without access to electricity, 2011

Most of the people without access to electricity live in rural areas of the developing countries. The challenge is to improve access to modern energy services using renewable energies as wind, solar and hydro power which are appropriated to accommodate the special needs of rural areas in terms of decentralized electricity generation. Electrification has a key role providing the preservation of food and medicine by refrigeration, providing lighting and pure drinking water, improving school and health services and irrigation for agriculture.

Clean cooking facilities

Biomass is the major resource meeting the energy needs of the households in developing world. More than 2.6 billion people rely mainly on the traditional three-stone open fires for cooking. More than half of the population of developing Asia (over 1.8 billion people) and around 80% of people in sub-Saharan Africa (nearly 700 million people) live without clean cooking facilities. While the number of people relying on biomass is larger in developing Asia than in sub-Saharan Africa, the share of the population is lower: 50% in developing Asia, compared with 80% in sub-Saharan Africa. In India, around two-thirds of the population, rely on traditional biomass, almost twice as many as in China, which is ranked second (Figure 37).

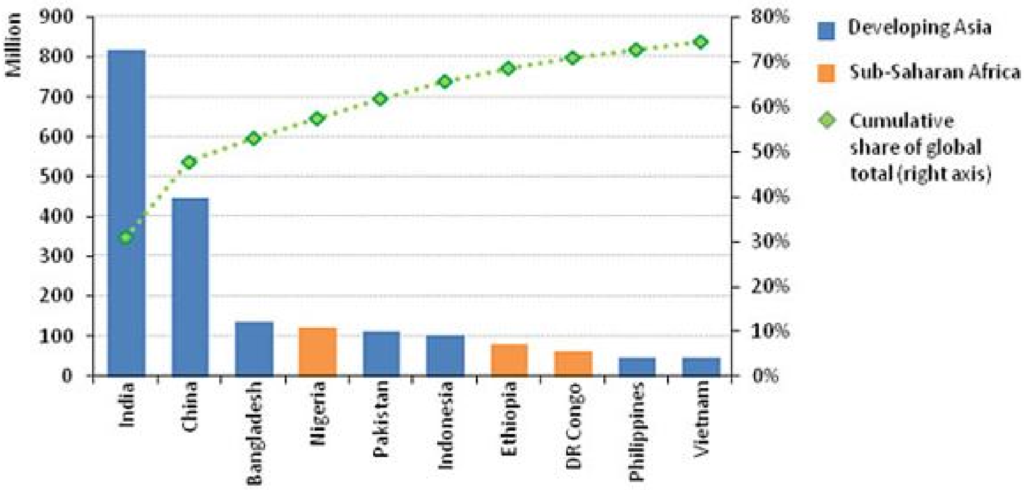


Figure 37: Countries with the largest population relying on traditional use biomass for cooking, 2011

The use of biomass for energy production is not only inefficient but can have negative effects on people's health. Smoke emission resulting from indoor cooking can lead to various respiratory diseases in poorly ventilated kitchens and goes along with a high risk of fire. The World Health Organization (WHO) estimates that each year about 2 million deaths, or 2.7% of the global disease burden, are related to indoor air pollution. Mostly women and children are affected, as they are more exposed to emissions from preparing and cooking food inside the house.

Access to biomass fuels is also increasingly difficult. In rural areas, women and children spend an estimated 5 to 6 hours a day collecting fuel wood, which can result in physical impairments such as postural deformities. This time could otherwise be used for education or income-generating activities.

The growing demand for fuel wood resulting from the importance of biomass for energy supply and high population growth has serious impacts on natural resources. Deforestation and economic land concessions accelerate the decline in available fuel wood resources, leading to further shortages in fuel availability. Alternatives such as liquid petroleum gas (LPG) and kerosene require substantial initial capital funds and increasing prices put an additional pressure on the limited cash resources in rural communities in which most households are still subsistence farmers, reliant on the food that they grow for their daily needs.

Energy and MDGs

The importance of energy access in combating poverty and meeting the MDGs has been increasingly recognized in the last years. Detailed studies have shown how meeting the MDGs is contingent on an increase in access to energy as summarized in the table below (Figure 38).

MDG	Energy Services Contribution
To halve extreme poverty	Access to energy services facilitates economic development - micro-enterprise, livelihood activities beyond daylight hours, locally owned businesses, which will create employment - and assists in bridging the 'digital divide'.
To reduce hunger and improve access to safe drinking water	Energy services can improve access to pumped drinking water and 95% of staple foods need cooking before they can be eaten. Irrigation, aided by energy access, can increase local food production. Energy installations that pump water in drought prone areas can increase the resilience of livestock.
To reduce child and maternal mortality; and to reduce diseases	Energy is a key component of a functioning health system, for example, lighting health centers, refrigeration of vaccines and other medicines, sterilization of equipment and transport to health clinics. Improved lighting and cooking units can significantly reduce the incidence of respiratory diseases: a major killer of under fives in Africa. Improved access to energy increases the retention of health workers in remote areas.
To achieve universal primary education; and to promote gender equality and empowerment of women	Energy services reduce the time spent by women and children (especially girls) on basic survival activities (gathering firewood, fetching water, cooking, etc.); lighting permits home study, increases security and enables the use of educational media and communications in schools, including information and communication technologies (ICTs).
Environmental sustainability	Improved energy efficiency and use of cleaner alternatives can help to achieve sustainable use of natural resources, as well as reducing emissions, which protects the local and global environment.

Figure 38: Energy contribution to MDGs

Energy enables people to work their way out of poverty, provides better access to education and other basic services and improves health and wellbeing, especially for women and children.

How the international community tries to help poor countries

Business as usual projections predict that the situation will be the same in 20 years' time. By 2030, 900 million people will not have access to electricity, billion people will still cook with traditional fuels, more than 30 million people will have died due to smoke-related diseases and many hundreds of millions will be confined to poverty due to lack of energy access.

The IEA and World Bank have devoted attention to the topic of energy access for many years, informing the international community with key quantitative analyses, including energy access databases, projections and estimates of the investment needs and implications for global energy use and CO_2 emissions of universal energy access. New commitments and new actions towards a goal of achieving universal modern energy access are growing.

The ACP-EU Energy Facility is a co-financing instrument which was established in 2005 in order to support projects on increasing access to sustainable and affordable energy services for the poor living in rural and peri-urban areas in African, Caribbean and Pacific (ACP) countries.

The Energy for All (E4All) program is funded by Asian Development Bank in 2008, with the aim of increasing access to modern energy services for the poor. The goal is to provide energy access to 100 million people in Asia and the Pacific Region by 2015. E4All is a partnership which was built specifically to create platforms for cooperation from global finance to village-level technologies and it is built on cooperation, exchange, innovation and project development. Partners include key stakeholders (businesses, finance government and NGOs) and working groups are at the core of the partnership, which cover topics including domestic biogas and financing.

The Sustainable Energy for All (SE4ALL) initiative is a multi-stakeholder partnership between governments, the private sector and civil society. Launched by the UN Secretary-General in 2011, it has three interlinked objectives to be achieved by 2030:

1. universal access to electricity and clean cooking solutions
2. double the share of the world's energy supplied by renewable sources from 18% to 36%
3. double the rate of improvement in energy efficiency. Seventy-seven countries have opted in to the initiative.

These three objectives, each one important in its own right, reinforce each other in important ways. For example, affordable renewable energy technologies bring modern energy services to rural communities where extension of the conventional power grid is prohibitively expensive and impractical. Bolstering energy efficiency can provide substantial cost savings to governments, businesses and households, while freeing up power for other more productive uses. Achieving the three objectives together will maximize development benefits and help stabilize climate change over the long run.

The UN Year of Sustainable Energy for All in 2012 has now made way for a Decade of Sustainable Energy for All beginning in 2014. Global Tracking Framework, led by the IEA and the World Bank, is the first major analytical report produced under the SE4All initiative. The report defines the starting point against which progress can be measured and the scale of the challenge understood. This new focus is encouraging but much more is required.

The United States has launched in 2013 a Power Africa initiative aimed at doubling electricity access in Africa over five years.

Analysis from WEO finds that nearly $1 trillion in cumulative investment, around $49 billion per year, is needed to achieve universal energy access by 2030. Investments are also required to fight climate change that affect developing countries. For these reasons, the World Bank established the Carbon Finance Unit (CFU) with the aim of creating a global carbon market that reduces transaction costs, supports sustainable development and reaches and benefits the poorer communities of the developing world. The CFU handles a portfolio of projects, many of which have been developed separately from the Bank's regular lending operations. There is now a move to mainstream carbon finance into the Bank's regular lending and development assistance projects. The CFU does not give grants or loans to projects but purchases emission reductions on behalf of governments and companies in developed countries that use these to meet their commitments under the UNFCCC and Kyoto Protocol. It manages a series of carbon funds, which purchase project-based emission reductions. Each fund is characterized by the nature of the projects and technologies it targets, or by the source of the funds, or in some cases by both.

The Prototype Carbon Fund was the first carbon fund set up by the CFU. The objective was to test carbon finance and learn by doing. This was followed by two funds: the CDCF and the BioCarbon Fund. These three funds pool capital contributed by governments and companies in Organization for Economic Cooperation and Development (OECD) countries to purchase GHG emission reductions from CDM projects. The CDCF targets small-scale CDM projects that benefit local communities. The BioCarbon Fund targets sustainable resource management and conservation projects that reduce emissions as well as help to alleviate poverty of local communities.

The Global Alliance on Clean Cookstoves, launched in September 2010, aims to help 100 million homes to adopt new clean stoves by 2020, by investing in a range of support measures including improved R&D and standards, campaigning to create real commercial markets for stoves and integration of stoves into other development programmes.

From the developing country perspective, the CDM and VCM can:

- Attract capital for projects that assist in the shift to a more prosperous but less carbon-intensive economy;
- Encourage and permit the active participation of both private and public sectors;

- Provide a tool for technology transfer, if investment is channelled into projects that replace old and inefficient fossil fuel technology or create new industries in environmentally sustainable technologies;
- Help define investment priorities in projects that meet sustainable development goals.

There are a number of advantages for host country governments to tapping into carbon finance. Having this additional revenue stream may enable them to accelerate World Bank loan payments and reduce interest payments. Certain characteristics of carbon credits are particularly advantageous. As buyers are almost always located in industrialized countries, the credits are foreign currency denominated and tend to be associated with low risk purchasers. Their payment schedule is likely to follow a different timing to that of other revenue streams, helping to relieve cash flow problems. This may help to attract other sources of finance to the project.

World Bank and governments funds have played an important role in promoting small-scale projects, supporting NGOs involved in improving social and environmental situation in developing countries.

3.2 Development cooperation and NGOs

Development Cooperation means the practical work that is undertaken with the aim of improving the economic, political and social position of developing countries putting into practice development policy. The actors of this political process are some countries, alone or in collaboration with others, but also non-governmental players that try to etch upon environment of undeveloped countries. Although development cooperation was born from the fundamental need of living in peace and wealth for mankind, it is also an essential tool to promote political and economic relationships between countries to obtain specific common objectives. The work of NGOs is an important part of international development cooperation.

The World Bank defines NGOs as *"private organizations that pursue activities to relieve suffering, promote the interests of the poor, protect the environment, provide basic social services or undertake community development"*. In wider usage, the term NGO can be applied to any non-profit organization which is independent from government. NGOs are typically value-based organizations which depend, in whole or in part, on charitable donations and voluntary service. Although the NGO sector has become increasingly professional over the last two decades, principles of altruism and voluntarism remain key defining characteristics.

As per the World Bank, the NGOs can be classified into Operational and Advocacy NGOs. The main purpose of operational NGO is to design and implement the development-related projects. The scope of the Operational

NGOs can be national, international or even community-based. The main purpose of an Advocacy NGO is to promote a specific cause. It makes efforts to raise awareness and knowledge by doing various activities like lobbying, press work and activist events.

Because the nature and quality of individual NGOs vary greatly, it is extremely difficult to make generalizations about the sector as a whole. Despite this diversity, some specific strength generally associated with the NGO sector includes the following:

- ✓ strong grassroots links
- ✓ field-based development expertise
- ✓ the ability to innovate and adapt
- ✓ process-oriented approach to development
- ✓ participatory methodologies and tools
- ✓ long-term commitment and emphasis on sustainability
- ✓ cost-effectiveness

The most commonly identified weaknesses of the sector include:

- ✓ limited financial and management expertise
- ✓ limited institutional capacity
- ✓ low levels of self-sustainability
- ✓ isolation/lack of inter-organizational communication and/or coordination
- ✓ small scale interventions
- ✓ lack of understanding of the broader social or economic context.

The history of NGOs can be traced back to 1807, the year when the British abolished the slave trade, followed by the formation of a number of organized, non-profit movements which addressed the issues of slavery. In this time period one can witness the founding of some of today's major world NGOs, many soon followed. The ICRC, International Committee of the Red Cross, founded in 1864, became one of the leading humanitarian organizations in conflict areas. The American Friends Service Committee was set up in 1917; Save the Children came into being in 1919, followed by Oxfam in 1942, all initially oriented in addressing consequences of victims of war. After World War II a series of service-oriented organizations, which avoided political confrontation and chose the path of neutrality in conflict emerged, Salvation Army, YMCA, YWCA, Cooperative for Assistance and Relief Everywhere (CARE), dealing with aid, war relief and postwar reconstruction. The 1960s and 70s brought on confrontational approaches by the NGOs. Addressing not only issues of war and famine, but through lobbying and campaigning they began bringing attention to the causes of these. Amnesty International, MSF, Christian Aid and Oxfam became vocal critics of states, multilateral organizations and their positions on war and violent conflict. Since the mid-1970s, the NGO sector in both developed and developing countries has experienced exponential growth. From 1970 to 1985 total development aid disbursed by international NGOs increased ten-fold. In 1992 international NGOs channeled over $7.6 billion of aid to developing countries. It is now estimated that over 15 percent of total overseas development aid is channeled through NGOs.

Notwithstanding many difficulties and constant debate for decades with some governments that were not in favor of public participation, NGOs have increasingly gained recognition, credibility and consensus on their involvement in UN processes. The UN Earth Summit, held in Rio de Janeiro in 1992 was an unprecedented event with respect to NGO participation in global environmental politics. At various levels, NGOs have helped governments and other stakeholders to identify issues and set agendas, have provided policy analysis as well as normative and regulations criteria and have carried out monitoring and implementation activities.

The energy sector is a high priority on NGOs' agendas due to the increasing demand for energy services in both developed and developing countries and its high environmental and social impacts. Through their bottom-up approach, NGOs have shown increasing expertise, technical knowledge and capability to monitor the implementation of energy policies, highlight problems and suggest solutions to governments, UN agencies, multilateral aid agencies and other energy stakeholders.

Given the centrality of energy services in improving the human condition, numerous development NGOs have involved in efforts to increase and improve the delivery of essential energy services to poor people in many developing countries. NGO involvement in energy service delivery takes many forms, but these organizations have been particularly useful at overcoming some of the major barriers, such as technology, finance and information, that often impede efforts to increase access to energy in rural areas.

Thus, the main thrusts of these activities have been on improving the availability and use of energy for basic human needs, such as lighting and cooking, as well as for enhancing health services and opportunities for basic economic development. Hence, NGO efforts have aimed to enhance and make more reliable supplies of electricity using renewable resources as well as to make available technologies for economically or socially productive uses of energy and improved cooking stoves for reducing health-adverse impacts of traditional stoves.

Effective implementation of small-scale energy projects in rural areas often hinges on the availability of appropriate energy technologies. Although specific components of these technologies may be available in the commercial markets, often the development of the overall system is dependent on local resources and constraints. This necessitates making careful choices about technology design, possibly carrying out modifications to existing designs or developing new designs or components altogether. To be successful, the designs have had to take into account the locally available energy sources, the preferences of the users in terms of stove characteristics and the skills and materials available locally for stove manufacture.

The NGOs highlights both the importance of microcredit in rural areas and the feasibility of community organizations in bridging the financing gap for poor people who are deemed credit risks by banks and other traditional lending agencies. The resulting microcredit revolution has had an impact on the energy sector also where rural users were often unable to purchase energy systems for lack of financing options. NGOs, often with the help of development agencies, have begun to play a role by helping to provide microfinance to individual users or local entrepreneurs for promoting energy access.

NGOs also provide other kinds of assistance to entrepreneurs and other actors in the energy service delivery arena by providing training and building capacity in technical as well as business issues. They can also play a critical role through public education and dissemination of information about energy options.

Over last years, the VCM has given the opportunity to NGOs to access revenue from projects which promote energy access and climate change mitigation. Not-for-profit organizations often develop projects based on forestry, renewables and household device (Figure 39).

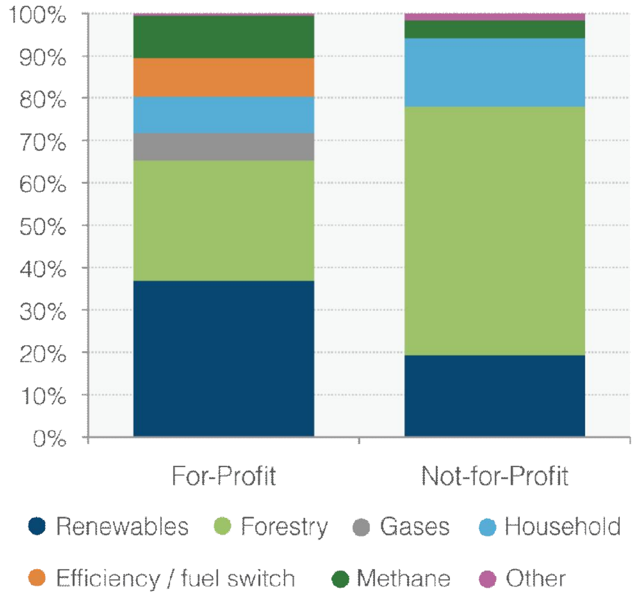


Figure 39: Market share by project category and supplier profit status

Project types vary from projects with little benefits to local communities, to projects in which communities are key participants, to projects that address biodiversity and communities. Energy-based projects vary from large renewable energy projects to energy efficient cooking stoves in very poor communities. Although some NGOs specialize in energy-based projects, the majority of retailers appear to focus on forestry projects. It is argued that trees are easier to sell to the general public, as trees are a more tangible and understandable counter to global warming.

Two examples of Italian NGOs involved in implementing sustainable energy projects in developing countries are COOPI and LVIA.

COOPI, Cooperazione Internazionale, is an humanitarian, non confessional and independent organization that fights against all kinds of poverty to make the world a better place. Founded in 1965 by Vincenzo Barbieri (Italian father of international volunteering), COOPI is based in Milan and it has 24 headquarters in the South of the World. It works to assist populations struck by emergencies (disasters and conflicts) and to facilitate their civil, economic and social development. The association intervenes in Africa, Latin America and the Middle East in collaboration with local actors (civil society, public administration and so on). In 2012 it has implemented 176 projects.

LVIA, Lay Volunteers International Association, is an Italian organization dealing with solidarity and international cooperation. It has been working since 1966 with the aim of fighting social inequality, food insecurity and poverty and of operating concretely for peace and human development. LVIA has 40 volunteers and 150 local experts in 12 African and eastern-European countries, where operates with local partners to grant access to water and the right to health, to strengthen agriculture and livestock farming, to support vocational training, to enhance craft skills and local enterprises and to improve the urban and rural environment.

3.3 Typical energy projects

There are various emission reduction technologies which have been tried and tested in CDM or VER projects and other more general contexts. These technologies all contribute to sustainable development and cause no harm to the environment, relative to other technologies. All these technologies are appropriate as small-scale CDM or VER projects and therefore have the potential to benefit small communities.

The main NGOs mitigation technologies can be divided into four main categories, such as switching to less carbon-intensive fuel, increasing energy efficiency, using renewable energy sources, managing solid and water waste to reduce emissions. Which of these are appropriate will depend on the local conditions. Sometimes these approaches can be applied in combination, for example using renewable energy and improving the efficiency of its use.

Typically, the benefit activities are the building of schools and health centers, improvements in water supplies or other infrastructure.

Community benefits are inherent to the nature of the NGOs project. For example, provision of electricity in rural areas using renewable technologies will not only deliver emission reductions but will have positive impacts on people's livelihoods. For projects that are deemed to provide sufficient direct benefits without the need for an additional benefits package, the project developer periodically provides a report.

Renewable energy projects are crucial for the long-term protection of the global climate because they help developing world move away from fossil fuel based electricity and heat production to more benign forms of energy production.

Sometimes, due to prohibitive implementation costs, micro-scale NGOs projects that deliver life-changing co-benefits to communities that need them the most have not been viable. Hence, Gold Standard gives the possibility to used the Programme of Activities approach for micro-scale projects whereby small, individual projects that apply the same baseline and monitoring methodologies can be united under one umbrella. This scheme allows for an unlimited number of these project activities to be amalgamated under a single Programme.

The list below presents an overview of the relevant technologies of NGOs energy projects:

- ✓ Improved Cook Stoves
- ✓ Biogas
- ✓ Solar
- ✓ Hydro
- ✓ Wind
- ✓ Biodiesel from Jatropha

3.3.1 Improved Cook Stoves (ICS)

A large number of NGOs projects are based on distribution of Improved Cook Stoves (ICS). As described above, over two billion people cook on wood, charcoal, agricultural residues and coal. Many use open fires or simple stoves which are smoky and inefficient because the wood does not burn completely and much of the heat does not reach the food. A simple stove cuts heat losses by burning the wood in an enclosed chamber, directing the hot combustion gases to the cooking pots, and sometimes using a chimney to take smoke away from the cook. However, many stoves still burn fuel inefficiently and produce smoke and much of the heat is lost because of poor insulation.

Classification

Cookstoves could be fed by a wide range of fuels and other energy sources such as biomass (mainly wood), kerosene, natural gas, or by solar energy and electricity.Consequently, a great variety of stove's models are available on international and local markets, in addition to the self-made ones. The existing types of cook-stoves are subdivided based on the different fuels exploited; this criterion is used as the selection of a suitable stove for a specific context mainly depends on locally available fuels. The most employed fuels and energy sources are:

1. wood and often residues, dung and other waste materials;
2. charcoal;
3. gaseous fuels, such as liquefied petroleum gas (LPG) and natural gas;
4. liquid fuels, such as kerosene (including paraffin), alcohols (such as ethanol and methanol) and biofuels;
5. solar energy;
6. electrical energy.

These fuels can be traditional, such as non-commercial biomasses (categories 1 and 2), or modern (categories 3, 4, 5 and 6).

Moreover, the stoves can be further subdivided according to their level of performances; in case of traditional fuels, the stoves can be traditional or improved. It is worth saying that increasing performances follow increasing technological levels of the devices. Hence, here below, stoves are firstly classified according to the fuel, and then in each category, stoves are subdivided according to their level of performance.

Wood Stoves

Wood is likely the most used fuel for cooking in developing countries and, as a consequence, countless wood stove models exist. They range from the most traditional ones, the three-stone fire, to the most developed ones, such as the gasifiers (which are considered advanced biomass cooking stoves) and ones that also allow electricity production. Below, a further subdivision of the wood stoves is presented, in order of increasing performances.

- Three-stone fire (Figure 40): a fire lit directly on the ground or simply supported by stones, bricks or a mud base. It is the most traditional cooking device, and it is commonly used in developing countries. It presents very low performances, both in terms of fuel consumption and of pollutant emissions. It is often considered as the baseline for the evaluation of other stove performances.

Figure 40: Three stone

- Traditional stoves: they are among the most diffused cooking devices in developing countries. Some of the most used models are the Kalan stove, the Takate stove and the fixed clay stoves. Generally, they have a metal or ceramic combustion chamber of a cylindrical shape. On average, traditional stoves have emission levels and thermal efficiencies that are still distant from adequate standards, even though they achieve better performances than open fires, except for particulate matter (PM) emissions; PM production is due to insufficient air draft or cold zones in the combustion chamber, that are phenomena caused by an improper design.
- Improved Cook-Stoves: they should meet the criteria established by the UN, enabling a more efficient combustion, reducing fuel consumption and pollutant emissions. Several models exist, built using different materials (e.g., Jiko, VITA, Vesto, Basintuthu, Shisa, Tsotso), but the rocket type ones are worth to be mentioned. In order to be classified as a rocket designed model, the stove should have a combustion chamber made up of two orthogonal parts: an insulated upright chimney (having a height of two or three times the diameter) and a horizontal zone where wood sticks are placed. This greatly helps combustion efficiency; hence, this configuration is often exploited in ICS' design. Rocket stoves were first conceived by Dr. L. Winiarsk, from the Aprovecho Research Center, who defined 10 principles they have to respect.
- Stoves with chimney or fan: the presence of a chimney could greatly help in reducing harmful emissions, driving away pollutant substances; nevertheless, the heat reaching the pot is diminished, as the hot gases are not in direct contact with it, causing an increase in fuel consumption. For this reason stoves with a chimney have much better results if sunken pots or skirts are used. Hence, stoves with chimneys are suitable for a different kind of cooking: they are not the best ones for boiling or simmering food, but they are highly performing for frying. In the same way, fan-assisted stoves allow for the control of fuel burning thanks to forced air convection, that permits reducing CO and PM emission levels

over 90 % in comparison with three-stone fires. On the other hand, they need to be fed with electricity, which is not always available and reliable in developing countries.

- Gasifiers or wood-gas stoves: the working principle of gasifiers is the realization of a multistage combustion. Solid biomass combustion is a sequence of four phases (drying, pyrolysis, char-gasification and gas-combustion) that often overlap each other. Gasifiers allow separating these stages in space and time, permitting a great improvement in combustion efficiency (e.g., Sampada gasifier, rice husk gasifier, My Little Cookstove). Another advantage of the gasifiers, in comparison with the other cooking devices, is that gases burn above the generating zone, next to the stove top, and therefore heat can directly reach the pot, avoiding further thermal losses. Nonetheless, gasifiers generally present costs higher than the previous models, also due to the complexity of the design. Besides this, the phase of char-gasification can be suppressed if the hot char is not exposed to a sufficient air draft; in this case, there is biochar production and, consequently, these stoves are usually named biochar-making pyrolytic gasifiers. Biochar can be employed to be burnt in other stoves, having a higher calorific value than raw wood, or to improve soil productivity, as a natural fertilizer (doing this, the carbon contained in the char is fixed in the soil). In the last case, since char combustion is avoided, less CO2 emissions are released. However, this technology is not yet mature and needs to be further investigated.
- Stoves with TEG modules: cook-stoves can be provided with thermoelectric generator (TEG) modules, which could produce small amounts of electricity exploiting the Seebeck effect. This allows ICSs to meet users' needs in a more complete way, as the generated electricity could be employed to feed LED lights or small electrical devices. However, stoves with TEG modules are rather more expensive.

Finally, it is worth noting that other criteria to classify stoves exist. At present, several among the most influencing stakeholders in the process of ICSs' development are working to define precise and widely shared standards to classify stoves, according to fuel consumption, emissions and safety. They try to subdivide stoves into "tiers", which partially overlap with the above-mentioned categories. Figure 41 synthesizes the possible subdivision based on different levels of fuel consumption.

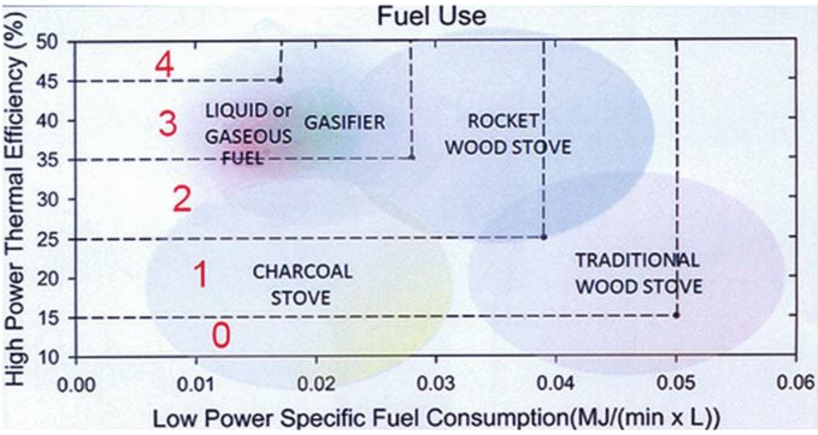


Figure 41:Thermal efficiency vs Low power fuel consumption

Besides this, a growing attention is also given to the issue of safety; indeed, women and children are often exposed to burns and scalds because of the inadequate safety standards of cooking devices. Hence, ICSs should be designed with adequate safety standards, in order to protect the users also from this kind of risks.

In developing countries many models of traditional stoves are used, although they are actually far from the satisfactory quality standards; on the other hand, modern fuels stoves also exist, but they are not really adopted in the developing countries due to the unavailability of those fuels. Hence, ICSs can be employed as a more efficient way to utilize traditional fuels.

Drivers and Barriers for ICS

Some of the criteria required for the selection of a suitable stove to be disseminated in a certain area are synthesized below. These criteria should assure that the selected stove is appropriate from technical points of view, while also considering the economic, environmental and social aspects. These criteria include:

- ✓ fuel: the stove has to be fuelled by a material which should be easily accessible in the area of interest. Furthermore, the fuel should be collected without causing environmental concerns;
- ✓ quality standards: the stove must reach high performances and must help to reduce the above-mentioned risks related to improper cooking activities (technical aspect);
- ✓ economic aspect: the stove should be affordable to local populations;
- ✓ users' needs: the stove should meet the users' requirements and respect local cultures of the populations adopting it.

ICSs can be exploited in order to meet adequate quality standards; however, some issues about the adoption of ICSs arise. First of all, to assess the actual stove performances, the WBT could be insufficient as field tests should also be carried out. Field performances are greatly influenced by users' behavior (e.g., how often and how well women use ICS and carry out the maintenance). In addition to this, other tests should be employed: for instance, the Control Cooking Test (CCT) and the Kitchen Performance Test (KPT) better evaluate the performances of different kind of stoves, such the frying ones. Furthermore, although these cooking appliances can be considered potentially successful, they often present an important weakness in comparison with traditional devices: they do not provide sufficient light in the households, due to their closed combustion chamber. A possible solution to this is to consider stoves equipped with thermoelectric generator modules, producing electricity that could feed small LED lights. Last but not least, a further improvement could be to foster the dissemination of locally produced ICSs, thus promoting income generating activities in the developing countries.

Among ICS and carbon market, as shown in Figure 42, The Gold Standard is the preferred standard for this type of project and reaches also the higher prices.

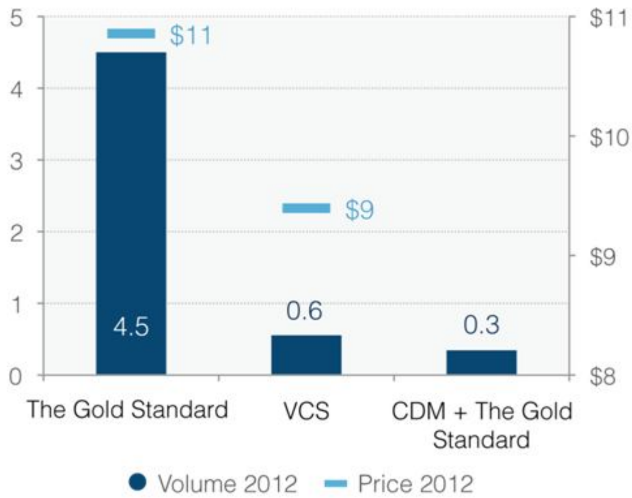


Figure 42: Volume and Average Price by Cookstove Project Standard

An example of cookstoves project developed by COOPI in Malawi is treated in the first case study.

3.3.2 Biogas

Another type of NGOs project is based on biogas technology which provides a short to medium term solution towards switching to cleaner and more efficient energy services. The bio-digester, or simply digester, is the essential component of biogas technology and it offers a great opportunity to improve access to sustainable energy in developing countries.

One of the main products of the digester is biogas. Biogas is a renewable and clean fuel obtained from the biochemical decomposition of organic matter in a digester. It is composed of several gases as showed below in Table 6.

	Chemical formula	Percentage
Methane	CH_4	25–75
Carbon dioxide	CO_2	30–40
Hydrogen sulphide	H_2S	0.1–0.5
Water vapor	H_2O	1–2
Ammonia	NH_3	0.1–0.5
Carbon monoxide	CO	0–0.5

Table 6: Biogas components

It has a calorific value of 21–37.5 MJ/m^3; hence, 1 m^3 of biogas is equivalent to 5.5 kg of firewood and burns with a blue flame. The gas can have various end-uses which include cooking, water heating, lighting, running of engines for various applications (for example electricity production), milling, grinding and transportation. Almost everything considered as waste that is organic, including household residues, agricultural residues, animal dung, human excreta and municipal organic waste, can be used for the production of biogas in the digester.

The Anaerobic Process

Biogas is produced thanks to the biochemical process called anaerobic digestion, a process that takes place in the absence of oxygen in an enclosure called biodigester (simply a digester), or in a reactor. The anaerobic process consists of essentially four sub-processes or stages, namely hydrolysis, acidogenesis (fermentation), acetogenesis/dehydrogenation and methanogenesis (Figure 43).

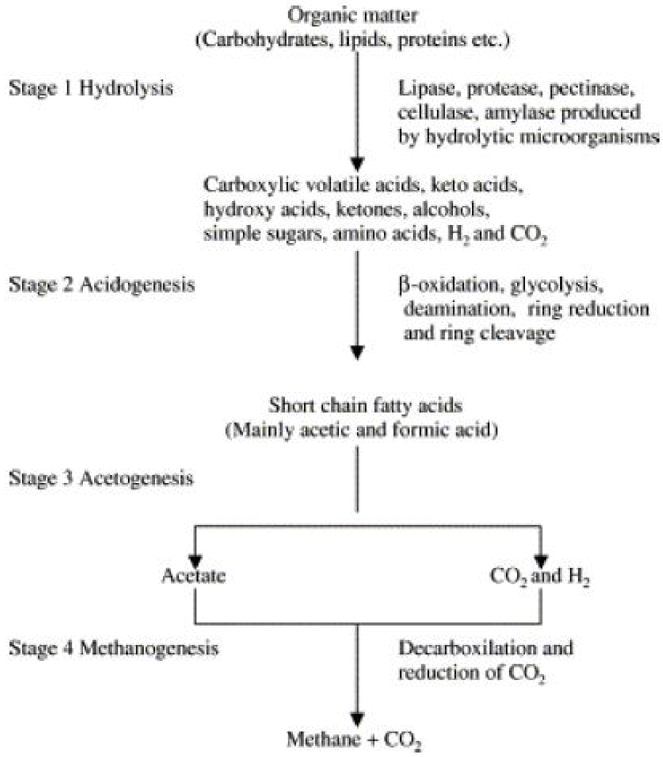


Figure 43: Pathways of anaerobic digestion

1. Hydrolysis - Hydrolytic bacteria break down complex polymers and higher molecular mass compounds into soluble organic products (simple sugars) with the help of exo-enzymes
2. Acididogenesis - The acidogenic (fermetative) bacteria degrade the hydrolyzed soluble substrate to volatile fatty acids (VFA), such as butyric, propionic and acetic acid while also carbon dioxide and hydrogen are formed.
3. Acetogenesis- the acetogenic bacteria convert the higher VFAs to acetic acid.
4. Methanogenesis - acetoclastic methanogenic bacteria reduce the acetic acid to methane and another strain of bacteria reduce CO2 and H2 to methane. Methanogens are obligate anaerobic, they cannot function in an aerobic environment.

Hence, the digester operation is very much influenced by temperatures. Three temperature ranges are often used to characterize the process:

- ✓ Psychrophilic 20 °C.
- ✓ Mesophilic 20–40 °C.
- ✓ Thermophilic 40–60 °C.

In the case of domestic and community biogas systems, the operating temperature range is often close to ambient temperature. Due to this temperature influence on the functioning of the digester, different operation modes and models have been developed.

Classification

As mentioned above, the biogas digester is the fundamental component of a biogas system usually referred to as the biogas plant. The biogas plant for the household and community level comprises the following essential components:

- the inlet: for the input of the raw material referred to as feedstock;
- the digester: hosts the feedstock and is where the anaerobic process takes place;
- the gas holder: stores the gas produced for later use;
- the outlet or compensation tank: collects the digested material from the digester;
- the pipeline: conveys the gas to the consumption point.

Biodigesters have many environmental, economic, and social benefits at many levels, from households to communities. However, the technology has also some shortcomings, which include:

- ✓ relatively high investment cost for the poor living in rural areas;
- ✓ very demanding operation and maintenance activities;
- ✓ not suitable in some regions, especially cold and arid ones;
- ✓ need of a high and reliable source of feedstock supply;low efficiency.

Digesters' geometry has evolved from simply rectangular shaped digester through cylindrical and spherical or oval, to tubular models. The configuration of the digester together with other components has also evolved. The evolution has been motivated by the search for greater efficiency, suitability of operation under different temperature regimes and simplicity of operation and maintenance. Hence, based on operation mode, digesters may be grouped into three main categories, namely batch, semi-continuous and continuous modes.

Batch Mode Digesters

The operation mode of this category is periodic load and discharge of the feedstock. Once loaded, the feedstock is allowed to be digested until no gas is produced. The feedstock used in such digesters ranges from fruits, vegetables, straw, animal dung, human excreta to municipal organic waste. The configuration of the system could be such that the gasholder or storage is separated from the digester. The digester usually requires little space. The operation and maintenance of such digesters is laborious. Batch digesters could be very cheap and affordable to households; however, their size may limit the quantity of gas produced. They are not so popular amongst the models promoted at household level in rural areas of developing countries; nonetheless, they may be applicable in urban households where space is an issue.

Semi-Continuous Mode Digesters

The operation mode of this category is frequent (usually daily) loading of the digester through an inlet and automatic discharge of slurry through the outlet to the slurry (compensation) tank. Once loaded, the feedstock circulates in the digester for a period of time called Hydraulic Retention Time (HRT), during which it is digested. Semi-continuous digesters are usually designed as mono-feedstock (pig, cattle or fowl) digesters; however in practice two or more other feedstocks may be included.

This model of digesters for household application is more expensive, less laborious for O&M, and usually requires more space than the batch type. The configuration of the system could be such that the gasholder or storage is separated from the digester. Whenever the digester and the gasholder constitute single units, the latter may be of variable or fixed volume: this gives rise to two sub-types, namely floating drum (or dome) and fixed dome types.

- ✓ Floating drum model: it was first developed by the Khadi and Village Commission (KVIC) in India and was standardized in 1962. It is characterized by a variable volume gasholder. Its main advantage is that the gas pressure at the point of use is fixed, thus enabling effective functioning of the burner. It has a relatively high maintenance (associated with steel dome's renovation) and construction costs, and requires relative skilled labour to realize the construction. The preferred feedstock is animal (pig, cattle or cow) dung. Several variations of the design for different geographical locations include the KVIC, Pragati, Ganesh, and Ferro-cement models.
- ✓ Fixed dome model: it is characterized by a fixed volume gasholder. Its mainadvantage is the relatively low maintenance and construction cost, and relative less skilled labour necessary to realize the construction. The preferred feedstock is animal (pig, cattle or cow) dung. Even for this model, different variations for the various locations exist, such as the Indian fixed dome, the Chinese fixed dome, the Nepali models, and the Vietnamese models.

While the installation for the fixed dome model is cheaper than for the floating drum type, the cost varies amongst the different fixed dome varieties with the Indian Deenbandhu model claimed to be the cheapest.

Any of the above-mentioned models (floating or fixed dome) are applicable to households and community (schools, hospitals, prisons, etc.) levels, the discriminating factor being only the size. Usually, digester sizes of 4, 6, 8 and

10 m^3 are applicable at the household level, while the ones greater than 10 m^3 are applicable at the community level.

Continuous Mode Digesters

Unlike the batch mode digesters, where the feedstock remains stationary in the system until it is completely digested, this category is characterized by the continuous flow of the feedstock through the digester. It can use feedstock with dry matter content of 20–40 %. There are two sub operational modes available, namely plug-flow (tubular) and well (completely)-mixed systems.

- ✓ Plug-flow (tubular) digesters: this model has been in application on the industrial scale in developed countries. It is the youngest arrival amongst the different models applicable at the household level in developing countries (Figure 44).

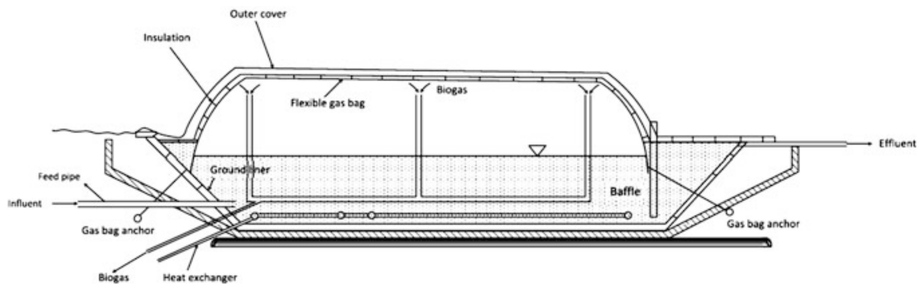


Figure 44: Plug-flow digester scheme

The digester is usually in a tubular form and the construction material is mostly polythene (hence it is often referred to as the polythene or plastic digesters). Its configuration is such that the tube can either be vertical or horizontal, with the latter most applicable in developing countries. The gasholder is usually detached from the digester. It is the cheapest amongst the models promoted in developing countries in terms of construction and O&M; however, it is very fragile and its daily gas yield is low.

- ✓ Well (completely)-mixed: mostly applicable on a large scale, though, it could be employed at the community level for the digestion of municipal waste. Its O&M is relatively complicated and costly, so it is not suitable for developing countries.

Benefits of Biogas Technology

Since its introduction in the late 60s and early 70s and its evolution till present days, biodigester technology has made diverse benefits at the household, community, national and international levels. In terms of numbers, more than 43 million small (household) scale bio-digesters exist in the developing world, with China and India having the largest number of installed digesters (over 38 million and 5 million, respectively), with annual gas yield of over 14.5 billion m^3 of biogas. The gas, as a high quality renewable energy source, is used for various applications, ranging from heat for cooking and heating to electricity generation at the household and community level. Many environmental, economic and social benefits of the technology are reported. These benefits vary from country to country and even amongst communities and households. Some of these benefits are summarized below.

- Environmental
  - ✓ reduction in GHG emission through the production of clean energy;
  - ✓ reduction in deforestation;
  - ✓ better management and treatment of waste;
  - ✓ significant contribution to the transformation of household energy consumption structure;
  - ✓ more efficient use of natural resources through recycling;
  - ✓ improvement of pest control through the use of slurry as pesticide;
  - ✓ reduction of indoor air pollution;
  - ✓ reduced per capita energy consumption due to its higher heating value than other fuels lower down in the energy ladder.
- Economic
  - ✓ reduction in expenses for chemical fertilizers in agriculture;
  - ✓ increased agricultural yields;
  - ✓ creation of employment;
  - ✓ alleviation of poverty;
  - ✓ cost and time saving from firewood;
  - ✓ increased income and employment from integrate cattle rearing and farming.
- Social
  - ✓ time saving for women;
  - ✓ reduction of drudgery for women.

Technology Performance

The performances of the technology greatly determine its chances for adoption by the target users. The performance of small scale biomass technology may be viewed from several angles, which include the effectiveness and efficiency of the digester and its durability. The functional state and reliability of gas production is a measure of the effectiveness of the technology; the sufficiency of the produced gas is a measure of the digester's efficiency, determined by the gas yield. The life span of the digester is a measure of its durability. The functional state of the digester simply refers to whether the digester is in use and is producing gas. From literature, the functional state of digesters varies between 30 and 81 % depending on the age and the design of the digester. The reasons for digesters' failure include: insufficient operation (irregular feeding of the digester), lack of repairs because users are usually not trained to do them, use of non-standardized models and insufficient feedstock. The functional state depends on the operation and maintenance activities which in turn depend on who are responsible for these activities, and on the use of standardized models. Reliability of gas yield per day largely depends on the type of model used. Amongst the models promoted in the developing countries the fixed dome model (all varieties inclusive) has the highest reliability (95 % and annual reliability of 86 %), followed by the floating drum model with the reliability of 80 % (70 % per annum) and the inflatable tubular digester (29 %).

A key performance indicator is the quantity of produced gas. The gas yield depends on the design and the type of feedstock. For a given type of feedstock and digester design, the gas yield is influenced by several parameters, which include the operating temperatures, pH (acid-base concentration of the slurry), the Hydraulic Retention Time (HRT) and agitation. From literature, laboratory studies show that the potential gas yield of biomass feedstock ranges between 300 and 500 l biogas/kg total solid.

Substrate	Daily production kg/animal	% DM	Biogas yield m^3/kg DM	Biogas yield m^3/animal/day$_a$
Pig manure	2	17	3.6–4.8	1.43
Cow manure	8 Table 3	16	0.2–0.3	0.32
Chicken manure	0.08	25	0.35–0.8	0.01
Human excreta/sewage	0.5	20	0.35–0.5	0.04
Straw/grass		80	0.35–0.4	
Water hyacinth		7	0.17–0.25	
Maize		20	0.25–0.40	
Rice straw		87	0.18	
Rice husk		86	0.014–0.018	
Bagasse			0.165 (m^3/kg organic DM)	
Leaf matter			0.6 (m^3/kg)	
DM = Dry Matter, a = based on mean biogas yield (m^3/kg DM)				

Figure 45: Gas yield for common feedstocks

The quantity of gas yields varies amongst different models. For the most popular models, the yield is higher for the fixed dome model (82 %), followed by the floating drum model (70 %) and the tubular model (14 %). Various techniques have been used to increase the gas yield, such as the design of model variations (for instance the fixed dome has several varieties including the

Chinese, Deenbandhu, Janta, and Nepali (GGC2045) versions), the design of completely new models (for example the inflatable tubular model), the use of admixture (so called co-digestion) of biomass feedstock in viscous animal dung slurry fermented in conventional digester or even slurry recirculation.

The durability here simply refers to "being able to remain functional over a long time". The durability of the household scale digester, as the main component of the biogas system, depends on the kind of plant and essentially on the type of materials used. In the developing world the most popular digesters' life span ranges from 2 to 15 years as follows: inflatable tubular (plug flow) digester 2–5 years, floating drum up to 15 years and fixed dome 15–20 years. It is necessary to standardize digesters both at the household and community levels in order to ensure good quality and long operational life. Learning from the Chinese experience, a standard system comprising four categories, namely basic standards, product standard, technical qualification and construction specification, with the associated criteria, can serve as a starting point.

Drivers and Barriers for Domestic Biogas

Within the context of sustainable development and Sustainable Energy For All, the bio-digester is a mature and appropriate technology for improving access to modern energy services for a majority of the "energy poor". It therefore merits large scale dissemination. However, the implementation of biogas projects has both technical and non-technical constraints to be considered.

From a technical point of view the following constraints have to be contemplated

- climatic conditions: determine the digester operating temperature range;
- availability of the feedstock: in quantity and variability which dictate the digester's optimal size and design;
- availability of water: a very important input for the feedstock preparation;
- local construction materials: affect the cost of the system and hence its affordability to the target users;
- local technical capacity: for the proper construction of the digester and operation and maintenance services.

The non-technical constraints may be financial, social and institutional , as highlighted below.

- Financial
  - ✓ level of disposable income of the target users;
  - ✓ availability of subsidies;
  - ✓ availability of loan facilities;
  - ✓ availability of alternative energy sources (cost).

- Social
  - ✓ gender issues, decision making at the household and community level;
  - ✓ integration of the technology in the daily routines;
  - ✓ awareness of (alternative) technologies;
  - ✓ willingness to use biogas (from excreta) as energy source.
- Institutional
  - ✓ political will of the central government;
  - ✓ dissemination infrastructure (stakeholders such as local NGOs).

A number of NGOs are promoting biogas projects in Africa and one of them is LVIA. The third case study analyzes a project of this NGO in Ethiopia.

3.3.3 Solar

NGOs project based on solar power technologies can be used for generating electricity, drying, heating and cooling and reduce the need for other energy sources such as fossil fuels. Solar energy is most useful in areas of high and consistent sunshine like developing countries.

Solar photovoltaic (SPV) generators convert the energy from the sun thanks to solar cells. Solar cells are made with semiconductor-based materials. Most common material is monocrystalline or polycrystalline silicon. A number of solar cells are gathered together to form a solar panel. Typical power for each solar panel is in a range from 80 to 200 W, depending on size and technology, while the conversion efficiency of each panel is generally in the range 15–18 % when silicon cells are used. Two or more panels can be combined in order to achieve the desired output capacity. This fact gives SPV a high degree of modularity and scalability the technology is suitable for a wide range of different applications, from small lanterns up to mini-grid systems. Since values of solar radiation at the ground level generally are higher in tropical areas, SPV systems tend to have higher performance in most developing countries than in North America or Europe. In North America, the insolation varies from 1,400 to 2,300 kWh/m2, whereas in Tanzania values are in the range of2,500 kWh/m2. High reliability, long lifetime, the absence of moving parts, and its use of sun as a free fuel make PVS virtually free to use during its entire lifetime.

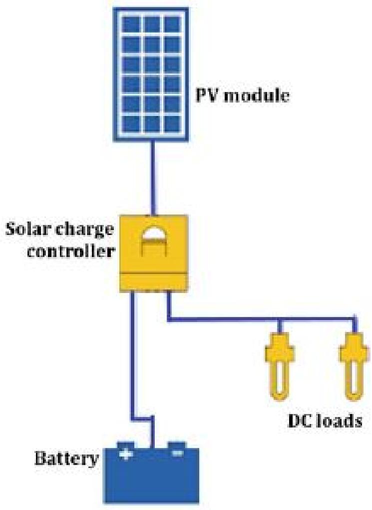
In addition to the solar panels, SPV systems typically consist of the following components:

- Batteries and charge controller for energy storage
- Inverter
- Wires/cables and other hardware for electric connections.

Depending on the size, the application, and other criteria, SPV systems can be classified according to three main categories:

- SPV home-based systems
  - ✓ Pico SPV systems;
  - ✓ Classical solar home systems.
- SPV community-based systems
- Micro-grid SPV systems.

Solar home-based systems are stand-alone SPV systems built for a particular end use, for example lighting or water pumping. Pico PVSs are defined as small solar home systems with a power output of 1–10 W, mainly used for lighting, and thus able to replace sources such as kerosene lamps and candles. Devices are powered by a small solar panel and use a battery which can be integrated in the device itself. Classical solar home systems consist of a SPV module, a charge regulator, lead acid deep-cycle battery, and optionally an inverter. Generally these systems cover a power output of up to some hundred Watts. Since SPV generate DC power, DC loads like DC energy saving lamps, radios, and special DC fridges make optional the presence of the inverter when the system is designed for basic needs. The configuration without an inverter makes solar home systems very energy efficient without any conversion losses. In this case, the charge controller is the core of home-based systems, since it controls the energy inflow and outflow into and from the battery bank, ensuring optimal charging and discharging and avoiding damages.



Community based systems are larger stand-alone PV systems that provide energy to community services such as health centres, schools, factories. In this case generally an inverter is needed, and the charge controller is embedded in this device. With a typical range from some hundred to some thousand Watts output power, community systems usually integrate 12 or 24 V batteries, even if bigger systems work with higher voltage (48 V).

Also solar battery-charging stations are a typical application of PV for communities: the station is set up at a central place in a village, and is provided with a battery bank charged from an array of SPV modules. A DC–DC converter is used to charge batteries of individual solar lanterns or other devices.

Finally, SPV mini-grids can provide electricity to a number of households and community services. In this case solar panels arrays are assembled in the range of some hundreds of kWp, and a distribution network provides the electricity to the connected loads. The complexity of the system is higher. Essential elements of the systems are:

- ✓ PV array(s)
- ✓ Battery banks for electricity storage
- ✓ Power conditioning unit (PCU) consisting of junction boxes, charge controllers, inverters, distribution boards and necessary wiring/cabling
- ✓ Power distribution network (PDN) consisting of poles, conductors, insulators, wiring/cabling.

The tablebelow give an overview of the different types of SPV systems.

System	Production voltage	Presence of inverter	Loads
Home-based Pico SPV	12 V DC	No	Lamps, radio, mobile charger
Home-based Classical	12–24 V DC	Optional	Light, TV, fridge, PC, mobile charger
Community-based SPV	12–24–48 V DC	Optional	Light, cooler, water pump, hardware for artisanal work, ...
SPV mini-grid	24–48 V DC	Yes	Light, cooler, water pump, hardware for artisanal work, ...

Figure 46: Different types of SPV systems

Among GHG emissions from SPV systems, usually they are in the range 23–45 gCO_2e./kWh, which is about an order of magnitude smaller than that of fossil-based electricity.

Solar cookers, dryers, heaters and coolers

Some NGOs projects are based on solar cookers and collectors which concentrate the sun and convert it directly to heat. They are useful in areas with strong sun and requirement for an alternative energy source due to biomass fuel shortages. Several high-quality and efficient solar cookers are available at a relatively modest cost, although cultural resistance to change and more limited cooking practices, as well as a wider understanding of the technologies, still remain a challenge for wider acceptance.

Another type of NGOs project is based on solar dryers. Solar dryers can dry a wide range of agricultural products for preservation. The basic principal of a solar dryer is that air is heated by the sun in a collector and then passed over the product to be dried. There are three basic designs, each with its advantages and disadvantages: solar cabinet dryer, tent-dryer and solar tunnel dryer. Solar dryers are only useful during short periods of the year when crops are harvested and need to be dried.

Some NGOs install solar water heaters and ceiling insulation to reduce the need for heating. Solar thermal heaters collect solar energy and use air or water to transfer the heat to where it is needed. Low temperature collectors are flat plates that can be used to heat swimming pools or the inside of buildings. Medium temperature collectors are also usually flat plates and are used to heat water for residential and commercial use.

A number of NGOs are distributing evaporative coolers to vulnerable communities as part of food security and livelihood programmes. Evaporative cooling is a method of cold storage for fruits and vegetables which is simple and does not require any external power supply. Generally, an evaporative cooler is made of a porous material that is fed with water. Common designs include the zeer pot and the static cooling chamber. All vaccines have to be kept within a limited temperature range throughout transportation and storage. The provision of refrigeration for this is a major logistical undertaking in areas where electricity supplies are non-existent or erratic. The performance of refrigerators fuelled by kerosene and bottled gas is often inadequate. Diesel powered systems frequently suffer fuel supply problems. Solar power is therefore of great importance to health care.

Communities and households with access to these technologies can reduce the time and cost involved in collecting or purchasing firewood or other fuels and the cost of electricity where it is available. Hot water can also improve hygiene and increase comfort. Solar drying technologies can increase the shelf-life of food, increasing income potential and food security.

The solar technologies mentioned above are cheap, simple and easy to build. These solar technologies can be installed anywhere and across many households and institutions. They are useful for providing small amounts of heat energy, particularly in remote areas without access to the national grid. These technologies are useful for poverty reduction purposes and for this reason are applied in programs across poor and remote regions of the developing world, such as in Africa.

3.3.4 Hydro

NGOs develop also projects based on Pico and Micro-hydro plants which produce power from streams and small rivers, are relatively cheap to build and once running are easy to maintain. These schemes are used to generate electricity or to drive machinery and are eligible for the CDM or VCM.

Systems are categorized by their power output: pico-hydro (less than 10kW) and micro-hydro (10kW up to 300kW) are suitable for supplying power to a household or community. The power is dependent on the volume of water and the available head of falling water.

Hydropower plants transform the kinetic energy of a water flow into mechanical energy using a hydraulic turbine. Mechanic energy can be used to directly drive machineries, or is converted in electric power using an electricity generator. There is no unique definition of small hydropower (SHP), but in the context of rural areas it generally includes pico, micro and mini-hydro, with maximum generating capacities up to about 5 MW. Unlike other renewable-based technologies, the electricity production is continuous, without interruption as long as the water is flowing.

SHP is the most mature renewable technology: a huge number of plants have been installed in the last 30 years all over the world. Best geographical areas are characterized by the presence of perennial rivers and a hilly or mountainous terrain. Unlike other renewable technologies, hydro plants generally require some infrastructure work, since a canalization system is necessary to send the flow to the turbine, and the construction of a building provides protection to the generator from damage. On the other hand, SHP are characterized by a conversion efficiency up to 90 % and require low maintenance operations. A typical SHP includes the following elements:

- ✓ Weir, intake and channel
- ✓ Forebay tank
- ✓ Penstock
- ✓ Turbine
- ✓ Generator
- ✓ Electronic controllers and converters.

The turbine is the core element, the type depending on the flow and head pressure: turbines are generally classified as high-head, medium-head, and lowhead. For high and medium head SHP applications, most used turbines are Pelton, Turgo and Banki, while Kaplan or Francis turbines are suitable for low heads. In the case of medium or low heads, an interesting solution is the use of pumps as turbines. This solution has as its main advantages a lower cost and a greater availability of mechanical and electrical equipments. On the other hand, pumps are not optimized for functioning as turbines, therefore the conversion efficiency is lower.

Here are listed the main NGOs hydro projects:

- ➢ SHP home based systems.

- SHP community based systems.
- Micro-grid SHP systems.

Home-based systems are pico-hydroelectric installations with electric power up to about 2–3 kW. This kind of system is easy to install, and can incorporate all the electro-mechanical elements into a single device. A head of 5–6 m can be sufficient for 1 kW output power. For this reason, pico-hydro installations generally don't need channels and penstock. The generator is permanent magnets type. Electricity production is continuous, hence storage is optional. Also the use of voltage and load regulation is not mandatory, but is strongly recommended in order to avoid problems to the electric loads. Most simple regulators are mechanical (automatically driven valves which adjusts the flow to meet variations in power demand) or electronic (excess electrical power is switched in and out of a ballast load by a controller).

Community-based systems are used to supply the same services described for SPV and wind community systems. In this case, micro-hydro plants can be used, with generating power from some kilowatt up to about 20 kW. Most systems are run-of-river type, this meaning that no water storage is needed. On the other hand, channels and penstock are in general used.

Finally, micro and mini-hydro plants are used for micro-grid systems with electrical power from a few tens of kilowatt up to 5 MW. Larger infrastructure works are required in this case: according to the site configuration, bigger plants could require a basin and/or a small dam, and the construction of an electricity distribution network is necessary. The generator is typically synchronous, given that it is no longer possible to use simpler systems when such power generation capacities are provided. Moreover, for turbines above 20 kW a proper regulator should be installed in order to guarantee the optimal functioning of the system.

In remote areas, micro-hydro schemes can bring cheap and reliable electricity for the first time to whole communities to meet basic cooking, heating and lighting needs. The electrical power from micro-hydro also is sufficient to run machinery and refrigerators and to set up small enterprises increasing employment opportunities in rural areas and discourage young people from drifting to the cities.

The main environmental benefit of micro-hydro is reducing GHG emissions and local pollution from fossil fuels. This includes kerosene for lighting, diesel for driving machinery and diesel and other fossil fuels for generating electricity. GHG emissions vary greatly depending on the presence of a reservoir: run-ofriver hydropower emissions are in the range 0.3–13 gCO2e./kWh, while in the 6 Technologies for Power Generation in Rural Contexts case of reservoir hydropower the range is 4.2–152 gCO2e./kWh when potential GHG emissions from flooded land are included.

There are concerns about the environmental impact of hydro schemes, but carefully-designed micro-hydro plants take only a limited amount of water from a river or stream, have a small storage volume and return the water a short distance downstream, thus have very little environmental impact.

Water power can also be harnessed to pump water for a potable supply or irrigation. Hydraulic ram pumps operate automatically, using a large amount of water falling through a low height to pump a small amount of water to a much greater height. Appropriate models are available that can provide a reliable and affordable of water supply for rural areas.

The third case study consists in an analysis of a micro-hydro project developed by LVIA in Ethiopia.

3.3.5 Wind

Developing countries can take advantage of wind power on a small scale, both for irrigation (wind pumps) and for generation of electricity (wind generators). Usually, NGOs wind projects provide off-grid electrical and mechanical power, bringing useful services to wind farm located in remote areas.

Wind turbines can be classified in two macro-categories according to their design: horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT). HAWT are the most used, due to their higher efficiency, even if VAWT are also suitable in particular for small size applications. HAWT turbines can be upwind or downwind type. In the first case, the most common, wind first invests the rotor, and then the hub, the generator and the orientation mechanism (tail). The opposite is true for downwind turbines, hence the blade orientation mechanism (if present) acts before the rotor (Figure 47).

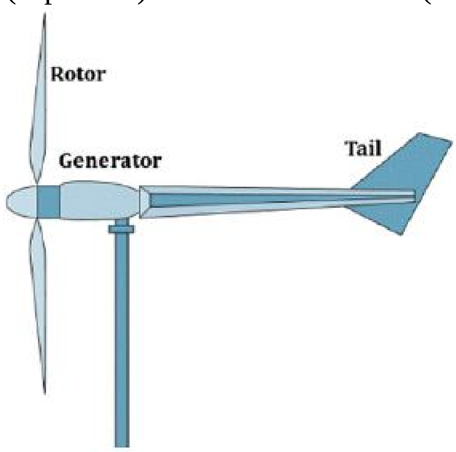


Figure 47: Wind system

The three-blades design is prevalent, since it minimizes vibrations and noise. Most SW turbines have a direct drive, permanent magnet rotor generator: this configuration is the simplest possible since gearbox is not needed. This kind of generator produces alternate current. The turbines are generally placed on a pole, preferably higher than 15 m to keep them out of ground turbulence. Tilt-up poles or towers are the best solution for turbines up to some kW since they are easy to install and offer good accessibility for maintenance. SW systems can be subdivided into three categories:

- SW home-based systems
- SW community-based systems
- Micro-grid SW systems.

The layout of SW home-based systems is similar to the one of classical SPV home systems, and is suitable to supply energy for household requirements (lighting, mobile charging, radio, TV, etc.). Typically, pico or micro-wind turbines up to about 1.5 kW are used for this application. In addition to the turbine, the simplest DC system requires a bridge rectifier (i.e. an electronic device that converts alternate current in direct current), a charge regulator and batteries for energy storage. The turbine can be mounted roof-top or on a pole. When AC loads are present, the bridge rectifier is replaced by a power conditioning unit in order to deliver proper voltage and frequency.

SW community-based systems are characterized by the use of SW turbines in the range 1.5–15 kW. When average wind speed in the location is adequate, they are ideal for dwellings, schools, hospitals, telecom towers, water-pumps, etc. SW community-based systems can be used also for battery charging, whit a layout very similar to SPV battery-charging stations.

Small and medium size turbines are used in micro-grid systems, with a typical power range of 15–100 kW. Also in this case, the layout of the system is similar to the one described for SPV systems. Clearly, depending on the context, it is possible to connect to the mini-grid one or more turbines. However, it is worth noting that there are few examples of mini-grid systems supplied only by wind turbines.

More frequently, mini-grid systems using SW turbines are hybrid systems in which the wind turbine is coupled with a diesel generator, a SPV system, etc.

Wind energy technologies require careful design by an experienced technical person to match the wind resource, technology and application and regular maintenance from a trained local user. So, for NGOs is also important to transfer all the useful knowledge to local people.

Appropriate technology models are available (100W up to 5 kW) and are used in a number NGOs projects in developing countries. Horizontal and vertical axis models are used, although the horizontal axis model is more common. Small wind turbines can be a cheap alternative to solar PV in areas with a good wind resource and in some case they are combined with solar PV panels and/or diesel generators to ensure a reliable supply in times of low wind speeds.

Another function of wind system is to charge batteries. Families living in rural areas who do not have access to the national grid may have to travel long distances and wait long times for their batteries to be recharged in urban zone. NGOs provide reliable and cost effective wind energy systems for charging batteries to help meet the electrical energy needs of these people. Small wind turbine systems, with a capacity ranging from 50 W to 10 kW and rotor diameter ranging from about 0.5 m to 7 m are primarily used for this task. The batteries can then be used for energy supply for houses, hospitals, farms and telecommunication.

Small scale wind energy generators also have the potential to stimulate village-level charging enterprises for either community or private use. Therefore NGOs aim to develop and promote local industries capable of manufacturing and maintaining the generators.

Wind pumps harness the power in the wind to drive a mechanical pump to lift groundwater. They have low operating costs so can be cheaper to run than a diesel powered pump. They are suitable for village and livestock water supplies and irrigation. Wind pumps are effective at lower wind speeds than small wind turbines. There are manufacturers in several developing countries promoting wind pumps on a commercial basis, including for example the Kijito wind pump in Kenya and are useful for NGOs which are implementing projects.

Finally, the main benefits to users of NGOs wind projects are access to modern electrical power in areas not accessible by the grid, opportunities to develop income generating businesses, reduction of distance to walk or travel to reach alternative battery charging services and, of course, reduction of GHG emissions values in the range 4.6–55.4 gCO2e./kWh.

3.3.6 Biodiesel from Jatropha

Through this type of projects, NGOs promote at the household and community level the production and use of jatropha to address environmental degradation and providing other complementary livelihoods options to the conventional crop and livestock management activities in which smallholder farmers have been involved.

Diesel engines can be adapted to run on biofuels and oils that can be grown locally. Sustainable cultivation of a local biofuel crop can support the local economy and isolate the system against high and fluctuating diesel prices. Jatropha is a non-edible shrub originally from South America but is now wide spread throughout arid and semi-arid tropical regions of the world on degraded soils having low fertility and moisture like some parts of Africa. The seeds of Jatropha contain 50-60% oil which can be extracted and have similar properties as diesel. Some properties such as kinematic viscosity, solidifying point, flash point and ignition point are very high in jatropha oil. Oil processing can be done using simple hand operated oil presses or using motor driven presses.

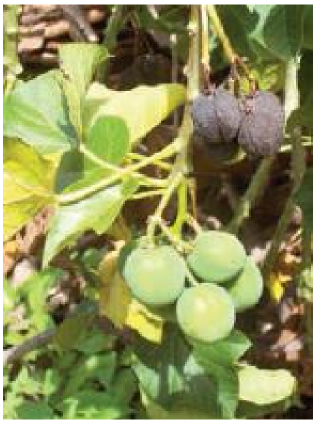


Figure 48: The nuts from Jatropha curcas

Jatropha oil is an important product from the plant for meeting the cooking and lighting needs of the rural population and as a viable substitute for diesel. Substitution of firewood by plant oil for household cooking in rural areas will not only alleviate the problems of deforestation but also improve the health of rural women who are subjected to the indoor smoke pollution from cooking by inefficient fuel and stoves in poorly ventilated space.

The oil extracted is used also in making soap, candles and lubricants. Jatropha is not browsed by livestock and is therefore used as live fence to keep stock out of homestead and fields. It is also used to reduce wind and water erosion. The byproduct of jatropha seeds contain high nitrogen, phosphorous and potassium which is used for fish foods, domestic animals food and in lands as fertilizer.

NGOs jatropha project can access carbon credits because it help to mitigate the effects of climate change by reducing emission of GHG, meeting rural energy needs, protecting the environment and generating employment.

Cultivation at the landscape level will help mitigate global warming considering its potential for carbon sequestration. Jatropha oil emissions are low in carbon dioxide since it has already assimilated carbon during the growth of the growth of the plant. The carbon dioxide balance therefore remains equable.

3.4 Forestry projects

The most important share of NGOs projects is based on GHG emissions removal by sinks. NGOs forestry mitigation projects make a very significant contribution to a low-cost global mitigation portfolio that provides synergies with adaptation and sustainable development. There are two main types of projects, collectively called Land Use, Land-Use Change and Forestry (LULUCF) activities:

1) those that increase carbon storage by sequestration named afforestation and reforestation (A/R)
2) those that avoid emissions via conservation of existing carbon stocks called Reduced Emissions from Deforestation and forest Degradation (REDD)

As mentioned above, the BioCarbon Fund, administered by the World Bank, purchases carbon credits from CDM projects and finances demonstration projects for carbon sequestration and conservation in forest and agro-ecosystems outside the Kyoto market. The main contributors to this public/private partnership are governments such as Canada and Italy and companies like Japanese power companies.

3.4.1 Afforestation/Reforestation

The term afforestation is generally used for the planting of trees on land that is currently not forested; either agricultural or severely degraded land. This can be anything from a mono-culture forest for timber production to a mix of native tree species, with limited or no intention to harvest trees.
The majority of land will then remain under forest cover. For certification purposes, project developer needs to calculate the average amount of carbon that is sequestered over the project period.

Within the context of carbon credits what is generally called agro-forestry also falls under afforestation. This is the introduction of trees to agricultural land that will grow in between crops, or a plantation of tree crops such as cashew nut trees. Obviously, in this case one needs to prove that the tree crops alone are not profitable enough to pay for the planting in order to comply with the additionality principle.

Reforestation describes the planting of trees on land that was once forest or is currently a degraded forest as a result of charcoal harvesting or commercial logging. Though the term is different, reforestation is generally treated in the same way as afforestation, which is why they tend to be mentioned together. In fact, these types of NGOs projects are named A/R or AR projects.

There are different types of A/R projects depending on the land on which are implemented:

- ✓ On grasslands or croplands
- ✓ Of settlement lands
- ✓ Of wetlands
- ✓ For agro-forestry activities
- ✓ Of lands having low inherent potential to support living biomass
- ✓ Of degraded land for silvo-pastoral activities

Typically these projects are associated with farming communities and cooperatives. Depending on the project, the main benefits can include job creation, reduction of soil erosion through root growth, protection of river banks, biodiversity conservation, shade for humans and livestock, moderation of wind and dust storm, food diversity and green spaces.

3.4.2 Reducing Emissions from Deforestation and Forest Degradation

REDD is a relatively new concept in carbon credits and has only recently gained acceptance in the voluntary markets. NGOs REDD projects differ from other project types because they are a strategy for motivating communities, companies and governments not to cut down forests. NGOs aim to reduce deforestation and forest degradation in developing countries.

The term “REDD+” is also sometimes used to describe REDD projects that include the role of conservation, sustainable management of forests or enhancement of forest carbon stocks.

VCS is the most popular standard that approved various methodologies for REDD projects. This standard helps to alleviate buyers’ perceptions of forestry’s reputational and investment risks.

NGOs REDD projects can be:

- ✓ activities to avoid planned deforestation that reduce GHG emissions by stopping or reducing deforestation on forest land that is both legally authorized (by relevant government authorities) and documented to be converted to non-forest land
- ✓ activities to avoid unplanned deforestation and degradation that reduce deforestation and/or degradation on forest land that is either not legally authorized or is not documented for conversion to non-forest land. Unplanned deforestation and degradation typically occurs due to poor law enforcement or lack of property rights that result in piecemeal conversion of forest land to non forest land.

The main benefits of this NGOs project are the generation of income for local communities, employment, conservation of species, ecotourism, water regulation, contribution to food and fuel wood security because billion people in developing countries depend on forest. REDD can also help conserve forest ecosystems and biodiversity.

Chapter 4

4 Analysis of carbon credit accounting and economic revenue for typical NGOs' energy projects

In this section, the potential of carbon finance to contribute to the promotion of NGOs' energy projects in developing countries will be analyzed for four case studies located in Malawi and Ethiopia.

4.1 Method of analysis

First of all, the analysis are based on developing a project under the Gold Standard for the voluntary market because this type of certification is supported by NGOs and it is an assurance of meeting sustainable development requirements. The analysis follows these steps for each case study:

- Choice of two baseline methodologies, one approved under the CDM and one under the Gold Standard;
- Application of the methodologies to determine the baseline scenario;
- Ex ante estimation of emission reductions;
- Estimation of earnings from carbon credits;
- Comparison between the two methodologies and analysis of results under an economic point of view.

For all projects, the emission reductions are calculated as:

$$ER_y = BE_y - PE_y - LE_y$$

Where:

ER_y	Emission Reductions in the year *y* (tCO2e/y)
BE_y	Baseline emissions in the year *y* (tCO2e/y)
PE_y	Project emissions in the year *y* (tCO2e/y)
LE_y	Leakage emissions in the year *y* (tCO2e/y)

- ✓ Project emission are equal to zero for most renewable energy project activities. This is the case of the project considered.
- ✓ If the energy generating equipment is transferred from another activity, leakage is to be considered, but in the case studies below there is no leakage.
- ✓ For all the case studies it was chosen a crediting period of 7 years, because this is the selected duration time for the majority of NGOs' energy projects.
- ✓ Another assumption for all projects is that the number of household involves in the project area is constant during all the crediting period.

4.1.1 Methodologies

There are a lot of methodologies that specify how to determine the baseline scenario and how to calculate the emission reductions. The choice for analysis focuses on small scale and micro-scale methodologies because of the size of NGOs' case studies. The CDM Approved Methodologies for Small scale projects and the GS VER methodologies used in the analysis are listed in the table below.

Project developer	Technology	Methodology		Description
COOPI	Stoves	CDM	AMS-II G	Energy efficiency measures in thermal applications of non-renewable biomass
		VER	GS Cookstoves	Simplified methodology for efficient cookstoves
	PV	CDM	AMS-I A	Electricity generation by the user
		VER	GS Electrification	The GS suppressed demand methodology for micro-scale Electrification and Energization
LVIA	Biogas	CDM	AMS-I E	Switch from non-renewable biomass for thermal applications by the user
		VER	GS Biodigester	Small scale biodigester
	Hydro	CDM	AMS-I A	Electricity generation by the user
		VER	GS Electrification	The GS suppressed demand methodology for micro-scale Electrification and Energization

Table 7: Methodologies used to calculate emission reductions

According to all methodologies above, uncertainty due to lack of data is often to be limited by using default factors from the 2006 IPCC guidelines for national greenhouse gas inventories, as required by the small scale rules of CDM.

4.1.2 Carbon price

It is difficult to get an accurate read of the wholesale price of carbon credits in the VCM, as most transactions occur over-the-counter and price information is often not made public by the suppliers and purchasers. VER price assumptions are based on surveys published on the “State and trend of Voluntary Carbon Markets” by Ecosystem Marketplace and Bloomberg New Energy Finance.

- Compared to other project location, as shown in Figure 27 (Chapter 2.3.1), the average price in Africa is one of the higher with 8 $/tCO2e corresponding to 5,83 EUR/tCO2e.
- The price varies also by the project type. For the case studies four technologies are taken into consideration: Cookstoves, Photovoltaic, Biogas and Hydro.

  Figure 49 shows the minimum, maximum and average prices for credits from different technologies in 2012. Average prices are weighted on the transacted volume of tCO_2e. As displayed, cookstoves projects has the highest average price compared to the other projects.

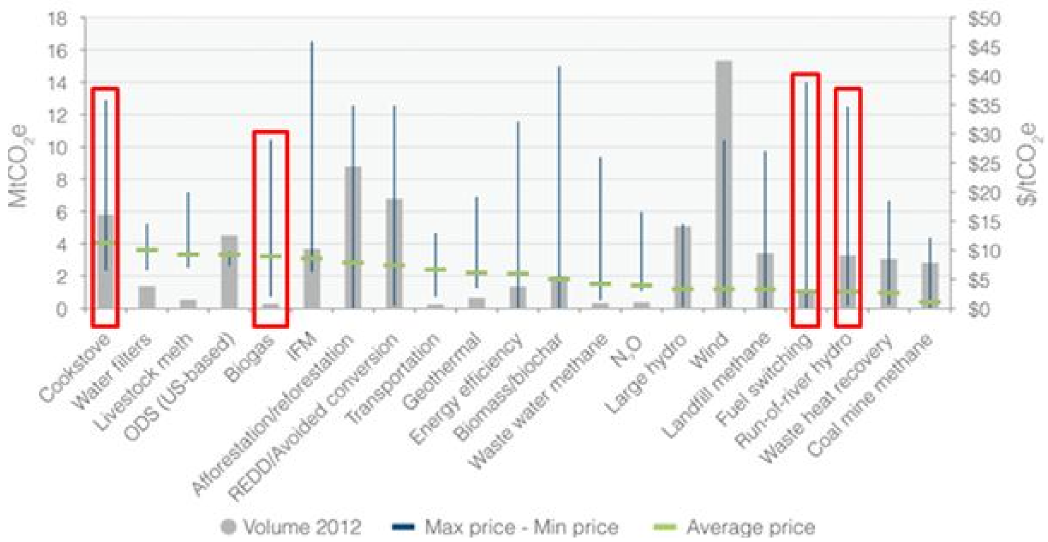


Figure 49: Volume and average price by project type

According to Bloomberg New Energy finance, the trend of the value of credits from solar system is similar to the fuel switching projects.

- A factor influencing credit prices more significantly is the third party standard applied for verification and/or verification. As displayed in the graph below (Figure 50), Gold Standard prices for VERs is about 30% less than GS CDM. This is the proportional factor used to determine the prices of CDM in the analysis.

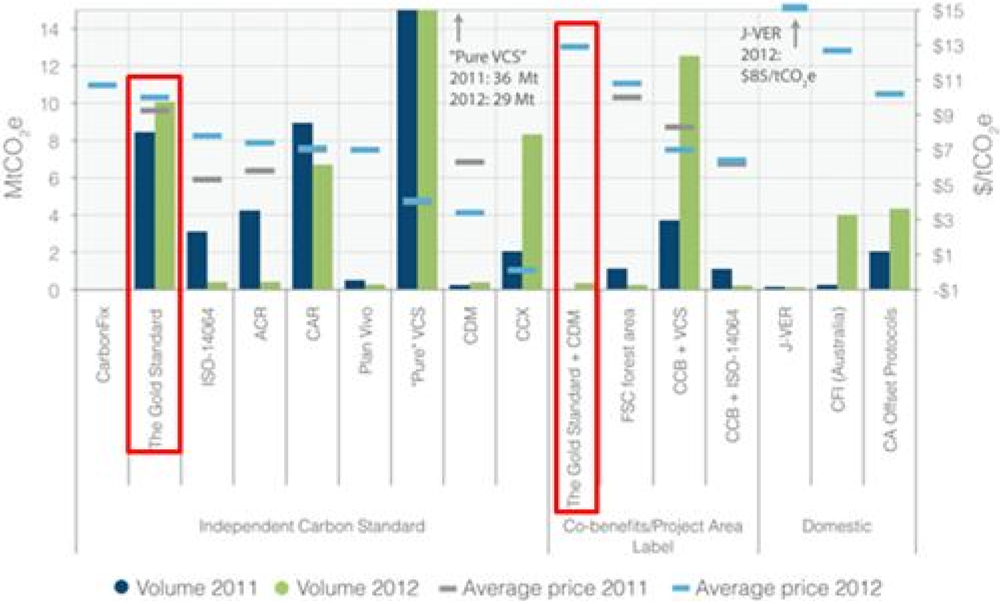


Figure 50: Volume and prices by project certification standard

- Last but not least, project size is an important factor. Credit price is the inverse of the project size as can be seen in the table below (Table 8).

Reductions / Year	Average Price ($/tCO2e)
Micro (<5ktCO2e)	$10
Small (5-20 ktCO2e)	$8.7
Med (20-100 ktCO2e)	$6.2
Large (100-500 ktCO2e)	$6.1
Very Large (500 ktCO2e – 1 MtCO2e)	$5.6
Mega (> 1 MtCO2e)	$5.8

Table 8: Prices of VERs by project scale

Especially for micro-scale projects, the higher pricing is significant compared to larger projects.

Project technology	Certification	Price scenarios (EUR/tCO2e)		
		MIN	MAX	Average
Cookstoves	CDM	4,37	25,50	8,02
	VER	5,68	33,16	10,42
PV	CDM	0,36	28,42	2,19
	VER	0,47	36,95	2,84
Hydro run-of-river	CDM	0,36	25,50	2,19
	VER	0,47	33,16	2,84
Biogas	CDM	1,46	20,40	5,83
	VER	1,89	26,52	7,58

Table 9: Price scenarios

As stated above, estimations of 9 EUR/tCO2e for VER energy projects are seen realistic (11,7 EUR/tCO2e for CDM). Therefore, this price value is another used in the economic analysis as 'Standard Price'.

4.1.3 Transaction costs

Projects applying for the Gold Standard are charged under a share of proceeds fee structure. At his, the project proponent deducts a predetermined percentage of credits (2% for VERs) from the final credit issuance and transfers it to the Gold Standard's Foundation registry account. A pre-feasibility of 0,1 $ per credit for one year of average expected emission reductions is due in the first year. The small and micro-scale validation fee of 5000 $ is to be paid in the first year of crediting period to initiate the internal validation. Another cost, is the GS annual flat fee which is due for small and micro-scale project verification: 2500 $ per year have to be paid to the GS Verification Fund. Instead, the GS account subscription fee is waived for project developers.

For CDM projects, the transaction cost are higher. CDM has the same amount of share of proceeds fee, but the prefeasibility study stands at 0,13 $ per credit for the first year, the validation is valued 10000 $ and the annual flat fee for verification that is due is 4000 $.

All the fees, converted in EUR, are summarized in the table below (Table 10).

Fees	VER	CDM	
Share of proceeds fee	1,5	1,5	% of credits
Pre-feasibility study	0,073	0,095	EUR per credit in year 1
Micro scale validation	3644	7287	EUR in year 1
Annual flat fee for verification	1822	2915	EUR yearly

Table 10: Micro-scale Gold Standard Fees

4.2 Case study: Cookstoves Malawi

As explained before the promoter of the first project is COOPI. This project is part of an Energy Facility for Malawi and is located in two rural districts, Kasungu and Likoma Island. The overall objective is to contribute to the improvement of access to sustainable energy services in order to reduce climate change and improve the livelihood of rural communities. The estimates results is that 9000 people (1600 households) will reduce at least 40% wood consumption through the use of improved stoves for cooking and will produce less smoke.

Malawi's major indigenous energy resource is biomass which is used in the form of firewood and charcoal. Biomass meets the bulk of households and a significant proportion of agricultural energy needs and accounts for 96 percent of the total of energy needs in the country. Commercial fuels account for the remaining 4 percent. In aggregate, sustainable biomass supply is estimated to be lower than the current national consumption, a situation which is contributing to deforestation. Most rural people in Kasungu district and Likoma Island cannot afford alternative sources of energy to fuel-wood. Furthermore one of the poor peoples' strategies for survival is to sell forest products in order to obtain cash for purchasing basic items and accessing services. The great majority of the population uses highly inefficient wood stoves, requiring 50-60% more wood and producing much more CO2 compared to energy saving stoves locally made and already promoted in other areas of the country. This behaviour generates:

- ✓ Environmental problems such as lack of a proper forest co-management scheme, deforestation, soil erosion and encroachment within protected area; extensive deforestation due to high demand of fire wood for households uses.
- ✓ Health problems, indoor smoke inhalation associated to respiratory other non communicable diseases.
- ✓ Social and economic problems such as excessive use of inefficient, smoke producing stoves, absence of lighting energy in rural schools, lack of local business opportunities.

To improve this household livelihood, COOPI chooses to distribute 1600 stoves, one for each household, of the Chitetezo Mbaula type (Figure 51).

Figure 51: Chitetezo Mbaula

For the typical environmental condition of Malawi, the field efficiency of the Mbaula stove is 21% , value known from the literature.

To perform the analysis below, some strong hypothesis are necessary:

- Stoves dissemination by the NGO
- Stove lifetime
- Wood consumption
- Households percentage of usage
- Efficiency loss

The first hypothesis is based on COOPI project document and describes how the stoves have been distributed. The dissemination is done in two years: 800 Mbaula stoves are distributed in the first year and the other 800 in the second year.

From a GTZ study results that the lifetime of this type of energy saving stoves is about two years. Hence, the number of stoves should decrease every year, but the assumption for the analysis is that the number of stoves remains constant from the second year and this implies an immediate replacement of broken stoves.

The third hypothesis is the wood consumption. From literature, the households wood consumption with the base technology (the three stone fire) is equal to 4500 kg/year for each household. This assessment will be used to calculate the baseline scenario.

Another assumption is a percentage of usage by households equal to the 100% every year. In the real scenario, the number of households that decide to not use the stove is an important variable because this can reduce significantly the effect of the project. In a developing country like Malawi, where the tradition are very strong and deeply inside, introducing a new way to burn wood or new devices can create a rejection of the new stoves. For this reason COOPI has planned a sensitization activity about the adoption of the improved cookstoves.

Another ideal hypothesis is that there is no efficiency loss. Instead, in the real world the loss for this device is at least 1% every year.

CDM and VER Methodologies for Stoves

The methodologies used for the analysis are listed below:

- **CDM AMS-II G** version 6.0
  Energy efficiency measures in thermal applications of non-renewable biomass
- **GS VER Cookstoves**
  Simplified methodology for efficient cookstoves

AMS-II G methodology is applicable to single pot or multi pot portable or in-situ cook stoves with rated efficiency of at least 20 per cent based on certification by a national standards body or an appropriate certifying agent recognized by that body or, alternatively, manufacturer specifications based on water boiling test (WBT). Another condition is that the aggregate energy savings of a single project shall not exceed the equivalent of 60 GWh per year or 180 GWh thermal per year in fuel input.

GS VER methodology for efficient cookstoves is applicable to micro-scale programmes and micro-scale projects:

- that introduce new wood burning cookstoves to reduce the use of non - renewable firewood or
- switch from non-renewable to renewable firewood to meet thermal energy requirements for household cooking.

This methodology is applicable if the following conditions are true:

1. the baseline fuel is only firewood
2. the baseline stove is a three stone fire, or a conventional device without a grate or a chimney i.e. with no improved combustion air supply or flue gas ventilation
3. the project stove is a single pot or multi pot portable or an in -situ cookstove with a specified efficiency of at least 20%.

4.2.1 Estimation of emission reductions - CDM AMS-II G

Emission reductions for household cook stoves during year y for the type of project device are calculated as in t CO_2e

$$ER_y = \sum_{a=1}^{a=y} B_{y,savings,i,a} * N_{y,a} * \frac{\mu_y}{365} * f_{NRB,y} * EF_{fossilfuel} - LE_y$$

Where:

a	The age in years of the cook stoves that are operating in the year 'y' of the crediting period
$B_{y,savings,a}$	Quantity of woody biomass that is saved in tonnes per cook stove device
$f_{NRB,y}$	Fraction of woody biomass saved by the project activity. Without survey, the non-renewable biomass is established using default country data available on the CDM website (f_{NRB} = 0,81 for Malawi)
$NCV_{biomass}$	Net calorific value of the non-renewable woody biomass that is substituted (IPCC default for wood fuel, 0.015 TJ/tonne)
$EF_{fossilfuel}$	Emission factor for the fossil fuels projected to be used for substitution of non-renewable woody biomass. (Default value of 81.6 t CO_2/TJ)
$N_{y,a}$	Number of project devices
μ_y	Number of days of utilization of the project device during the year 'y'. (365 because for hypothesis the pre-project device has been decommissioned and is no longer used)
LE_y	Leakage emissions in the year y (always zero)

The biomass saved for cookstoves is estimated using the Water Boiling Test, a simplified simulation of the cooking process. It measures how efficiently a stove uses fuel to heat water in a cooking pot.

$$B_{y,savings,i,a} = B_{old,i} * (1 - \frac{\eta_{old}}{\eta_{new,i,a=1} * \Delta\eta_{y,i,a}})$$

η_{old}	Efficiency of the three stone fire. (Default value of 0.10)
$\eta_{new,a=1}$	Thermal efficiency of the project device (0.21 for Mbaula)

$\Delta\eta_{y,a}$ Factor to consider the efficiency loss of the project device expressed as the ratio of the thermal efficiency determined using WBT and the efficiency at the first year of operation.

B_{old} is estimated as the average annual consumption of woody biomass per device (tonnes/year) and derived from historical data or a sample survey of local usage (4,50 t fuelwood/y)

The emission reductions at the end of the 7 years crediting period are 24304 tCO2e, as shown in Table 11.

Year	Number of stoves	Yearly Emission Reductions (tCO_2e/y)
1	800	1870
2	1600	3739
3	1600	3739
4	1600	3739
5	1600	3739
6	1600	3739
7	1600	3739
	Total tCO_2e in 7 years	**24304**

Table 11: Emission reduction for cookstoves project (AMS-II G)

To check if the methodology is applicable, energy saving is calculated from the fuelwood baseline consumption multiplied by the rate of efficiency of three stone system and the Mbaula stove. For all 1600 appliances, the total energy saving is equal to 15,72 GWh/year which is less than the threshold of 60 GWh/year.

4.2.2 Estimation of emission reductions - GS VER Cookstoves

Using this methodology, the emissions reductions are calculated as follows:

$$ER_y = \sum_{0\ to\ 1}^{x\ to\ y} N_{P,y} * P_y * U_{P,y} * (f_{NRB,y} * EF_{b,fuel,CO2} + EF_{b,fuel,non\ CO2}) * (1 - DF_{b,stove\ y})$$

Where:

$N_{P,y}$	Number of project cookstoves operational in the year y
P_y	Quantity of firewood saved (t/households/y)
$U_{P,y}$	Usage rate for project cookstoves
$f_{NRB,y}$	Fraction of biomass used in baseline scenario which can be established as non renewable. (0,81 for Malawi)
$EF_{b,fuel,CO2}$	CO_2 emission factor of firewood substituted or reduced (Default value 1,747 tCO_2/t wood)
$EF_{b,fuel,non\ CO2}$	Non-CO_2 emission factor of firewood substituted or reduced (Default value 0,455 tCO_2/t wood)
$DF_{b,stove,y}$	Usage of baseline cookstove in project scenario (0 for hypothesis)
$U_{P,y}$	Usage rate for project cookstove
y	Year of crediting period
x	y-1

The quantity of biomass saved is evaluated through this equation:

$$P_y = B_{b,y} * (1 - \eta_b \ / \ \eta_{p,y})$$

$B_{b,y}$	Quantity of firewood consumed in baseline scenario
$\eta_{p,y}$	Efficiency of project cookstove in year y
η_b	Efficiency of the baseline cookstove being replaced. (As for CDM methodology, default value of 0,10)

The project cookstoves efficiency in year y is estimated, from the efficiency at the start of the project, considering a discount factor for efficiency loss per year of operation and an adjustment factor of 0,94 to account uncertainty related to project cookstove test:

$$\eta_{p,y} = \eta_p * (DF\eta)^{y-1} * 0{,}94$$

Also for this case, the efficiency of project cookstoves needs to be determine following the Water Boiling Test protocol.

The emissions reductions are showed in Table 12.

Year	Number of stoves	Yearly Emission Reductions (tCO_2e/y)
1	800	3315
2	1600	6181
3	1600	6181
4	1600	6181
5	1600	6181
6	1600	6181
7	1600	6181
	Total tCO_2e in 7 years	**40400**

Table 12: Emission reduction for cookstoves project (GS VER)

4.2.3 Estimation of earnings from carbon credits

The budget for the action is based on COOPI project document. Considering that the total cost includes both the implementation of cookstoves project and PV project in Malawi, the expenses due to human resources, travel, administrative action and other costs are allocated proportionally to the different cost of the technologies. The cost of construction material for the 1600 energy saving stoves is only the 3% of total cost of technologies. The other 97% belongs to PV installations.

Other costs for Stoves and PV	EUR
Human resources	354000
Travel	19200
Office equipment, Vehicles and Supplies	93820
Local office	97200
Other costs, services	29200
Administrative	41931
Services	1000
Total other costs	**636351**

Table 13: Other Costs for Stoves and PV

Whereas the cost of cookstove is 3,5 EUR per unit, the outgoings become:

Costs of Stoves project	EUR
Construction material	5600
Other Costs	19886
Total	**25486**

Table 14: Cookstoves project cost

Adding the transaction costs for CDM and GS VER certification, the total expenses become:

	CDM	GS VER
Transaction cost (EUR)	28222	17226
Total cost (EUR)	**53708**	**42712**

Table 15: Cookstoves project cost including certification

Assigning the related value to the carbon credits, as described above, the revenue from carbon finance can be estimated.

	CDM revenue for different prices (EUR/y)				VER revenue for different prices (EUR/y)			
Year	MIN	MAX	Average	Standard	MIN	MAX	Average	Standard
1	10626	61988	19482	15940	14494	84551	26573	21742
2	21253	123975	38964	31879	27024	157637	49543	40535
3	21253	123975	38964	31879	27024	157637	49543	40535
4	21253	123975	38964	31879	27024	157637	49543	40535
5	21253	123975	38964	31879	27024	157637	49543	40535
6	21253	123975	38964	31879	27024	157637	49543	40535
7	21253	123975	38964	31879	27024	157637	49543	40535
Total EUR (7 years)	**138144**	**805839**	**253264**	**207216**	**176636**	**1030375**	**323832**	**264954**

Table 16: Carbon revenue from Cookstoves project for different price scenarios

4.3 Case study: PV Malawi

This project is developed by COOPI in Kasungu and Likoma Island in Malawi. The provision of electricity in Malawi is inadequate, unreliable and inaccessible to many who need it due to small grid coverage (about 5% of the population), inability to pay and under investment in the struggling power utility Electricity Supply Corporation of Malawi (ESCOM) as reported in the EU Country Strategy Paper 2008-2013. In Kasungu, out of 606028 people, 18,971 (3%) are connected to the electricity grid ESCOM and only 3,717 use electricity

for cooking, and not only for lightening. In Likoma Island lives 10445 people, but less than 600 households are connected to ESCOM.
In spite of many rural areas having the potential demand for electricity, only less than one percent of rural homes are electrified. This is due to high capital costs associated with grid extension and high connection fees against a background of low income of potential consumers. The absence of ESCOM grid and other sources of energy in the districts have resulted in over reliance on fossil fuel energy for lighting and mills. However, Malawi experienced in the last years erratic supply of fossil fuel within the entire country, affecting particularly rural areas such as Kasungu and remote isolated areas such as Likoma Island, where electricity is generated with local generators. This impaired seriously local business and households activities.

To try to solve these problems, COOPI project improve energy access for 15008 people by the action summarized below (Table 17).

	Installations	Category target	People	Units
A	Six (6) water towers with solar energy motorized pumps and pipes for enhanced irrigation	Commercial - Farmers accessing energy for improved irrigation	4675	6
B	Solar panels for 21 NRC small business centers in the communities and spare parts (up to 300 kWh/year / year / site)	Commercial - New enterprises	100	21
C	One integrated Solar + Wind generator for Likoma island for LITA and other small businesses associated (between 5.000 and 20.000 kWh/year / year) estimated to 15.000kWh/year	Commercial - New enterprises	83	1
D	Solar panels (1300 small units and 1000 (KU HH) + 300 (Likoma) (app. 10-20 kWh/year / year / Household) for planting trees and enrolling in a environment friendly activities	Farmers households engaged in afforesting program receiving solar unit as incentives	7150	1300
E	Solar panels for 6 schools and spare parts (up to 2000 kWh/year / year / site)	School with Students and local community involvement	3000	6
		Total	15008	1334

Table 17: COOPI PV and hybrid system

As described above, COOPI purchases two solar powered electric energy supply system combined with wind generators, one for one Natural Resources Committees (NRC) to generate up to 300 kWh/ year and one to Likoma Island Tours Association (LITA). The total output of energy produced by the hybrid system solar wind of LITA should be not less than 10000 to a potential maximum of 20000 kWh per year depending on the wind speed and real solar insulation. For Malawi, average insulation is 21100 kJ/m^2/day. This energy can be put to various uses including drying. The average wind speed in Likoma Island is estimated between 4.5 and 6 m/s and it is advantageous because can work also on night hours. The estimated energy to be produced during all the crediting period is shown in Table 18:

	Energy production		
	kWh/y/unit	**kWh in 1 year**	**kWh in 7 year**
A	6000	36000	252000
B	300	6300	44100
C	20000	20000	140000
D	20	26000	182000
E	2000	10000	70000
Total Energy production	**28320**	**98300**	**688100**

Table 18: Energy production from the five PV actions

CDM and VER Methodologies for Stoves

The methodologies used for the analysis are listed below:

- **CDM AMS-I A** version 16.0
  Electricity generation by the user
- **GS VER Electrification**
  The GS suppressed demand methodology for micro-scale Electrification and Energization

AMS-I A is applicable to users in off-grid locations, i.e. they do not have connection to a national/regional grid, unless exceptional situations.

GS VER Electrification methodology is applicable to renewable energy based electrification/energization activities for communities that do not have access to the national or regional grid or for communities who have less than 50% grid availability. The methodology is eligible for activities under the consolidated standalone micro-scale scheme with total emission reductions of less than or equal to 10,000 tCO2/year per activity. The renewable energy sources eligible for this methodology are limited to solar, hydro, wind, renewable biomass and biogas.

4.3.1 Estimation of emission reductions - CDM AMS-IA

The energy baseline is the fuel consumption of the technology in use or that would have been used in the absence of the project activity to generate the equivalent quantity of energy The energy baseline is calculated based on annual electricity generation from project renewable energy technologies as:

$$E_{BL,y} = \sum_i EG_{i,y} / (1 - l)$$

Where

$E_{BL,y}$	Annual energy baseline; kWh
$\sum_i$	The sum over the group of *i* renewable energy technologies implemented as part of the project activity
$EG_{i,y}$	Annual output of the renewable energy technologies installed; kWh
L	Average technical distribution losses that would have been observed in diesel powered mini-grids installed by public programmes or distribution companies in isolated areas

The baseline emissions are calculated as:

$$BE_{CO2,y} = E_{BL,y} * EF_{CO2}$$

Where:

$BE_{CO2,y}$	Emissions in the baseline in year *y*; tCO_2
$E_{BL,y}$	Annual energy baseline in year *y*; kWh
EF_{CO2}	CO_2 emission factor; tCO_2/kWh

For EF_{CO2} is used a default value of 0.8 kg CO_2e/kWh, which is derived from diesel generation units.

Hence, the emission reduction according to AMS I-A methodology are:

Year	Yearly Emission Reductions (tCO_2e/y)
1	87
2	87
3	87
4	87
5	87
6	87
7	87
Total tCO_2e in 7 years	**612**

Table 19: Emission reductions for PV project (AMS-I A)

4.3.2 Estimation of emission reductions – GS VER Electrification

GS VER micro-scale electrification and energization methodology is based on the concept of suppressed demand: in many developing countries the level of energy service is not sufficient to meet human development needs due to lack of financial means and/or access to modern energy infrastructure or resources. Therefore, this methodology defines the Minimum Service Level (MSL) for each eligible consumer group, which expresses the maximum level of the electricity consumption (in kWh/day) that can be included in the baseline (Table 20).

Parameter	Description of parameter for each eligible consumer group	Default MSL energy consumption value
$MSL_{ec,hh,y}$	Energy consumption in kWh (ec) for a household (hh) in year (y)	3.0 kWh/day
$MSL_{ec,hc,y}$	Energy consumption in kWh (ec) for a health center (hc) in year (y)	8.6 kWh/day
$MSL_{ec,d,y}$	Energy consumption in kWh (ec) for a dispensary (d) in year (y)	4.1 kWh/day
$MSL_{ec,s,y}$	Energy consumption in kWh (ec) for a school (s) in year (y)	10.0 kWh/day
$MSL_{ec,k,y}$	Energy consumption in kWh (ec) for a kindergarten (k) in year (y)	4.4 kWh/day
$MSL_{ec,pa,y}$	Energy consumption in kWh (ec) for a public administration building (pa) in year (y)	4.4 kWh/day
$MSL_{ec,tp,y}$	Energy consumption in kWh (ec) for a trading place (tp) in year (y)	11.0 kWh/day

Table 20: Default MSL energy consumption value for eligible consumer group

In this project, the only eligible consumer groups are the households and the schools, and the annual MSL is the sum of each energy consumption for a consumer group in a year times the number of unit in the consumer group. Then, to calculate the baseline emissions referred to a diesel generator is necessary to use an emission factor. Default value is 1,3 $kgCO_2/kWh$. The equation for baseline emissions is:

$$BEy = MIN(E_{d,y}\,; MSL_{ec,y}) * ((MSL_{ec,y} * EF))$$

If $E_{d,y}$ the delivered renewable electricity in kWh in a year, is higher than or equal to the $MSL_{ec,y}$ for the entire system, then MSLec is the maximum electricity consumption which can be credited. Viceversa, in this case study, $E_{d,y}$ is less than the Minimum Service Level for the entire system, therefore renewable electricity delivered constitutes the maximum amount of electricity which can be credited. Hence, the new equation for baseline emissions is:

$$BEy = (E_{d,y}) * ((MSL_{ec,y} * EF))$$

Year	Number of HH	Number of schools	MSLec,y	$E_{d,y}$	BE_y
			kWh	kWh	tCO_2e/y
1	2418	6	241350	98300	128
2	2418	6	241350	98300	128
3	2418	6	241350	98300	128
4	2418	6	241350	98300	128
5	2418	6	241350	98300	128
6	2418	6	241350	98300	128
7	2418	6	241350	98300	128
				Total tCO_2e in 7 years	**895**

Table 21: Emission reductions for PV project (GS VER)

The emission reductions correspond to the baseline emissions and are 895 tCO_2e

4.3.3 Estimation of earnings from carbon credits

The expenses for PV and hybrid system are equal to the sum of the cost of technology for the five components of the project and the other costs (human resources, travel, services etc.) as we have explained above for cookstoves. The total cost of the five components of the solar project is 173600 EUR, so the total expenses become:

Costs of PV project	EUR
Technology (A+B+C+D+E)	173600
Other Costs	616465
Total	**790065**

Table 22: PV project cost

The table below shows the amount of the outgoings for PV including the transaction costs:

	CDM	GS VER
Transaction cost (EUR)	27708	16418
Total cost (EUR)	**817773**	**806483**

Table 23: PV project cost including certification

Applying the different price scenario, the total earnings from carbon credits are estimated as in table.

	CDM revenue for different prices (EUR/y)				VER revenue for different prices (EUR/y)			
Year	MIN	MAX	Average	Standard	MIN	MAX	Average	Standard
1	41	3228	248	745	47	3632	279	838
2	41	3228	248	745	47	3632	279	838
3	41	3228	248	745	47	3632	279	838
4	41	3228	248	745	47	3632	279	838
5	41	3228	248	745	47	3632	279	838
6	41	3228	248	745	47	3632	279	838
7	41	3228	248	745	47	3632	279	838
Total EUR (7 years)	**290**	**22597**	**1738**	**5215**	**326**	**25422**	**1956**	**5867**

Table 24: Carbon revenue from PV project for different price scenarios

4.4 Case study: Biogas Ethiopia

The third case study is a project developed by LVIA in Ethiopia, in 45 villages in Oromia Regional State and SNNPRS. The rural areas of Ethiopia have a very low access to modern energy sources while the traditional energy sources (wood fuel, agricultural residue, charcoal and cattle dung) account for almost 96% of the total energy supply. The remaining 4% is shared between, petroleum derivates and electricity. In detail, electricity accounts for less than

1% of the total energy amount. In detail, oil derivates are used for indoor lighting through lamps (kerosene and acetylene) and eventually, even in far less amount, for cooking purposes. Batteries are for outdoor illumination as well as radio devices. At household level, which accounts for about 84% of the total energy consumption, the use of biomass fuel sources is even higher in percentage is analyzed: only 0.5% of the total final energy comes from modern sources, whereas 99.5% is obtained through biomass consumption. Diesel generators are mainly utilized for agro processing (milling and coffee processing) activities, whereas only in rural town generators are sometimes utilized for electricity production.

The project proposes the implementation of 1400 low-cost biogas plants (200 with latrines and 1200 without it) at household level. The construction of the schemes will be carried out in two step: a pilot phase for adaptation and preparation of promotional material and the main installation phase subcontracted to local SMEs through tender processes fully supervised by LVIA. In the first year of operation, will be installed 170 plants for a total of 1020 people, in the second year 1400 plants for a total of 8400 people.

The installed plant consists of a digestor of transparent double film tubular polyethylene. The diameter is 80 cm (equivalent to a circumference of 2.5 m), the thickness is 250 microns, and the length is 10 m for a total volume of approximately 4 m^3. The most appropriate material is that used for greenhouses since this usually contains an ultraviolet filter which helps to prolong the life of the plastic when it is fully exposed to the sun. Inlet and outlet to fill and discharge the digestor are made by PVC pipe of 150 mm i.d. Gas line from the digestor to the reservoir sack is composed of washer assembly, PVC pipe 12 mm i.d., hand made pressure release system. The reservoir sack is transparent tubular polyethylene film of 2 m^3 volume. The process of fermentation in bio-digester results in transformation of excreta into gaseous carbon dioxide and methane into anaerobic environment which prevent the survival of internal parasite and make the discharge material suitable for agriculture purposes, without health risks for the users. One lamp and one burner constitute the basic appliances kit for lightening and cooking activities. Simple latrines, constituted of a cement slab with an outlet in PVC, will also be coupled to the biogas digestor for some of the installations. For a biogas production of 1 m3/day/plant the energy output is 6 kWh/day/plant, since the resulting gas is a mixture of methane (averagely 56%), carbon dioxide and others. This fuel source is to be intended as substitution mean in order to reduce the firewood consumption. For biogas schemes of the proposed size the request in terms of fresh daily manure is from 3-4 cattle, that are available for a large strata of the population in the target areas, inclusive of medium-poor people. All material for biodigester and appliances are of local manufacture with more convenient investment and replacement cost, easer repair and lesser out of order time. The action foresees an adequate technical back-up and experience sharing among users and installers. Moreover, the supply of a biogas lamp will increase the availability and the quality of the house lighting. Summarizing, the available energy for household due to the biogas plant installation will be:

- heat energy for cooking and baking
- light energy for house illumination

The fuel substituted by the project are fuelwood (4116 ton/year) and kerosene: 25.2 ton/year.

Like cookstoves project, to perform the analysis below some strong hypothesis are necessary:

- Biogas lifetime
- Households percentage of usage

Both the hypothesis are related to the number of operational biogas during the crediting period: in fact, the first assumption is that the number of schemes is constant from the second year to the end of the crediting period implying that the working life of each biogas plant is equal to at least 7 years instead of 5, and the second hypothesis is a 100% of usage of plants by the households with no rejection for the new device.

CDM and VER Methodologies for Biogas

There are more than one existing methodologies for biogas project. The selection for the analysis is the following:

- **CDM AMS I-E** version 5.0
  Switch from non-renewable biomass for thermal applications by the user
- **GS VER Biodigester**
  Small scale biodigester

AMS-I E methodology is applicable to activities that displace the use of non-renewable biomass by introducing renewable energy technologies. Examples of these technologies include, but are not limited to biogas stoves, solar cookers, passive solar homes, renewable energy based drinking water treatment technologies (e.g. sand filters followed by solar water disinfection; water boiling using renewable biomass).

GS VER Biodigester methodology is applicable to programmes of activities involving the implementation of biodigesters in households within the project's boundaries. The individual households will not act as project participants. The consumption of biogas from the biodigesters replaces the consumption of fossil fuel and/or biomass.
Furthermore, the following conditions apply to the methodology:

- The biodigester programme promotes the wide-scale use of biogas as substitute for wood, agricultural residues, animal dung and fossil fuels that are presently used for the cooking, space heating and lighting needs of most rural households.
- The methodology applies to project with biodigesters with a maximum total biodigester volume of 20 m3

4.4.1 Estimation of emission reductions – CDM AMS-I E

It is assumed that in the absence of the project activity, the baseline scenario would be the use of fossil fuels for meeting similar thermal energy needs. Emission reductions are calculated as:

$$\mathrm{ER_y} = \mathrm{B_y} * f_{NRB,y} * \mathrm{NCV_{biomass}} * \mathrm{EF_{projected\_fossilfuel}}$$

Where:

$\mathrm{ER_y}$	Emission reductions during the year *y* in tCO_2e
$\mathrm{B_y}$	Quantity of woody biomass that is substituted or displaced in tonnes
$f_{NRB,y}$	Fraction of woody biomass used in the absence of the project activity in year *y* that can be established as non-renewable biomass (default value for Ethiopia 0,88)
$\mathrm{NCV_{biomass}}$	Net calorific value of the non-renewable woody biomass that is substituted (IPCC default for wood fuel, 0.015 TJ/tonne)
$\mathrm{EF_{projected\_fossilfuel}}$	Emission factor for the substitution of non-renewable woody biomass by similar consumers. (Default value 81.6 tCO2/TJ)

$\mathrm{B_y}$ is calculated from the thermal energy generated in the project activity as:

$$\mathrm{B_y} = HG_{p,y} / (\mathrm{NCV_{biomass}} * \eta_{\mathrm{old}})$$

Where:

$HG_{p,y}$	Quantity of thermal energy generated by the new renewable energy technology in the project (TJ)
η_{old}	Efficiency of the system being replaced (A default value of 0.10 for a three stone fire)

Considering that a daily production of biogas from domestic plant is about $1m^3$/day and NCV_{biogas} for 56% of CH_4 is $22,2MJ/m^3$, the emission reductions can be calculated.

Year	Number of biogas plant	Yearly volume of biogas	HG_y	B_y	ER_y
		m^3/y	TJ/y	$t_{fuelwood}/y$	tCO_{2e}/y
1	170	62050	1,38	918	989
2	1400	511000	11,34	7563	8146
3	1400	511000	11,34	7563	8146
4	1400	511000	11,34	7563	8146
5	1400	511000	11,34	7563	8146
6	1400	511000	11,34	7563	8146
7	1400	511000	11,34	7563	8146
				Total tCO_2e in 7 years	**49865**

Table 25: Emission reductions for Biogas project (AMS-I E)

4.4.2 Estimation of emission reductions – GS VER Biodigester

According to this methodology, the total baseline emission per household is determined by:

$$BE_h = BE_{th,h} + BE_{aw,h}$$

BE_h Baseline emissions of household h (tCO_2e/y)

$BE_{aw,h}$ Baseline emissions from animal waste handling of household

$BE_{th,h}$ Baseline emissions from fuel consumption for thermal energy needs of household h (tCO_2e/y)

The baseline emissions used to meet the thermal energy need of one household is calculated as:

$$BE_{th,h} = \sum((F_{i,bl,h}) * NCV_i * EF_{CO2i}$$

$F_{i,bl,h}$ The total amount of fuel i in the baseline situation (mass or volume) of one household

NCV_i The net calorific value (energy content) per mass or volume unit of a fuel i

$EF_{CO2,i}$ The CO_2 emission factor per unit of energy of the fuel i.

Using LVIA data and the default values of IPCC 2006, baseline emission can be calculated.

	LVIA data	IPCC 2006 default value		
Fuel type	$F_{i,bl,h}$	**NCVi**	EF_{CO2}	$Be_{th,h}$
	kg per HH	TJ/tonnes	kgCO2/TJ	**tCO_2e/y per HH**
Fuelwood	490	0,0156	112000	**0,856**

Table 26: Yearly baseline emissions from fuel consumption per HH

From LVIA document, is known that biogas scheme is fuelled by fresh manure every day and at least 3 cattle are available for each family, therefore the analysis can include the baseline emissions from animal waste handling because these can be clearly identified.
According the IPCC TIER 2 approach, the baseline from animal waste is equal to:

$$BE_{aw,h,T2} = \sum((EF_{(T)} * LC_{T,h})$$

Where:

$$EF_{(T)} = VS_{(T)} * 365 * GWP_{CH4} * \left(Bo_{(T)} * \frac{0{,}67kg}{m^3} * \sum MCF_{BL,k} \frac{1}{100}\right) * MS_{(T,k)}$$

T	Livestock category	cattle	
k	Climate zone	Africa	
$VS_{(T)}$	Daily volatile solid excreted for livestock	1,9	kg/animal/day
GWP_{CH4}	Global Warming Potential of methane	21	
Bo	Maximum methane producing capacity for manure produced by livestock	0,13	m^3_{CH4}/kg_{VS}
$MS_{(TSK)}$	Fraction of livestock category T's manure treated in the animal waste management system	0,5	
$MCF_{(BL,k)}$	Methane conversion factors for the animal waste handling system in the baseline situation	0,1	
EF	Annual CH_4 emission factor for livestock category T	0,634	**tCO_2e/animal/y**
LC	Number of animals of livestock category T in household h	3	
$BE_{aw,h,T2}$	Baseline emission from handling of animal waste for household	1,903	**tCO_2e/y**

Table 27: Yearly baseline emissions from handling of animal waste

Hence, the amount of emission reductions is shown in the table below.

Year	Number of biogas plant	Number of people	BE_{th}	BE_{aw}	ER_y
			tCO_2e/y	tCO_2e/y	tCO_2e/y
1	170	1020	873	323	1197
2	1400	8400	7191	2664	9855
3	1400	8400	7191	2664	9855
4	1400	8400	7191	2664	9855
5	1400	8400	7191	2664	9855
6	1400	8400	7191	2664	9855
7	1400	8400	7191	2664	9855
				Total tCO_2e in 7 years	**60328**

Table 28: Emission reductions for Biogas project (GS VER)

4.4.3 Estimation of earnings from carbon credits

The outgoings of biogas action are described in LVIA project document. The total cost of biogas technology is 106631 EUR and the other costs are allocated among biogas and hydro project in proportion to cost of technology and the time of the action. In this way, 27% of the other costs pertains to the biogas project.

Other costs for Biogas and Hydro	EUR
Human Resources	232126
Travel	6750
Office equipment, vehicles and supplies	58800
Local office/Action costs	57600
Services	24154
Institutional Capacity Building	19712
Administrative costs	42796
Subcontracting related to construction activities	164013
Total other costs	**605951**

Table 29: Other Costs for Biogas and Hydro

Therefore, the total costs of biogas become (Table 30):

Costs of Biogas project	EUR
Technology	106631
Other Costs	163987
Total	**270618**

Table 30: Biogas project cost

Including the cost of certification, the expenses become (Table 31):

	CDM	GS VER
Transaction cost (EUR)	28511	17362
Total cost (EUR)	**460728**	**449579**

Table 31: Biogas project cost including certification

According to the different price scenarios, the totality of revenue from carbon credits is displayed in the table below.

	CDM revenue for different prices (EUR/y)				VER revenue for different prices (EUR/y)			
Year	MIN	MAX	Average	Standard	MIN	MAX	Average	Standard
1	1874	26237	7496	8433	1744	24417	6976	7848
2	15434	216072	61735	69452	14363	201084	57453	64634
3	15434	216072	61735	69452	14363	201084	57453	64634
4	15434	216072	61735	69452	14363	201084	57453	64634
5	15434	216072	61735	69452	14363	201084	57453	64634
6	15434	216072	61735	69452	14363	201084	57453	64634
7	15434	216072	61735	69452	14363	201084	57453	64634
Total EUR (7 years)	**94476**	**1322671**	**377906**	**425144**	**87923**	**1230923**	**351692**	**395654**

Table 32: Carbon revenue from Biogas project for different price scenarios

4.5 Case study: Hydro Ethiopia

The latest case study is a project based on hydropower plants and developed by LVIA in Ethiopia, in Nansebo and Kokosa Wereda (West Arsi in Oromia) and Bensa Wereda (Sidama in SNNPRS). This African country has an enormous hydropower generating potentiality, of which only very little is exploited. Apart from big hydropower plants, which are under development by the Government, the main potentiality for the rural electrification development to be exploited consists of pico and micro hydropower plants, for the following reasons:

- ✓ big scale hydropower plants imply the extension of electrical grids, which often cannot reach rural communities;
- ✓ investment as well as operation and maintenance costs can be affordable for rural communities, in comparison with other energy supply system.

Pico and micro hydropower schemes ranges from few hundreds of watt up to 100 kW of installed power, and, since it interferes minimally with the river flow system and demands no removal of existing tree or vegetation nor wide land utilization, it can be considered one of the most environmentally benign technology. Hydro-turbines convert water pressure into mechanical shaft power, which can be used to drive an electricity generator, or other machinery. The power available is proportional to the product of head an flow rate and in the mountainous area of West Arsi and Sidamo Zone there is a good potential for installation of pico and micro hydropower schemes (mostly from 2 to 20 kW in the said area) which could satisfy the demand of electricity for communities ranging from 50 to 500 HHs at the cost of 3800 Euro/kW or 95 Euro/HH. The electricity demand arises from the needs for lighting, radio, fridges for health post, processing machines and where possible communication facilities. The proposed action is complementary for already existent electricity delivery main program (Universal Access Program) by EEPCO, because addresses off-road small communities which are not covered by grid extension.

The project of LVIA proposes the implementation of 5 pico and 5 micro hydropower plants at village level, the electrical line connection for the household and for the eventual commercial activities present in the settlement and the supplying of power pack (consisting of one CLF lamp and a socket) for each household. The installed power is to be assumed 5-6 kW for pico-level generation plants and 12-14 kW for micro-level generation plants. The beneficiary households will have 25 W connection of electricity, which is enough for energy-saving 10W CFL (Compact Fluorescent Lamp) and 15W socket for battery charger or small radio. Community public services like school, kebele office, health post will also get access to electricity, possibly with more than one 25 W power-pack. Furthermore, the possible share of energy during daytime can make available electricity for agro processing activities like milling or coffee processing. The fuel substituted is kerosene for about 88 ton/year.

The project will be implemented in two steps:

- ➢ The first year, 3 schemes (2 pico level and 1 micro level) for a total of 3300 people
- ➢ From the second year, 10 schemes (5 pico level and 5 micro level) for a total of 18500 people (3360 HH)

The total proposed power installation is 100 kW and the working time of the plants is estimated to about 16 working/hours/day.

	Pico Hydro	Micro Hydro	
Installed Power	5	15	kW
Working hours per day	16	16	hours/day
Working days per year	280	280	day/y
Yearly energy production	22400	67200	kWh/y

Table 33: Energy production from Pico and Micro Hydro plant

CDM and VER Methodologies for Hydro

As for PV project, the methodologies used for the analysis are:

- **CDM AMS-I A** Version 16.0
  Electricity generation by the user
- **GS VER Electrification**
  The GS suppressed demand methodology for micro-scale Electrification and Energization

4.5.1 Estimation of emission reductions - CDM AMS-I A

As for PV case study, according to CDM AMS I-A methodology the energy baseline is evaluated through these two equations, considering a default value of 0.8 kg CO_2e/kWh for EF_{CO2}:

$$E_{BL,y} = \sum_i EG_{i,y} / (1 - l)$$
$$BE_{CO2,y} = E_{BL,y} * EF_{CO2}$$

Year	Number of Pico Hydro	Number of Micro Hydro	EG_{iy}	E_{BLy}	ER_y
			kWh/y	kWh/y	tCO_2e/y
1	2	1	112000	124444	100
2	5	5	448000	497778	398
3	5	5	448000	497778	398
4	5	5	448000	497778	398
5	5	5	448000	497778	398
6	5	5	448000	497778	398
7	5	5	448000	497778	398
				Total tCO_2e in 7 years	2489

Table 34: Emission reductions for Hydro project (AMS-I A)

In this case, the total amount of emission reductions at the end of the crediting period is 2489 tCO_2.

4.5.2 Estimation of emission reductions – GS VER Electrification

Agree with Micro-scale electrification and energization methodology baseline emissions are evaluated by this equation:

$$BEy = MIN(E_{d,y}\,; MSL_{ec,y}) * ((MSL_{ec,y} * EF))$$

The energy delivered with hydropower action for satisfying the household requests of having a light and a socket for battery charger and the likes, is also in this case very little than the whole energy consumption referred to a Minimum Service Level of 3 kWh/day for each household (Table 20).Therefore renewable electricity delivered constitutes the maximum amount of electricity which can be credited.

Year	Number of HH	MSLec,y	Edy	BEy
		kWh	kWh	tCO2e/y
1	600	657000	112000	146
2	3360	3679200	448000	582
3	3360	3679200	448000	582
4	3360	3679200	448000	582
5	3360	3679200	448000	582
6	3360	3679200	448000	582
7	3360	3679200	448000	582
			Total tCO_2e in 7 years	3640

Table 35: Emission reductions for Hydro project (GS VER)

In this situation, without leakage and project emissions, the baseline emissions are the same of the emission reductions in ex-ante estimation. Hence, the total number of credits is 3640 VERs.

4.5.3 Estimation of earnings from carbon credits

The budget for the action is based on LVIA project document. Because the total cost includes both the implementation of biogas and hydro project in Ethiopia, the amount of expenses due to human resources, travel and administrative costs are allocated in a proportional way according to the different cost of the technologies and time of the actions. The share for hydro project is 73% of other costs.

Costs of Hydro project	EUR
Technology	287382
Other Costs	441963
Total	**729345**

Table 36: Hydro project cost

In order to apply the project to certification standard to ensure carbon credits, the total costs increase as listed in Table 37.

	CDM	GS VER
Transaction cost (EUR)	27736	16459
Total cost (EUR)	**595484**	**584207**

Table 37: Hydro project cost including certification

In the table below are summarized the possible revenue from carbon finance according to changes of price.

	CDM revenue for different prices (EUR/y)				VER revenue for different prices (EUR/y)			
Year	MIN	MAX	Average	Standard	MIN	MAX	Average	Standard
1	47	3301	283	849	53	3713	318	955
2	189	13203	1132	3395	212	14854	1273	3820
3	189	13203	1132	3395	212	14854	1273	3820
4	189	13203	1132	3395	212	14854	1273	3820
5	189	13203	1132	3395	212	14854	1273	3820
6	189	13203	1132	3395	212	14854	1273	3820
7	189	13203	1132	3395	212	14854	1273	3820
Total EUR (7 years)	**1179**	**82522**	**7073**	**21220**	**1326**	**92837**	**7957**	**23872**

Table 38: Carbon revenue from Hydro project for different price scenarios

4.6 Analysis of results

Finally, the analysis highlight two different aspects:

- Carbon credits accounting;
- Impact of carbon revenue on project cost

4.6.1 Carbon credits accounting

Displaying the results of carbon credits (equal to the emission reductions expressed in tCO2e) at the end of the crediting period, the first thing that is worth noting is the different amount of GHG emission reductions calculated applying CDM methodology or GS VER methodology to the same project.

Project developer	Technology	Methodology		Emission Reductions or Carbon credits in 7 years (tCO2e)
COOPI	Stoves	CDM	AMS-II G	24304
		VER	GS Cookstoves	40400
	PV	CDM	AMS-I A	612
		VER	GS Electrification	895
LVIA	Biogas	CDM	AMS-I E	49865
		VER	GS Biodigester	60328
	Hydro	CDM	AMS-I A	2489
		VER	GS Electrification	3640

Table 39: Carbon credits accounting

As shown in Table 39, COOPI stoves project reaches an amount of CERs (applying CDM methodology) which is 39,8 % less than the potential number of VERs. Similar results for PV project, with a difference of 31,6 % between carbon credits using CDM methodology instead of GS VER methodology.
The same discrepancy emerges comparing credits from hydro project because of the same methodologies that have been applied (CDM AMS-I A and GS VER Electrification). Finally, LVIA biogas project shows an increase of 17,3% of credits adopting GS biodigester methodology instead of CDM AMS-I E.

Comparing in detail the methods applied will highlight the differences shown in the next table.

Technology	Methodology		Main differences between methodology in estimation of emission reductions
Stoves	CDM	AMS-II G	Only CO_2 emissions during combustion are eligible
	VER	GS Cookstoves	Emissions from non-CO_2 are also considered during combustion and fuel production
PV and Hydro	CDM	AMS-I A	Emission factor of 0,0008 tCO_2e/kWh for diesel
	VER	GS Electrification	Emission factor of 0,0013 tCO_2e/kWh for diesel
Biogas	CDM	AMS-I E	Manure management not considered
	VER	GS Biodigester	Emission reductions from animal waste handling

Table 40: Main differences between methodology used

CDM methodology seems to be more conservative. The reason for the differences between the methods is mainly due to the different time when they were created. In fact, they require updates.

4.6.2 Potential impact of carbon revenue on project cost

In the ideal context, with the assumptions explained at the start of this chapter, the evaluation of undiscounted revenue gives indication of the possible impact of carbon revenue on the total cost of the project.

Estimation of the percentage of total cost of carbon revenue generated from the sale of credits is summarized in Table 41.

Project developer	Technology	Methodology		Total cost (System + Fees)	Carbon Revenue for different price scenarios at the end of 7 years (% of total cost)			
				EUR	Average	MIN	MAX	Standard
COOPI	Stoves	CDM	AMS-II G	53708	472	257	1500	386
		VER	GS Cookstoves	42712	758	414	2412	620
	PV	CDM	AMS-I A	817773	0,21	0,04	2,76	0,64
		VER	GS Electrification	806483	0,24	0,04	3,15	0,73
LVIA	Biogas	CDM	AMS-I E	460728	82	21	287	92
		VER	GS Biodigester	449579	78	20	274	88
	Hydro	CDM	AMS-I A	595484	1,19	0,20	13,86	3,56
		VER	GS Electrification	584207	1,36	0,23	15,89	4,09

Table 41: Potential impact of carbon revenue on project cost

As shown in table, the impact of carbon revenue varies according to the type of project and the price scenarios.

The results demonstrate the advantage for NGOs of accessing carbon finance through the dissemination of improved cook stoves. Also, biogas project can reduce a large amount of emissions and so accessing to carbon credits can cover a great part of the costs. However, also the other technologies can obtain some small but useful revenue. For electricity generation hydro is better than PV, according to earnings percentage. PV is disadvantage for the high costs of the project.

It seems strange a percentage too high for cookstoves projects but first, it must be remembered that this is only an ex-ante estimation of emission reductions with some ‘strong’ assumptions.
However, in order to compare the results and support the analysis, in the table below are reported some data of different systems realized by Green Market International in 2007.

Example Project	Total Installed System Cost	Net ER Revenue, 1st Year	Net ER Revenue, 10 Year Crediting	Net Carbon Revenue as % of System Cost*
1,000 PV Home Lighting Systems	$500,000	-$22,300	$2,000	0.4%
2 MW Wind Farm	$2,500,000	$29,000	$515,000	21%
1,000 Home Solar Water Heaters	$350,000	-$13,750	$87,500	25%
15 Micro-hydro Systems	$412,500	-$475	$220,250	53%
1,000 Biogas Stoves	$300,000	$11,750	$342,500	114%
5,000 Efficient Wood Stoves	$50,000	$68,750	$209,375**	419%**

*Assumptions: $7.50/tCO$_2$ emission reduction price; undiscounted 10 yr crediting; carbon market participation costs of $25,000 over the project life. Actual market participation costs, emission reductions, and equipment costs could vary considerably.
**In this example the efficient stoves are assumed to have a 2.5 year life, so emission reduction revenue is based on crediting for just 2.5 years. Due to monitoring needs, participation costs for such a project could substantially exceed the assumed $25,000, so net revenue could be substantially lower than the figures presented.

Green Markets International

Figure 52: Example of revenue potential after participation cost

Comparing in a qualitative way the values obtained, they are very similar a part from the Micro hydro project which result penalized in the analysis above.

Conclusions

The potential of carbon finance to promote NGOs' typical energy projects in developing countries has been analyzed. Some technologies, like cookstoves, PV, Hydro and Biogas can significantly reduce GHG emissions by decreasing the use of firewood and fossil fuels otherwise used for thermal and electricity needs. Households can profit from energy savings and reduced local air pollution from clean and safe energy source. It has been studied whether registration as a carbon offset project at the Voluntary Carbon Market or at CDM can help to overcome barriers as lack of awareness and high upfront costs for NGOs' energy projects. For small and micro-scale energy projects in developing countries accessing finance is one of the major constraints to expansion.

The results demonstrate that the application of a different methodology (CDM or GDS VER) does result in a different number of carbon credits because of the date and version of the method. In fact, some methodologies include emissions from other gases than CO_2, for example, or use a different value for the same emission factor.

The big difference between CDM and GS VER is the transaction costs, too high for CDM and The main disadvantages of the CDM is its bureaucracy, reflected in the lack of flexibility and the high costs and time getting through the approval process. However, this lengthy process is rewarded by the generally higher prices that will be paid for the CERs compared to cheaper VERs, which can offset the additional development costs. Nevertheless, prices for both types of offsets can fluctuate considerably. An advantage of Gold Standard is the assurance to meet sustainable development requirements. Hence, the right market for NGOs is the voluntary market.

Micro-scale is the most favorable project scale as the emission reduction will not exceed 5000 tCO_2/y during the next years. A crediting period of 7 years is recommended because the crediting period can be renewed twice.

Earnings from VER revenue are recommended to be used to cover a part of the project installation, operation and maintenance costs in order to reduce the financial barrier for NGOs, ensure long term operation of the systems and increase confidence in the technology.

The analysis of potential impact of carbon revenue highlights the advantage for NGOs of accessing carbon finance through the dissemination of improved cook stoves and biogas project. However, also the other technologies can obtain some small but useful revenue. For electricity generation hydro is better than PV, according to the earnings percentage. PV is disadvantage for the high costs of the project.

Considering the increasing interest of politician, marketing and even ordinary citizens on environmental issues, carbon market is expected to grow and can lead to significant investments in specific projects in the energy sector. Hence, carbon credits could play an important role in combating climate change and financing projects to improve energy access.

Suggestions for further work

Whereas there is much to do, methodologies can be improved by energy engineers to become more real and measurable. Hence, there is the possibility to propose to the UNFCCC some new method f estimation of emission reductions.

Another further work could be the evaluation of the impact of a specific energy technology to reduce the amount of emissions of a developing country and boost renewable energy penetration.

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