PoA BLUEPRINT BOOK

Guidebook for PoA coordinators under CDM/JI

2. Revised Edition

perspectives climate change

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

KfW BANKENGRUPPE

Published by/ Copyright © 2010
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Third printing November 2010
Frankfurt am Main

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Preface

The Programmatic CDM continues to be a major opportunity especially for small-scale project activities that reduce greenhouse gases to access the international carbon market and thus to obtain additional financing to support climate protection.

The idea of a Programme of Activity (PoA) is to aggregate small emission reductions by actors, sectors and regions, which have so far not been addressed by the traditional stand-alone project-based CDM (Clean Development Mechanism) or JI (Joint Implementation) and have not had any possibilities to obtain carbon financing for these activities. The main reason is the small and dispersed nature of the related project activities that are too small to bear the high transaction costs related with the CDM or JI.

The development of the concept of PoAs was meant to overcome this barrier by giving primarily small-scale emission reduction projects the possibility to become aggregated under the frame of the overarching PoA. This fosters the promotion of environmentally friendly activities and can support project activities such as the introduction of energy-efficient appliances or small-scale renewable energy measures such as solar water heaters or domestic biogas.

In this spirit the CMP[1] decided to introduce the “Programmes of Activities” (PoA) as a variation of the CDM.

The CDM Executive Board (EB) operationalised the concept of the PoA at its 32nd and 33rd meetings in June 2007. Considering the fact that from the meeting in June 2007 until June 2009 no PoA managed to get registered, it became apparent that there is an urgent need to adapt rules and procedures for PoAs. The EB meeting 47 in May 2009 brought some of the expected relaxations in the regulations. These changes, amongst others, relate to more flexibility in the appliance of methodologies (more than one methodology allowed in one PoA) and to the possibility to start the PoA project activities (CDM project activities - CPAs) earlier than before. Moreover, at the Copenhagen climate conference, PoA, small-scale projects and projects in countries with less than 10 registered CDM projects were given a boost. The 55th meeting of the Executive Board in July 2010 specified further how to deal with a potential erroneous inclusion of CPAs to a PoA.

Nevertheless PoAs are still facing a number of barriers and obstacles, such as the inherent complexity of the Programme Management, the transaction cost issue and the lack of seed financing and still remaining regulatory fine-tuning.

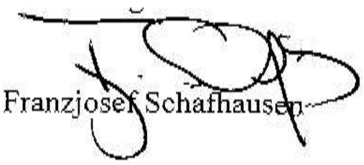
[1] Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol

Although the PoA Pipeline grew to 5 PoAs registered and more than 50 in validation in October 2010 we feel that PoAs continue to face significant barriers and costs.

The further improvement of the CDM and JI is one of the strategic objectives of the CDM/JI Initiative of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The KfW-managed “PoA Support Centre” established by the BMU continues to encourage project developers to elaborate feasible PoA ideas and to escort and facilitate the activities at least throughout the entire PoA project cycle.

The blueprint book contributes to increasing the knowledge on programmatic CDM and we are very pleased to present this second revised edition to you. The aim of this publication is to give you an update on some of the above-mentioned regulatory issues, offer a deeper insight in recent PoA case studies and enlarge the scope of the book by adding new technology chapters and an introduction to legal issues. All this is meant to encourage you to explore the opportunities presented.

We hope you enjoy reading the book or individual chapters.



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Acknowledgements

This updated blueprint book (2nd revised Version) has been developed by KfW within the CDM/JI Initiative of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and co-authored by the consulting company Perspectives GmbH. It has been refined with the assistance of high-level experts in the field of programmatic CDM/JI and CDM/JI development who reviewed the document and gave valuable input and recommendations on both shape and scope. The publisher wishes to thank the following for their unique contributions:

Roland Geres	FutureCamp
Sandra Greiner	Climate Focus
Miriam L. Hinostroza S.	UNEP Risoe Centre on Energy, Climate and Sustainable Development (URC)
Stefanie Hoelscher	FutureCamp
Jelmer Hoogzaad	Climate Focus
Adriaan Korthuis	Climate Focus
Cathy Lee	Lee International
Benoît Leguet	CDC Climat
Monali Ranade	World Bank
Charlotte Streck	Climate Focus
Sidney Thomas	Decan (Decision Analytics) Corp.
Moritz von Unger	Climate Focus
Anja Wucke	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)

PoA Support Centre Germany

KfW, on behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), supports the development of a portfolio of eligible Programmes of Activities (PoA), for which it is soliciting programme proposals.

An experienced partner for your projects, KfW offers advisory, structuring and assessment services for your programme proposals as well as financing and grants to cover the preparation of programme concepts, project design documents (PDDs) and monitoring plans. In addition, it offers its know-how to help with programme implementation and can assist with marketing expected carbon credits. Please contact the PoA Support Centre via our webpage www.kfw.de/carbonfund or email (carbonfund@kfw.de).

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AC	Air Conditioning
ADB	Agricultural Development Bank of Nepal
ACM	Approved consolidated methodology
AIE	Accredited Independent Entity
AM	Approved methodology
AMS	Approved methodology for small-scale CDM project activities
A&R	Afforestation & Reforestation
BAT	Best available techniques
BAU	Business as usual
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BSP	Biogas Support Programme
CDM	Clean Development Mechanism
CE	Coordinating Entity
CER	Certified Emission Reduction
CFC	Chlorofluorocarbons
CMP	Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol
CNISP	Chinese National Improved Cook Stove Programme
CFL	Compact fluorescent lamp
CH_4	Methane
CHP	Combined heat and power
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COP	Coefficient of performance
COP/MOP	Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol
CPA	CDM Programme Activity
CPA-DD	CDM Programme Activity Design Document
DEHSt	Deutsche Emissionshandelsstelle (Designated National Authority of Germany)
DNA	Designated National Authority
DENR	Department of Environment and National Resources
DOE	Designated Operational Entity
EB	CDM Executive Board
EERE	U.S. Department of Energy, Energy Efficiency and Renewable Energy
EIA	Environmental Impact Assessment
ENEF	Energy efficiency
ESCO	Energy service company
ERU	Emission reduction unit

ESHA	European Small Hydropower Association
EUR	Euro
GEF	Global Environment Facility
GHG	Greenhouse gas
IEA	International Energy Agency
ILB	Incandescent light bulbs
IPCC	Intergovernmental Panel on Climate Change
GTZ	German Technical Cooperation
GWh	Gigawatt-hours
GWP	Global Warming Potential
HVAC	Energy efficient heating, ventilation and air conditioning
IHA	International Hydropower Association
IRR	Internal rate of return
JI	Joint Implementation
JI PoA-DD	Joint Implementation Programme of Activity Design Document
JPA	JI Programme Activity
JV	Joint venture
kW (h)	Kilowatt (hours)
KPT	Kitchen performance test
LoA	Letter of Approval
LPG	Liquefied petroleum gas
M&V	Measurement and verification
MFI	Microfinance Institution
MLF	Multilateral Fund
MW	Megawatt
MWh	Megawatt-hours
MW_{th}	Megawatt thermal
NGO	Non-governmental organisation
NTG	Net-to-gross
O&M	Operating and maintenance
ODS	Ozone Depleting Substances
pCDM	Programmatic CDM
PDD	Project Design Document
PIN	Programme Idea Note
PMC	Project Management Contractor
PoA	Programme of Activity
PoA-DD	Programme of Activity Design Document
PPA	Power purchase agreement
PWh	Petawatt-hours
SA	South Africa
SABS	South African Bureau of Standards
SESSA	Sustainable Energy Society of Southern Africa
SHP	Small hydro power

SME	Small and medium enterprises
SSC	Small-scale
SNV	Netherlands Development Organisation
SWH	Solar water heating
Tph	Tonnes of steam per hour
TR	Tonnes of Refrigeration
TWh	Terawatt-hours
UK	United Kingdom
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
USD	United States Dollar
VITA	Volunteers in Technical Assistance
WBT	Water boiling test
WB	World Bank
ZAR	South African Rand

1. Introduction

The impacts of climate change on human development have been widely recognised and discussed in the past years, especially since the publication in 2007 of the fourth report of the Inter-Governmental Panel on Climate Change (IPCC). Experts, national leaders and the public are aware of the impact which greenhouse gases (GHG) concentrated in the atmosphere have on global climate change and global warming and the related consequences, such as draughts, flooding, changes in vegetation and loss of biodiversity. To fight climate change, many industrialised countries have committed themselves to reduce GHG emissions.

The market-based mechanisms under the Kyoto Protocol Clean Development Mechanism (CDM) and Joint Implementation (JI) allow developers of greenhouse gas (GHG) emission reduction projects taking place in developing countries (in the case of CDM) and in industrialised countries (JI) to generate emission reduction credits. In the case of CDM these credits are called Certified Emission Reductions (CERs), and in the case of JI, Emission Reduction Units (ERUs). They are tradable and can be used for compliance with the emissions commitments of the industrialised countries specified in the Kyoto Protocol and therefore can generate revenues in hard currency. So far, the CDM has mobilised thousands of projects and billions of Euro have been budgeted for the acquisition of CERs. It can thus be seen as one of the most successful elements of the global climate policy regime. Nevertheless it has to be pointed out that up to now CDM/JI has been rather limited to larger stand-alone activities like hydropower stations or landfill projects.

A Solar Home System generating electricity for a rural family in Morocco. Source: KfW photo archives, photographer: G.J. Lopata

New opportunities

In 2007 this project-based approach was enlarged to allow so called Programmes of Activities (PoAs) to be registered as CDM or JI projects. A PoA is a programme that can comprise multiple and combined emission reduction activities or projects. By aggregating the combined emission reductions of the different participants in the programme, it especially gives small and dispersed activities and projects that would be too small for the traditional stand-alone approach a chance to participate and profit from CER or ERU revenues.

PoAs constitute a new instrument and a great opportunity for different actors, such as governments, utilities, banks, municipalities and other private or public entities and institutions, to tap a low-cost GHG reduction and certification potential by doing their core business - reaching out to micro and small activities in private households, agriculture, small enterprises and the transport sector.

The additional revenue through CERs/ERUs which can be generated by the PoA is one of the main incentives but not the only one. Synergies evolve from bringing together different actors to develop new creative programmes that go hand in hand with their core business strategy and the goal of reducing greenhouse gas emissions. Opening up new client bases and penetrating different market segments might be an incentive to banks and microfinance institutions, reducing the peak demand of electricity by electricity savings an incentive to utilities in power-strapped countries. Other non-pecuniary benefits accrue for the different actors by developing PoAs.

At the same time, there are various challenges in developing Programmes of Activities. The nature of the CDM/JI project cycle, the complexity of the rules and the related transaction costs as well as the task of designing ambitious programmes leading to policy implementation and GHG reduction for multiple actors is not an easy mission. So far the experience with PoAs is relatively limited, but emerging in 2009 with the first CDM PoA registered. By the end of October 2010, 12 PoAs have been registered on the UNFCCC website (five under the CDM, and seven under JI in Germany). Additional PoAs in the pipeline[2] under the CDM are hosted in more than 15 countries all over the world and in a very wide spectrum of technical options from biogas to energy efficiency in buildings.

The seven PoAs covered by JI in Germany comprise amongst others energy efficiency at the industry level (replacement and refurbishment of low-efficiency heating boilers), at the household level (introduction of heat pumps) and fuel switching measures. They include relevant deviations from CDM regulation/guidance due to the specific JI procedures allowed under Track I.

By offering PoA blueprints for selected types of programmes, this guidebook aims to help the developer and implementer of a PoA to understand the way a PoA is generally structured as well as the specifics of the chosen project types. The blueprint book provides insights for interested private or public entities such as power utilities, development agencies or financial institutions on the rationale

[2] An overview of the current PoA pipeline (CDM and JI) including PoAs that are submitted for validation and registered PoAs is provided in chapter 12.

of different types of programmes. Consequently, it shows ways to structure PoA up-scaling experiences of the day-to-day business with carbon credit revenues.

Compared to the first version of the PoA Blueprint Book (first printed in May 2009) several rules and procedures relevant for the development of PoAs have been revised in the course of 2009 and 2010. The Conference of the Parties (COP) in Copenhagen, taking place in the end of 2009, stated the need to further streamline the PoA rules and procedures and enable PoAs to further scale up the CDM market. Furthermore a special focus has been put on CDM in Least Developed Countries (LDCs) were particularly PoAs have the potential to help overcome investment barriers and reduce CDM transaction costs compared to stand-alone project activities.

Moreover, with the first PoAs registered and a relatively large number of PoAs currently in the pipeline, the level of experience about PoAs has largely increased since the first *KfW PoA Blueprint Book* was developed. This updated version of the PoA Blueprint Book takes into account the revised framework conditions for PoA development as well as it incorporates the advanced level of experience with the still very young concept. In addition to the revised regulatory framework, this updated version includes 2 additional technology chapters (small hydro power and efficient chillers) as well as provides 3 case studies of real PoAs in three different countries. A very much needed insight on legal issues that have to be considered is given to increase the awareness of this important topic. Due to the risen PoA pipeline compared to the beginning of 2009, an overview of the current PoA pipeline for CDM and JI PoAs is also provided to enable a closer look at e.g. the preferred host countries and project types for PoA development.

In the following chapters, the guidebook provides information to help PoA coordinators to understand the specific logic and challenges in designing a PoA under the CDM/JI. They are organised as follows:

Chapter 2 gives a general orientation on programmatic CDM/PoAs by answering the following questions: Why develop a Programme of Activities, what is a PoA (basic definitions and methods), who are the actors (roles, incentives and responsibilities), how to design and implement the programme and what are the related costs of developing a PoA.

Chapters 3 to 10 show PoA business cases which are structured identically to allow the comparison of different subchapters and to allow the interested reader to navigate directly to the type of programme he or she is interested in. Each chapter introduces the background of the concerned technology and analyses key methodological issues that affect the programme design.

The following types of programmes are discussed: replacement of **incandescent light bulbs** through **CFLs** (Chapter 3), improvement or replacement of **household stoves** (Chapter 4), **domestic biogas** (Chapter 5), **solar water heating** (Chapter 6), **industrial boilers** (Chapter 7), **energy efficiency in buildings** (building refurbishment, Chapter 8), **efficient chillers** (Chapter 9) and **small hydro power plants** (Chapter 10). Based on the experiences from existing programmes, this guidebook analyses expected carbon revenues and financial requirements[3] of a "model" project under a PoA. For each technology it provides an overview of fixed and variable costs of a model programme which serves as a basis for the analysis of thresholds, in terms of carbon credit price and project size, for making the project financially attractive. Additionally, a PoA business model is proposed on the basis of lessons learnt in the relevant existing programmes.

It should be kept in mind that each programme is specific and needs to be shaped according to the local conditions, the overall objective of the PoA and the involved institutions. Therefore the analyses provided in the guidebook – in particular, the financial parameters – must be understood as examples and models. Although the blueprints cannot be copied one to one in reality, the models offer a concrete basis for understanding the key steps for the PoA design and its implementation.

Chapter 11 for the first time so far provides valuable insights in the world of legal issues for PoAs and highlights the different issues that need to be taken into consideration when designing the contractual framework of a PoA.

In **Chapter 12** three real case studies of PoAs on CFLs, solar water heaters and efficient chillers are provided to show how some real case examples are planned and set up. An overview of current PoA activities (e.g. PoAs submitted for validation) is provided in Chapter 13.

The **Chapter 13** presents an overview of the current PoA pipeline, including all PoAs that have been registered or submitted for validation. A qualitative analysis that comprises a comparison of the PoA pipeline with the CDM project pipeline in terms host countries and project types is provided in this chapter.

Chapter 14 outlines the lessons learnt from the development of PoAs under CDM and JI and the perspectives in the development of a market for PoA activities.

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[3] The financial sections are developed from the perspective of a PoA coordinator, but not from that of households or end-users. Therefore, energy savings for the end-users are not considered in the calculations.

2. Programmatic CDM/JI - an overview

This PoA blueprint book provides an orientation in the young and complex field of programmatic CDM/JI, so called Programmes of Activities (PoAs) under the flexible Clean Development Mechanism (CDM) and Joint Implementation (JI). These mechanisms allow developers of greenhouse gas (GHG) emission reduction projects in developing countries (in the case of CDM) and in industrialised countries (JI) to generate emission reduction credits.

In the case of CDM these credits are called Certified Emission Reductions (CERs), and in the case of JI, Emission Reduction Units (ERUs). Per tonne of CO_2e emission reduction, one CER or one ERU will be issued. Carbon revenues refer to the monetary value of the expected emission reductions under the PoA.

CERs and ERUs are tradable and can be used for compliance with the emissions commitments of the industrialised countries specified in the Kyoto Protocol. In the case of the CDM, the sustainable development of host countries is an important policy target that led to the requirement of approval of CDM projects by a Designated National Authority (DNA) of the host country. To avoid the creation of fictitious credits, a comprehensive system of rules has been introduced for the CDM, which is developed and managed by the CDM Executive Board (EB). Independent auditors, known as Designated Operational Entities (DOEs) are to check whether the projects or programmes conform to the rules.[4]

So far, the 'traditional' CDM approach has mobilised several thousand projects and billions of Euro have been budgeted for the acquisition of CERs. It can thus be seen as one of the most successful elements of the global climate policy regime. However, these emission reductions so far arise from single project activities in single locations in limited and very specific sectors.

2.1 Why programmatic CDM (pCDM)?

The potential of programmatic CDM to a large extend lies in high numbers of small and homogeneous low-cost greenhouse gas abatement activities. Of particular importance is the sector of demand-side energy efficiency (efficient lighting; appliances; industrial equipment like boilers, motors, pumps; fuel-efficient vehicles). However, with the right set-up programmes can provide additional benefits to many other sectors, too. Small-scale fuel switch measures

[4] In order to ease the presentation in the following, reference is made only to CDM. JI will only be treated explicitly in case of more substantial differences to CDM procedures. In general, the guiding principles for programmatic JI are very much the same as those for programmatic CDM.

in residential heating or in small and medium-sized enterprises (SMEs) are another interesting area. A considerable potential also exists for small-scale waste management activities and renewable energies.
Opportunities exist for governments, institutions and entities that have an interest in and the capacity to tap into this potential. Actual experience shows that the developers of PoAs must not be involved in carbon finance yet but must have experience in setting up programmes for a wide range of participants. Examples include but are not limited to banks with environmental finance experience, including promotional banks and microfinance institutions; utilities experienced in demand side management programmes and public sector entities like energy agencies or public authorities in the areas of environmental protection, energy, transport or housing.

Another argument for programmatic CDM is the nature of the CDM project cycle as well as the increasing complexity of the rules, which leads to high transaction costs for project activities. CDM-related transaction costs occur both before and during a project's implementation. These transaction costs constitute a barrier to the development of CDM projects, especially for small and dispersed projects which have low volumes of emission reductions if submitted as separate CDM projects. The programmatic CDM is therefore an option to achieve economies of scale and at the same time to reach wider groups of stakeholders and types of activities that are too small to be developed as stand-alone CDM projects. The programmatic CDM has therefore the potential to open sectors that have so far been almost untouched by the CDM.

In this spirit PoAs can be regarded as a climate policy instrument with a high potential to promote environmentally friendly development. Additionally, programmatic CDM is in a far better position to support and accelerate national and local climate policy implementation and to help fast developing countries to embark on a climate-friendly and sustainable development and growth path and simultaneously promote the market introduction of climate-friendly technologies.

The PoA approach opens up opportunities for the implementation of small-scale emission reduction activities in households, in the agricultural sector (see below) and in areas where the traditional CDM projects did not gain ground. That makes PoAs an excellent chance for smaller countries[5] and Least Developed Countries to participate in the global carbon market.

PoAs will find their natural niches in the field of small to medium-sized projects which are geographically and/or temporally dispersed and have a large number of project owners unknown before the start of the PoA. Reflecting the current

[5] Small countries in the CDM are defined as countries with less then 10 CDM projects.

regulatory situation and the aim of PoAs, this guidebook for PoA coordinators focuses on the following technologies that fit within these natural niches and are regarded as highly suitable for PoAs:

(1) Compact fluorescent lamps
(2) Household stoves
(3) Domestic biogas
(4) Solar water heating
(5) Industrial boilers
(6) Building refurbishment
(7) Efficient chillers
(8) Small hydro power plants

This list is of course not complete and constitutes only a small fraction of PoA opportunities. The above technologies were selected because of available first CDM experiences with these types of activities and because of the broad range of different program designs they allow to discuss.

2.2 What is a Programme of Activities (PoA)?

The PoA originates from a decision of the 2005 Conference of the Parties serving as the Meeting of the Parties (CMP) of the United Nations Framework Convention on Climate Change (UNFCCC). In general the CDM programmes, known as Programmes of Activities (PoAs), are measures that are coordinated and implemented voluntarily by private or public entities that implement policies or measures leading to real GHG emission reductions.

> … *Decides* that project activities under a programme of activities can be registered as a single Clean Development Mechanism project activity provided that approved baseline and monitoring methodologies are used that, inter alia, define the appropriate boundary, avoid double-counting and account for leakage, ensuring that the emission reductions are real, measurable and verifiable, and additional to any that would occur in the absence of the project activity (7/CMP.1, paragraph 20).

A PoA operates on the programme level and the programme activity level. The programme provides the organizational, financial, and methodological framework for the emission reductions to occur, but the programme does not actually achieve the emission reductions. Those are attained at the level of the **CDM Programme activities (CPAs)**, the specific measures through which the emission reductions are actually achieved. A CPA is a single, or a set of interrelated measure(s), to reduce GHG emissions applied in either a single or many locations of the same type, within an area that is defined in the baseline methodology[6]. This definition allows for four main types

[6] EB 32, Annex 38, page 1

of CPAs, based on whether the CPA applies a single measure or several measures, at a single location or several locations:

- Single measure, single location
- Several measures, single location
- Single measure, many locations
- Several measures, many locations

That means that a CPA can be the activity in one facility (such as a fuel switch in an enterprise or the installation of a biogas digester in one household) or can be grouped together reasonably because of the amount of activities (such as the replacement of incandescent light bulbs in a number of households or the installation of solar water heaters in households or buildings). Other criteria for grouping activities could be - inter alia - geographic, chronological or according to CER amount. By definition, the overall size of a PoA is unknown at the start of the PoA implementation. Numerous CPAs can be included under a PoA either at the time of registration or during the implementation of the PoA.

The private or public entity that coordinates the PoA is referred to as a **PoA Coordinating Entity**. The Coordinating Entity serves as the focal point for the whole PoA and is the main project participant of the programme. The operators of individual CPAs are not required to be project participants. The capabilities and capacities of the Coordinating Entity are core for a successful PoA. Hence, the identification of an appropriate Coordinating Entity as well as a comprehensive assessment and definition of tasks and responsibilities the Coordinating Entity is supposed to take on is highly recommended. The duration of a PoA cannot exceed 28 years (up to 60 years in the forestry sector), but it can be any period shorter than 28 years, depending on the type of the programme. The duration must be defined by the Coordinating Entity at latest at the time of registration.

Just as in regular CDM projects, the **crediting period** for CPAs can be either

- a 7-year crediting period (forestry sector: 20-year crediting period), renewable twice; or
- a single 10-year crediting period (forestry sector: 30-year crediting period).

CPAs can start at any time during the lifetime of the PoA (at earliest from the date of PoA registration), but the CPA crediting period will always end with the expiry of the PoA.

The physical boundary of a PoA can extend beyond the boundary of a single host country, provided each participating country provides a letter of approval from the respective CDM Designated National Authority (DNA). Hence programmes can be national within the boundary of one host country, regional, or including various countries.

Baseline and monitoring

- The **baseline** of a CDM project (including a programme) is the most plausible alternative scenario to the implementation of the project (the business-as-usual scenario). A CDM methodology determines how the baseline of a particular type of project needs to be established and how the baseline emissions shall be calculated. It also defines the modalities of determination of emissions under the project scenario. The difference between baseline emissions and project emissions constitutes the emissions reductions that can be claimed under CDM (reduced by potential leakage, i.e. emissions outside the boundary of the project). Both baseline and project emissions need to be monitored. The required monitoring procedures are also part of a CDM methodology.

A PoA can use any approved baseline and monitoring methodology, large or small-scale (SSC).[7] An important advantage of PoAs is the fact that small-scale methodologies can be applied without any limit to the size of the PoA as the thresholds for the SSC Methodologies apply for the CPA not for the PoA. Furthermore, after the revision of the rules and procedures in 2009 a PoA may apply a combination of baseline and monitoring methodologies (see section on recent regulatory updates below). An important advantage of PoAs is that the baseline for the whole programme is determined at the beginning in the **PoA design document** (PoA-DD) for the Programme of Activities. The baseline is allowed to stay consistent for each crediting period of the CPA unless a baseline revision becomes necessary because of a major methodology revision by the EB.

The choice of the methodological approach has important implications for the programme design, especially for the **monitoring requirements**. How the monitoring is conducted and who is responsible depends on the underlying methodology, the project type, the involved institutions and how the PoA is designed. It is one of the most important steps for the set up of the PoA design, to develop monitoring procedures that are in line with the methodology(ies) and that are practicable. It is crucial to define the responsibilities for conducting the monitoring precisely and in a way that enables a reliable and accurate monitoring. The PoA allows full flexibility of responsibilities between the Coordinating Entity and the CPA developers. The monitoring tasks are generally shared between the Coordinating Entity and the CPA developers.

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[7] Nevertheless, PoA-specific versions of the small-scale methodologies have to be used. The PoA-specific regulation accounts for leakage. The leakage rules basically require independent monitoring of scrapping of replaced equipment, which in some project categories can substantially increase transaction costs. In the case of fuel switch, upstream emissions have to be considered whereas regarding biomass, the leakage rules from the respective large-scale methodologies apply.

Of particular importance are the following two approaches for the quantification of GHG reductions:

(i) deemed savings approach and
(ii) measurement & verification (M&V) approach.

With the deemed savings approach, gross energy savings are estimated on the basis of stipulated values, which come from historical savings values of typical projects. The savings determined for a sample of projects are applied to all the projects in the programme. However, with the use of deemed savings there are no or very limited measurement activities and only the installation and operation of measures is verified. On the other hand, the M&V approach selects a representative sample of projects in the programme and the savings from those selected projects are determined and applied to the entire population of projects, that is, the programme. The M&V approach has been a typical approach employed in the existing CDM/JI methodologies, while the deemed savings approach is rather new, currently it is only available for one methodology that addresses CFLs (AMS-II.J, see Chapter 3).

Once methodological changes have been approved by the EB, the inclusion of all new CPAs shall follow the latest version of the most current version of the methodology. If the methodology is put on hold or withdrawn (i.e. in case of a consolidation of a methodology), the PoA shall be revised accordingly. The changes shall be subsequently documented in a new version of the PoA, validated by a DOE and approved by the EB. The EB´s approval defines a new version of the PoA and the PoA specific CDM-CPA-DD. Such revisions to the PoA are not required in cases where a methodology is revised without being placed on hold or withdrawn. While methodologies are put on hold or withdrawn, no new CPAs shall be included to the PoA in the meantime.

Documentation

A general description of the PoA, the application of the used methodology(ies) and detailed information of the GHG reduction potential and definition of a CPA have to be presented in the CDM project cycle to the UNFCCC Executive Board (EB) for registration. Furthermore, information on the additionality of the programme has to be transparently provided. The term **additionality** refers to the demonstration that both the PoA itself and each CPA would not have been implemented, or implemented to the same extent, without counting on the registration under the CDM. According to the rules for PoAs for demonstrating additionality, the demonstration has to be done at the PoA level (PoA-DD) and at CPA level (CPA-DD). The PoA itself is additional if it is shown that in the absence of the CDM,

- the proposed voluntary measure would not be implemented,

- the mandatory policy/regulation would not be enforced as envisaged but rather depends on the CDM to enforce it, or
- that the PoA will lead to a greater level of enforcement of the existing mandatory policy/regulation.

The PoA must define and include eligibility criteria, including criteria for the demonstration of additionality of CPAs, for the inclusion of a CPA under the PoA. For the demonstration of additionality for the PoA and for all CPAs to be integrated under the PoA the approved tool for the demonstration of additionality can but must not be applied. In case a barrier analysis is used, the guidelines for the objective demonstration and assessment of barriers need to be considerated.[8] On the CPA level the used methodology will determine if the use of the tool for the demonstration of additionality is mandatory.

The document in which all information relevant for the programme is presented to the EB is the design document for the Programme of Activities, the CDM Programme of Activities Design Document **(CDM-PoA-DD)**. The second important document to be developed and submitted to the EB is the CDM Programme Activity Design Document **(CDM-CPA-DD)** for the first specific CDM programme activity (project or aggregated project activities).

Furthermore a generic CDM-CPA-DD is requested (basically a template that can be used for the submission of further CPAs under the PoA). Independent auditors, **Designated Operational Entities (DOEs)** will conduct the validation of the PoA to check whether the documentation conforms to the requirements and rules. A DOE is either a domestic legal entity or an international organisation accredited and designated, on a provisional basis until confirmed, by the Executive Board (EB) and later by the CMP.

Similar to conventional CDM project activities the DOE has two key functions: first it validates and subsequently requests registration of a proposed CDM project activity and second, a second DOE verifies emissions reductions of a registered CDM project activity and confirms that the CPA certifies as appropriate. The verifying DOE than requests the Executive Board (EB) to issue the Certified Emission Reductions to the authorised institution (e.g. PoA Coordinator or CER Buyer). The “procedures for review of erroneous inclusion”[9] stipulate a liability for DOEs that include CPAs that has already affected the business behaviour of DOEs towards PoAs and hopefully will be adapted in the near future (see below).

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[8] EB Report 50, Annex 13 (http://cdm.unfccc.int/EB/050/eb50_repan13.pdf)
[9] EB Report 47, Annex 30 (http://cdm.unfccc.int/Reference/Procedures/PoA_proc02.pdf)

After the PoA is registered any CPA can be added to the PoA at any time during the duration of the PoA by the Coordinating Entity. To include an additional CPA in a registered PoA, the Coordinating Entity shall forward the completed CDM-CPA-DD form of the CPA to any DOE for consistency check. The DOE shall scrutinize the information in the CDM-CPA-DD against the latest version of the PoA and, if consistency is confirmed, include the proposed CPA(s) in the registered PoA by forwarding the CDM-CPA-DD to the EB via uploading it through a dedicated interface on the UNFCCC CDM website. The DOE, the Coordinating Entity and the Designated National Authority are automatically notified of the change in the status of the PoA.

Not formally required by the EB but generally developed in the preparation phase of a project or programme is a **Programme Idea Note (PIN),** which contains the identification of a promising PoA, a first feasibility assessment and the eligibility under the CDM or JI.
In order to prepare and structure the promising programme idea carefully and to circumvent unwanted surprises it is recommendable to invest time and resources in this initial assessment. PINs, PDDs and - if necessary - feasibility studies are essential documents to present to possible carbon buyers for their appraisal and subsequent purchasing agreements[10]. The following formal steps have to be undertaken to develop a new PoA:

[10] For more information please refer to the website of the UNFCCC, http://cdm.unfccc.int/ProgrammeOfActivities/index.html or the website of CD4CDM: Hinostroza et al. A Primer on CDM Programme of Activities. http://www.cd4cdm.org/Publications/PrimerCMDPoA.pdf (2009).

Task	Frequency	Competence required
Preparation Phase		
1. Development of the PoA idea and a PIN	Once. Initial activity	Concept development Economic/financial competence Competence to contract necessary supplementary pCDM knowledge
2. Development of PoA Design Document and CPA Design Document, including the monitoring plan.	Once. Initial activity	Concept development Economic/financial competence (p)CDM knowledge or competence to contract necessary supplementary CDM knowledge
3. Approval by designated national authority (DNA)	Once. Initial activity	Understanding of PoA-DD and CPA-DD content
4. Validation of the CDM-PoA-DD and CDM-CPA-DD through a Designated Operational Entity (DOE)	Once. Initial activity	Understanding of PoA-DD and CPA-DD content
5. Registration with the EB of the UNFCCC.	Once. Initial activity	Understanding of PoA-DD and CPA-DD content
Inclusion / Implementation Phase		
6. Check whether submitted CPAs fulfil the eligibility criteria Submission of CPA Design Documents (CPA-DDs) to DOE	Continuously to include the CPAs, when CPA-DD is finalised.	Understanding of PoA-DD and CPA-DD content
7. Operation of record keeping system for each CPA	Continuously	Organisational / programme implementation and reporting experience.
8. Implementation of monitoring with each CPA according to the monitoring methodology	Continuously	Experience to hire engineering knowledge regarding measurement equipment used; understanding of the baseline and monitoring methodology.
9. Communication with DOE regarding monitoring reports	After each request for issuance.	See above
10. Distribution of CERs to PoA Coordinator / CPA coordinator or CPA directly, depending on incentive system	After each issuance of CER.	Knowledge of the performance of each CPA and the contractual arrangements between coordinator and CPA coordinators

Table 1: Steps in PoA development

PoA versus a bundled CDM activity

Under the CDM procedures for traditional projects the opportunity to bundle several project activities exists. Bundling is defined as bringing together several CDM project activities to form a single CDM project activity.
The advantage of bundling is that bundled projects can obtain a single validation report and a single certification report for the entire bundle, which streamlines these processes for project participants. Furthermore, depending on the underlying CDM methodology, a bundle can use sampling procedures for monitoring. Bundling therefore reduces transaction costs.
However, the limits of a bundle are that

(i) it is a pre-defined, fixed structure (no activities can be added to the pre-defined bundle),
(ii) each participant in a bundle is a CDM project participant,
(iii) thresholds for simplified methodologies for small scale CDM projects (e.g. 15 MW installed capacity for renewable energy projects) apply on the level of the bundle and not only on the level of an individual activity.

These restrictions do not apply to PoAs. The key difference between a PoA and a bundle is therefore that the number and timing of projects developed under the PoA are completely flexible. Basically, bundling was designed for individual project sponsors that deal with a limited number of similar and already known activities (e.g. retrofitting of 10 boilers within one company) whereas PoAs were made for programmes that give incentives to a large number of different entities to undertake a certain type of emission reduction activity (e.g. a country-wide boiler modernisation programme run by a public agency).

2.3 The PoA coordinator and other actors

The PoA must be submitted by one coordinating or managing entity, which can be private or public. This entity does not necessarily implement the GHG reductions but rather provides the framework and incentives for the participants in the programme to do so. The Coordinating Entity is the project participant, which communicates with the EB on all matters, including the distribution of certified emission reductions (CERs). The coordinating entity has the obligation to ensure that double counting does not occur by verifying that emission reduction activities in the programme are not registered as a separate CDM project activity, nor are they part of another registered CDM programme. The minimum logistical tasks required by the coordinating entity are as follows:

- Ensure debundling SSC-CPAs (if applicable)
- Check submitted CPAs regarding eligibility
- Interface for CPA-developer and DOE for validation and verification

- Re-Validation of PoA-DD after revision of methodology
- Record keeping of submitted CPAs; collect CPAs and submit them to DOE
- Distribute issued CERs to CPA-developer
- Registration fees are to be paid to the secretariat (based on CER volume estimated in the first CPA (no fees for subsequent CPAs)
- Setting incentives for participation in the PoA
- Promoting the PoA

In designing a PoA, the PoA coordinator plays a decisive role. The coordinator must be able to define the programme concept, including the implementation arrangements. It is important that the coordinator is clear on the possible target group(s), the service or activity to implement, organisational issues involved in the start of implementation and to establish a solid idea on how to organise the monitoring. Generally the PoA coordinator will be responsible for the structure and business model of the PoA, the underlying organisation of contracts and agreements with programme partners or CPAs and the marketing of the carbon certificates (Certified Emission Reductions – CER). The PoA coordinator is also responsible for designing the incentive system that attracts possible programme participants (households or SME) to undertake the proposed measures and to manage the financial flows within the programme and in relation to the carbon buyers.

An understanding of CDM/JI-related topics is important as in most cases the design of the Programme will have to follow the requirements in the methodologies. If the PoA Coordinator does not have a thorough understanding of the CDM he should contract the necessary knowledge at the earliest stage on the international or national consulting market. Nevertheless, it is essential that the PoA coordinator has an outstanding local network (especially in the field for which the PoA is developed), credibility and a good understanding of the barriers and difficulties the target group (enterprises or households) is facing in introducing or implementing the relevant activities (e.g. energy efficiency or renewable energy measures). Another crucial capability is to be able to organise a high-quality monitoring system which is indispensable for being able to claim the achieved emissions reductions as CERs under CDM.

The starting point of PoA development is typically the determination of the required type and level of incentive a programme needs to offer in order to be attractive for its target group. Which type and level of incentive is most appropriate depends on the special circumstances of the programme implementation but also on more generic features, like the type of activity the programme intends to stimulate (e.g. retrofitting/rehabilitation of existing equipment, accelerated replacement of devices or new investment in equipment or purchases of appliances). Possible types of incentives include price discounts, grants, loans at favourable rates or simply payments-on-delivery for achieved emission reductions. Besides economic incentives, policy incentives can also be chosen if the programme consists of implementing a policy or regulation. In case of loans, up-front grants or price discounts, a financial transformation would be needed to transform future income of CER into today's financing need.

Usually PoA coordinators tend to be larger organisations with the required institutional capacity to run a PoA. However PoAs might also offer opportunities for newcomers like smaller private companies interested to venture into a new business area. Running a PoA can become particularly interesting if it has strong links to and synergies with the core business activities and interests of the PoA coordinator.

PoA coordinators can be **banks** which engage more and more in the fast growing markets for climate friendly technology. In this context programmatic CDM can become an interesting opportunity to design attractive financial products or to support traditional lending in low-carbon projects using the revenues to subsidise interest rates or shorten the loan repayment period, etc.

Energy supply companies are often main drivers of demand-side energy efficiency measures in order to reduce peaks in energy demand and to contribute to an optimisation of power generation over time. Furthermore, for many utilities, energy saving and also generation of clean energy is part of their corporate responsibility strategy. Programmatic CDM can support utilities in achieving energy savings and cleaner energy generation. In this context, programmatic CDM/JI could become an interesting instrument for utilities. **Public agencies** will benefit from introducing PoA revenues, promoting policy implementation and generating revenues to secure the operating costs of the necessary managing units of the sector policy or strategy.

In all these examples, PoA operators not only have strong links to their core business activities but also major synergy potentials. An example are monitoring procedures that can be well integrated into loan approval and monitoring processes of banks and, in particular, microfinance institutions. Utilities can build on existing customer data bases and public institutions on established institutional structures and outreach. However, PoAs also offer opportunities for smaller companies in opening a new business area for private sector activities that are primarily the domain of the public sector and of governments.

The target group or CPA has different incentives to take part in a programme. **Agricultural enterprises and households,** for example, might benefit from clean, safe and healthier energy by switching from coal or wood to biogas for cooking or lighting given the risk connected with firing for cooking or lighting.

Biogas digesters can provide farmers with organic fertiliser. In the case of energy efficiency measures, **households and small enterprises** may benefit from new and more efficient devices and technologies, a reduced energy bill or better access to loans, which could spur the economics of their businesses. The business model for a new PoA should be structured in a way that gives incentives and at the same time counts on the core competencies of all participants. However, CPA developers do not need to be formal programme participants.

Seed funding

An important point which has to be analysed carefully by the programme developer and the PoA coordinator is the necessity of seed funding. Seed funding as the term is used within this publication **does not** include the preparation costs or investment costs of a programme (such as costs for the CDM documentation or for a biogas plant or a boiler). Seed funding is the amount of funds which is needed to pre-finance the incentive. The necessity for seed funding mainly depends on the structure of the programme.

In **payment-on-delivery** programmes there is no need for seed funding. The revenues of sold certificates will be handed over to programme participants at the time of accrual, which is after the successful verification of the CPA. That means that programme participants will take the delivery risk of the CERs. This type of programme will become relevant if, for example, the barrier for participants to implement a measure does not lie in high upfront costs or missing upfront awareness-raising but, for example, in the burden of ongoing costs (such as electricity or maintenance costs). With a payment-on-delivery-approach the participants in the programme receive an ex-post payment in proportion to the achieved emission reductions.

Other types of programmes such as **grant programmes**, **loan programmes** or **supply programmes** would generally need some amount of seed funding to prefinance the incentive for the participants. This incentive could be a

- **grant** where the implementing agent offers fixed upfront grant payments to the programme participants on the condition that they undertake the targeted activities. In return for the provided grants the implementing agent will typically request the ownership of the emission reductions which it can sell in order to finance the grant programme. The delivery risk for the emission reduction will then lie with the implementing agent rather than with the programme participants (e.g. case study on Solar Water Heater, Chapter 12). Purchases of efficient household appliances (cooking stoves, refrigerators, air conditioners) are examples of activities where a grant programme could become most appropriate.

- **subsidised loan** where the carbon revenues of the programme are used to soften loan conditions in particular to bring down interest rates. Then the lender would take the carbon delivery risk and offer uniform loan conditions to each participant in the programme.

A **Supply programme** is similar to a grant programme. Carbon revenues are used to pay for price discounts or free distribution for energy efficient devices. The PoA coordinator takes the delivery risk of CERs and provides the price discount for ownership of achieved emission reductions. Supply programmes are most relevant for micro activities where the seed funding risk can be reduced to technical default, allowing a statistical approach to risk assessment such as CFL programmes.

The required **seed funding** accrues out of the need for financial transformation of carbon revenues (sold CER) into some kind of incentive payments offered to the participants of the programme. Even if these incentive payments can be financed entirely out of carbon revenues there is a need for some seed funding in the starting phase of the programme before the first generation of activities generates enough carbon revenues to pay for the incentives to be provided to the next generation. This seed funding can be provided by the PoA coordinator himself, by programme participants, by public funds, private funds (banks or other financiers), carbon buyers or international donors.

2.4 Obstacles in PoA development

Transaction costs

Transaction costs[11] under CDM comprise costs that arise during the CDM-project cycle, e.g. development of the concept and the proper CDM-project documentation and/or the development of new methodologies, hiring external auditors (DOEs), and payment of registration and administration fees under the UNFCCC.

For a Programme of Activities the transaction costs (not including operational costs of the programme itself) result, inter alia, from fixed costs for PoA development (e.g. concept development, sector studies, setting up the business model, develop necessary documentation, monitoring plans etc.), and running costs for monitoring, verification and administration.

For traditional stand-alone projects, estimates for the different transaction costs incurred prior to programme implementation (up-front transaction costs) lead up to almost EUR 200,000 (Ellis et al. 2004)[12]. However, these transaction costs

[11] For references on transaction cost elements, see Michaelowa and Jotzo (2005) as well as Cames et al. (2007)

[12] 1 USD = 0.73 EUR as on February 16th 2010 (http://www.oanda.com).

may vary depending on the underlying methodology, the project type, host country in which the PoA is planned and on the overall size and complexity of the planned PoA. Especially with more experience with PoAs and a higher number of PoAs in the pipeline, more clarity about the overall costs will be achieved.

For being able to compare the different PoA types described in this book and for being rather conservative in the assumptions made, the fixed initial CDM-related transaction costs for the PoA development are assumed to be the same for all PoA types described in the subsequent chapters. Where appropriate, cost reduction potentials are provided in the individual chapters.
The registration fee of the PoA is calculated according to the estimated GHG emission reductions from the CPA that is submitted with the PoA-DD for registration. Subsequent CPAs do not have to pay a registration fee.

The figures in Table 2 represent estimates for a PoA and are based on first experiences in PoA development.

Activity	Estimated Costs[13]	Comments
	Preparation phase	
Development of PoA idea and a PIN.	Between EUR 8,000 and EUR 15,000 plus travel expenses Up to 15 days	Without feasibility studies / field visits / baseline surveys etc. Upfront
Development of PoA Design Document and CPA Design Document, including the monitoring plan.	Between EUR 30,000 and EUR 80,000, including the monitoring plan	Using a small-scale methodology which is likely in the case of PoAs Upfront
Initial Validation of the CDM-PoA-DD /CDM-CPA-DD through a DOE	Between EUR 30,000 and EUR 50,000 upfront.	Costs for subsequent CPA inclusions by DOEs are not included and mainly depend on number and complexity of eligibility criteria of the CPAs.
Implementation concept.	Up to EUR 100,000	Incl. record keeping system for each CPA, adaptation of internal procedures, documentation etc.
Registration fee, UNFCCC[14].	Registration costs of a PoA are determined by the first CPA.	Calculation of the amount to be paid and the procedures for payment will follow the existing rules for the payment of a registration fee (annex 35 to EB 23 Report).
	Operational phase	
Monitoring reports. Installation of monitoring equipment and establishment of a monitoring database.	EUR 30,000 – EUR 100,000	Upfront and yearly expenses depending on the project type and applied methodology
Ongoing verification	Approx. EUR 15,000 – EUR 40,000	Depending on number of CPAs for which monitoring needs to be verified
Issuance fee, UNFCCC.	USD 0.10 for the first 15,000 t CO_2e; USD 0.20 for any amount in excess of 15,000 t CO_2e in a given calendar year	

Table 2: Estimated costs of the development of a PoA.

[13] We expect that international consulting knowledge is needed in the majority of the cases.
[14] No registration fee and share of proceeds at issuance have to be paid for CDM project activities hosted in least developed countries.

Each of the following PoA blueprint chapters classifies project costs into fixed and variable cost components based on the estimated costs provided in Table 2.[15]

2.5 Recent regulatory updates

In 2009 and 2010, some regulatory barriers were relieved after PoA rules were reviewed and modified by the CDM Executive Board (EB)[16]. After the update of the PoA rules and procedures in May 2009 and July 2010 a PoA can apply a **combination of methodologies** (combination of multiple approved baseline and monitoring methodologies) to the respective CPAs. Methodologies can involve one type of technology or a set of interrelated measures, as long as they are all applied in the same type of facility (e.g., all are households, all are similar industrial processing plants, etc.). The combination must be applied to all CPAs in a consistent manner. Each combination proposal is to be either checked by the relevant Panel or Working Group[17] which can cause a delay of 2.5 to 3 months. The final approval is given by the EB. The PoA coordinating or managing entity will incur the full cost of PoA/CPA-DD development and validation before the methodology check can be initiated, which in turn increases the cash at risk. In September 2010 the EB agreed at its 56th meeting that several standard combinations of small scale methodologies related to methane generation (Type III) and energy production (Type I) do not require the process of a previous approval. Prior to that, at the 53rd meeting of the Board, the combination of a biogas methodology and thermal energy was already approved (AMS-III.R / AMS-I.C). Beyond this, the small scale working group has received the task to continue its work on the extension of the list of standard methodology combinations under PoAs.

With change of regulation from now on **additionality** of each CPA has to be demonstrated through the eligibility criteria for inclusion of CPAs and not solely on the CPA level itself. For demonstration a desk review by the DOEs will be conducted without individually on-site visits at the CPA sites. This means for example once it has been determined that a certain technical equipment is additional (on PoA level), e.g. a 5 W CFL of a specific manufacturer, every CPA with the same CFL meets the additionality criteria. However, in 2010 the EB has continued its discussion on CPA additionality in several meetings. The issuance of further guidance and requirements on this topic is considered likely.

[15] The financial sections are developed from the perspective of a PoA coordinator, but not from that of households or end-users. Therefore, energy savings for the end-users are not considered in the calculations.
[16] EB 55 Annex 37-38: Latest revision of the PoA rules
[17] e.g. UNFCCC Methodology Panel, the small scale working group or the Afforestation & Reforestation (A&R) working group.

Furthermore, **no de-bundling check** has to be conducted anymore for small-scale CPAs in which each independent subsystem/measure (e.g. biogas digester, solar home system) included in the CPA does not exceed 1% of the small scale threshold[18], i.e. less than 15 kW installed capacity or 0.6 GWh annual energy savings or 0.6 ktCO_2e annual emission reductions.

The EB is requested by the Conference of the Parties (COP) to provide guidance on defining more clearly the situations in which DOEs could be held liable for erroneous inclusion of a CPA, in order to reduce barriers for the PoA validation. There are challenging **liability rules for DOEs** in case of erroneous inclusion of CPAs. While the 55th EB meeting in July 2010 has provided an updated procedure on the subject of "erroneous inclusion", the mentioned liability issues continue to provide grounds for discussion.

The EB has regulated that the validating DOE shall bear the responsibility for the (erroneous) CPA inclusion. In consequence this DOE needs to transfer an amount of CERs equivalent to the amount of CERs resulting from the concerned CPA. The DOE can be held liable for a CPA included in a PoA if the error is found during a period of 12 months after the inclusion of the CPA or within 6 months after the first issuance of CERs of the CPA.

Since the DOEs only have the mandate to conduct a consistency check of the CPAs, they rely on the information from the PoA Coordinator. Due to the prohibitive risk for DOEs they will try to pass the liability down to the PoA Coordinator. Hence, the liability conflict may be eased without additional guidance, when a shared contractual arrangement between DOEs and PoA Coordinator can be found.

Even though the PoA rules allow for either a consistency check for a sample of included CPAs or for each individual CPA, the liability of DOEs for wrongly included CPAs has lead to the tendency that DOEs are only accepting the consistency check of each individual CPA. Some DOEs also insist on having an on-site visit for each individual CPA, which is against the initial objective of reducing transaction costs by using the programmatic approach.

Additionally, PoA/CPA reviews can still be triggered by only one Executive Board (EB) member. However, CPAs can only be reviewed within one year after the inclusion of the CPA into the PoA, at the point of time of the crediting period renewal of the CPA, or six months after the issuance of CERs for that CPA. If triggered, a random sample of 10 % of all CPAs currently included in the PoA has to be checked by a DOE that is not involved in the PoA to date. So far, it is not fully arranged how those costs of the review are covered. Based on the result the EB can "extend" the review, and meanwhile no CPA can be added to the

[18] The following small-scale thresholds apply: For Type I project activities (e.g. renewable energy technology) 15 MW installed capacity, for Type II (energy efficiency) a maximum of 60 GWh annual energy savings and for Type III (other project types) a maximum of 60 kt CO2 reduction per annum.

PoA, CER issuance is put on hold and another set of 15 % of CPAs has to be reviewed.

During the COP in Copenhagen the EB was requested to further streamline certain CDM rules and procedures which may also have a direct or indirect impact on the development of PoAs.[19]

Various simplifications for example are planned and were partially implemented for CDM projects taking place in countries which have less than 10 registered CDM projects. It was decided that the registration fee for projects in such countries need only be paid after the first issuance of CERs and not as usual when the project is submitted for registration. The EB is also requested to support the development of top-down methodologies that are especially suitable for the surrounding conditions in such countries and to financially support the development of PDDs and the validation procedure for projects taking place in those countries. In order to ease the burden of transaction costs, a loan scheme for PDD development and auditing costs is envisioned.

Furthermore the EB has been requested to provide simplified procedures for proving additionality for small projects with either less than 5 MW installed capacity for renewable energy projects or less than 20 GWh annual energy savings for energy efficiency projects. A corresponding additionality guideline on these very small scale measures was approved by EB 54 (Annex 15) and is applicable to small scale as well as large scale methodologies.

Another requested simplification is related to the Grid Emission Factor determination in countries where no sufficient data is available. Beside those planned improvements for the underlying CDM rules & procedures, the insisted support for DNAs in terms of knowledge transfer and capacity building may also have further positive implications for the development of PoAs, since the PoA approach is still relatively new and many DNAs struggle to find appropriate procedures for dealing with the approval of PoAs.

Some new CDM procedures have already had a positive impact on single projects but also on PoAs. In October 2009 the EB approved general guidelines for sampling and surveys for small-scale project activities. This is especially relevant for project types where a large number of appliances are involved (e.g. compact fluorescent lamps) and where the monitoring can not be conducted per individual appliance. Since PoAs are rather suitable for project types that are more complex, and the involvement of a high number of appliances often leads to a higher complexity, these guidelines will be very helpful in terms of PoAs. Additional guidance on how sampling could be effectively applied for specific project types would further increase applicability under field conditions.

[19] UNFCCC (2009)

2.6 JI PoA - Procedures and experiences

Just as the CDM, Joint Implementation (JI) is a project based mechanism under the Kyoto-Protocol. The mechanism foresees two alternative procedures for the implementation of projects and PoAs, JI Track 1 and JI Track 2.

The rules for **JI Track 1** are defined by each JI country concerned and projects are implemented without intervention of an international governance body.

JI Track 2, by contrast, resembles the CDM with a common regulatory framework and project cycle, supervised by an international body, the Joint Implementation Supervisory Committee (JISC). The establishment of PoAs under JI is a fairly new development with Germany having had a pioneer role (under JI Track 1).

PoAs under JI Track 2

In October 2009, at its 18th meeting, the Joint Implementation Supervisory Committee (JISC) adopted procedures for JI programmes of activities (**JI PoA**) under JI Track 2.[20] As of 1 December 2009 JI PoAs can be submitted under the new procedures. JI PoAs have since been eligible for implementation in all JI host countries. Under this framework a JI PoA is defined as a coordinated action (CDM-PoA: a voluntary coordinated action) by a legal or governmental entity that implements a policy or stated goal and is comprised of one or more interrelated types of JI programme activities (**JPAs**).

A **JPA** is, analogously to the CPA under the CDM, a project activity (or an aggregation of project activities) undertaken under a JI PoA that result in additional emission reductions. The JPA is defined by the technologies and/or measures to be used and includes a selection and a justification of the baseline setting and monitoring plan chosen for each technology and/or measure.

The **demonstration of additionality**, either for a JI PoA or for each type of JPA in the JI PoA, has to be included in the Joint Implementation Programme of Activity Design Document (JI PoA-DD). At least on real case JPA of each JPA type needs to be included in the JI PoA-DD but not in an extra template as is the case with the CDM[21]. Operators of JPAs must agree to the addition of their activities to the JI PoA.

Aberrant from CDM-PoA procedures the procedures under JI do not fix the duration of the whole PoA although the starting date can not be before 2008. The crediting period of a JI PoA may extend after 2012 subject to host Party(ies)

[20] See JISC webpage at: http://ji.unfccc.int/Sup_Committee/Meetings/index.html
[21] Here a CPA-DD form and a real case CPA-DD needs to be submitted for registration and completed CPA-DDs for inclusion.

approval. The status of the emission reductions thereafter will need to be determined by an international agreement.[22]

The **inclusion process** of JPAs differs from the CPA inclusion procedure: Under JI the PoA Coordinator can directly submit additional JPAs at any time during the crediting period of the JI-PoA as long as each proposed JPA fulfils all the eligibility requirements defined in the JI PoA. JPA-submissions require completion and updating of a JPA table that is part of the JI-PoA-DD. The updated JPA-table will be posted on the UNFCCC JI website for a 30 days public stakeholder process and will then be added to the JI-PoA subject to non-objection of a Party involved or the JISC.

Within the CDM the PoA Coordinator is responsible for the CPA-DD. The inclusion though happens through the DOE which uploads the document to the UNFCCC website. CPAs must fulfil the eligibility criteria stated in the PoA-DD. No public stakeholder process is foreseen for the inclusion of CPAs.

Deviant from the CDM-PoA procedures the validating AIE is not involved in the inclusion of the JPA and therefore cannot be held liable for an erroneous inclusion. The verifying AIE needs to inform the JISC if they 'learn' of an erroneously included JPA during verification (para 46).

As with the CDM, each JPA needs to be monitored by the PoA Coordinator. "The AIE's[23] verification of the JPA shall be based on the monitoring reports of all JPAs to be verified and shall ensure the accuracy and conservativeness of the emission reductions generated by each JPA although the verifier may decide to use any common-practice auditing technique, among others, risk based assessments and/or a sample-based approach, as appropriate." (para. 45 of JI PoA procedures). In addition to and different from the CDM-PoA procedures; "The AIE shall make site inspections of at least the square root of the number of total JPAs". (para. 51 of JI PoA procedures).

In general the DOEs and AIEs are basically supposed to detect all kinds of errors during validation or verification and to react accordingly (e.g. to inform regulating body – CDM EB or JISC).

The main differences between JI PoAs (Track 2) and CDM PoAs are summarised in table 3 below.

[22] See. JISC 18th meeting, Annex 7, point 15.
[23] An AIE (Accredited Indepent Entity) is, comparable to the Designated Operational Entity – DOE, an entity responsible for validation and verification of projects and programmes.

	CDM PoA	JI Track 2 PoA
Duration of PoA	28 years PoA lifetime.	Duration of the JI-PoA is not specified or limited in the recent regulation.
Use of Methodologies	- Combination of multiple approved baseline and monitoring methodologies to the respective CPAs is allowed. - The EB approves the combination of methodologies on a case by case base. - Changes of methodologies need to be applied in subsequent CPA design or may lead to a compulsory adaptation of PoA-DD.	- JI PoAs can apply a combination of multiple approved baseline and monitoring methodologies without prior approval of JISC to the respective JPAs. - In case of methodological changes JI PoA can continue with existing documentation.
Documents required for requesting registration / determination	PoA-DD 1 generic CPA-DD 1 real case CPA-DD	JI PoA-DD including a description of each JPA-type that will be included in the JI PoA and at least one real case for each JPA-type (information on technology/ measures to be used and justification and application of the baseline setting).
Inclusion of CPAs/JPAs	Through the DOE at any time during the 28 years PoA lifetime. - Completion of a CDM-CPA-DD per CPA to be added. . - The completed CDM-CPA-DD receives consistency check by the DOE. - In the positive case the DOE includes the proposed CPA(s) in the registered PoA by uploading the CDM-CPA-DD on the UNFCCC CDM website.	Through the CE at any time during the crediting period. - Updating of a JPA table as part of the JI-PoA-DD per JPA. - The CE shall inform the JISC of the addition of JPAs directly by using the respective template (updated JPA table). - The updated JPA table is posted on the UNFCCC JI website for a public stakeholder process (30 days) and is added to the PoA subject to no-objection of an involved Party or the JISC.
Starting date	The starting date of the first CPA can not be before the publishing for the global stakeholder consultation (validation).	JPA starting date can be from year 2006 onwards.

	CDM PoA	JI Track 2 PoA
Crediting Period	- Each CPA has its own crediting period (10 years fix or 7 years two times renewable). CPA crediting periods can only start at the time of CPA inclusion or any time later. - No crediting possible beyond 28 years lifetime of PoA.	- The JI procedures do not specify the crediting period or duration of the whole JI-PoA, nevertheless the crediting of a JI-PoA can only start from 1st of January 2008 onwards. - Each JPA included over time can only generate ERUs within the overall JI-PoA crediting period.
Erroneous inclusion	Erroneous inclusion is detected by the CDM Executive Board or Parties involved.	Verifying AIE detects erroneously included JPAs and informs JISC.
Verification		AIEs may use a sample-based approach to verify PoAs.
DOE liability	Validating DOE is held liable for the erroneous inclusion of CPAs.	No AIE liability under the Kyoto rules in case of erroneous inclusion.
Additionality	Demonstration of additionality on PoA Level and on CPA Level (pre-defined criteria shall be used on CPA level).	Demonstration of additionality either on PoA Level or for each type of JPA (both within the JI-PoA-DD).

Table 3: Main differences of key rules between PoAs developed under JI Track 2[24] and CDM.

By the end of October 2010 seven PoAs have been registered under JI – all of them in Germany. Nevertheless Project Developers in other countries are working on PoAs that will soon enter the published PoA Pipeline.

In general the development and implementation of JI projects under **JI Track 1** allows for different procedures, set up by **host countries** and following their own specific requirements. In particular, Track 1 JI projects do not require the involvement of the JISC. Nevertheless they need to be in accordance with the national regulations of the JI host and investor country. Only host countries that fulfil the complete JI eligibility criteria[25] are eligible to verify the emission reductions or their storage in sinks and to issue the relevant Emission Reduction Units (ERUs) under Track 1. It needs to be mentioned that at present only ERUs that fall in the period from 2008 – 2012 are guaranteed (see above).

The German Emissions Trading Authority (DEHSt) elaborated already in 2008 simplified (Track 1) procedures for JI PoAs in Germany that deviated from the PoA-CDM procedures mainly on the following aspects: a) inclusion, b) verification, c) methodology. In these areas the German Track 1 anticipated the core elements of the later JI-PoA track 2 procedures and provided German PoAs an early start advantage.

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[24] For more information on JI Track 2 PoA Procedures see for example: JISC 18th Meeting, Annex 7 and 8. JISC 19th Meeting, Annex. Link: http://ji.unfccc.int/JI_PoA/index.html

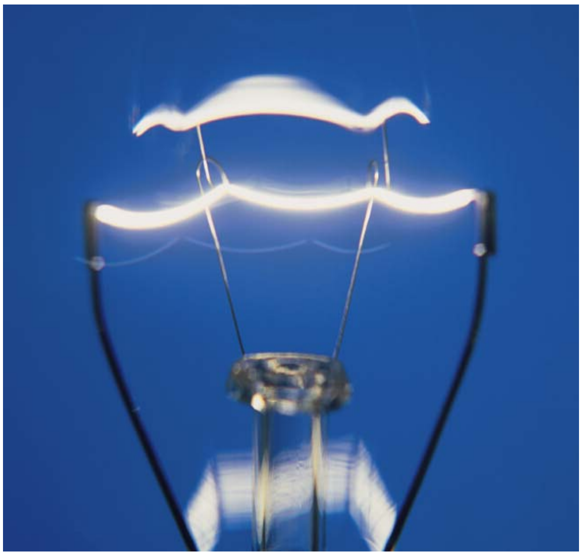
[25] According to the JI guidelines the JI eligibility criteria require, that the parties (a) are party to the Kyoto Protocol, (b) Assigned amount has been calculated , (c) implement a national system for the estimation of anthropogenic emissions, (d) implement a national registry, (e) submit their GHG inventory annually and (f) submit supplementary information on assigned amount.

3. Compact fluorescent lamps

3.1 Background

Electricity consumes massive amounts of energy worldwide. The residential sector contributes to the electricity consumption to a large extent and the part which lighting consumption plays is estimated to reach up to 28% (Mills 2002). Huge energy savings and CO_2 reductions could be achieved by introducing energy efficient lighting. The most popular example of energy-efficient lighting is **compact fluorescent lamps** (CFLs).

CFLs consume only 20% to 25% of the energy used by **incandescent light bulbs** (ILBs), the conventional lighting technology, with the remaining 75% to 80% wasted as heat. In contrast, a CFL uses all of its electricity input to produce light. CFLs also have much longer lifetimes with rated life spans of 5,000 to 25,000 hours compared with 1,000 hours on average for ILBs. Although CFLs have much higher initial costs than ILBs (about 20 times higher), they are far more economical on a life cycle basis due to their longer lifetimes and energy savings potential. The total lighting costs for 10,000 hours use are estimated to be ca. EUR 18 for CFLs and EUR 58 for ILBs (IEA 2006). Therefore, replacing ILBs with CFLs is a win-win-win solution with benefits from a climate, economic, and – by reducing system load and/or the consumption of primary fuels exposed to international market risks - energy security perspective (Lefévre et al. 2006).



Incandescent light bulb.
Source: KfW photo archives, photographer: Thomas Klewar

However, in many potential CDM countries the penetration rate of CFLs (especially high quality) is still very low, especially in the residential sector. The high initial costs have been the biggest barrier to CFL dissemination, particularly for poorer sections of the community. Coupled with the initial cost barrier, the poor performance of first generation CFLs (e.g. cooler light colors, a tendency to flicker, and a higher rate of failure before the end of rated lifetimes) created some consumer distrust in the technology. Furthermore, lack of consumer awareness of the energy savings potential and the difficulty of altering consumer habits also contributed to the barriers to CFL dissemination (Lefévre et al. 2007). Lastly, but not the least, the split-incentives problem[26] is also an important barrier to the energy-efficient lighting technology.

The CDM/JI could help overcome these barriers, especially the initial cost barrier, by providing additional carbon revenues that can be securitised and thus mobilise upfront financing. The following sections discuss methodological and financial requirements for a CFL programme, and develop a model for CFL programme implementation building on the lessons learnt from existing CFL programmes.

3.2 Methodological requirements

In order to claim for CERs from a CFL programme, the energy savings from the programme have to be monitored and calculated first. Key parameters for the energy savings calculation, depending on the chosen methodology, include - *inter alia* – the number of CFLs installed and replaced ILBs, power rating of the CFLs and ILBs, and daily lighting usage. Alternatively, they include the number of distributed CFLs and replaced ILBs and the energy use of the CFLs and ILBs.[27]

The energy savings are multiplied by the grid emission factor to calculate the emission reductions by the programme. In determining the energy savings, there are two broad categories of methodological approaches: (i) M&V approach and (ii) deemed savings approach. The key difference between the two approaches is the degree of monitoring requirements (the former involves greater monitoring efforts since a sample of CFLs has to be monitored to estimate the average daily lighting usage in hours).

For the application of CFL distribution programmes within the CDM currently, as of October 2010, three approved methodologies exist that could generally be applied: 2 small scale methodologies (AMS II.C, version 13[28] and AMS II.J, version 04[29]) and one large scale methodology (AM0046, version 2[30]). AMS II.J is characterised by simplicity regarding monitoring and baseline determination especially compared to AM0046 and AMS II.C.

However, the majority of existing CDM projects applying CFL technology as well as the first registered PoA on CFL applying AMS II.C instead. That is mainly due to the fact that AMS II.C has been available much longer and that the first 3 CFL project activities, which were successfully registered applied AMS II.C. However,

[26] Also known as “principal-agent” barriers, in which one party makes decisions regarding the energy efficiency of a building or energy-consuming device as an “agent” on behalf of the “principal”, the party that pays the end-use energy bill. This problem might appear in new home and commercial building markets where the builders’ motivation is to minimize first (not long-term) energy costs, and in landlord-tenant relationships for residential and commercial space (ASHRAE 2007).

[27] Depending on the methodology applied to the programme, additional parameters need to be considered.

[28] AMS-II.C (version 13): Demand-side energy efficiency activities for specific technologies

[29] AMS-II.J (version 04): Demand-side activities for efficient lighting technologies

[30] AM0046 (version 02): Distribution of efficient light bulbs to households

the majority of CDM CFL projects recently planned and currently in the CDM pipeline apply AMS II.J.
Due to special requirements for the baseline (adjusted baseline) AM0046 in its current version is not a relevant choice for a PoA development.

Methodological differences between AMS-II.C and AMS-II.J

By using **AMS-II.J, which is only applicable for efficient lighting in the residential sector,** CERs can be earned only for the rated lifetime of CFLs (i.e. rated life to 50% failures). For the daily lighting hours a default value of 3.5 hours can be used or alternatively a continuous baseline measurement campaign of usage hours of at least 90 days must be conducted[31]. Another important implication for the programme design is that AMS-II.J requires at least one of the following measures:

- (i) A direct installation of CFLs;
- (ii) A minimal price charged for the CFLs;
- (iii) A limitation of CFLs per household to six.

The latter criterion is probably relatively easy to meet. The most significant difference is the extent of ex-post monitoring. AMS-II.J is based on the deemed savings approach.

AMS-II.J assumes the daily lighting usage to continue with a pre-determined value (using default values), hence does not involve ex-post monitoring of this specific parameter and reduces the associated risks of ex-post monitoring.

AMS-II.C is based on the Monitoring and Verification (M&V) approach. It requires continuous measurement of daily lighting usage or energy use of CFLs in a project sample group which is selected randomly at the beginning of the project implementation and will be fixed for the entire crediting period.

Regardless of the methodology applied, however, the project needs to inspect a sample of households annually to check whether the distributed CFLs are still in operation. This project cross check group has to be randomly selected every year.

In sum, the methodological differences imply that AMS-II.C is suitable for a programme which aims at higher risks and higher returns and which has the possibility to implement a more sophisticated monitoring system (e.g. using remote sensing technologies). AMS-II.J has a lower return but might be more secure in its returns as the monitoring requirements do not require an ex-post

[31] Compare Paragraph 12 of AMS-II.J:http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html

monitoring of daily lighting usage. The gain from the simpler monitoring requirement for daily lighting usage should be carefully compared against the possible loss in the amount of CERs.

PoA Coordinators have to keep this in mind and should check the key variables carefully at the beginning of the PoA development. They should determine the possibilities to set up a sophisticated monitoring system and compare the costs and risks with the revenues they would obtain with the more secure and easier system. A decision will also depend on the amount of planned CFLs to be distributed. On those results the decision on the methodology can be taken.

Category	Key methodological differences for application to a PoA
Ex-ante survey & implementation planning	AMS-II.C: ILB usage pattern;[32] CFL penetration rate. AMS-II.J: ILB usage pattern.
CFL distribution & ILB replacement	AMS-II.C: Direct installation and/or distribution at dedicated distribution points; no formal requirement on CFL prices or replacement of defective CFLs. AMS-II.J: Direct installation, minimal price charge for the CFLs (i.e. no give-away) or restriction of CFL distributed per household; mandatory replacement of defective CFLs.
Monitoring	AMS-II.C: Sample-group monitoring for daily lighting usage; ex-post CFL functionality check. AMS-II.J: Deemed value for daily lighting usage; ex-post sample group monitoring for CFL functionality check -> done by survey
Scrapping	AMS-II.C and AMS-II.J: Disposal of ILB to be documented and independently verified. The number of destroyed ILB to match number of distributed CFLs.

Table 4: Key methodological differences between AMS-II.C and AMS-II.J

3.3 Programme design

3.3.1 Lessons from existing CFL programmes

Based on the survey of 26 CFL programmes (not CDM) implemented in 14 countries around the world, du Pont (2007) found that the most popular CFL programme type was public awareness programmes, followed by give-away, discounted sale, testing & certification, and labelling. CFL programmes are most commonly implemented by utilities or governments, supported by manufacturers/suppliers, utilities (if they are not the implementing agency), and

[32] Option 1: Daily lighting usage and power rating of ILB, or Option 2: Energy use of ILB. AMS-II.J only allows Option 2.

retailers (du Pont 2007). These programmes have been conducted before the programmatic CDM was introduced by the UNFCCC.

Du Pont (2007) summarises the following key success factors for CFL programme implementation:

(i) promotion & marketing,
(ii) partnership with suppliers/retailers,
(iii) testing & labelling, and
(iv) subsidy/discount.

Regarding promotion & marketing, lack of consumer awareness is a limiting factor. In order to overcome the barrier, information and education need to be central to any promotional programme. In the context of partnerships with suppliers/retailers, retail delivery channels seem to be superior to direct mails due to higher installed rates and groundwork laid to promote adoption (Skumatz and Howlett 2006). The quality of CFLs is a key to successful programme implementation. Testing & labelling can help alleviate consumer distrust in CFLs due to the poor performance of early generation CFLs.

The biggest barrier of high initial costs can be overcome by providing a subsidy/discount. However, it should be kept in mind that too much subsidy/discount could devalue the product and might lower the effectiveness of a programme. Charging a certain amount of fee will tend to increase the adoption of distributed CFLs for actual usage and will curb resale.

It is also important to note that successful CFL programmes combined several measures to address multiple barriers (Lefévre et al. 2006). For example, the effectiveness of subsidy and give-away programmes (initial cost barrier) can be increased by parallel efforts to raise public awareness (information/behaviour barrier) and to ensure the product quality by testing & certification (technological barrier).

3.3.2 Business model and institutional requirements

Building on the lessons learnt from the CFL programmes described above, a CFL PoA business model is conceptualised in Figure 1. This business model is only one possibility to structure the Programme as other options regarding the different actors and their roles and responsibilities are possible. The PoA coordinator could as well be a CFL supplier, a public energy agency, a large ESCO or other. The structure of the business model should be oriented towards the core competencies of the different actors, especially the core interests and strengths of the PoA coordinator. The figure summarises the key actors and their responsibilities.

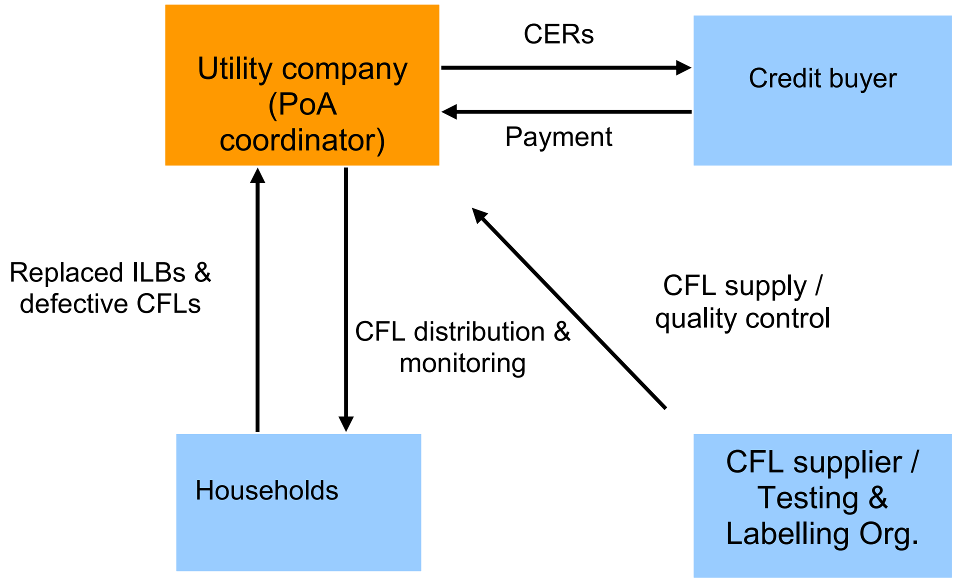


Figure 1: CFL programme business model example

The model strives to address the barriers to CFL penetration in the following manner:

- Initial cost barrier: CFL distribution for free or at discounted prices[33]. The CFLs are procured at production cost.
- Technological barrier: CFL testing & labelling to ascertain the quality of CFLs; free replacement of defective CFLs (e.g. one-year guarantee)
- Information/behaviour barrier: Awareness raising by a utility company, CFL supplier, and retailer

Aim of the PoA: The aim of the PoA is to enhance the penetration of CFLs by bringing down the price of CFLs, which has been the biggest barrier to the technology penetration. The carbon revenues are utilised to recover the balance of costs. This would lead to reduced energy costs for households and longer durability of CFL compared with ILB.

Target group: The CFLs are distributed to grid-connected households, which currently use ILBs.

[33] The difference to the stove programmes described below is that the target households are not as concerned about lighting costs. While the fuel costs for stove users are a very high proportion of the expenses of the households and thus awareness is not a problem.

Managing entity: The PoA coordinator is a utility company with a very strong logistical capability and excellent local network to enable an effective monitoring. CFLs come from local production or are imported.
As the PoA coordinator, the utility takes care of the CFL distribution and replacement of ILBs, free replacement of defective CFLs within a year, safe disposal of used CFLs, and awareness raising of the CFL programme. In case of use of remote sensing equipment, it develops the technical specifications for the monitoring equipment used and administers sample selection, installation of meters and data collection. The utility customer database is an asset for establishing a database for household random sampling required for the monitoring (the utility customers fulfil the eligibility requirement for household participation, i.e. grid-connected households). In case of remote sensing monitoring, data collection should be done centrally by the PoA coordinator. If this is not the case, the utility company performs the monitoring of daily lighting usage and CFL functionality check as they regularly have to go to each customer household to meter its electricity consumption.

Actors involved: Besides the power utility and the households, the business model involves one or more CFL suppliers, either local or international, to secure the timely provision of a large amount of high-quality CFLs. In addition, the involvement of a testing & labelling organisation helps to assure the quality of the distributed CFLs and overcome the customer distrust that the first-generation CFLs created. Furthermore, retailers can support the CFL distribution process. The retailers are often well-equipped for promotional and awareness raising activities, which is central to any CFL programme. Also, the use of barcodes can significantly simplify the distribution process for retailers (Skumatz, Howlett 2006). These actors could receive an incentive out of the CER revenues if necessary to change business habits or promotional activities. The subsequent contractual structure needs to be coordinated by the PoA coordinator.

Different compact fluorescent lamps to save energy. Source: KfW photo archives, photographer: Thomas Klewar

Programme implementation:

- The PoA coordinator shall prepare all necessary contractual arrangements with the CFL suppliers, the testing & labelling organisation, and the retailers. The PoA Coordinator organises awareness raising activities for the CFL programme. The testing & labelling organisation should set the minimum quality standard of the CFLs. If appropriate, the retailers can help distribute the CFLs and organise the awareness raising activities. In case of remote sensing monitoring, the PoA coordinator would issue the tender for the equipment, define the sample, install the equipment in the sample households and collect the data. In case of monitoring through physical checks in the sample households, the utility should be responsible for the monitoring of daily lighting usage and functionality of the distributed CFLs.
- Even though not compulsory anymore, an ex-ante survey in the proposed project area would be highly recommended to gain more clarity on the underlying assumption (lamps to be replaced, wattages of replaceable ILBs) for calculating the CER volume.. The ex-ante survey shall be based on randomly sampled households in the area, so the utility customer database needs to be provided by the utility company. According to the results of the survey, a detailed project implementation plan shall be established. The key issues are the number, power rating, and lumen output of CFLs to be distributed / ILBs to be replaced. As the energy saving of a SSC-CPA project under the PoA is capped by the 60 GWh/year threshold, careful consideration of these items is indispensable. The logistics for the CFL distribution is also key to the implementation plan.
- The CFLs have to be distributed either door-to-door or through centralised distribution channels. A door-to-door distribution is labour-intensive and requires substantial time and costs. Therefore, it is important for the project viability to streamline the distribution process and reduce the associated costs. One possibility for the cost reduction is to ask local NGOs to distribute the CFLs because they are often well informed about the local geography and CFLs are not very complicated technology even for non-technicians to deal with. Another possibility is to involve local retailers and utilise the existing business relationship with the CFL supplier. How to organise the process depends strongly on the actual working procedures of the utility. If customers are visited at home regularly it would be the easiest to exchange the CFLs then and take care of the requirement to collect all the ILB and take responsibility for their destruction, verified by a third party.
- Monitoring should be conducted by the PoA coordinator. When applying AMS II.C the daily lighting usage is to be monitored at sample households

which are chosen from the utility customer database. Along with their customer visit for metering the electricity consumption, they can also read the daily lighting usage meters and check if the distributed CFLs are still in operation or not. The monitoring procedures require physical inspection at respective sample households.[34] In case of applying AMS II.J for the daily lighting usage a default value of 3,5 hours per day can be taken instead of metering. The physical inspection at respective sample households would need to be done as well. These procedures have to be integrated into the utility's existing business procedure.

3.4 Carbon revenues and financial requirements

3.4.1 Carbon revenues

Taking one of the most advanced CDM projects on CFL distribution in India as a case study, Table 5 summarises key parameters for CER estimation of this specific programme.

Number of households	Number of CFLs to be distributed	Average daily lighting usage	Weighted average power rating [W]	Grid emission factor [tCO_2e/ MWh]	Annual amount of CERs	Annual amount of CERs per CFL
400,000	530,000	4.0 hours	ILB: 98 CFL: 19.9	0.81	41,500	0.08

Table 5: CER estimation of a model CFL programme[35].

The CER potential largely depends on the programme design and the location. It would be highly recommendable to conduct an ex-ante survey at the location where a programme is planned. It would help the programme developer find out which lamp types exist and the potential number of lamps that can be replaced. This can vary extremely between countries, states and even villages.

One of the most distinctive features of the financial requirement of CFL programmes is that this programme type in general only allows for one main revenue stream coming from the sale of CERs. Otherwise, the additionality would be difficult to demonstrate due to the low life-cycle cost of CFLs.

Depending on the programme design, additional minor revenue streams might

[34] If remote sensing monitoring equipment is used for the daily lighting usage monitoring, the physical inspection at households in the sample group(s) is not necessary.

[35] Note: The project is based on AMS-II.C (version 09). As opposed to AMS-II.C (version 10 following), it does not take transmission & distribution loss into account for the emission reduction calculation. Hence, the transmission & distribution loss is not included in the table.

occur (e.g. when distributing the CFLs for a minimal fee)[36].

3.4.2 Financial requirements

According to the Indian CFL programmes, the total costs for CFL procurement are EUR 3.3 – 5.8/CFL, including CFL production and ordering costs of EUR 3.0 – 5.0/CFL and other programme costs (transport, tax & duty) of EUR 0.3 – 0.8/CFL. It should be kept in mind that these programmes are using the highest quality CFLs with an average lifetime of at least 15,000 hours. Depending on the quality standards of the CFL technology used, the specific investment costs per CFL vary. It is recommended to use high quality CFLs to ensure the life-cycle of the device.

If door-to-door distribution is used and cannot be accomplished during the usual business activities of the power utility as PoA coordinator, it might easily sum up to be the biggest cost component in the development of CFL PoAs as this process tends to be labour-intensive and requires a large number of people for the distribution.

The cost of the distribution can be very low if, for example, a local NGO is willing to assist voluntarily or normal procedures of the utility personnel can be used. Other options to distribute CFLs include, for example, central distribution by inviting the households to pick up the devices on a special CFL date at a central point or by distributing CFLs during the regular visits of the power utility etc. The way this is implemented depends on local networks and local possibilities of the PoA Coordinator. The way the CFLs are distributed is not determined in the methodologies. Traceability of the installation of every single CFL and the safe disposal of the light bulbs has to be ensured by the PoA coordinator, for example by using the utilities' data and/or consumer awareness processes.

Once the distribution of CFLs is completed, the operational costs are minor, except for the costs for conducting the monitoring.

Some additional revenues might be generated depending on the programme design (e.g. a minimal fee charge for CFLs). But as these revenues and the revenues of the selling of the CERs will only accrue at a later stage the pre-financing or seed funding issue is often a barrier to programme implementation. Even if a small-scale methodology is applied, programmes involve greater complexity in design and implementation than most other CDM programme types. By nature, these programmes involve a high number of appliances in numerous locations (e.g. households) in a geographically dispersed area, which requires a highly sophisticated organisational structure. In particular, costs for the

[36] The Indian project aims to distribute CFLs for free or for a minimal fee. In case a fee is charged, it will not be higher than 15 Indian Rupees (INR), which is comparable to the price of an ILB (e.g. INR 15 is around EUR 0.26)

logistical efforts (e.g. CFL distribution, ILB replacement and safe, certified disposure, necessary training for distribution and monitoring teams) should not be underestimated. Possible providers of seed funding can be (at least partly) the buyer of the CERs, international and local financial institutions, international CFL producers or public funding, either international or national.

The cost overview of a model CFL CDM programme is summarised in Table 6, assuming distribution of 530,000 CFLs, a CFL lifetime of 10 years, and a monitoring sample size of 200 households. It is estimated for a model CFL programme based on AMS-II.C. For the model CFL programme the estimate assumes advanced remote sensing monitoring equipment for the daily lighting usage. If conventional equipment is used, the upfront cost becomes lower and the annual cost higher (as physical inspection of the sample households will be necessary). In addition, although not a mandatory requirement of the CDM/JI, safe disposal of CFLs is recommended to increase public acceptability of a CFL programme.
Like all other fluorescent lamps, CFLs contain a small amount of mercury. Experiences with CFL safe disposal have been concentrated in industrialised countries, so authentic cost estimates of such an exercise in developing countries are not publicly available and need to be assessed in the preparation of the Programme. Therefore, the cost overview below does not account for safe disposal of CFLs.

Cost components		**Upfront (EUR)**	**Annual (EUR p.a.)**
Fixed costs	Programme design and CDM documentation	up to 200,000	30,000
	Monitoring	70,000	3,000
	CDM fees	50,000	30,000
Variable costs	CFL procurement	4.50 per CFL	-
	CFL distribution and ILB replacement[37]	0.51 per CFL	-
	Other costs	-	< 0.01 per CFL

Table 6: Overview of the estimated costs of the model CFL programme (nominal)[38]

For this specific example with 530,000 distributed CFLs, the nominal costs per CFL would thus reach EUR 5.6 upfront plus EUR 0.1 annually.
This generates the following attractiveness table, assuming no significant revenues are earned from the CFL distribution. The annual CER per CFL are

[37] Assumed person-month required: 7 months for experts, 100 months for local skilled staff, and 1,000 months for ground-work staff.
[38] Note: Distribution of 530,000 CFLs; CFL lifetime of 10 years; Monitoring sample size of 200 households. The CDM methodologies require the monitoring only in the sample households. It is assumed in this report that the sample size is 200 households, so the monitoring costs are considered fixed.

calculated using the methodological requirements. The determinants are, inter alia, the operating hours per day, baseline penetration, grid emissions factor etc. For details please refer to chapter 3.2 on methodological issues.

Annual CERs per CFL	CER minimum price for break-even (EUR)	CER price for IRR of 15% (EUR)
0.16	6.5	7.8
0.08	13.0	15.5
0.04	25.9	31.0

Table 7: Indicative level of CER prices and CER per CFL required for break-even & IRR of 15%[39]

Furthermore, the financial information of the model programme allows for the calculation of the critical programme size to achieve financial viability. The following CER revenue levels are considered for the analysis, assuming a CER price of EUR 12 and annual CER generation per CFL of 0.04, 0.08 (as in the Indian case) and 0.16. Based on the three scenarios for the CER revenue per CFL, the critical programme sizes for the break-even and IRR of 15% are summarised in Table 8.

Annual CERs per CFL	Critical size (number of CFLs)	
	Break- even	IRR of 15%
0.16	105,000	139,000
0.08	830,000	Unlikely to achieve
0.04	Unlikely to achieve	Unlikely to achieve

Table 8: Critical size of a CFL programme for reaching break-even & IRR of 15%[40]

The analysis shows that CFL programmes in countries with high baseline emission factors, low CFL baseline penetration factors and high lamp utilisation rates are financially more attractive. Nevertheless the programmes make sense everywhere. Choosing lamps with a lifetime that allows full utilisation of a 10-year crediting period is also important. The overall size of the PoA should reach at least 1 million unless it is possible for the coordinator to procure CFLs at lower costs than those achieved in current CFL programmes.

[39] Note: Calculated using AMS-II.C (v.09). Discount rate of 10% for the calculation of the break-even. (For simplification the calculation of the break-even applies a discount rate of 10% for the NPV in each blueprint.)
[40] Note: Calculated using AMS-II.C (v.09). Discount rate of 10% for the calculation of the break-even.

Key points and challenges

1. The exchange of compact fluorescent lamps for incandescent light bulbs in residential lighting has great potential to reduce electricity consumption and thereby contribute to the reduction of GHG. CFLs only consume 20% to 25% of the energy used by ILB.
2. Barriers to introducing and disseminating these ILB lie in the high initial cost, technical problems in the first generations of CFLs and in customers' scepticism and lack of awareness.
3. The programmatic CDM could help overcome these barriers by providing additional revenues from the sale of CERs to finance a price discount or the complete subsidisation of the devices.
4. Successful programmes combine a mixture of promotion and marketing measures with high-quality CFLs. Free distribution should be avoided as it devalues the product and might diminish the effectiveness of the programme.
5. The costs per CFL vary, in the case study they are EUR 5.6. The CER revenue per CFL vary between 0.4 and 0.16 t CO_2/a, depending on the baseline emissions and other factors.
6. Challenge I: In most cases the PoA developer will need seed-funding to (pre-)finance the CFLs. Seed-funding can be provided by carbon credit buyers, private investors (CFL suppliers, banks etc.) national public funds or international donors. Nevertheless this might result in a key challenge for the programme.
7. Challenge II: The monitoring needs to be feasible and cost-efficient. At the beginning of the PoA an accurate assessment of the use of the deemed savings approach or the measurement and verification approach is necessary.

4. Household stoves

4.1 Background

Despite all efforts to extend the reach of modern forms of energy, almost 50% of the world's population still prepares their food on small stoves fired by biomass or solid fossil fuels (Kammen 2007). Often, these stoves are very primitive and have an extremely low efficiency. They also lead to severe pollution of the indoor air, which causes respiratory diseases. According to Kammen (2007), these diseases kill four to five million children worldwide every year and are the leading health hazard in developing countries.

The traditional three-stone cooking device (Figure 2 c)) has an efficiency of less than 10%. Metal stoves (Figure 2 b)) achieve 10-15%. Improved stoves, such as the "Jiko" (Figure 2 a)) developed for a large-scale stove distribution programme in Kenya, reach an efficiency of 25–40%. For a detailed description of all common stove types, see GTZ (2008).

a) improved b) traditional c) three-stone fire

Figure 2: Improved compared to traditional stove and three-stone fire
Source: Kammen (2007)

Improved cook stoves contribute to the reduction of pressure on native forest and scrubland, which are frequently degraded by biomass collection. They reduce indoor pollution and can lead to substantial savings in fuel costs for urban households that have to buy their fuel on the market. They free up time for productive activity for rural households collecting fuel in forests or scrubland. The replacement of biomass/fossil fuel stoves by renewable energy-operated stoves such as solar cookers can reduce biomass use even further, but it has encountered cultural barriers (cooking is done before sunrise or after sunset, unwillingness to cook outdoors). The stoves in Figure 2 show an example of

devices that could be used in a PoA. Of course there are other technical options which might serve the specific local needs of a PoA better, such as stoves built into houses.
No solar cooker programme has been able to achieve penetration rates comparable to efficient biomass cook stove programmes. We thus do not discuss such programmes in this section. We also do not address cooking devices using biogas, as biogas will be covered in a subsequent section.

Despite their undeniable benefits, and although formal payback periods are as short as 3 months (GTZ 2008), the penetration rate of improved stoves is still very low, especially in rural areas. The initial costs of EUR 6-15 per stove have been the single biggest barrier to efficient stove dissemination, particularly for poorer sections of the community. Coupled with the initial cost barrier, the poor performance of first-generation improved stoves (e.g. cracking of ceramic components, tendency to fall over, overheating of pots) created user distrust in the technology. Trust can only be built by introducing (semi-) industrial manufacturing of stoves, which would also bring costs down due to scale effects. Furthermore, lack of consumer awareness of the energy savings potential and the difficulty of altering cooking habits also contributed to the barriers to efficient stove dissemination.

The programmatic CDM[41] could help overcome these barriers, especially the initial cost barrier, by providing additional revenues from the sale of CERs to finance efficient manufacturing equipment. The following sections discuss methodological and financial requirements for an efficient stove programme, and develop a model for efficient stove programme implementation building on the lessons learnt from existing efficient stove programmes.

4.2 Methodological requirements

In order to claim CERs from an efficient stove programme, the fuel savings from the programme have to be calculated first. Fuel use in the baseline situation depends on the efficiency of baseline stoves, the number of distributed efficient stoves and their capacity rating as well as daily stove usage. Fuel use in the project situation is determined by the efficiency of stoves distributed by the project, the number of distributed efficient stoves and their capacity rating as well as daily stove usage. The fuel savings are multiplied by the carbon content of the fuel used to calculate the emission reductions achieved by the programme; this requires knowledge of the fuel types. The methodological approach in the case of the existing methodologies useable for cook stove Programmes is the Monitoring

[41] JI is not relevant for this technology, as biomass stoves are not widely used in industrialised countries.

and Verification (M&V) approach[42] as to date, no deemed savings methodology has been approved for stove programmes.

There is no approved methodology for large-scale stove projects. For SSC projects achieving a renewable biomass firing capacity of up to 45 MW_{th} (approximately 50,000 stoves[43]) or an annual biomass savings capacity of up to 180 GWh_{th} (about 35,000 improved stoves[44]), several methodologies are available. For greenfield renewable biomass stoves replacing fossil fuelled stoves, the methodology "Thermal energy for the user with or without electricity" (AMS-I.C) is available. Improvement of fossil fuelled stoves is addressed by the methodology "Demand-side energy efficiency activities for specific technologies" (AMS-II.C). Both methodologies have been available since 2003 but have only been used by developers of solar cooker projects.

AMS-I.C (version 18) is only applicable for new, **renewable energy stoves** that replace fossil fuel ones. This is a rare condition but might exist i.e. in China. It requires measurement of the efficiency of baseline fossil fuel stoves or at least two manufacturers' specifications. Alternatively, 100 % baseline efficiency can be assumed. While M&V is not required for technologies that reduce less than 5 tCO_2e per year per application, this is not the case for biomass appliances such as stoves, where the amount of biomass used needs to be monitored.

AMS-II.C (version 13) addresses improvement of **fossil fuel stoves**. The baseline is fossil fuel use of the existing stoves. A representative sample of existing stoves needs to be checked with regard to their capacity. For a sample of stoves installed through the programme, usage hours have to be monitored.

A key question that stifled stove programmes for a considerable time was the treatment of non-renewable biomass use under the CDM. Non-renewable biomass is defined as biomass from deforestation, forest degradation and degradation of agricultural areas. The key indicator for non-renewable nature of biomass is a decrease in the level of carbon stocks on the area where the biomass is harvested. For over two years, projects reducing use of non-renewable biomass were not eligible. Only in December 2007, two non-renewable biomass methodologies were approved: (i) switch from non-renewable biomass for thermal application by the user (AMS-I.E), and (ii) energy efficiency measures in thermal applications of non-renewable biomass (AMS-II.G).

[42] See Chapter 2.2 for short descriptions of the deemed savings and the Monitoring and Verification approach to determine fuel savings.
[43] This assumes an average power of 1 kW per stove, which might be an overestimate for the small portable stoves generally used.
[44] According to Bailis et al. (2007a), the average savings per stove is about 50 MJ/stove and day, i.e. about 5 MWh_{th} per year. Then the threshold of 180 GWh_{th} is reached at around 36,000 stoves. The level can vary widely depending on the actual efficiency improvement per stove and stove usage intensity.

For the **non-renewable biomass methodologies** (AMS-I.E, version 03 and AMS-II.G, version 02), it has to be proven through a survey that non-renewable biomass has been used since 31 December 1989. This will impact on PoA preparation costs.

AMS-II.G (version 02) is the only methodology applicable to the typical improved cook stove programmes where improved biomass stoves are distributed to substitute inefficient ones. AMS-II.G has been revised in December 2009 to version 02 incorporating (a) default efficiency factors for baseline cook stoves, (b) procedures for sampling, (c) revised procedures for determination of quantity of woody biomass that can be considered as non-renewable, and (d) clarifications as to which leakage requirements are appropriate for projects versus PoAs.
The baseline is based on the assumption that in the absence of the CDM project, the fossil fuel (kerosene, LPG or coal) most typically used for cooking applications in the region/host country would have been used. The CO_2 emissions factor of that fuel is multiplied by the energy content of the non-renewable biomass used before the project start and the total use of non-renewable biomass by the project.

Thus, a PoA has to determine which fossil fuel is normally used for cooking in the host country. To determine the use of non-renewable biomass, its share in total biomass used before project start has to be determined by survey methods or through historical data. For calculation of total biomass use before project start, the number of pre-project stoves has to be multiplied by the estimated average annual consumption of biomass per stove. The difference in efficiencies between baseline stove and project stove is a key parameter, which is to be determined using representative sampling methods or referenced literature values. The latter is probably easier for PoA developers, but might not be available everywhere. If the saving of non-renewable biomass leads to the replacement of renewable biomass elsewhere by non-renewable biomass, this needs to be deducted from the emissions reductions. This can lead to complicated analyses of indirect effects of the PoA.

The efficiency of a sample of stoves introduced by the programme has to be checked annually. Programme stoves that are broken and have been replaced also need to be monitored. Data on the amount of biomass saved by the programme that is used by non-project households/users have to be monitored as well. These three monitoring requirements have an important impact on PoA design.

To date, AMS-II.G has only rarely been applied due to its complexity; as of October 2010 only one regular CDM project activity was registered using the methodology.[45]

AMS-I.E (version 03) is applicable for new renewable biomass technologies, i.e. only for new stoves exclusively fired by renewable biomass. The monitoring required by the methodology should confirm the displacement or substitution of the non-renewable biomass at each location. For projects replacing non-renewable biomass with renewable biomass the quantity of renewable biomass used shall be monitored, since it is unlikely in most projects that the use of only renewable biomass is ensured. In almost all situations where biomass is used in developing country contexts for cooking and heating, some biomass is likely to be non-renewable.

Any project activity has to ensure and document in details the supply and consumption of renewable biomass sources and any leakage in the production of renewable biomass must be considered using the general guidance on leakage in biomass project activities.[46] AMS-I.E uses a similar approach for the baseline determination and monitoring as AMS-II.G (see above).

Until October 2010, AMS-I.E counts with three regular CDM project activities that were registered using the methodology.

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[45] UNFCCC CDM Project activity 2711: Efficient Fuel Wood Stoves for Nigeria

[46] Compare for example UNFCCC Project 2969 : CDM LUSAKA SUSTAINABLE ENERGY PROJECT 1

For all the methodologies, it is advantageous to include the scrapping of replaced stoves to avoid loss of CERs due to the need to calculate emissions from utilisation of the replaced stoves elsewhere.
Table 9 shows the differences between the methodologies theoretically applicable for stove programmes.

Category	Key methodological differences
Applicability	AMS-II.G: Stove improvement using (partly) non-renewable biomass. AMS-I.E: New stoves using exclusively renewable biomass. AMS-II.C: Stove improvement using exclusively fossil fuels. AMS-I.C: Replacement of (exclusively) fossil-fuelled stoves by biomass stoves.
Biomass source	AMS-II.G and AMS-I.E require a survey or historical data to prove that non-renewable biomass has been used since 31 December 1989. AMS-II.C and AMS-I.C do not require such data.
Monitoring	AMS-II.G and AMS-I.E: Share of non-renewable biomass in total biomass used by stoves before project start. Check of efficiency of all appliances or a representative sample of baseline stoves as well as programme stoves (annually) to ensure that they are still working at the spec. efficiency or replaced. Non-renewable biomass leaked to non-project participants. AMS-II.C: Usage hours and capacity of a stove sample. AMS-I.C: Total biomass use.

Table 9: Key methodological differences between AMS-II.G (version 02), I.E (version 03), I.C (version 18) and II.C (version 13)

Monitoring of stove efficiency is based on international standards initially developed at a Volunteers-in Technical-Assistance (VITA) Conference in 1982, involving donors and other institutions. Several procedures were established (Smith et al. 2007). However, Bailis et al. (2007a) show that monitoring efficiency under laboratory conditions ("water boiling test", WBT, see Bailis et al. 2007b) gives strongly differing results from monitoring under kitchen conditions ("kitchen performance tests", KPT). The former sometimes gives lower energy efficiency for improved stoves compared with traditional ones, while kitchen-based tests showed a clear reduction of fuel use through the introduction of efficient stoves, albeit with a wide range (see Bailis et al. 2007a). Programme developers should therefore be extremely careful in the choice of stove model and do testing with a small group of users. Otherwise, negative surprises regarding CER volume are possible.

4.3 Programme design

4.3.1 Lessons from existing efficient stove programmes

Since the 1970s, international donors and aid organisations have tried to disseminate improved stoves through several hundred projects spread throughout dozens of countries. These efforts range from national initiatives that have introduced more than 180 million stoves for rural Chinese households (Ergeneman 2003) to village training programmes in East Africa in which small groups of women learn to build and maintain their own stoves (for links to a few of the programmes see REPP 2007). It has to be kept in mind that the programmes presented hereafter were designed without using the CDM mechanisms.

Mixed experiences

History shows that successful stove programmes are rare and require good preparation and cultural understanding. The development of the Kenya ceramic *Jiko* programme, which distributed over one million stoves, is a good case study. The first improved stoves began to appear in the early 1980s and were designed by aid groups such as UNICEF and CARE Kenya. The response from stove users was mixed at best. The designers, mainly natives of the U.S. and Europe, had not done sufficient field testing. In one of the first models, the stove's opening did not match the size of most pots. Key design improvements were achieved by user groups and small-scale stove manufacturers. Schools, churches and businesses started to buy the stoves, setting an example for individual households. Penetration of the Jiko is over 50% in urban areas but much lower in rural areas. This shows that even at prices of EUR 2-5 per stove, the financing barrier for people with low opportunity costs of time and the ability to collect fuel "for free" is prohibitive. Therefore, a "light" version of the Jiko was developed costing just EUR 0.8; its design was strongly influenced by women's groups (Kammen 2007).

The large stove programme in India suffered from low utilisation rates due to an emphasis on distributing large numbers of stoves for free without raising the awareness of the rural population regarding benefits of the improved stoves (Ergeneman 2003). Moreover, the programme had a complicated structure with unclear roles for the different government agencies involved.

Based on the survey of efficient stove programmes implemented in India, China, Eritrea, and Ethiopia, Ergeneman (2003) found that programmes should include incentives for stove utilisation, ramp up quickly to utilise scale effects and encourage competition between stove suppliers. He sees an annual increase of dissemination by 5% as the maximum long-term expansion rate of a stove programme.

The Chinese success story

The most successful programme was implemented in China (Smith et al. 1993), where now 70% of rural households operate an improved stove. The Chinese National Improved Stove Programme (CNISP) started in 1980 under the leadership of the Department of Environmental Protection and Energy within the Ministry of Agriculture. The CNISP promoted the use of approximately 10 different types suitable for users in different regions of China, mostly made of prefabricated cast iron, ceramic, or concrete slabs. Besides conducting stove research, the government confined itself to clearing away bureaucratic hurdles, giving local energy offices the responsibility for technical training, and setting standards for manufacturing production. Direct government subsidies paid to the stove suppliers cover 10% of the cost of the average stove, and including government wages and foregone taxes increase to 15%. Most households had to pay most or all of the costs of stove purchases and installation. Nevertheless, direct subsidies to households did feature in the CNISP. Subsidies mostly ranged from 10% to 40% of the cost of biomass stove purchases and installation (Sinton et al. 2004). The organisation bypassed the provinces by addressing 1,500 Rural Energy Offices on the county level, which competed for a limited number of support contracts with dissemination target levels. These offices decided on the types of stoves that should be disseminated. The Rural Energy Offices at the provincial level monitored the awarded contracts through standardised inspections of a specified subset of households. Stoves in at least 30 homes were randomly sampled and 90% had to achieve a minimum of 18% thermal efficiency. Only then could a county obtain its final payments from the national central government (Smith 2007, Bailis et al. 2007).

Lessons learnt

The lesson from the stove programmes is that giving stoves away for free is unlikely to be effective. Programmes that focused on support to stove suppliers to expand production and utilise scale effects coupled with quality control of stove production have been the most effective ones. This generates a challenge for CDM, as PoAs that support the scale-up of production and sell stoves at a price that is lower than the current market price might face challenges in additionality determination, given that improved stoves are financially attractive already at current market prices.[47]

[47] For details and further information please refer to, inter alia, GTZ publication: Carbon Markets for Improved Cooking Stoves. http://www.gtz.de/en/themen/umwelt-infrastruktur/energie/20674.htm.

4.3.2 Business model and institutional requirements

Building on the lessons learnt from the efficient stove programmes described above, an example of an efficient stove PoA business model is conceptualised in Figure 3. The figure summarises the key actors and their responsibilities. It has to be kept in mind that other options (e.g. private company / NGO specialised in commercialising cook stoves, etc.) regarding the different actors and their roles and responsibilities are possible. The development of the business model should be oriented towards the core competencies of the different actors, especially the core interests and strengths of the PoA coordinator.

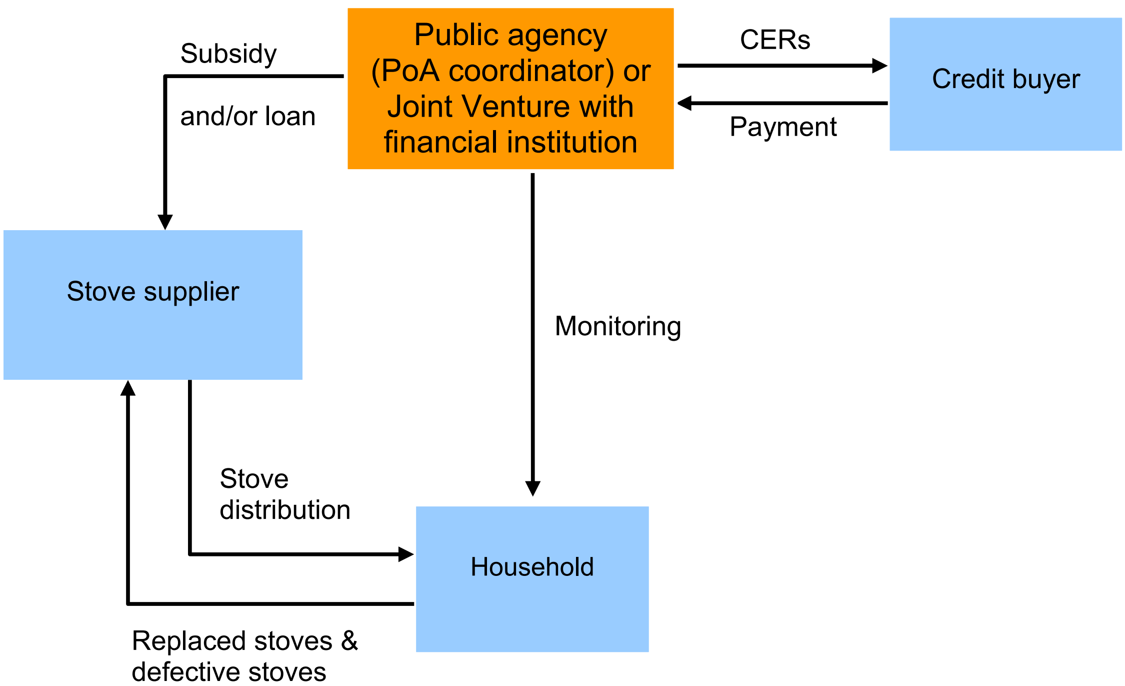

Figure 3: Efficient stove programme business model example

The model strives to address the barriers to efficient stove penetration in the following manner:

- Initial cost barrier: efficient stove distribution at reduced prices due to increased scale of production and some additional discount. Free distribution is ineffective as utilisation rates will be low in that case (see the Indian example compared with the Chinese success). Obviously the degree of discount should be commensurate with the purchasing power of the target population.

- Technological barrier: support of producers to switch from artisanal to factory-level stove production. Efficient stove labelling is required to ascertain the quality of efficient stoves; replacement of defective stoves at nominal cost within one year.
- Information/behaviour barrier: awareness raising through NGOs

Aim of the PoA: The aim of the PoA is to enhance the penetration of efficient cook stoves by making stoves more affordable through subsidisation of effective production processes. This allows offering the products at reduced prices. The carbon revenues are utilised to recover the balance of costs. In addition to the reduction of greenhouse gas this would lead to reduced indoor air pollution and better health conditions mainly for persons living below or close to the poverty line. The time for collection of biomass as fuel would be saved.

Target group: The efficient cook stoves are distributed to households, which currently use cook stoves of low efficiency. Most probably the target group comprises mainly women.

Managing entity: The PoA coordinator is a public agency with a very strong logistical capability and excellent local network in areas that are normally not conducive to business activities. These qualifications are indispensable to lead the complex programme implementation steps such as stove production support, distribution and monitoring. The PoA coordinator is responsible for the financial transformation (e.g. providing a subsidy to stove suppliers and/or buyers or introducing a soft loan) and takes a lead in monitoring. To increase sales, a joint venture with a financial institution could be envisaged to enable a micro-credit facility for stove buyers.

Actors involved: Besides the public agency, the financial institution and the households, the business model involves stove suppliers. They are responsible for efficient stove distribution to households, scrapping of replaced stoves, and free replacement of efficient stoves failing in the first year.

In addition, the involvement of a testing & labelling organisation helps assure the quality of the efficient cook stoves. Also, local NGOs or rural energy centres (if available) could assist in the stove distribution and monitoring as well as raising awareness of the efficient stove programme.

Programme implementation: First of all, the PoA coordinator is to prepare necessary contractual arrangements with the stove suppliers, the testing & labelling organisation, and the local NGOs or rural energy centres. The PoA coordinators should pay the stove suppliers a lump sum per stove produced sufficient to cover the price discount and to allow expansion of high-quality production. A substantial amount of pre-financing should be provided to enable early up-scaling of production capacity. Stove suppliers should also receive a CER share because this provides an incentive to produce long-lasting stoves and to market them to the right target group.

Secondly, the PoA coordinator needs to conduct an ex-ante survey of randomly selected households in the project area. The key issues for investigation are: stove usage pattern, efficient stove penetration rate, and non-renewable biomass usage in the area. According to the results of the survey, a detailed project implementation plan has to be established. The key issues are the minimum quality standard for efficient stoves, the number and efficiency of the efficient stoves, and logistics for distribution of the efficient stoves. As the energy savings of a SSC CPA under the PoA are capped by thresholds which are determined by the different methodologies, careful consideration of these items is indispensable.

Thirdly, the efficient cook stoves have to be distributed either door-to-door or through centralised distribution channels. As is the case with CFL distribution, the process is labour-intensive and requires substantial time and costs. Possibilities for cost reductions include, but are not limited to: assistance by local NGOs, a rural energy centre and/or retailers.

If a micro-credit facility is part of the PoA, monitoring can be linked to the payment of instalments, where bank agents perform the KPT when they collect payments. The introduction of a MFI would require the training of bank employees in the application of the KPT. Furthermore the role of a financial institution might be strengthened further if it is used to determining the flow of funds, or handing over financial incentives to the end users or stove suppliers, e.g. if soft loans are included. Programmatic CDM/JI can become an interesting opportunity for a MFI to design attractive financial products or to support traditional lending in this type of project. If there is no micro-credit facility, the PoA coordinator can hire a rural energy centre or local NGO to implement the monitoring. It is important to build up on existing networks the PoA coordinator or other institutions have to arrange the monitoring as efficient and effective as possible at the lowest possible cost.

Another key factor for the design of the Programme is the accurate consideration of consumer habitats. In order to be successfully implemented the programme has to take the cooking habitats and the behaviour of potential participating household into account. Otherwise cultural barriers, i.e. cooking at a certain time of the day or the unwillingness to cook outdoors, could be the crux of the matter.

4.4 Carbon revenues and financial requirements

4.4.1 Carbon revenues

Taking one of the few programmes on efficient stove distribution evaluated under CDM aspects as a case study[48], Table 10 summarises key parameters for CER estimation.

Number of efficient stoves to be distributed	Share of non-renewable biomass	Annual biomass usage (t/stove) in baseline	Stove efficiency (%)	Energy use (GJ/stove)	Fossil fuel emission factor (tCO_2/GJ)	Annual amount of CERs	Annual amount of CERs per stove
785,000	98%	1.2 wood 2.5 charcoal	Baseline: 16 Project: 25	Baseline: 93 Project: 60	0.06	1,550,000	1.97

Table 10: CER estimation of a model efficient stove programme (based on AMS-II.G v. 01)
Source: Data provided by GTZ (2006), own calculations. The baseline fossil fuel would be LPG.

The CER potential depends on several key factors. A project implemented in an area with a low share of non-renewable biomass will have a low CER generation rate. Likewise, the baseline biomass utilisation can vary widely. Stove efficiencies can vary widely, even among stoves of the same design. The emissions factor of the baseline fossil fuel is another important parameter. Altogether, the CER potential can vary by more than an order of magnitude. The parameters of the Senegalese PoA are all on the optimistic side; they would allow the generation of 2 CERs per stove and year[49]. Normally, non-renewable biomass would make up a much lower share – around 25% to 50%. At 25%, annual CER volume per stove would reach 0.5 CERs, at 50% 1 CER.

As in the case of other demand-side energy efficiency activities, efficient stove distribution allows for one main revenue stream coming from the sale of CERs. If there are more income options (e.g. through governmental support) the additionality needs to be argued carefully and oriented to the different barriers the PoA would encounter. The additionality argumentation could include, for example (depending on the local situation), the barriers caused by large transport, access or awareness costs, especially when the programme serves remote and poor communities.

[48] The data have been provided by the GTZ - Programme to Promote Rural Electrification and a Sustainable Supply of Domestic Fuel in Senegal, which is currently elaborating PoA documentation for its component FASEN ("Foyers améliorés Sénégal"). For detailed information see www.peracod.sn.
[49] Van Buskirk (2004) reports 2.3 VERs per stove for a project in Eritrea, but uses a much less conservative methodology.

Free distribution of stoves might lead to careless handling and low utilisation rates, as shown in past stove dissemination programmes. The design of the programme will also determine the amount of seed funding required. This is especially the case if the programme is not a pure payment-on-delivery but needs a financial transformation to cover up-front grants or soft loans. However, efficient stoves lead to substantial fuel cost savings and, due to the resulting short payback period, can be seen as a financially attractive option.

4.4.2 Financial requirements

Due to the short lifetime of new cook stoves disseminated by a CDM project (i.e. between 1 and 3 years), the project costs have a cyclical aspect. After initial distribution, costs fall for 2 years to increase again once the first major replacement is required. Depending on the organisational structure this might be complicated, as old stoves have to be recovered and disposed. So, even if only a 10-year crediting period is aimed at, a good organisation for replacement has to be in place. In particular, costs for the logistical efforts (e.g. efficient stove distribution and necessary training for distribution and monitoring teams) have to be calculated carefully.

The efficient stove procurement costs range from EUR 1 to EUR 30 per stove. In the large stove dissemination programmes in China and India, stove costs reached around EUR 15 (Engeneman 2003), in African programmes around EUR 6. The distribution of efficient stoves is likely to take the lion's share mainly because of the need for hiring a large number of people for the distribution team (e.g. if a person is able to distribute 10 stoves per day, dissemination of 100,000 stoves requires about 50 person-years)[50]. We have to point out that the way to distribute the stoves or organise the replacement depends on the possibilities the participating actors see in developing the programme. It might well be possible to sub-contract a local microfinance institution (MFI) or a local NGO depending on the network that exists in the geographical boundary of the programme.

Monitoring costs are sensitive to the sample size and the spatial dispersion of sample households. Instruments used for the kitchen performance test (KPT) cost about EUR 900 per set. Labour costs vary widely across different developing regions – particularly for technically skilled personnel, which in Africa have wage levels half of those paid in Latin America.

[50] If distribution efficiency can be improved, this will have a crucial impact on project costs.

In terms of labour time for each pair of stoves tested, a KPT could take anywhere from 10 person-days for a small sample of tightly clustered households to 40-50 person-days for a rigorous and statistically significant large sample of widely dispersed households (Bailis 2008). The water boiling test can take 1-2 person-days for each stove pair tested.

Transport costs should also be considered and would be highly sensitive to the area and sample design; Bailis (2008) sees them at EUR 15 per person-day spent testing. Hulscher et al. (1999) give a rough estimate for staff requirements of different phases of a stove dissemination programme. Combined with the values provided by Bailis (2008), they present the calculations in Table 11. The analysis assumes distribution of 1 million stoves, stove lifetime of two years, and a monitoring sample size of 200 households.

Cost components		Upfront (EUR)	Annual (EUR p.a.)
Fixed costs	Project design and CDM documentation	200,000	30,000
	Monitoring[51]	3,000	36,000
	CDM fees	50,000	30,000
Variable costs	Efficient stove procurement	6.00 per stove	-
	Efficient stove distribution and baseline stove replacement[52]	1.30 per stove	-
	Other costs	-	0.02 per stove

Table 11: Overview of the estimated costs of the model stove programme (nominal)[53]

[51] Assumed costs for purchase & installation of monitoring equipment (flow meter, instruments used for the kitchen performance test) at 200 households (sample group) and set up of database are EUR 3,000 upfront. Annual costs of EUR 36,000 comprise the required physical inspection and meter reading at the stove (assumed person-months required for the annual monitoring: 2 months for experts, 40 months for local skilled staff, and 50 months for ground-work staff).

[52] Assumed person-month required: 6 months for experts, 44 months for local skilled staff, and 6,300 months for ground-work staff.

[53]Note: Distribution of 1 million stoves; stove lifetime of 2 years; monitoring sample size of 200 households.

In the African context, nominal costs per stove would reach EUR 7.80 upfront plus EUR 0.10 per year. This generates the following attractiveness table for annual CER volumes of 0.5, 1 and 2, respectively, assuming no significant revenues are earned from the stove distribution.

Annual CERs per stove	CER minimum price for break-even (EUR)	CER price for IRR of 15 % (EUR)
2	2.3	2.4
1	4.5	4.8
0.5	9.0	9.6

Table 12: Indicative level of CER prices and CERs per stove for 1 mio. stove programme required for break-even & IRR of 15 %.[54]

The financial information of the model project allows for the calculation of the critical project size to achieve financial viability.

The following CER revenue levels are considered for the analysis, assuming a CER price of EUR 12. Based on the three scenarios for the CER revenue per stove, the critical project sizes for the break-even and IRR of 15% are summarised in Table 13.

Annual CERs per stove	Critical size (number of stoves)	
	Break-even	IRR of 15 %
2	13,500	13,900
1	34,000	36,500
0.5	145,000	180,000

Table 13: Critical size of a stove programme for the break-even & IRR of 15%[55]

Stove programmes are quite attractive once the challenge of determining the share of non-renewable biomass is overcome. In a situation with a share of non-renewable biomass of more than 50%, already the distribution of 50,000 stoves makes commercial sense. However, programme design has to set incentives for high stove utilisation rates.

[54] Note: Discount rate of 10% for the calculation of the break-even.
[55] Note: Discount rate of 10% for the calculation of the break-even.

Key points and challenges

1. Almost 50% of the world's population prepares their food on small stoves fired by biomass or solid fossil fuels that generally have a low efficiency and high consumption of non-renewable biomass or fossil fuels.
2. Barriers in introducing and disseminating more efficient stoves include high initial costs of the devices, high transaction costs, low product quality and a lack of consumer awareness of the energy savings potential.
3. The programmatic CDM could help overcome these barriers by providing additional revenues from the sale of CERs to finance efficient manufacturing equipment.
4. Programmes that focused on support to stove suppliers to expand production and utilise scale effects coupled with quality control of stove production have been the most effective ones. Consumer habits must be considered for a successful introduction of the new stove type.
5. The first key challenge is a careful investigation of the baseline of the programme, especially if households that use mainly dung, waste or other renewable energy for firing the baseline reductions are too small to legitimate the development of a PoA.
6. The second key challenge is the design of an appropriate structure of the business model working together with actors that possess the necessary local network to

5. Domestic biogas

5.1 Background

Greenhouse gas emissions from firing as well as methane emissions from manure contribute to a very high extent to the global warming process. This makes fuel switch from non-renewable biomass or fossil fuels or manure management through anaerobic bio-digestion interesting for CDM/JI. Livestock breeding takes place not only in large scales in animal production farms, but also in smaller scales in rural areas at the individual level.

On the individual level, biogas plants are much less prevalent but could ideally be implemented with small-scale fixed domes with a capacity of just a few cubic meters. In this chapter **small-scale farming** activities with only little livestock are focused. Methane recovery plays therefore a smaller role and fuel switch is the most important measure to implement.

Nepalese cattle farmer feeding manure to his biogas plant.
Source: KfW Entwicklungbank, Biogas Support Programme - Nepal

Besides preventing methane emissions, the biogas can be used at households where normally fossil fuel or firewood is combusted e.g. for heating, lighting or cooking, generating emission reductions through the fuel switch. The average lifetime of a bio-digester is above 20 years (van Nes 2007).

As discussed in the stove chapter, such fuel switch will reduce indoor pollution and reduce drudgery related to fuel wood collection. The availability of at least 20 kg dung per day allows running of a small bio-digester (SNV 2005), two cows or seven pigs provide enough fuel to meet the daily cooking needs of a rural family (Teune 2007). At the end the slurry residue out of the digester is no waste but a valuable fertiliser.
Even though the above benefits seem to be obvious, small bio-digesters are in practice not the commonly used technology at the household level. The dissemination is mostly hindered by the high initial cost of the digester, which ranges from EUR 200 to EUR 400. Most of the rural households in developing countries, especially middle and low income households, have difficulties in accessing financing from commercial banks. A survey of biogas CDM projects showed that the bio-digester investment is between 60 and 80% of an annual

family's income (UNFCCC 2008). In Asia a payback period of a digester is expected to be 2 to 3 years (Teune 2007).
Furthermore, the digester is a very sensitive technology that needs surveillance of trained staff. In rural areas, this kind of knowledge is not common. Also aggravating is that the handling of dung and excrements is a taboo in some cultures. Thus, an awareness raising campaign should not only inform potential users about the technology and benefits, but also aim at overcoming the reservation about the use of animal waste.

A few projects already tried to disseminate domestic bio-digesters. The biggest and most widely known are the Biogas Support Programmes (BSPs) in Nepal and Vietnam, which were implemented by the Netherlands Development Organization (SNV) jointly with other partners such as KfW Development Bank. They aimed at dissemination of nearly 200,000 biogas plants in different phases. Other ones were implemented in China, India and Africa. The programmes were mostly dependent on external investors and ODA.
The outcome of the early programmes was that the financial attractiveness would highly depend on the size of the bio-digester (Karnel 1999). Smaller bio-digesters scattered across remote areas are less financially attractive than installations in smaller farms with a higher density of animals. Due to the larger number of animals, farmers can use bigger bio-digester types. In addition, the increasing management effort for dispersed activities can easily eat up the revenue from biogas projects at the household level.[56]

To overcome these barriers the programmatic CDM approach is necessary to increase the income of the domestic biogas programmes.

5.2 Methodological requirements

The first step for a domestic biogas project is the identification of an area where large quantities of manure exist and/or there is the potential for fuel switch. As of February 2010 two small scale (SSC) methodologies exist for the mitigation of methane emissions of manure management. These are: AMS-III.D "Methane recovery in animal manure management systems" (version 16), and AMS-III.R "Methane recovery in agricultural activities at household/small farm level" (version 01). For the energetic use of the recovered methane, the following methodologies are currently available: AMS-I.C "Thermal energy for the user with or without electricity" (version 18), and AMS-I.E "Switch from non-renewable biomass for thermal applications by the user" (version 03).

[56] For further information please see, inter alia, UNEP "A Primer on CDM Programme of Activities" (2009) and UNEP, CD4CDM Working Paper Series, Working Paper No. 8, "PoA CDM Manual - Mini Biogas Plants for Households" at http://cd4cdm.org

As a PoA benefits from the application of a SSC methodology without being limited to the SSC threshold (that is 60 kt CO_2e), the following analysis focuses on SSC methodologies. Therefore, ACM0010, a large-scale methodology for this technology category, is out of the scope.

AMS-III.R can only be used in combination with AMS.-I.C so that in this case the two methodologies play a role, this is because the production of biogas (methane recovery) needs to be destructed by the end use in for cooking, heating, electricity or other thermal energy uses.

Methane emission avoidance: The two methodologies focus on different target groups for manure handling. AMS-III.D is applicable in livestock production units, whereas AMS-III.R aims at rural households which have just a couple of animals for their livelihood. Therefore, the most suitable methodology for domestic biogas projects is considered to be AMS-III.R.

AMS-III.R (version 01): In the application of AMS-III.R, annual emission reductions at each household are limited to 5 t CO_2e. The amount of anaerobically decayed manure has to be determined by an ex-ante survey. The projects in the pipeline using AMS-III.R show that one could generate nearly 3.5 t CO_2 reductions per year with 2 to 3 cattle. Also, capturing methane from manure of 4 to 5 pigs reduces emissions between 0.5 and 0.8 t CO_2e per year. On one hand, the emission reduction range points out that the AMS-III.R threshold of 5 tCO_2e/a is sufficiently high to accommodate normal domestic biogas programmes. On the other hand, it shows that a PoA must involve a large number of households to generate a significant amount of CERs. The project size ranges from 10,000 to over 30,000 involved households (UNFCCC 2008). Due to reasons of conservatism the methodology applies a default factor for the physical leakage rate of the bio-digester of 10 %.

The monitoring of bio-digesters is conducted with a sample group. This sampling approach implicates that not all the bio-digesters have to be equipped with monitoring devices, but just a small number of randomly chosen bio-digesters.

Use of biogas methane as energy source: AMS-III.R only covers the anaerobic decay of manure. For the energetic use of the recovered biogas, it refers to AMS-I.C.

AMS-I.C (version 18) is designed for renewable thermal energy for users who previously generated heat with fossil fuels. It allows for the use of simplified monitoring for projects that reduces emissions less than 5 t CO_2e/year per bio-digester (for more details, see Chapter 6 “Solar water heating”). In the past, AMS-I.C was used to cover the switch from non-renewable to renewable biomass, but the current version excludes the option (see Chapter 3 “Household stoves”). The applicable methodology for the switch from non-renewable biomass is AMS-I.E (also see Chapter 4 “Household stoves”). The version 18 of AMS-I.C includes in its applicability criteria biomass based cogeneration project activities supplying surplus electricity to a grid. Table 14 summarises the key methodological differences of the methodologies potentially applicable to domestic biogas programmes.

Category	Key methodological differences
Applicability	AMS-III.R: Mitigation of manure methane emissions (annual emission reductions per bio-digester is limited to 5 tCO_2e/a. AMS-I.C: Biogas use replaces fossil fuels. AMS-I.E: Biogas use replaces non-renewable biomass.
Biomass source	AMS-I.E requires a survey to prove that non-renewable biomass has been used since 31 December 1989. AMS-III.R and AMS-I.C do not require such survey.
Monitoring	AMS-III.R: Survey of operating systems, average operation hours, animal population and waste generated and fed into digester and the proper soil application of the digester. AMS-I.C: Survey of operating systems, average operating hours and total biomass use. Simplified monitoring procedures are available if the annual emission reductions per bio-digester is less than 5 tCO_2e/a. AMS-I.E: Share of non-renewable biomass in total biomass used before project start. Efficiency of a sample of baseline equipment as well as project equipment (annually). Efficiency of equipment broken and replaced. Non-renewable biomass leaked to non-project participants.

Table 14: Key methodological requirements of AMS-III.R (version 01), I.C (version 18) and I.E (version 03)

After all, the decision on which emission reduction options the PoA should aim at, i.e. methane reductions or the fuel switch depends on the potential of each option in the concerned area. Generally no substantial amounts of methane are produced if manure is spread on the fields or piled in small stocks, the only source of emission reduction for this cases is then the replacement of fossil fuels or the use of non-renewable biomass.

An important restriction appears for a PoA business model due to the methodological requirement. The two methodologies favourable for PoAs, i.e. AMS-I.C and AMS-III.R, offer the simplified monitoring procedure for small projects (< 5 t CO_2e/year per bio-digester). Although domestic biogas programmes are normally below this threshold, PoAs shall carefully investigate the issue to be able to use the simplified procedure.

5.3 Programme design

5.3.1 Lessons from existing domestic biogas programs

Mendis and van Nes (2001) summarise the key success factors of the BSP Nepal as follows:

- Identifying the most appropriate and cost-effective design for the product before launching a wide-scale dissemination programme;
- Establishing and enforcing solid design, quality and service criteria that will ensure the reliable and cost-effective operation of installed plants;
- Identifying the key institutional players and assisting in strengthening the capacity of these players to effectively carry out their respective roles;
- Securing the commitment and support of financial institutions to work in close partnership for the dissemination and financing of the product;
- Designing and applying financial incentives needed to stimulate the market and attract buyers in a manner that is uniform, transparent, and easy to administer.
- Ensuring that financial incentives reach the target groups to bring down prices of the biogas plants.
- Providing technical and management support to all key players;
- Instituting coordinating committees to ensure the cooperation and partnership of stakeholders, and
- Sufficient resources for product support and market development.

The successful biogas programme model shows the need for a multi-facet approach for programme implementation.

5.3.2 Business model and institutional requirements

Building on the lessons learnt from the CFL programmes described above, a domestic biogas PoA business model is conceptualised in Figure 4. It has to be kept in mind that other options (e.g. public agency or cooperation with various bio-digester suppliers etc.) regarding the different actors and their roles and responsibilities are possible. The development of the business model should be oriented towards the core competencies of the different actors, especially the core interests and strengths' of the PoA coordinator. The figure summarises the key actors and their responsibilities.

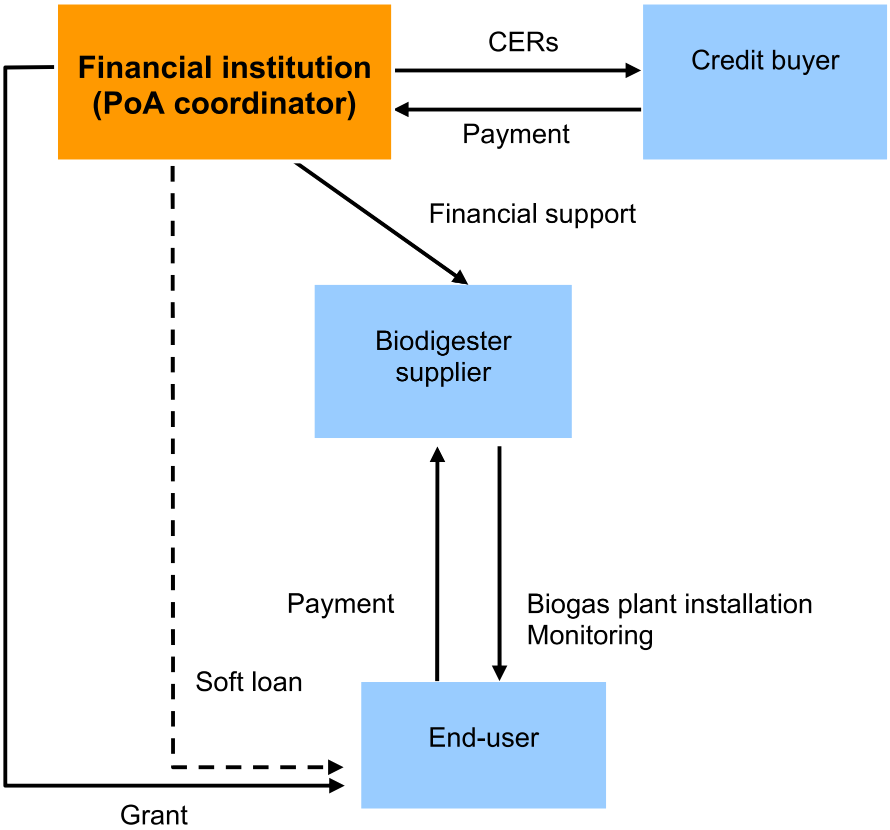

Figure 4: Domestic biogas programme business model example

The business model is developed in regard to overcome the barriers that prevent a stronger market penetration of domestic bio-digesters as follows:

- Initial cost barrier: Provision of grant to bio-digester buyers to lower the initial costs to a more attractive level. In addition, for poorer people this measure can be combined with a measure to ensure the access to the required financing (availability of microcredit).
- Technological barrier: Ensuring high quality of equipment by adjusting the design of the bio-digester to the need of the applicants and implementing a quality standard for the digester production. Furthermore, users should receive information how to operate the bio-digester in an easy-to-understand format.
- Information/behaviour barrier: Awareness raising and promoting by the PoA coordinator.

Investment subsidies and microcredit facilities for buyers of bio-digesters are a necessary, but not sufficient condition for accelerated dissemination of biogas plants. This requires the involvement of a rural development bank right from the start of the programme. Soft loans could use projected carbon revenues as collateral.

Quality and design standards for bio-digesters are important to generate trust in the technology; they have to be developed in close cooperation with bio-digester component manufacturers. The quality standard also assures a high level of leak-tightness of the bio-digester to avoid a gas pass-off into the atmosphere. Users have to be trained and an after-sales service is important to keep digesters operational during the crediting period. Customer satisfaction with the product leads to a programme reputation, which eventually works as the best promotion strategy. In the case of operating problems of the plant the owner is thankful for a contact person and for fast and experienced help. The first phase of the BSP Nepal program showed that for the contracted private company especially the after-sales service was not profitable, which lead to non-compliance with the maintenance contracts for periodical inspection and emergency help. The consequence is also to train local staff to achieve a better availability of competent people and make sure that dissemination is only done in areas with a sufficient availability of maintenance staff. This would best be achieved by having several servicing companies, each covering a relatively small area.

The PoA coordinator should be integrated in existing networks which reach the local population as well as decision makers at regional or state level. Ideally, it would be a development organisation or an association of small and medium enterprises. Given the importance of local knowledge, an organisation with a number of local branches would be best suited for the purpose. A good standing of the organisation can help to dispel doubts about the functioning of the technology and its benefits for the users.

Nepalese family using biogas from their biogas plant for cooking.
Source: KfW Entwicklungbank/ Biogas Support Programme - Nepal

Aim of the PoA: The aim of the PoA is to promote the dissemination of bio-digesters that utilise animal manure at household's level to reduce the utilisation of non-renewable biogas or the methane production and thereby reduce greenhouse gases. The carbon revenues are utilised to reduce the technology's main barrier: the initial costs through a subsidy paid to buyers of the bio-digesters. This would then lead to use of biogas for heating, lighting or cooking instead of fossil fuel.

Target group: The bio-digesters are introduced to rural, animal keeping households. Currently the manure decays anaerobically and the household use cooking or heating techniques of a low efficiency.

Managing entity: The PoA coordinator is a financial institution that possesses very strong logistical capability and excellent local network. The financial institution provides partial grants to the end-users coupled with a micro-credit facility for poor households. Moreover, it supports small and medium-sized companies to set up a bio-digester production line conforming to the standards for bio-digester quality set by the programme. The starting point should be companies that already have experience with such technologies. Loans for setting up bio-digester production lines can be collateralised by carbon revenues from bio-digesters sold by the company. If AMS-I.C is applied, the regular repayment of the micro loan can serve as a proof of real, actual use of the digester. For this the database of the bank is integrated into the monitoring process. The PoA coordinator has the responsibility to run the awareness raising campaign of the bio-digester programme.

Actors involved: Once the bio-digester producers have set up their production lines, they start their sales programmes, coupled with training programmes for target households. This training should ensure that households are able to operate the plant under normal circumstances and tackle smaller problems themselves. To minimize systems failures, dedicated biogas service facilities should be set up. They can either be affiliated to a digester manufacturer or operate independently. At each bio-digester sale, a maintenance contract has to be signed with clear responsibilities. Contracts should include annual maintenance visits used for the collection of monitoring data. It is also possible to work with other actors; this depends on the local circumstances.

Programme implementation: Under the assumption that no bio-digester producer exists, the financial institution first has to tender grants for bio-digester production line. The grants should be linked to strict technical standards for the bio-digesters. These standards have to take into account prior experience with bio-digesters in the host country. If no experience exists, a field testing has to be done to identify an appropriate design.

Parallel to the development or improvement of the bio-digester production lines, a survey should be conducted to identify households with animals. If AMS-III.R is applied, this survey should also investigate the common practice of the animal keeping and manure management and in case of using AMS-I.E a survey to verify the use of non-renewable biomass in the past needs to be carried out.

Once the production lines are operational, the roll-out of bio-digester sales should be started. This has to be linked with an awareness raising campaign implemented by the producer, a local NGO and/or a bio-digester company association. Through the campaign, the identified end-users should get information about the technology, connected requirements and a realistic outlook of the benefits. The financial institution offers grants and micro-credits.

The construction of bio-digesters is executed by the company producing the digesters. It is joined by a maintenance provider who is responsible for the continued operation of the digesters throughout its technical lifetime. Monitoring data will be collected by the maintenance provider at the sampling households during the regular maintenance visits.

A very important point in designing the PoA is the way different actors are incentivised. All actors need a strong inherent interest in participating in the programme either by a financial incentive (grant, loan subsidy for the households) or nonmonetary benefits (health of family members, expansion of client base for financial institution, cost-recovery for maintenance, quality improvements of suppliers or technical assistance etc.). These incentives are success factors for the PoA.

5.4 Carbon revenues and financial requirements

5.4.1 Carbon revenues

There are several domestic biogas projects under the CDM as summarised in Table 15. The first two projects listed in the table claimed for methane emission reductions only, while the last two were both methane and fuel switch options.

Needless to say, the size of bio-digesters has a decisive impact on the emission reduction potential. In addition, the methane emission reduction potential highly depends on the local conditions because, for example, ambient temperature has a strong impact and the feed regime of animals may vary widely due to the available feedstock sources. Furthermore, the emission reduction potential from the fuel switch is sensitive to the baseline fuel type.

Programme name	Nr. of house-holds (hh)	Size of bio-digester (m^3)	Costs of bio-digester (EUR)	Emis-sions from manure /hh (tCO_2e)	Emissions from fossil fuels/hh (tCO_2e)	Emis-sions from fuel-wood/hh (tCO_2e)	Annual amount of CERs	Average amount of CERs per bio-digester
Bagepalli CDM Biogas Programme (India) (AMS-I.C)	5,500	2	N/A	N/A	0.08 (kerosene)	3.56	19,553	3.56
Biogas Support Program – Nepal (BSP-Nepal) Activity-1 & 2 AMS.-I.C	Project 1: 9,708 Project 2: 9,688	4-10	183-287	N/A	0.07 (kerosene)	7.52	Project 1: 46,990 Project 2: 46,893	7.00
Hubei Eco-Farming Biogas Project Phase I (China) AMS.-I.C+ AMS-III.R	33,000	8-15	296-420	0.5-0.8	2.5-3.1 (coal)	N/A	58,219	1.76
Kolar Biogas Project and Hassan Biogas Project (India) AMS.-I.C+ AMS-III.R	10,000	2-3	250-290	3.47	0.09 (kerosene)	3.26	61,883	6.2

Table 15: CER estimation of model domestic biogas programme

5.4.2 Financial requirements

High initial costs are the main barrier for small biogas projects. The investment costs for one domestic bio-digester are around EUR 200 - 400 in Asia, and EUR 500 - 1,000 in Africa. The cost difference between the regions results from different aspects that – inter alia – include the costs of the production factors (raw materials, design, technology, human resources etc.), the way the installation is organised and the interaction between supply and demand. As stove production in Asia tends to have a bigger market it tends to have cheaper options for the end user. There are two ways to overcome the high initial cost barrier for the families: (i) grants and (ii) loan financing. A grant system can be introduced to reduce the amount of the initial payment. In the Nepal biogas programme the grants were adjusted to local circumstances and averaged around 25% - 40% of the whole investment. For farmers in the hills, the grant was increased as they had to compensate the higher construction cost and lower biogas output (SNV 2005).

To encourage poorer people without access to loans or just unrealistic loans, a micro credit system with more attractive interest rates should be introduced. The Nepal programme was organised in association with the Agricultural Development Bank (ADB) of Nepal and KfW Development Bank to provide affordable financing options. Loans were provided at 17% annual interest and with a 7-year repayment term. As a result, 76% of the first installed plants were constructed with loan financing.

The private biogas sector needs financial support to develop small-scale digesters suitable for country-specific conditions, especially in rural areas. The support is required over a long period (5 to 10 years) as sector development cannot be achieved quickly (van Nes 2007). During the different phases of the BSP programme, 5-15% of the entire budget was spent on the sector support, around 20% on the investment grant, and the rest on the net investment of the plant which was not covered by the owner's payments (van Nes 2007).

The following cost summary is adapted from the budget estimation of an African biogas programme for dissemination of 15,000 biogas plants (SNV 2005). To be on a conservative side, a 10-year crediting period is applied. The monitoring sample size is assumed to be 200 households.

Cost components		Upfront (EUR)	Annual (EUR p.a.)
Fixed costs	Project design and CDM documentation	200,000	30,000
	Monitoring[57]	15,000	10,000
	CDM fees	50,000	30,000
Variable costs	Bio-digester procurement and installation	348 per digester	-
	Training on bio-digesters	14.9 per digester	-
	Maintenance	-	14.0 per digester
	Other costs	-	0.2 per digester

Table 16: Overview of the estimated costs of the model domestic biogas programme (nominal)[58]

[57] Assumed costs for purchase & installation of monitoring equipment (flow meter) in 200 households (sample group) and setup of database are EUR 15,000 upfront. Annual costs of EUR 10,000 comprise the required physical inspection and meter reading at the biodigester (50 person-months for ground-work staff).
[58] Note: Distribution of 15,000 biodigesters; Biodigester lifetime of 20 years (crediting period of 10 years assumed); Monitoring sample size of 200 households.

For this specific example, the nominal costs per bio-digester would reach EUR 380.50 upfront and EUR 18.90 in annual costs. In order to allow successful dissemination of the bio-digesters, the project employs a soft loan instrument. The digesters are offered to households together with low interest loans with a payback period of five years and an interest rate of 7%.[59]
The assumptions lead to the following attractiveness table. The CER generation scenarios represent the following three cases: (i) 2.5 CERs/a resulting from a small to medium-sized bio-digester, (ii) 5 CERs/a for one large-scale digester applying one methodology (either AMS-I.C or AMS-III.R), (iii) 10 CERs/a by the combination of the two methodologies.

Annual CERs per bio-digester	CER minimum price for break-even (EUR)	CER price for IRR of 15 % (EUR)
10	2.4	3.3
5	4.7	6.5
2.5	9.4	12.9

Table 17: Indicative level of CER revenues and CERs per bio-digester required for break-even & IRR of 15%[60]

The financial information of the model projects allows for the calculation of the critical project size to achieve financial viability. The following CER revenue levels are considered for the analysis, assuming a CER price of EUR 12 and the annual CER per digester of 2.5, 5 and 7. Based on the three scenarios for the CER revenue per digester, the critical project size for the break-even and IRR of 15% are summarised in Table 18.

Annual CERs per bio-digester	Critical size (number of bio-digesters)	
	Break-even	IRR of 15%
10	1,100	1,300
5	2,600	3,500
2.5	8,000	21,000

Table 18: Critical size of a domestic biogas programme for the break-even & IRR of 15%[61]

A household-level bio-digester programme is attractive at a level of a few thousand systems, which can be achieved in countries with a high degree of smallholder livestock ownership.

[59] The interest rate is to be lower than an average market interest rate for individuals. For the model calculation an interest rate of 7% is assumed. However, the offered loan conditions depend on the financial institution involved and the regional circumstances. The difference between the average market interest rate for individuals and the low interest rate may be considered as the programme subsidy. If the average market interest rate is 10%, the total programme subsidy over the 5-year payback period would be about EUR 514,000.
[60] Note: Discount rate of 10% for the calculation of the break-even.
[61] Note: Discount rate of 10% for the calculation of the break-even.

Key points and challenges

1. Biodigesters help farmers deal with their waste management problems and create organic fertiliser for the farm or market. They contribute to the mitigation of greenhouse gases through methane recovery and avoidance of firing of firewood or fossil fuel. Biodigester programmes also have positive sustainable development effects such as, for example, alleviating the workload for women and children and easing health problems due to indoor pollution.
2. High initial costs and lack of access to the financial system are the main barriers for rural households to invest in biodigesters.
3. The programmatic CDM could help overcome these barriers by providing additional revenues from sale of CERs to finance grants to end-users or subsidise loan conditions of financial institutions.
4. A high-quality and cost-effective design of biodigesters and annual and solid after-sales service is important to ensure the lifetime of the installation and its use in the households.
5. Biodigesters cost between EUR 200 and EUR 1000, depending on size and region and reduce between 2 and 10 t CO_2e/a.
6. Key Challenge I is the need for financial transformation, as seed funding for grants and subsidies to credit lines is needed in this case. That implies that the financial institution, a potential CER buyer or a private investor would need to take the various risks of the programme if no public institution or international donor could play a role.
7. Key Challenge II is the need for technical and management support which is particularly important when there is no biodigester producer available.

6. Solar water heating

6.1 Background

Hot water plays an important role in the daily life of all societies. However, as energy prices increase steadily, so do the costs of hot water supply as the residential water heating systems are mainly based on fossil fuels or electricity from the grid. In developing countries, hot water at the households' disposal is often a luxury good as the initial costs for the equipment and the fuel costs are high compared with average income. In cases where households use electricity from the grid to heat their water, they often face unstable electricity supply and spend considerable amounts of money on electricity. The latter also applies to households that use fossil-fuel-based water heating. In addition, fossil-fuel-based water heating has negative environmental impacts as it affects the indoor and outdoor air quality and contributes to global warming. An option for addressing these problems is solar water heating (SWH).

SWH is a cost-effective and environmentally friendly solution to provide hot water for households. Commonly used residential SWHs require only two thirds of the energy used by conventional systems. SWHs consist of a solar collector and a storage tank and use solar energy to heat either water or a heat-transfer fluid. The heated water is kept in the storage tank, which may optionally be equipped with a fossil-fuel-based back-up system providing additional heating (EERE 2008). With this, the hot water supply becomes more or less independent from the conventional systems, and leads to energy cost savings. Furthermore, the use of a SWH directly improves the air quality and significantly reduces GHG emissions (Milton and Kaufman 2005).

Although high energy prices are an important driver for the use of SWHs, market penetration of SWHs is still very low, especially in developing countries and countries in transition. A major barrier to a wider diffusion is the high initial cost of SWHs of several hundred euros – basically interested households often cannot afford the purchase of the system. Furthermore, the lack of trust in the performance of the technology may prevent households from taking up SWHs. In order to overcome these barriers, it is necessary to establish incentives and financing mechanisms for SWHs (GTZ 2006, 2).

Example of a Solar Water Heater in South Africa
Source: Theo Covary.

CDM/JI is an option to achieve the broader dissemination of SWHs by offering revenues from the reduction of GHG emissions. In the following sections, the methodological and financial requirements for SWH programmes are discussed. Building on the lessons learnt in existing SWH programmes, a business model for SWH programme implementation is developed.

6.2 Methodological requirements

At the time of writing the only approved methodology that allows for implementation of SWH programmes under the CDM is **AMS-I.C** "Thermal energy for the user with or without electricity" (version 18)[62]. By nature, small-scale (SSC) methodologies are just a very general outline for an emission reduction calculation, which allows project developers to shape the programme according to the specific characteristics of the project activity. In order to set up a PoA for SWHs with AMS-I.C, the following criteria have to be considered:

- AMS-I.C addresses SSC projects comprising renewable energy technologies that supply individual users with thermal energy that displaces energy from fossil fuels. The threshold of 45 MW_{th} (equals an installed area of 64,000 m²) for SSC projects applies to every individual CPA under the PoA. The entire PoA, however, is not limited in size and therefore can exceed the SSC threshold by aggregating a number of CPAs.
- The amount of emission reductions that can be generated under SWH programmes largely depends on the energy savings. As per AMS-I.C, baseline emissions are the sum of the energy use of each conventional water heating installation multiplied by the emission factor of the applicable fuel type. Therefore, project developers need to know the amount of energy used in the baseline scenario. Depending on the fuel type, the baseline scenario can either apply the grid emission factor[63] or use the emission factor of the specific fuel type(s). Parameters generally required for calculation of the energy savings under AMS-I.C are: (i) number of distributed SWHs (new installations or replacement of conventional systems) and (ii) energy use of the distributed SWHs.
- AMS-I.C. allows three options of monitoring, of which two are applicable to a SWH PoA. Monitoring comprises metering the energy produced by a sample of the systems where the simplified baseline is based on the energy produced multiplied by an emission coefficient[64]. Corresponding metering may be cost intensive. If emission reductions per SWH unit are less than 5 tCO_2e/year, the methodology only requires annual recording of the number of systems operating as evidence for their continuing operation (e.g. by ongoing rental/lease payments) as well as the annual

[62] An application for a new large scale methodology focusing on SWH was submitted, but rejected (NM0263). A specific small scale SWH methodology is currently still under development.
[63] According to the UNFCCC tool to calculate the emission factor for an electricity system.
[64] This option is based on the M&V approach.

estimation of operating hours of an average system (surveys may be used).

- Leakage is normally not considered under AMS-I.C unless replacement of old water heating systems occurs. However, project developers should ensure that the existing equipment is not used after the implementation of the project activity – neither outside nor inside the project boundary. The solar water heaters should also be new equipment, not transferred from another location (i.e., second-hand sales).

6.3 Programme design

6.3.1 Lessons from existing SWH programmes

A number of programmes promoting SWH have been implemented in industrialised and developing countries. The German Technical Cooperation (GTZ)[65] conducted a survey on the international experiences with the promotion of SWH at household level (GTZ 2006, 2). Based on the assessment of five programmes[66], the following recommendations were made for the design of promotion mechanisms for the dissemination of SWHs.

The overarching statement is that financial incentives can significantly increase the market penetration of SWHs. However, a financial incentive alone is not a sufficient condition for programme success. As regards the main barrier of high initial costs, the applicability of a specific financial incentive needs to be assessed carefully. Direct grants and tax deduction, for instance, offer incentives that materialise after the implementation of the SWH. Payments are either made on submission of the receipts or via tax depreciation after the SWH is bought by the end-user.

Another financing option is low-interest loans on a micro financing[67] level that offer financing for SWHs at an attractive interest rate and therefore do not require the buyer to lend the money in advance. It has been very effective to pay back the loan through the electricity bill, which, however, requires collaboration by a utility company.

The programmes were initiated and managed by governmental or supranational bodies like environment ministries, development agencies or the United Nations. Regarding the institutional transaction costs that arise with the management of a PoA, it seems promising to let such an organisation be the PoA operator. Governmental or supranational authorities enjoy credibility with private and public partners; moreover, they are assumed to have a reasonable infrastructure as well as the existing network to set up a functioning framework. Since financial incentives are applied, a financial institution can also serve as the PoA operator.

[65] The GTZ is active in the field of development aid and is involved in several programmes to promote solar water heating.
[66] The programmes were conducted in Germany, Greece, France, Tunisia and Spain.
[67] For example, Grameen Shakti Bank in Solar Home System Project in Bangladesh

The motivation of individual households to purchase an SWH is mainly driven by financial reasons; other parameters such as ecological considerations or the climatic conditions (e.g. insulation rate) of the host country play a minor role. A reduced energy bill is therefore the key success factor.
The programme should be easy to understand and access in order to ensure demand for the incentive provided by the programme. Complexity as well as high transaction costs will discourage interested people. Regarding the accessibility of the incentives, programmes should focus on a binding, reliable and medium to long-term framework. As with the technologies assessed in the other chapters, the technology must be easy to use and be of good quality to generate a steady demand for the SWHs under the programme.

Linking the incentives with quality standards is important to enhance trust in the technology. Also, marketing and capacity building measures are important. Campaigns should point out particularly the financial benefits associated with the programme. Involving players from the private sector both in design and intermediation of the promotion seems reasonable. In order to establish a sustainable market that persists after the end of the programme, it could be beneficial to decrease the amount of incentives over time. Otherwise, the demand for SWHs might decrease significantly after the end of the programme.

6.3.2 Business model and institutional requirements

Reflecting the experiences from the existing SWH programmes, the following SWH PoA business model is developed. Figure 5 illustrates the key actors and their responsibilities in the business model.

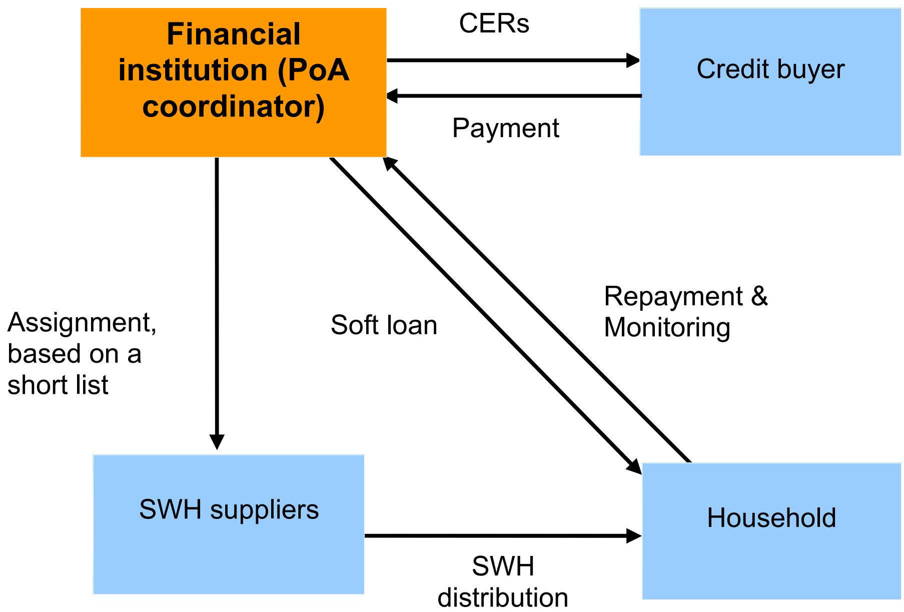

Figure 5: SWH programme business model example

The model is developed in regard to overcoming the barriers that prevent stronger market penetration of SWHs as follows:

- Initial cost barrier - Provision of low interest loan keeps the financial and administrative burden for the households to a minimum
- Technological barrier- Ensuring high quality of equipment, e.g. by applying quality standards
- Information/behaviour barrier - Awareness raising by the PoA coordinator, the power utility and the SWH supplier

Regarding the ownership of SWHs, two scenarios are thinkable: Either the PoA coordinator or the household owns the SWH. The model proposes that the households should finance the SWH.

Aim of the PoA: The aim of the PoA is to provide a motivation to individual households through a financial incentive (e.g. soft loans) to buy residential SWH systems in order to help overcome the main barriers that prevent higher market penetration.

Target group: The PoA addresses the residential sector, i.e. individual households using the SWH to heat water for private use.

Managing entity: The PoA coordinator is a financial institution. Experiences in developing comparable programmes is required as well as the logistical capacity in the programme area. A good reputation is paramount.

The PoA coordinator has to manage the financial streams under the programme, i.e. to set up financing contracts with the SWH producer in order to allow them to offer the SWHs and receive the monthly repayment from the households.

Actors involved: Besides the PoA coordinator and the households, the programme involves SWH companies (producers with retail network and available technicians). Moreover, local craftspeople should be involved for maintenance of SWHs.

Programme implementation:

- The PoA coordinator assigns the respective SWH supplier(s) for the production and distribution of the SWH to the households. The SWH supplier offers SWHs via its retailer(s), together with a loan contract of the coordinating bank that is provided at a low interest rate and has to be paid back over about five years. The contract has to include maintenance over the crediting period. To ensure a smooth processing, contractual arrangements need to be made between the PoA coordinator and the

SWH supplier as well as the PoA coordinator and the households (via retail/loan agreement).

- The repayment of the loan is done either via the retailers or directly to the PoA coordinator. It comprises the payback rate for the SWH and the applicable interest. As the household saves costs for electricity (or fossil fuel) to run the conventional water heating, the financial burden is partially absorbed.
- Since the assumed emission reductions per system (SWH) are less than 5 t CO_2/a, the monitoring requirements comprise only the annual recording of the number of systems operating as evidence of continuing operation as well as the annual estimation of operation hours of average systems. As all SWHs are registered and frequent payments are to be made under the soft loan programme, the number of operating SWHs can be tracked by the loan collection agents of the PoA coordinator. For example, the annual repayment receipt of each participating household would be processed by the PoA coordinator for direct use in monitoring reports. Regarding the estimation of the operation hours, the annual insolation duration for the specific region can be applied.

6.4 Carbon revenues and financial requirements

6.4.1 Carbon revenues

As of February 2010, eight CDM project activities for SWH dissemination are at the validation stage, all of which apply AMS-I.C. Four of them are conventional SSC projects in India. The other four projects are PoAs based in India, South Africa, Tunisia and Vietnam.[68] Whereas the Indian and the Tunisian activities focus on private households, the South African programme supports larger public installations of SWHs. The difference in the application of SWHs makes them difficult to compare. As this guidebook focuses on distribution of SWHs to households, the following analysis concentrates on the Indian and Tunisian projects/programmes.

Estimating the CER potential of a SWH programme under the CDM largely depends on the project design and the location. Table 19 summarises the key parameters for the CER estimation of the concerned projects.

[68] Point Carbon, Carbon Project Manager as of February 2010

Project name	Number of SWHs to be distrib-uted	Base-line fuel	Average tank capacity [l]	Average installed capacity [m²]	Average annual energy output of SWHs [MWh_{th}]	Emission factor [tCO_2/MWh_{th}]	Annual amount of CERs	Annual amount of CERs per m^2
Solar Water Heater Programme, Tunisia* (AMS-I.C,v.13)	20,000	Various fuels	250	3.0	1.96	0.26	10,000	0.17
CDM Solar Hot Water Project of Emmvee Ltd., India (AMS-I.C,v.12)	21,333	Electric geyser	150	3.0	2.62	0.93	51,907	0.81
Bagepalli CDM Solar Hot Water Heating Programme, India ** (AMS-I.C,v.08)	25,790	Electric geyser	200	2.5	1.75	0.88	39,783	0.62

Table 19: CER estimation of a model SWH programme

*PoA under validation, data from real-case CPA.

** The CER estimation for Bagepalli is based on the number of SWHs. However, the PDD applies a different baseline approach and therefore calculates more CERs.

The expected annual potential for CERs varies over the different projects according to the project design. The most important parameters in this regard are the average installed capacity and the baseline emissions. For the calculation of baseline emissions, different approaches can be applied. As can be seen from the Indian and the South African examples, one possibility is to assume that all households are connected to the grid. The baseline emissions in this case are calculated by multiplying the cumulated annual energy output of all SWHs with the grid emission factor. The Tunisian case applies a more complex baseline considering all fuel types that are commonly used to heat water. Then the baseline emissions are calculated by multiplying the cumulated annual energy output of all SWHs with the specific fuel emission factors. The annual emission reductions per installed m² range from 0.17 tCO_2e/year to 0.81 tCO_2/year.

6.4.2 Financial requirements

Market surveys indicate the average procurement costs for a SWH at approximately EUR 700 ranging from around EUR 200 in India and China over EUR 650 in Brazil and South Africa to EUR 1,300 in Barbados and Mexico (Milton and Kaufman 2005). SWHs have a relatively long lifetime (between 15 and 30 years) and therefore procurement costs are only caused once during the first crediting period. Installing a system is expected to take one to two person-days of a local skilled technician at a wage level of EUR 500 per month. This leads to a SWH installation cost of approximately EUR 30/SWH.[69] Therefore, the SWH procurement and installation costs are estimated to be EUR 730/SWH.

As to the monitoring costs, the SWH system size normally does not lead to annual emission reductions over 5 tCO_2. As described above, AMS-I.C allows for a simplified monitoring procedure in this case. As long as the installations are registered under the project (e.g. via soft loan mechanism), the monitoring requirements can easily be met. Therefore, it is assumed that the monitoring costs are marginal. State-of-the-art SWHs run on their own and do not require extensive maintenance services. An annual check by the SWH user and a detailed check by a professional technician every 3-5 years should be sufficient. On average, 0.3 person-days of local technicians are assumed at a wage level of EUR 500 per month, which leads to annual maintenance costs of EUR 5/SWH.

Based on the above information, Table 20 summarises the costs of a model SWH project. SWHs typically have a lifetime of 15-30 years. To be on the conservative side, a 10-year crediting period is applied. Monitoring is performed for all SWHs.

Cost components		Upfront (EUR)	Annual (EUR p.a.)
Fixed costs	Project design and CDM documentation	200,000	30,000
	Monitoring[70]	3,000	200
	CDM fees	50,000	30,000
Variable costs	SWH procurement	700 per SWH	-
	SWH installation and baseline water heating equipment replacement[71]	31.3 per SWH	-
	Maintenance	-	5.0 per SWH
	Other costs	-	0.2 per SWH

Table 20: Overview of the costs of the model SWH programme (nominal)[72]

For this specific example, the nominal costs per SWH would thus reach EUR 743.90 upfront plus EUR 8.20 in annual costs. In order to allow a successful dissemination of the SWHs the project employs a soft loan instrument. The SWH are offered to households together with low-interest loans with a payback period

[69] For installation details see for instance the producer Quantumenergy (http://www.quantumenergy.ca/products_and_services/solar_water_heaters.html) or the renewable energy portal energy saving trust (http://www.energysavingtrust.org.uk/generate_your_own_energy/types_of_renewables/solar_water_heating)

[70] Assumed upfront costs comprise the set up of a database (EUR 3,000). Annual costs assume that the monitoring is integrated into the existing business and the additional costs are marginal (approx. EUR 200 p.a. for administration).

[71] Installing a system is expected to take one to two person-days of a local skilled technician at a wage level of EUR 500 per month.

[72] Note: Distribution of 20,000 SWHs; SWH lifetime of 15-30 years (crediting period of 10 years assumed); monitoring of all SWHs.

of five years and an interest rate of 7%[73]. It is furthermore estimated that the average SWH has a collector area of 3 m^2, which leads to an annual range of 0.5 to 2.5 CERs per SWH. Given the above assumptions the following attractiveness table is illustrated for a model SWH programme.

Annual CERs per SWH	CER minimum price for break-even (EUR)	CER price for IRR of 15% (EUR)
2.5	6.8	13.7
1.25	13.6	27.4
0.5	33.9	68.5

Table 21: Indicative level of CER prices and CERs per SWH required for break-even & IRR of 15%[74]

The financial information of the model project allows for the calculation of the critical project size to achieve financial viability. The following CER revenue levels are considered for the analysis, assuming a CER price of EUR 12 and the annual CER per SWH of 0.5, 1.25 and 2.5. Based on the three scenarios for the CER revenue per SWH, the critical project size for the break-even and IRR of 15% are summarised in Table 22.

Annual CERs per SWH (EUR)	Critical size (number of SWHs)	
	Break-even	IRR of 15%
2.5	5,600	85,000
1.25	32,500	Unlikely to achieve
0.5	Unlikely to achieve	Unlikely to achieve

Table 22: Critical size of a SWH programme for the break-even & IRR of 15%[75]

The financial attractiveness of SWH programmes strongly depends on the baseline emissions factor; the higher the emission factor and baseline emissions are, the higher the financial viability will be. Nevertheless, projects can and should be considered everywhere. In all countries, high numbers of SWHs have to be distributed to make the PoA a success.

[73] The interest rate is to be lower than an average market interest rate for individuals. For the model calculation an interest rate of 7% is assumed. However, loan conditions depend on the financial institution involved and the regional circumstances. The difference between the average market interest rate for individuals and the low interest rate may be considered as the programme subsidy. If the average market interest rate is 10%, the total programme subsidy over the 5-year payback period would be about EUR 1.34 million.

[74] Note: Discount rate of 10% for the calculation of the break-even.

[75] Note: Discount rate of 10% for the calculation of the break-even.

Key points and challenges

1. Hot water plays an important role in the daily life of all societies. Residential water heating systems are mainly based on fossil fuels or electricity from the grid which leads to high electricity or fuel costs and a contribution to GHG emissions and outdoor air pollution.
2. Solar Water Heaters are an environmentally friendly solution to provide hot water for households as commonly used SWHs require only 30% of the energy used by conventional systems. State-of-the-art SWHs are easy to handle and do not require extensive maintenance. The reduced energy bill for the end-user is key for the success of the PoA.
3. High initial costs are the main barrier of investing in a SWH. Nevertheless, the applicability of a specific financial incentive needs to be assessed carefully.
4. The programmatic CDM can provide additional revenues from sale of CERs to finance grants to end-users, tax deductions or subsidised loan conditions of financial institutions. A SWH costs between EUR 500 and 1,500 and can reduce up to 5 t CO2/a.
5. A key challenge to the PoA is the need for financial transformation if seed funding for grants and/or subsidies to credit lines is needed. That implies that the financial institution, a potential CER buyer or a private investor would need to take the different risks of the programme if no public institution or international donor could play a role.
6. A high critical mass of SWHs has to be distributed to secure the financial attractiveness of the programme. This and the potentially high number of programme participants (SWH supplier, retailer, installers, households and – if applicable – various banks) leads to a complex programme which needs to be elaborated and implemented with care.

7. Industrial boilers

7.1 Background

Almost all continuous industrial process plants (e.g. in the pulp and paper, chemical, textile, food processing and sugar industry) require an uninterrupted input of energy in the form of electric power and/or steam to sustain their industrial processes. This energy is usually supplied by steam boilers that generate steam for electricity generation or process steam. Industrial steam boiler sizes range from less than 1 MW to around 100 MW. Steam boilers may be fired by coal, oil, naphtha, natural gas or biomass.

Boiler refurbishment or replacement projects by state-of-the-art industrial steam boilers are interesting candidates for the CDM (Hayashi and Krey 2005). The applied fuel type has a significant effect on boiler efficiency.

The thermal efficiency hierarchy in descending order is coal, heavy fuel oil and natural gas due to the high hydrogen to carbon ratio in natural gas (Bessette 2002). The hydrogen which burns to form water removes a significant amount of heat from the combustion process. Hence, it has to be borne in mind that 95% is the maximum achievable efficiency if coal is used. For other fuels the efficiency can be assumed to be a few percentage points lower.

Reduced energy consumption by improved processes and installations
Source: KfW photo archives

In developing countries, industrial boilers are often outdated and the efficiency gap compared with Western standards is wide. In the early 2000s, coal-fired industrial boilers in China on average only operated at 65% efficiency (Lu 2005). By 2000, 500,000 industrial boilers were reported to exist in China (GEF 2001) with an average size of 2.3 t of steam per hour (tph) which would approximately translate into 1.7 MW average installed capacity (Wu and Wei 1998). Annual boiler sales were 20,000 with an average capacity of 3 MW (Minchener 2001). Closing the efficiency gap of the existing boiler park in China by replacing the old with state of the art boilers could save about 2 Petawatthours (PWh) of thermal energy and lead to an annual reduction of 700 million t CO_2. Realistically, the potential would be considerably smaller, as efficiency increases through refurbishment typically reach 5-6%, limiting savings to 115-140 million t CO_2.

Pure boiler refurbishments can achieve energy efficiency improvements as illustrated in Table 23 below.

Measure	Energy efficiency improvement
Improved process control (optimisation of fuel/air mixture)	1.5% boiler efficiency improvement per 10% reduction in excess oxygen
Economiser (pre-heating of air, water or steam with flue gas)	1% of fuel saved per 20-25°C reduction in exhaust temperature
Condensate return	~10% fuel saved

Table 23: Efficiency gains of boilers due to refurbishment (Source: Galitsky et al., 2003))

Often, boiler replacement projects will not be limited to replacement of an inefficient steam-only boiler with a more efficient steam-only boiler of the same type, but involve a fuel switch (e.g. to natural gas), installation of a CHP unit or both. Table 24 below shows typical technical characteristics of state-of-the-art industrial Combined heat and power (CHP) systems.

Type	Typical fuel	Efficiency (%)		Grade of heat or pressure
		Thermal	Electric	
Gas turbine (combined cycle) with heat-recovery steam generator	Natural gas	31	42	Medium
Gas turbine (single cycle) with heat-recovery steam generator	Natural gas	47	33	High
Steam boiler and back-pressure steam turbine	Coal, oil	76	8	Low – Medium

Table 24: Technical characteristics of typical CHP system designs[76]
Source : Bessette (2002), Krushch et al. (1999), UK-ETSU (1999) and own assumptions

7.2 Methodological requirements

The following approved methodologies are available for boiler refurbishment and replacement programmes: AM0056,[77] AM0044[78] and AMS-II.D[79]. A very specific methodology with limited applicability is AM0054[80]. Cogeneration is covered by AM0049[81] and AM0014[82], but due to their very limited applicability and high complexity, these methodologies will not be assessed here.

[76] Note: Figures given represent typical orders of magnitude for thermal and electric efficiencies for the respective CHP systems
[77] AM0056 (version 01): Efficiency improvement by boiler replacement or rehabilitation and optional fuel switch in fossil fuel-fired steam boiler systems.
[78] AM0044 (version 01): Energy efficiency improvement projects: boiler rehabilitation or replacement in industrial and district heating sectors.
[79] AMS-II.D (version 12): Energy efficiency and fuel-switching measures for industrial facilities.
[80] AM0054 (version 02): Energy efficiency improvement of a boiler by introducing oil/water emulsion technology.
[81] AM0049 (version 03): Methodology for gas-based energy generation in an industrial facility.
[82] AM0014 (version 04): Natural gas-based package cogeneration.

All these methodologies have not yet been applied to a significant extent.
AM0056 (version 01), **AM0044** (version 01) and **AMS-II.D** (version 12) are the most widely applicable. The key challenge is to determine the remaining technical lifetime of the replaced or refurbished boiler. In all methodologies, common practice regarding boiler lifetimes in the sector and country has to be documented based on industry surveys, statistics, technical literature, etc. The common practices of the responsible industry regarding replacement schedules can also be used, e.g. through historical replacement records. Additionally, a new tool[83] to determine the remaining lifetime of equipment has been released by the CDM Executive Board (EB). The tool provides guidance to determine the remaining lifetime of baseline or project equipment based on three options:

- Use manufacturers information on the technical lifetime of equipment and compare to the date of first commissioning;
- Obtain an expert evaluation;
- Use default values.

Any methodology referring to this tool should clearly specify for which equipment the remaining lifetime should be determined. The remaining lifetime of relevant equipment shall be determined prior to the implementation of the project activity and it has to be documented transparently how the remaining lifetime of applicable equipment has been determined, including (references to) all documentation used.

Additionality can be tested in AM0056 and AM0044 using the following barriers:

- Access to capital required to replace/rehabilitate boiler(s) and implement fossil fuel switch by the owners of the project facility site is constrained;
- Access to capital by the third party to implement the proposed project activity is either constrained or expected returns are considerably low;
- Lack of technical expertise among the owners of the project facility to install/operate the new boiler(s) that may result in additional costs due to the need to hire required specialists

In **AM0044**, investment analysis is mandatory if the project is done by a third party, such as an energy service company (ESCO). A benchmark analysis is to be used. For calculation of the project IRR, the ten boilers with the highest efficiency improvements are to be looked at and the boiler with the highest IRR is used for comparison with the benchmark. A control group has to be surveyed to prove that less than 33% of that group uses improved boilers similar to the project boilers. **AM0056** uses the combined additionality tool, where a barrier analysis is followed by an investment analysis for the remaining alternatives.

[83] “Tool to determine the remaining lifetime of equipment” (version 01), EB 50, Annex 15

In **AMS-II.D**, the baseline is the historical boiler energy consumption, and monitoring is done through metering of boiler energy use. This seems straightforward, but given experiences with interpretation of small-scale (SSC) methodologies, it is likely that regulators will require a more elaborated procedure.

AM0056 requires measurement of the pre-project capacity of the boiler. In a relatively complex procedure, the load characteristics of the boiler have to be determined. Specific fuel consumption of the boiler is determined through performance tests defined by international standards, which are to be conducted for a range of loads within a load class. These tests have to be done three times before project start. During the project, boiler steam generation, pressure and temperature have to be measured every 15 minutes.

AM0044 requires three years measurement of average thermal output and fuel consumption of replaced/refurbished boilers before project start. Alternatively, thermal efficiency of the replaced/refurbished boiler can be measured once at project start, but this leads to a decrease of baseline emissions according to measurement uncertainty. For boilers of less than 29 MW, efficiency data from similar boilers in the region can be used but need to be discounted by 37%.
In case of CDM programmes using AMS II.D, scrapping of replaced boilers has to be shown.

The key methodology elements influencing the design of boiler refurbishment programmes are the data availability of the baseline boilers.
In case robust, long-term measurements are available, AM0044 is preferable. If this is not the case, AM0056 should be used as it only requires measurement of the capacity. The monitoring becomes more complex in return.
For multi-boiler systems, AM0056 is the only methodology that can be used.

As the 180 GWh_{th} threshold for conventional SSC projects does not apply to a SSC-PoA, it is very likely that AMS-II.D leads to an easier PoA implementation than AM0056 and AM0044 without compromising the scale of the PoA. The following sections focus on AMS-II.D and AM0056.

7.3 Programme design

7.3.1 Lessons from existing boiler programmes

The largest boiler efficiency programme to date was implemented by the Global Environment Facility (GEF) in China between 1996 and 2004 (World Bank 2004, GEF 2001, 1996). The programme had a total cost of EUR 73.9 million, of which EUR 25.4 million was provided by the GEF; EUR 2.0 million covered project management and technical assistance. It started with assistance to enable eight

Chinese manufacturers to produce state-of-the art boilers. Subsequently, production of such boilers was subsidised. Efficiency of sold models increased from 73% to 78% on average, with sales reaching 9,230 tph (i.e. 6,820 MW) in 2004, reducing annual CO_2 emissions by 0.35 million t (World Bank 2004). While the GEF-supported boilers cost 10% to 20% more to manufacture than traditional models, primarily due to an increase of steel consumption, the higher cost of GEF-supported boiler equipment is compensated by significant fuel cost savings with a payback time shorter than three years in most cases. Due to savings in refractory materials and shorter installation time, the installed cost of some GEF-supported boilers was lower than those of comparable traditional boilers.

The most problematic element of the project was the initial technology transfer which was delayed by two years compared with the plan. It was difficult to find companies willing to transfer the technology, and project management was cumbersome given 20 Chinese agencies, institutes, and companies were involved. The strict and complex approaches and rules of contracting, procurement, and project management slowed implementation. So far, no boiler refurbishment programme has been done with public subsidies. In some countries, ESCOs have embarked on boiler refurbishment.

7.3.2 Business model and institutional requirements

A boiler refurbishment PoA business model is conceptualised in Figure 6. The figure summarises the key actors and the responsibilities of these actors. The situation differs from other project types inasmuch as the financing of the boiler refurbishment has to be done in a way that integrates the subsidy into the finance package. Thus, the role of a local financial institution that collaborates with an industry association becomes paramount. Moreover, an experienced ESCO has to implement the refurbishment activities. Theoretically, the coordinator could implement the PoA without an ESCO but this is not recommended due to the lack of knowledge of the technical aspects of refurbishment.

It has to be kept in mind that other functional options (e.g. association as a PoA coordinator that ties up with one or multiple Financial Institutions or a joint implementation with manufacturers to provide additional discount and support with Measurement and Verification) regarding the different actors and their roles and responsibilities are possible. That depends on local interests and circumstances. The development of the business model should be oriented towards the core competencies of the different actors, especially the core interests and strengths of the PoA coordinator.

The figure summarises the key actors and their responsibilities.

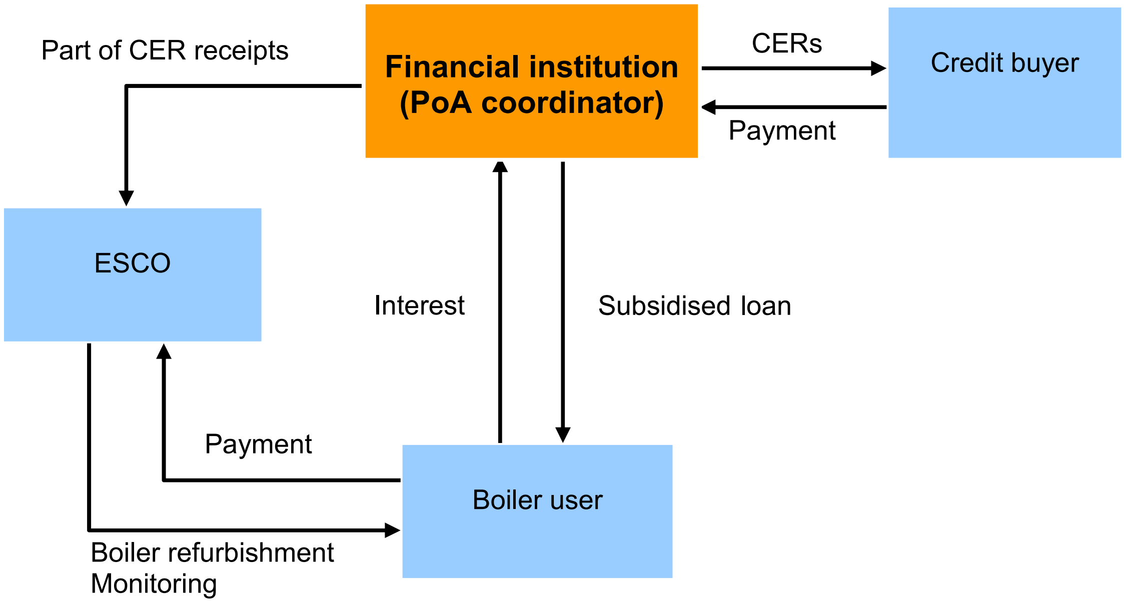

Figure 6: Boiler refurbishment programme business model example

The model seeks to address the barriers to boiler refurbishment in the following manner:

- Initial cost barrier - subsidised loans are made available
- Technological barrier involvement of a qualified ESCO to guarantee high-quality refurbishment.

Aim of the PoA: The aim of the PoA is to enhance the number of boiler refurbishments by bringing down the cost of refurbishment, which has been a high barrier to date. The carbon revenues are utilised to reduce the amount of loan financing.
Target group: Medium to large industries, which are members of the respective industry association.

Managing entity: The PoA coordinator is a joint venture of a financial institution with an institution with good links to industry, preferably a sectoral or umbrella industry association.

The financial institution provides concessional loans in exchange against a share in carbon revenues. This bank must have experience with the type of industrial clients targeted by the PoA.

The PoA coordinator identifies potential participants in the boiler refurbishment programme, develops PoA documentation and coordinates the ESCO's boiler refurbishment schedule.

Actors involved: An ESCO with substantial know-how in boiler engineering has to be involved to actually implement the refurbishments. It will be paid by the industries from the loan amount. In order to obtain competitive rates for refurbishment, several ESCOs can be involved. To provide an incentive for proper work by the ESCO, part of its payment should be dependent on the CER volume generated by each refurbishment. In countries with limited ESCO presence or quality, this could be a manufacturer, local suppliers or even engineering consultants.

Saving energy, equipment of a passive house, May 2008, Germany
Source: KfW photo archives, photographer: Thomas Klewar

Programme implementation: On the basis of the membership lists of the PoA coordinator, candidates for boiler refurbishment are identified. The bank and the ESCO arrange visits to these companies and present a refurbishment package including a loan. Once agreement on the package has been reached, the site is included in the PoA. An ESCO officer records fuel consumption of the boiler and then initiates the refurbishment. The ESCO monitors fuel consumption and sets up a monitoring report. The monitoring report has to be submitted by each industrial participant with each annual loan instalment repayment.

7.4 Carbon revenues and financial requirements

7.4.1 Carbon revenues

Taking an oil-fired boiler refurbishment programme in Peru (GTZ, 2003) as a case study, Table 25 summarises key parameters for CER estimation of the project.

Number of boilers	Capacity (MWth)	Fuel consumption before project (TJ)	Average lifetime of boiler (years)	Average pre-project efficiency (%)	Average efficiency improvement (%)	Annual amount of CERs	Annual amount of CERs per MWth
130	1,270	11,800	35	83	6	70,000	55

Table 25: CER estimation of a model boiler refurbishment programme[84]

[84] Note: The calculation is based on AMS-II.D.

The CER potential strongly depends on the achievable degree of efficiency improvement, the remaining lifetime of the boilers and the fuel used. The emissions impact is highest if coal is used, followed by oil and gas. Per unit of energy, CO_2 emissions from coal are about 30% higher than for fuel oil and 75% higher than for natural gas. Given that the costs of boiler replacement strongly depend on the remaining lifetime, it is appropriate to target boilers with a remaining lifetime of about 10 years if convincing barriers to boiler replacement can be shown.

Regarding the financial attractiveness, the fuel costs as well as the costs for boiler refurbishment/replacement play a key role. Boiler refurbishment usually consists of a package of many small measures (e.g. automatic control of excess air, automatic control of boiler blow down, replacement of the burner, and installation of an economiser). GTZ (2003) stresses that many measures have very short payback periods so actually have negative costs.

7.4.2 Financial requirements

Around 2000, a new coal-fired boiler cost about EUR 50,000/MW_{th} in the EU and about EUR 12,500/MW_{th} in China (Minchener 2001). Small gas-fired boilers were more expensive in China, reaching EUR 15,000/MWth, due to lower manufacturing costs, whereas the EU cost was around EUR 30,000/MW_{th}. In the meantime, steel prices have increased considerably, which means that recent boiler prices probably reached twice or even three times the level quoted above.

The refurbishment of a 1 MW_{th} gas boiler through new digital controls, economiser, new fan wheel and variable frequency drive on combustion air fan costs on average about EUR 110,000 (IDFA 2008). For a set of 20 to 50-year old boilers using various fuels and having sizes between 2 and 180 MW_{th} in the U.S., costs of a typical range of refurbishment options reach about EUR 150,000 (Delta Institute 2002). As the cost seems to be relatively independent of the boiler size, we assume that the average size of the refurbished boiler is 10 MW_{th} and average cost for refurbishment of 1 MW_{th} at EUR 15,000. This does not include costs of temporary production shutdown due to the refurbishment. These costs are extremely dependent on the capital intensity of the production process and thus cannot be calculated here.

Key assumptions on the cost overview for an average boiler refurbishment project for 500 boilers with a total of 5,000 MW_{th} are summarised in Table 26. Given that loan interest rates for industrial clients vary considerably from country to country, we do not specify a specific soft loan interest rate, but assume that a loan subsidy will be granted that covers 25% of the refurbishment cost. As boiler lifetime is case-specific and difficult to estimate, we simply assumed a 10-year crediting period. Monitoring is performed for all boilers.

Cost components		Upfront (EUR)	Annual (EUR p.a.)
Fixed costs	Project design and CDM documentation	200,000[85]	30,000
	Monitoring[86]	30,000	5,000
	CDM fees	50,000	30,000
Variable costs	Identification of measures for each boiler	8 per MW_{th}	-
	Boiler refurbishment loan subsidy costs (25% of total refurbishment cost)	3,750 per MW_{th}	-
	Monitoring	-	7 per MW_{th}
	Other costs	-	1 per MW_{th}

Table 26: Overview of the estimated costs of the model boiler refurbishment programme (nominal)[87]

For this specific example, the nominal costs per MW_{th} would thus reach EUR 3,759 upfront plus EUR 13 in annual costs. This generates the following attractiveness table. The CER generation scenarios represent the following three cases: (i) 44 CERs/year per MW_{th} in case of gas use, (ii) 55 CERs/year per MW_{th} in case of oil use (iii) 71 CERs/year per MW_{th} in case of coal use.

Annual CERs per MW_{th}	CER minimum price for break-even (EUR)	CER price for IRR of 15% (EUR)
71	9.0	10.9
55	11.6	14.1
44	14.5	17.6

Table 27: Indicative level of CER revenues and CERs per MW_{th} of boiler refurbishment required for break-even & IRR of 15%[88]

The financial information of the model projects allows for the calculation of the critical project size to achieve financial viability. The following CER revenue levels are considered for the analysis, assuming a CER price of EUR 12 and the annual CERs per MW_{th} as above. Based on the three scenarios for the CER revenue per boiler, the critical project sizes for the break-even and IRR of 15% are summarised in Table 27.

[85] The costs for the project design and CDM documentation may be reduced if the programme only involves a limited number of facilities and boiler types, so that the requirements for the design of the programme in terms of eligibility criteria and ownership can be kept straightforward.
[86] Assumed costs for purchase & installation of monitoring equipment and set up of database are EUR 30,000 upfront. Annual costs of EUR 5,000 comprise the required physical inspection and meter reading at the biodigester (25 person months for ground-work staff).
[87] Note: Refurbishment of 500 boilers; Crediting period of 10 years; Monitoring of all boilers.
[88] Note: Discount rate of 10% for the calculation of the break-even.

Annual CERs per MW_{th}	Critical size (MW_{th} refurbished)	
	Break-even	IRR of 15%
71	470	1,200
55	2,350	Unlikely to achieve
44	Unlikely to achieve	Unlikely to achieve

Table 28: Critical size of a boiler refurbishment programme for the break-even and IRR of 15%[89]

Boiler refurbishment programmes make commercial sense where coal is used and where several hundred boilers can be covered. This will especially be the case in economies with a large productive sector, such as China, India and Indonesia.

A very important point in designing the PoA is the way different actors are incentivised. All actors need a strong inherent interest in participating in the programme either by a financial incentive (grant, loan subsidy etc.) or non-monetary benefits (energy audits, expansion of client base for financial institution, cost-recovery for maintenance, quality improvements of suppliers or technical assistance etc.). Especially in this type of PoA, a careful assessment of the real barriers for the enterprises to invest in energy efficient equipment is important to prevent wasting CER revenues on the wrong incentive. Especially where enterprises have capital and the amortisation of the investment is short it might be more adequate to set up a grant programme or a combined measure.

As the revenues from the sale of the CERs will only accrue at a later stage the pre-financing or seed funding issue might be a barrier for the project implementation even if a financial institution is involved. Possible providers of seed funding can be (at least partly) the buyer of the CERs, international and local financial institutions, international manufacturers and, to a lesser extent, public funding.

[89] Note: Discount rate of 10% for the calculation of the break-even.

Key points and challenges

1. Industrial processes consume a huge amount of electric and thermal energy. Energy efficiency in producing companies can therefore contribute to a big extent to reduce GHG emissions. Industrial boilers are used in almost all industrial processes and are therefore a good candidate for replacement programmes.
2. In many cases high initial costs are the main barrier; nevertheless a careful analysis of the barriers is necessary to design the structure of incentives of the PoA.
3. The programmatic CDM could help overcome these barriers by providing additional revenues from sale of CERs to finance loan subsidies or grants to companies of the producing industry.
4. A key challenge to the PoA is the need for financial transformation, e.g. seed funding for grants and subsidies to credit lines. That implies that the financial institution, a potential CER buyer or a private investor would need to take the various risks of the programme where no public institution could play a role.
5. The CER potential depends strongly on the degree of efficiency improvements, the remaining lifetime of boilers and the fuels used. For a PoA it is therefore important to reach out to a good critical mass of mainly homogenous enterprises which are able to achieve high emission reductions.

8. Building refurbishment

8.1 Background

Every year around 4 billion square metres are constructed worldwide. Construction itself, but to a large extent the operation of already existing and new buildings consumes huge amounts of energy (Richerzhagen et al. 2008). Worldwide, 30%– 40% of all primary energy is used in residential and public buildings. The pattern of energy use in buildings is strongly related to the building type and the climate zone in which it is located. Importantly, most of the energy consumption occurs during the building's operational phase, for heating, cooling and lighting purposes. This clearly shows the need for producing more energy-efficient buildings and renovating existing building stocks (UNEP 2007). Through **mitigation** measures in the residential and commercial sectors, approximately 3.2, 3.6 and 4.0 billion tCO_2e can be avoided globally from the business-as-usual-level in 2020 at zero cost, EUR 14.6/tCO_2e and EUR 73/tCO_2e respectively (Levine et al. 2007).[90] Especially in countries in transition, decades of neglect of buildings means that there is a huge potential for building refurbishment programmes.


Insulation material
Source: KfW photo archives, photographer: Thomas Klewar

Common building refurbishment[91] options include:

- Improvement of insulation level;
- Modern window technology;
- Efficient lighting;
- Efficient heating and/or cooling systems; and
- Hot water production using renewable or regenerative sources (solar, heat pumps, waste heat from industry, etc.) (adapted from UNEP 2007; Thorne 2003).

In almost all countries, efficient lighting technologies are among the most promising measures in buildings, in terms of both cost-effectiveness and size of potential savings. In economies in transition (typically in cooler climates), insulation of walls, roofs, windows and floors, as well as improved heating controls for district heating are found most cost-effective. In terms of the size of savings, improved

[90] Converted from the original figures of USD 20/tCO_2e and USD 100/tCO_2e.
[91] By nature, building refurbishment has a certain overlap with efficient lighting (e.g. CFLs) and renewable thermal energy supply for users (e.g. SWHs).

insulation and district heating in the colder climates and efficiency measures related to space conditioning in the warmer climates are considered most important (Levine et al. 2007).
One of the most significant barriers to energy-efficient building design is that buildings are **complex systems**. Minimising energy use requires optimising the system as a whole by systematically addressing building form, orientation, envelope, glazing area and a host of interaction and control issues involving the building's mechanical and electrical systems (Levine et al. 2007).
The high investment costs involved, the lack of information on energy-efficient solutions at all levels, as well as the (perceived or real) lack of availability of solutions to specific conditions, are also considered as the major barriers.
Furthermore, there can be a number of organisational barriers, such as different decision making levels, privatisation/deregulation processes, different stakeholders deciding on the energy system and shouldering the energy bill accordingly (i.e. split incentive problem or principal-agent problem), etc. (UNEP 2007).

Under the CDM/JI, so far there are only a few projects in this category, all of which are limited to active solutions, such as CFLs, SWHs, energy-efficient heating, ventilation, and air conditioning (HVAC) systems, insulation, or other measures that make use of technological options. Passive solutions, such as the design of better oriented and ventilated buildings, have not yet been proposed (UNEP 2007).

The lack of building refurbishment projects is largely due to the comparatively high transaction costs and the lack of suitable approved methodologies. The programmatic approach could help overcome at least the transaction cost barrier by aggregating small and dispersed building refurbishment activities.

8.2 Methodological requirements

In case of building refurbishment, there is no "one size fits all" approach to quantify the energy savings achieved by the project. The size and complexity of the building refurbishment project determines the methodological approaches. The following three broad categories of methodological approaches are available for quantifying the energy savings from building refurbishment projects:

(i) Deemed savings approach,
(ii) Large-scale data analysis approach[92] and
(iii) Measurement and Verification (M&V) approach.

[92] Large-scale data analysis approach conducts statistical analyses on the energy usage data (typically collected from the meter data reported on utility bills) for all or most of the participants and possibly non-participants in the programme.

The methodological choice has important implications for the programme design, especially in monitoring. Therefore, the three options and suitable activity types are briefly summarised below.

- The deemed savings approach is most commonly used for programmes that involve simple retrofit energy-efficiency measures with well-defined applications. Examples might be T-8 fluorescent lamp retrofits in office buildings or CFL give-aways for households (compare Chapter 3). With the use of deemed savings, there are no or very limited measurement activities, and only the installation and operation of measures is verified. This approach is only valid for projects with fixed operating conditions and well-known, documented stipulation values (NAPEE 2007).
- The large-scale data analysis approach is most commonly used for programmes that involve large-scale retrofit programmes with many participants. It is primarily used for residential programmes with relatively homogeneous participants and measures, when project-specific analyses are not required or practical. A typical example is a residential customer weatherisation programme with thousands of homes being retrofitted with a variety of measures such as insulation, weather stripping, low-flow showerheads, and CFLs (NAPEE 2007).
- The M&V approach is used for almost any type of programme that involves retrofit projects. It is generally applied only to a sample of projects in a programme because it is more expensive on a per-project basis than the other two approaches. It is the most common approach used for programmes involving non-residential facilities, in which a wide variety of factors determine savings. In general, the M&V approach is applied when the other approaches are not applicable or when per-project results are needed. An example is a performance-contracting programme[93] with multiple contractors (NAPEE 2007).[94]

As of November 2009, there is only one approved methodology which is specifically designed for building refurbishment projects: **AMS-II.E** "Energy efficiency and fuel-switching measures for buildings" (version 10)[95].

It is based on the Measurement & Verification (M&V) approach and applicable only if it is possible to directly measure and record the energy use within the project boundary. Also, the impact of the measures implemented (improvements

[93] Through performance contracting, participating entities can hire the prequalified contractors for energy efficiency upgrades and pay for it with energy savings.

[94] The M&V approach is further divided into the four sub-categories: Option A - Retrofit isolation – key parameter measurement; Option B - Retrofit isolation – All parameters measurement; Option C - Whole facility; Option D – Calibrated simulation. For further details on the applications for each option, see NAPEE (2007).

[95] Excluding methodologies for technology-specific demand-side efficiency measures such as CFLs (AMS-II.C), SWHs (AMS-I.C), etc.

in energy efficiency) by the project activity must be clearly distinguished from changes in energy use due to other variables (including interactive effect of efficiency measures) not influenced by the project activity.

The strong emphasis on the causality between the project activity and the emission reductions put in AMS-II.E may be the main reason why all the existing building refurbishment CDM projects were developed for “system-specific” building refurbishment activities[96], which focused on particular building systems or components. In contrast, a “whole-facility” approach attempts to systematically address the biggest problems as identified by facility-by-facility analysis. The first step to taking a whole-facility energy-efficiency approach is to find out which parts of the building use the most energy.
A building energy audit will show where they are and suggest the most effective measures for reducing energy consumption. The whole-facility approach is a more comprehensive and effective measure for building energy-efficiency improvement, but requires highly sophisticated and comprehensive examination. As energy savings values per individual measure are likely to be difficult to measure, a new methodological approach (e.g. benchmarking) has to be developed to realise the potential of whole-facility building refurbishment activities.

Since July 2009, a specific methodology for new building constructions exists: **AMS-III.AE** version 01 (Energy efficiency and renewable energy measures in new residential buildings). Under this methodology activities that lead to reduced consumption of electricity in new, grid connected residential buildings (single or multiple-family residences) are eligible. Typical measures could be the following: efficient building design practices, efficiency technologies, and renewable energy technologies. Examples include efficient appliances, high efficiency heating and cooling systems, passive solar design, thermal insulation and solar photovoltaic systems.

8.3 Programme design

8.3.1 Lessons from existing building refurbishment programmes

Thorne (2003) reviewed a number of residential building refurbishment programmes implemented in the U.S. Common programme elements include contractor training and certification programmes, diagnostic tools, guidelines or specifications for best practices, customer education and marketing, and financial incentives (most commonly, rebates) (Thorne 2003).

[96] Following the definition of Thorne (2003), we use “system” in this report to refer to the set of components that work together to meet a particular functional need in a building.

These programmes were typically implemented by utilities, government, or specialised energy-efficiency institutions.

As discussed above, the programmes are categorised into system-specific and whole-facility refurbishment programmes. Early efforts to improve the efficiency of existing buildings, in particular, sought to address the most common problems contributing to building energy waste (e.g. HVAC systems in the early and mid-1990s) and to work through specific, established contractor trades. Generally speaking, the system-specific efforts have targeted the following equipment and services:

- HVAC installation and maintenance;
- Air sealing;
- Duct repair and scaling;
- Insulation;
- Window replacements;
- Lighting and appliances.

The substantial growth in knowledge of building science and understanding of the complex interactions among building systems and components enabled the development of new methods for diagnosing home performance problems and implementing solutions to these problems. In turn, this has led to a growing interest in promoting building refurbishment that can capture the compounding savings from addressing whole buildings instead of specific systems. Many whole-facility refurbishment programmes incorporated the components of the system-specific programmes described above (Thorne 2003).

Importantly, building refurbishment programmes, be it system-specific or whole-facility, require recruiting members of often highly fragmented and specialised contracting trades[97]. Greater consumer awareness and demand for whole-facility refurbishment will be required, especially if programme implementers expect contractors to invest in training, credentialing, new equipment, etc. Some key lessons learnt from the existing U.S. programmes are summarised below:

- Actors on both supply and demand sides of the building refurbishment market need capacity building and awareness raising. On the supply side, the most important initial efforts required are training, certification, and licensing for contractors. On the demand side, consumer education is required for creating lasting demand and transforming the market.

[97] In general, contractors for building refurbishment can be classified as either general contractors or specialty contractors. The general contractor will handle all aspects of a remodelling or building improvement project, but usually employs specialty sub-contractors to handle specific tasks such as insulation, window replacement, HVAC installation, etc. The specialty contractor rarely deals in more than one of these core trades (Thorne 2003).

- Consumer rebates can be a helpful tool to attract end-users' attention, but they cannot be the centrepiece of a programme or its main element. Without adequate consumer education and attention to building a strong contractor base, rebates cannot spur a sustainable demand for effective building refurbishment services or create the infrastructure to provide these services.
- Efforts to reduce the risk to contractors interested in offering the whole-facility services can be very important in encouraging them to take the first steps into the business. The successful strategies include: offering financing or other assistance with the purchase of necessary tools and equipment; providing strong marketing leads; and giving compensation for the time it takes to establish relationships with other contractors and make the necessary referrals.
- As building refurbishment is very heterogeneous, better characterisation of the opportunities available in different climate regions, in buildings of a particular construction and vintage, and in specific comfort conditioning systems may allow contractors to use a more prescriptive set of improvements as a starting point (Thorne 2003).

It is of note that Germany has also been implementing the very successful KfW CO_2 Building Rehabilitation Programme (KfW-CO_2-Gebäudesanierungsprogramm) (Neeteson 2007). The programme, established in 2001, provides subsidised loans for the refurbishment of buildings built in Germany before 1979. The subsidy reduced interest rates by about 1-2% compared with the market rate. A household is only eligible for a subsidised loan if the applied measures lead to an annual CO_2-reduction of 40 kgCO_2 per m^2, which has to be certified by an authorised energy consultant (Korytarova 2006).

Promotion of the CO_2 Rehabilitation Programme. Source: KfW Bankengruppe

The KfW programme is regarded very favourably by the policymakers. It is part of the National Programme of Climate Protection. KfW programme applications reached over 140,000 from 2001 to 2006 (Neeteson 2007), with a refusal rate of only 1% of applications, and the provided governmental funds to lower the interest rates were fully exhausted. In 2005 and 2006 the programme resulted in CO_2e-reductions of more than 1 million tons. In terms of energy savings more than 2 billion kWh/a was saved. Another important result revealed by an evaluation of the programme shows that the savings in heating costs added up to ca. EUR 4.2 billion over a period of 30 years. This is 83-90% of the investment

sum. That shows that from the perspective of an average household the investment is nearly amortised in the long term through the reduction of energy costs.
Jointly with IWU (Institut Wohnen und Umwelt) the programme has developed a model allowing the estimation of energy savings out of a variety of measures in individual buildings in using a limited number of building-specific data that can be collected through surveys. The model includes a typology of buildings as well as external parameters like temperature profiles which are country-specific. Currently the model is calibrated for Germany but it might be possible to recalibrate it for other countries as well. The advantage of the model is that it allows an energetic profiling on the level of each single building (probably required under JI) without the need to do (probably prohibitively expensive) individual energy audits.
The KfW programme was also successful in drawing public attention towards building modernisation with energy-efficient measures (Korytarova 2006).

One of the key success factors is a widespread and **well-targeted information dissemination** with the help of private banks, which lend on the KfW loans to private households and housing companies, together with the **reduced interest rates** and other favourable loan conditions (such as grace periods etc.). The large variety of modules of the KfW programmes and the possibility of combining the loans from several modules allowed most of the refurbishment costs to be covered by cheap loans. Moreover, the implementation at the level of the federal KfW bank enabled transparent administration. Furthermore, experience shows that it is recommended to establish a goal based on an indicator such as CO_2 reduction per square metre, kWh reduction per square metre etc. Lastly, the support for building refurbishment should be developed in two parallel paths: (i) support in the form of single measures (replacement of windows, ceiling insulation, boiler replacement, etc.), and (ii) complex refurbishment. Such parallel attempt would motivate both tenants and building owners to improve energy efficiency in buildings (Korytarova 2006).[98]

8.3.2 Business model and institutional requirements

Building on the lessons learnt from the building refurbishment programmes described above, a PoA business model for this category is conceptualised in Figure 7. Other options regarding the different actors and their roles and responsibilities are possible. That depends on local interests and circumstances. The development of the business model should be oriented towards the core competencies of the different actors, especially the core interests and strengths of the PoA coordinator.

[98] For more information please refer to www.kfw.de.

The figure summarises the key actors and their responsibilities.

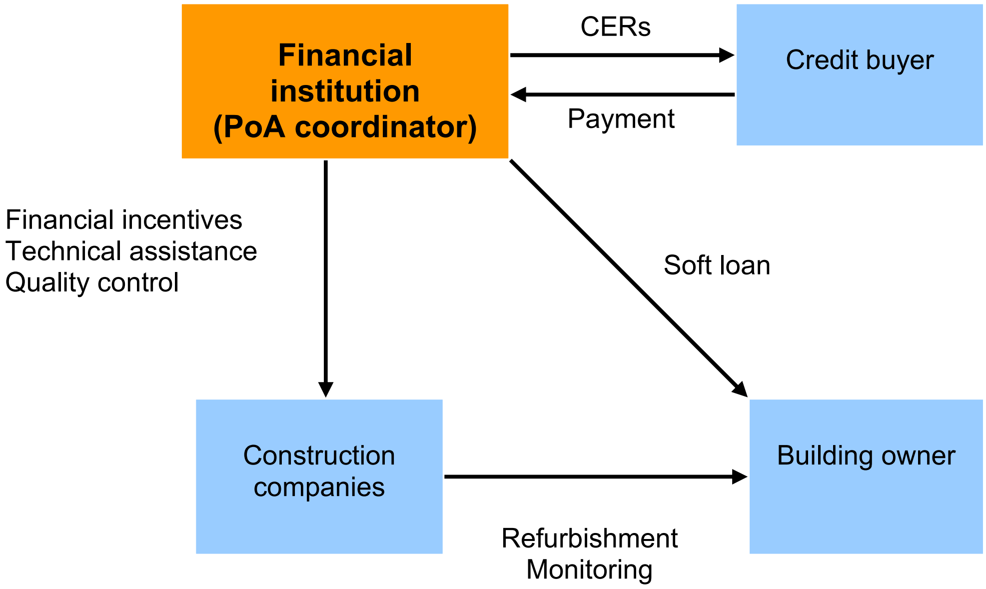

Figure 7: Building refurbishment programme business model example

The model is developed so as to overcome the barriers to building refurbishment in the following manner:

- Technological barrier - Training, certification, and licensing for construction companies as well as necessary equipment financing create an enabling environment for the construction companies to expand their expertise to address the building problems as complex systems.
- Initial cost barrier - Provision of soft loans to building owners helps create affordable finance to pay the costs associated with recommended building refurbishment measures.
- Information/behaviour barrier - Consumer education by the PoA coordinator helps create lasting demand and transform the market.

Aim of the PoA: The aim of the PoA is to enhance the energy efficiency of existing residential and/or commercial buildings by aggregating the often highly fragmented and specialised building refurbishment contractor market, and providing building owners with soft loans and education to create sustainable demand for the market.
Target group: Residential and/or commercial building owners. Strong market research should be conducted to identify key target segments by location or specific customer characteristics (e.g. high energy use) because the building refurbishment is very heterogeneous.
Managing entity: The PoA coordinator is a financial institution with strong technical and marketing skills in building refurbishment. Consider engaging one

or a panel of experienced construction companies to provide necessary technical assistance to participating construction companies (Thorne and Nadel 2003).

As the PoA coordinator, the financial institution shall provide financial incentives and – when necessary – technical assistance to the construction companies, and consumer education and soft loans to the building owners. It is also important to lead the marketing activities as construction companies often lack the marketing and sales skills or do not have the appropriate information to successfully sell their building refurbishment services (Thorne 2003).

Actors involved: Besides the financial institution and building owners, the business model involves construction companies to provide building refurbishment services and monitoring. In some cases utilities might also play a role in performing the monitoring. In order to facilitate the effective participation of construction companies, one may also consider involving an association of construction companies. Normally, such an association not only serves as an outlet for training and networking among their members, but also supports professional development activities such as certification programmes (Thorne 2003). Therefore, it can act as an effective coordinator of the construction companies.

A challenge to the programme could be maintaining the participation of construction companies during the busy months (e.g. summer). To encourage ongoing participation during the busy months, a sales incentive payable to the contractor can be introduced to give incentives for the time spent on selling the programme and bringing in sub-contractors to perform additional work (i.e. referral incentive). Also, it is a common challenge for many programme coordinators to engage small construction companies (Thorne 2003).

Programme implementation:

- The initial planning phase should focus on market research to identify the key target segment, and develop effective strategies for the assignment of construction companies to reach the identified target segment. The programme should assign trained construction companies that not only know how to perform quality work, but also how to sell quality to consumers. It is also important to develop a plan for directing specialised marketing materials to these building owners. The marketing efforts can be backed up by coordinated referrals that make the transaction as simple as possible for the building owners (Thorne 2003). Soft loans are to be set as a key instrument of a programme, which enables building owners to afford the recommended building efficiency improvement measures.

- The investigation phase is to include a clear building energy analysis based on thorough assessment of the building and its energy usage patterns, and development of proposals for recommended improvement measures. Clear information on the recommended options, sub-contractors, and financing helps building owners through the decision-making process (Thorne 2003).
- The implementation phase requires technical assistance and financial incentives to the construction companies. In addition, marketing, consumer education, and soft loans to the targeted building owners also play an important role. The PoA coordinator could provide the construction companies with necessary training at discounted rates, equipment financing, sales incentives for job completion, and co-op advertising. Marketing of whole-facility refurbishment will likely be more difficult than a system-specific one, as it involves much higher costs and its consumer awareness is lower. In order to overcome this barrier, the PoA coordinator can develop customer outreach materials that educate building owners on the higher return on investment, attractive paybacks, and improved comfort associated with whole-facility refurbishment. The soft loans can also be adjusted to cover a greater portion of the incremental cost (Thorne 2003).
- Whether the programme is system-specific or whole-facility refurbishment, construction companies are best positioned for monitoring the energy savings. In system-specific refurbishment programmes, the energy savings achieved by each refurbishment measure have to be measured. In case of whole-facility refurbishment, it is more appropriate to determine energy savings by utility meters or whole building sub-meters. The data can be used to improve or optimise the operation of the equipment, thereby improving the benefit of the refurbishment measure itself (IPMVP 2002).

8.4 Carbon revenues and financial requirements

Building refurbishment measures are extremely diverse. Furthermore, a combination of different measures would lead to positive (or negative, if badly designed) synergy effects. Therefore, the energy savings and costs of each measure are not additive. Table 29 provides an overview of investment and O&M costs of different building refurbishment measures (N.B.: the figures are estimated for a Greek case study (Mirasgedis et al. 2004).

Measure	Unit	Investment cost	O&M cost
Replacement of old diesel boilers (by diesel ones)	EUR/building	2,839	-
Replacement of old diesel boilers (by natural gas ones)	EUR/building	4,797	-
Regular inspection of boilers	EUR/building	-	103.5
Use of intelligent programmable controls	EUR/building	851	-
Use of thermostats in central heating boilers	EUR/unit	19.3	-
Insulation of external walls	EUR/m^2	34.8	-
Roof insulation	EUR/m^2	27.1	-
Sealing of openings	EUR/m^2 of opening	5.8	-
Double glazed windows	EUR/m^2 of opening	156	-
Use of low-energy bulbs	EUR/m^2 of floor	1	-
Solar collectors	EUR/m^2 of collector	290	2.9
External shading	EUR/m^2 of shading component	24.2	-
Roof ventilators	EUR/unit	48	-
Replacement of old air conditioners	EUR/unit	676	-

Table 29: Investment and O&M costs of building refurbishment measures[99]
Source: Mirasgedis et al. (2004)

Thorne (2003) roughly estimated energy savings from common building refurbishment measures, which are summarised in Table 30 (note the figures are estimated for a U.S. case study). Energy savings are highly dependent on the building construction and vintage, local climatic conditions, etc. Therefore, the figures must be handled carefully.

Measure	Annual energy savings
Air sealing (incl. insulation and window replacement)	20%
Duct repair and sealing	15%
HVAC equipment upgrade	20%
Improved HVAC installation practices	15%
Lighting and appliance upgrades	10%

Table 30: Energy savings of building refurbishment measures[100]
Source: Thorne (2003)

[99] Note: Costs of individual measures are not additive. Costs are estimated for a Greek case study.
[100] Note: Energy savings from individual measures are not additive. Energy savings are estimated for a U.S. case study.

The highly heterogeneous nature of building refurbishment measures makes the assessment of financial requirements and carbon revenues extremely difficult. Therefore, the following analysis will focus on system-specific improvement of thermal performance, one of the most logical solutions in order to reduce a building's energy consumption (UNEP 2007).

8.4.1 Carbon revenues

The "Kuyasa low-cost urban housing energy upgrade project, Khayelitsha" (Kuyasa project) is the first registered project which applied AMS-II.E. It targets low-income households in Cape Town, South Africa, and introduces CFLs, SWHs, and ceiling insulation to improve building efficiency. The relevant component of our analysis is the installation of ceiling boards (9 mm rhino board – gypsum and cardboards) and sisalation (one-sided foil sandwiched fibre). Table 31 summarises key parameters for CER estimation from the ceiling insulation part of the project.

Number of households	Average insulation area per household [m^2]	Total insulation area [m^2]	Total annual energy savings [MWh]	Grid emission factor [tCO_2e/ MWh]	Transmis-sion & distribution loss [%]	Annual amount of CERs	Annual amount of CERs per m^2
2,309	30	69,270	3,106	0.89	10	3,041	0.044

Table 31: CER estimation of Kuyasa programme in South Africa (ceiling insulation only)

The CER potential depends on a number of factors. For example, the energy savings are dependent on thermal performance of the baseline and project ceiling equipment, meteorological data of the project location, physical dimension of the households, etc. Furthermore, the type of energy used for heating and/or cooling plays a key role in converting the energy savings into emission reductions. The households in the Kuyasa project consume grid electricity for heating, which is coal-dominant.

8.4.2 Financial requirements

The financial data were not made available in the Kuyasa PDD. Therefore, the following financial analysis is based on publicly available information, which may differ significantly from that of the Kuyasa project. According to CIS (2008), the ceiling insulation costs are estimated to be around EUR 11.7/m^2 in South Africa (including the material and installation costs). Once installed, the ceiling insulation will incur virtually no maintenance costs.

The monitoring costs are divided into labour and non-labour costs. Over the 10-year crediting period, the labour costs assume 500 person-days of local skilled staff for metering of energy usage (4 households per person-day), 50 person-days of experts for supervision of the monitoring process. These contribute to the annual monitoring costs. The upfront monitoring costs include development of a database for recording monitoring parameters, installation of monitoring equipment in sample households, etc. The cost overview of the model project is given in Table 32. The analysis assumes a total ceiling insulation area of 69,270 m^2 (2,309 households with 30 m^2 each),an insulation lifetime of 21 years (crediting periods of 21 years are assumed), and a monitoring sample size of 200 households.

Cost components		Upfront (EUR)	Annual (EUR p.a.)
Fixed costs	Project design and CDM documentation	200,000	30,000
	Monitoring	14,000	1,800
	CDM fees	50,000	30,000
Variable costs	Ceiling insulation installation (incl. material costs)	11.7 per m^2	-
	Other costs	-	0.04 per m^2

Table 32: Overview of the estimated costs of the model ceiling insulation programme (nominal)[101]

For this specific example, the nominal costs of ceiling insulation per m^2 would thus reach EUR 15.50 upfront plus EUR 0.90 annually. In order to permit a successful promotion the project employs a soft loan instrument. The low-interest loans are offered to households with a payback period of five years and an interest rate of 7%[102]. The above assumptions generate the following attractiveness table.

Annual CERs per m^2	CER minimum price for break-even (EUR)	CER price for IRR of 15% (EUR)
0.088	12.2	15.6
0.044	24.4	31.2
0.022	48.7	62.4

Table 33: Indicative level of CER prices and CERs per m^2 required for break-even & IRR of 15 %[103]

The financial information of the model project allows for the calculation of the critical project size to achieve financial viability. The following CER revenue levels are considered for the analysis, assuming a CER price of EUR 12 and the annual CER per m^2 of 0.022, 0.044 and 0.088. Based on the three scenarios for the CER revenue per CFL, the critical project sizes for the break-even and IRR of 15% are summarised in Table 34.

[101] Note: Total insulation area of 69,270 m^2 (2,309 households with 30 m^2 each); Insulation lifetime of over 21 years (crediting period of 21 years assumed); monitoring sample size of 200 households. The CDM methodologies require the monitoring only in the sample households. It is assumed in this report that the sample size is 200 households, so the monitoring costs are considered fixed.
[102] The interest rate is to be lower than an average market interest rate for individuals. For the model calculation an interest rate of 7% is assumed. However, the loan conditions to be offered depend on the financial institution involved and the regional circumstances. The difference between the average market interest rate for individuals and the low interest rate may be considered as the programme subsidy. If the average market interest rate is 10%, the total programme subsidy over the 5-year payback period would be about EUR 97,000.
[103] Note: Discount rate of 10% for the calculation of the break-even.

Annual CERs per m^2	Critical size (insulation area in m^2)	
	Break-even	IRR of 15%
0.088	70,000	88,000
0.044	117,000	159,000
0.022	175,000	265,000

Table 34: Critical size of a ceiling insulation programme for the break-even and IRR of 15%[104]

Key points and challenges

1. Worldwide 30%-40% of all primary energy is used in residential and public buildings. Reducing energy consumption and contributing to GHG-reductions in residential areas can mitigate these emissions.
2. In many cases, high initial costs for the end-users and lack of awareness are the main barriers to investment in building refurbishment.
3. The programmatic CDM could help overcome these barriers by providing additional revenues from the sale of CERs to finance loan subsidies or grants (e.g. via a rebate system) to private homeowners.
4. Key Challenge I is the complexity of the programme which encompasses various measures if whole-facility refurbishment is aimed at. PoA developers should consider a step-by-step approach to develop experience when entering in building refurbishment programmes.
5. Key Challenge II might be the need for financial transformation, e.g. seed funding for grants and subsidies to credit lines. That implies that the financial institution, a potential CER buyer or a private investor would need to take the various risks of the programme if no public institution could play a role.

[104] Note: Discount rate of 10% for the calculation of the break-even.

9. Small hydropower

9.1 Background

Increasing demand and need for electricity are- a key characteristic of industrialisation. In developing countries the electricity demand is increasing enormously due to enhanced standards and development. Additional electricity generating capacities, required to some extent in remote areas, are usually met by the most common and most readily available technology: fossil fuel fired power stations. These pose a significant burden for the environment. As the prices for most fossil fuels are rising and supplies are limited, developing countries are also trying to increase their share of independent renewable power generation.

Hydropower is one of the most common and well known renewable energy sources. For large turbines the energy conversion efficiency of 90% is attractively high, whereas for smaller turbines this efficiency could decrease to 70-80%. However, the advantage of small hydropower plants (SHP) over large installations is the reduced environmental impact through the use of ‘run of river’ schemes and the absence of large reservoirs. Besides their lower environmental impacts, they usually require fewer or no resettlements . Therefore, SHPs are regarded and discussed as less controversial than large hydropower plants. However, the impact on the environment depends on the specific project design and has to be assessed for both large and small plantson a project by project basis. For example, depending on water conditions, a reservoir may emit additional GHG, namely methane, with a significant environmental impact.

The implementation of single CDM projects has already fostered the dissemination of hydropower in developing countries., India and China in particular are making use of this energy source under the CDM, typically on a large scale. Around one fourth of the registered CDM projects are hydropower[105] projects. Nevertheless, besides large-scale projects, developing countries still have a huge untapped SHP potential. According to the International Hydropower Association (IHA), only one third of our planets’ realistic hydropower potential is developed. The current hydropower production amounts to approximately 2,889 TWh/y while the realistic potential production could reach up to 9,000 TWh/y. The table below compares the undeveloped potential by region and level of development.

[105] Source: Point Carbon as at February 2010

Region	Current hydropower electricity generated (TWh/year)	Technical potential (TWh/year)	% developed
Africa	81	1,100	7
South East Asia	793	3,600	22
South America	531	1,600	33
North America	693	1,000	69
Australasia	42	107	~70
Europe	593	791	75

Table 35: Worldwide hydro power potential[106]

The definition of small hydropower (SHP) is not consistent or fixed. Mostly the upper threshold is set at 15 MW.[107] The lower capacity bound of SHP is subdivided into mini-hydro, which typically refers to schemes below 1 MW, micro-hydro below 100 kW and pico-hydro below 5 kW (ESHA 2005b).

Small hydropower units could generate electricity for

(i) national grids
(ii) isolated-grids
(iii) remote or off-grid power consumers

In general, SHP units would have a high reliability by combining low operating costs with reduced exposure to energy price volatility.
The initial installation and project realisation costs are typically very high. However, it is surprisingly not the core component that takes the lion's share of the cost. The civil works typically account for 60% of the plant's initial costs. Since the governing local conditions (topographical, geomorphological and/or hydrological conditions) have a strong impact on the overall project costs, a project may even become unviable depending on these surrounding conditions. On average, about 75% of costs are site-specific (Ratscreen 2004).

The overall investment costs vary in the range of 1,000 - 3,000 EUR/kW with the available head and the total capacity (ESHA 2005b). While the costs seem to be quite high, the investment is often worthwhile since the assets and equipment have a high technical lifetime, in many cases over 50 years. In addition, another advantage of hydropower is the independence from fuel prices. During the years of operation only low operation and maintenance costs accrue, e.g. due to refuse floating in the water which abrades the equipment. For small installations the core components require only periodic maintenance support by experienced staff and so, in total, only a part-time operator is needed.

[106] Source: International Hydropower Association (2009)
[107] This definition is also supported by the European Small Hydropower Association (ESHA) and the European Commission. On an international level, the small-scale threshold varies from country to country: In India and China this rises to 25 and 50 MW, respectively.

Besides the high investment costs, the project schedule is challenging. At first, the technical feasibility studies have to be implemented to identify suitable locations. Afterwards, many stakeholders need to be included in the systematic planning and project engineering. Human and administrational resources are needed for the environmental approvals and permits. Overall, the development time of SHP projects, without CDM consideration, can easily consume 2 to 5 years (Ratscreen 2004).

Compared to large hydropower projects, the impacts on the environment are greatly reduced, but of course the impacts and environmental requirements depend on the site and the type of SHP project (Ratscreen 2004).
Furthermore, with improved electrification and enhanced independence from unstable power grids and fossil fuel-driven prices for electricity, a rural area could significantly benefit from fostered economic development and potential job creation. An SHP project could increase the overall economic prosperity of a region.

9.2 Methodological requirements

The choice of the most suitable CDM methodology for SHP programmes depends very much on the clientele of the PoA and thus on the project design itself. The current most common CDM project design is a hydropower unit that feeds the generated electricity into an electricity grid and so replaces fossil fuel power.
The alternative project design is directly targeted to productive use of the hydro electricity. In many cases the power plant is not connected to a regional or national power grid. The CDM path in terms of the applicable methodology is defined depending on these design options.

Grid connected installations

In case the hydropower plant is connected to the grid, two major CDM methodologies are applicable: AMS-I.D "Grid connected renewable electricity generation" for small-scale projects and ACM0002 "Grid-connected electricity generation for renewable sources" for large-scale project activities. Hydropower is only one of a number of renewable electricity generation technologies for which these methodologies are designed. However, for small hydropower plants AMS-I.D is most suitable since ACM0002 is only applicable for facilities up to a size of 15 MW of installed capacity. In the following only AMS-I.D is described, but ACM0002 follows a similar approach and should be considered for larger projects.

As of October 2010, AMS-I.D exists in its 16th version, the methodology is one of the most frequently applied ones (647 projects, of which 406 are hydropower projects[108]) and is always developed further according to the latest development and findings.

[108] Source: IGES CDM project database, 1 Oct 2010, I.D projects requesting registration and registered

The application of the methodology is straightforward and incorporates greenfield installations, additions or retrofits. The only proposition for hydropower is that projects which require a new reservoir or include an existing reservoir have to exceed the so-called power density threshold of 4 Watts per m². In order to comply with the requirement, the reservoir should have a small surface area and a high depth. The impact on the environment is hence limited as less land is occupied and the reservoir causes fewer emissions.

In general, for the calculation of the baseline emissions the annually produced electricity in kWh is multiplied by the carbon intensity of the baseline electricity production (emission factor). In case only diesel generators supply electricity in the baseline system, the methodology provides default emission factors. For the classification only major characteristics of the mini-grid are needed, which slightly simplifies this step. For all other grid systems, the emission factor has to be determined according to the latest version of the CDM "Tool to calculate the emission factor for an electricity system" or by the weighted emissions of the current generation mix. The tool offers different options to calculate the emission factor depending on the amount of available data.
For additions and retrofits the baseline is limited to the net electricity generation and needs to reflect the remaining lifetime of the old equipment. These projects need 5 years of historic data[109].

Project emissions only have to be taken into account for hydro installations with a power density between 4 and 10 W/m² as mentioned above. In this case reservoir emissions are considered with 90 kgCO_2e per gross MWh production of the hydro plant.

For PoAs the leakage emissions can be neglected if in the case of a replacement the scrapping of the old equipment is monitored.

In addition, the monitoring requirements are also simple for hydropower projects. Only the hourly net electricity supplied to the grid should be measured and cross-checked with records from the utility, for example.

[109] Excluding abnormal years

Electricity generation by the user

Hydropower projects that are not connected to a large or national grid but directly supply power to an individual group of households or consumption devices, like irrigation pumps for agricultural fields or industrial facilities, have to apply the methodology AMS-I.A “Electricity generation by the user”. Although also AMS-I.A is in its 14th version and was set up already in the end of 2002, only four hydro projects are currently using this methodology[110]. One reason could be that individual household level projects have an even more critical viability. The methodological approach for hydropower is applicable to non-grid projects or mini-grids with a capacity smaller than 15 MW. Including mini-grids, AMS-I.A has a limited application overlap with AMS-I.D. In general, the methodological approach is similar, and only the following differences are remarkable.

For the determination of the baseline emissions, three options are given according to the project design to derive the energy baseline, i.e. the fuel consumption of the technology in use or what would have been used in the absence of the project activity to generate the equivalent quantity of energy. The first option is based on the average individual energy consumption observed in the geographically closest grid. The second one, as in AMS-I.D, is based on the electricity output of the technology applied. Thirdly, for replacement projects, the trend- adjusted projection of historic fuel consumption is taken. This value is multiplied by the default emission factor of 0.8 t CO_2/kWh[111] or, if justifiable, by higher values. In most cases Option 2 is the most suitable determination option for SHP.

Special attention is drawn to limited renewable sources and the project’s impact on existing units which could be relevant for hydropower. Thus, the baseline is decreased by the historic production of existing hydro units.

The same approach as in AMS-I.D is taken for additions and retrofits.

The simplicity is also noticeable in the monitoring requirements. Only the operation of all units or a sample group has to be checked annually. This is also possible with evidence of operation. The other option is to meter the electricity of a sample group of SHP units.

[110] Source: IGES CDM project database per 01.10.2010, hydro projects using I.A, requesting registration and registered.
[111] Assuming that only diesel generation units are used

Category	Key methodological differences	
Applicability	AMS-I.D:	Hydro projects below 15 MW Power density greater than 4 W/m² Retrofit projects need 5 years of historic data
	AMS-I.A:	Non-grid hydro projects or connected to mini-grids with a capacity smaller than 15 MW Retrofit projects need 5 years of historic data
Project emissions	AMS-I.D:	Only for projects with a power density between 4 and 10 W/m² → 90 $kgCO_2e$ per gross MWh produced
	AMS-I.A:	-
Monitoring	AMS-I.D:	Hourly net electricity supplied to the grid cross-checked with sold records
	AMS-I.A:	Annual operation check (or an evidence of operation); or metering of electricity production of a sample group

Table 36: Key methodological characteristics between AMS-I.A (version 14) and AMS-I.D (version 16)

As AMS-I.D is the methodology applied by the majority of SHP projects and even by one PoA which is at the validation stage, the following financial sections concentrate on the application of AMS-I.D.

9.3 Programme design

9.3.1 Lessons from existing SHP programmes

Currently, only a few SHP PoAs are found on the official UNFCCC website. One SHP PoA in Honduras has finalized successfully the first half of the carbon project cycle and was registered. The objective of this programme is to overcome institutional and, as a main reason, financial hurdles for development of hydropower plants in Honduras. By participating in a CDM PoA and thus to be able to obtain carbon certificates, private banks are and have been willing to provide loans to the project developers. The programme is managed by Hidromasca, the central coordinating company, a group of entrepreneurs joining forces to develop SHP plants. The PoA plans to incorporate seven grid connected run-of-river plants with a capacity between 0.7 and 2.3 MW. The applied methodology is AMS-I.D.
The Honduran grid is dominated by fossil fuel electricity generation and the investment attractiveness is still rather in favour of matured fossil fuel techniques than new renewable power sources. The PoA project would boost more greenhouse gas-free power generation in the country. Furthermore, the new plants should stabilise voltage and electricity supply in the regional/national grid (PACEAA 2009).

As of October 2010, additionally to the Honduran programme there are three other CDM PoA at the validation stage applying hydropower, one in Indonesia and two in Vietnam (large scale using ACM002). All three entered validation in late 2009 with an expected crediting period start date in 2010. See Table 37 below for details.
Besides the dominance of fossil fuels and exemption from favourable price conditions, SHP faces even more barriers than large hydropower projects in

Honduras. According to the CPA-DD, SHP is burdened with an unpredictable delay until a power purchase agreement (PPA) is closed and thus is more risky for an investor. To overcome the barrier of river access for the first CPA, representatives of the local communities were involved (UNFCCC 2008). This underlines the need for a network and coordinative management to include all stakeholders in the preparation and the early steps of the project.

The “International Network for Small Hydropower” (IN-SHP) was established by the United Nations and Chinese institutions aiming to promote SHP worldwide. One of the IN-SHP projects is called the “Light-up rural Africa Project”, launched in 2007, which is supporting the project design, consultation and rural power planning as well as promoting local small hydropower development. The objective is to exchange information, technical consultation, training activities, site survey and selection. To disseminate the SHP knowledge IN-SHP has trained over 600 engineers from 50 countries and sent consultation missions to Africa, South America and Asia. The “Light-up rural Africa Project” identified the lack of expertise, low budgets and little government support and management as the main barriers for African countries. This means that external assistance could be highly important for the success of SHP projects (IN-SHP 2007).

The European Small Hydropower Association (ESHA) has also identified the following success factors for this project type: studies of grid interconnections, the relevant contracts for interconnection, transmission of energy through the power grid, and power sales themselves (ESHA 2005a).

9.3.2 Business model and institutional requirements

Building on the lessons learnt from other programmes and the encountered barriers such as financial barriers, an SHP PoA business model is conceptualised in Figure 8. Under this structure, a financial institution will act as a PoA coordinator. The engagement of a financial institution would help to lessen especially the financial barriers, but also organisational obstacles, such as contracting a PPA due to usually high creditability. This business model is one possibility to structure the PoA; other options regarding the roles and responsibilities of different actors are possible. The PoA coordinator could also be a utility or a hydropower experienced institution. The development of the business model should be oriented towards the core competencies of the different actors, especially the core interests and strengths of the PoA coordinator. Figure 8 below summarises the potential key actors and their responsibilities of a PoA for SHP projects.

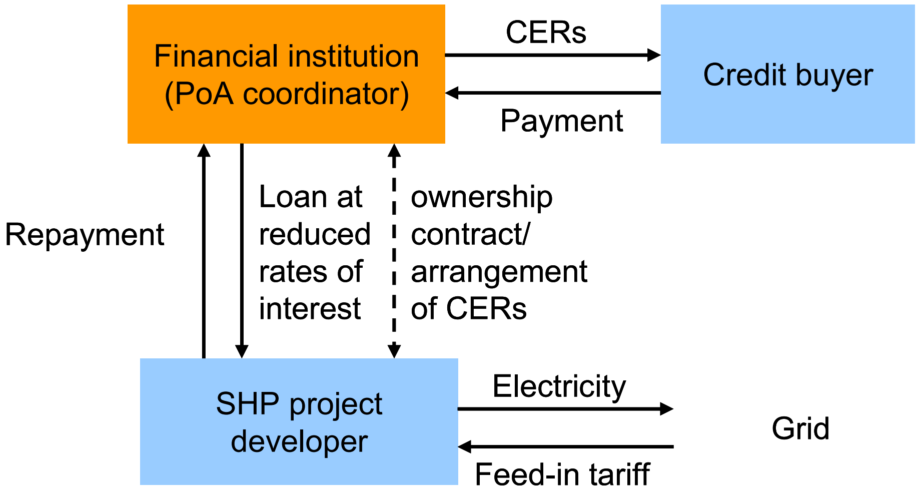

Figure 8: Possible business model for SHP

The model strives to address the barriers to SHP penetration in the following manner:

- Access to finance - by designating a bank as the PoA facilitator an SHP supportive financier is already included. This institution is well informed and aware of the carbon market financing instruments.
- Knowledge and experience barrier - there are two options for the position of the SHP developer. On the one hand, the focus could be on already experienced hydropower market players. These players do not need to receive considerable support from the coordinating entity in terms of, for instance, hydro project management, closing a power purchase agreement (PPA) or production permits. On the other hand, potential SHP developers such as municipalities could be rather inexperienced with hydropower projects and would therefore need support from the PoA coordinator. The PoA coordinator would then also function as a multiplier of the necessary knowledge. Of course this will at first entail a learning process within the PoA coordinating entity or require an outsourcing of such services.

Aim of the PoA: The aim of the PoA is to augment the application of SHP units by enabling access to finance and to support for the knowledge needed for planning and installation of such plants. If hydropower projects are realised, usually national and regional power producer corporations prefer large hydro installations over SHP as these have a higher power output and generally a more feasible cost recovery. The lower attractiveness of SHP for investors has resulted in disinterest on the part of the finance sector, which is one of the biggest barriers to SHP projects. Carbon revenues can be used to win a financier for an SHP project and to lower the payback period. Additionally, SHP projects lead to cleaner electricity generation and therefore reduce greenhouse gas emissions.

Target group: The above PoA addresses locations which are situated close to small, useful hydropower resources with surrounding electricity consumers who have used fossil fuel-based grid electricity in the past. Moreover, SHP plants could be constructed next to municipalities or factories.

Managing entity: The PoA coordinating entity is a financial institution. The institution must have experience in developing comparable programmes, competence in financing renewable energy projects (e.g. hydropower) and project financing in general, as well as a network within the PoA area. Additionally, internal technical expertise is necessary to evaluate project finance appropriately. The PoA coordinator has to manage the financial streams under the PoA, i.e. by providing attractive loans to the SHP developer in order to enable them to finance the individual CDM programme activities (CPAs) under the PoA. Alternatively, utilities or public intuitions are also conceivable as a managing entity, especially in a payment-on-delivery model structure.

If the SHP developers (CPA managers) are, for instance, utilities or other independent power producers (IPP), the stakeholders are presumably aware of all steps of a hydropower project, i.e. experienced in planning, constructing and operating these power units. Therefore, only minor supportive network connections and capacity building measures are needed. In this case the carbon finance effect makes the SHP project economically more attractive for the stakeholders.

If another objective of the PoA is to introduce more players to the electricity generating market, then a greater effort is required in terms of capacity building, knowledge transfer and matching up idle partners. Depending on the capabilities of the targeted SHP developers, the coordinating entity has to support them either with experience and knowledge or with networks and partners for hydrological and environmental assessments, preliminary designs, permits and approvals (for water, land use and construction), land rights, interconnection studies, contracting and obtaining power purchase agreements (PPA), plant manufacturing and project management.

The PoA coordinator would then function as a multiplier of the necessary hydropower management knowledge. Of course this will entail at first a leaning process within the PoA coordinating entity or an outsourcing of such services to appropriate companies or a regional or local energy agency.

Actors involved: Besides the financing institution and the SHP developer, a utility will be involved in the first CPA. With the utility the SHP developer will have a PPA and, for monitoring reasons, information form the utility will be required. The following actors have to be coordinated by the SHP developer itself:

(i) Municipality or regional government for permits
(ii) The constructing company
(iii) The operation or maintenance party responsible if the SHP developer is not taking care of this.

Programme implementation: At first, the identification of suitable project sites and of potential CPA developers, institutions or companies is required. This could be done in cooperation with local utilities. The PoA coordinator should decide and ensure that the target group is experienced in the electricity/hydropower sector. Depending on the decision about involved institutions, the above described knowledge transfer services have to be set up.

The bank as the PoA coordinator facilitates the attractive loan conditions to the CPA developer and arranges a contract regulating the ownership of the carbon certificates. The coordinator receives the certificates and is able to market them accordingly. This in turn enables the better loan conditions for the SHP developer. The next step of the SHP developer is the negotiation and contracting of the PPA with the utility. Afterwards, the SHP independently plans, constructs and maintains the SHP plant.

The annual monitoring report is delivered by the SHP developer with the support of the utility's invoices.

9.4 Carbon revenues and financial requirements

9.4.1 Carbon revenues

The installed capacity and water resource availability are the most important factors influencing carbon revenues. Both the capacity and the plant load factor determine the produced energy and thereby the income from a feed-in tariff and PPA as well as from the achieved emission reductions, respectively.
Furthermore, the CO_2 emissions factor of the national or regional grid of the target country/region has an influence on the overall emission reductions. A hydropower unit with the same MWh output could achieve significantly higher carbon revenues in a country/region with a carbon intensive generation mix than in one with an already remarkable amount of renewable power sources, for example. Therefore, the CER potential largely depends on the location.

The following table displays details of the SHP PoA under validation and most recently registered SHP standalone CDM projects, all of these projects dispatched into an existing power grid.

UNFCCC ID	Name of Programme/ Project	Country	Capacity	Expected annual amount of CERs	Expected annual amount of CERs per kW
3562	Masca Small Hydro Programme	Honduras	7 turbines: 0.7 – 2.3 MW	3,952	-
None (PoA)	Sustainable Small Hydropower Programme of Activities (PoA) in Indonesia (1.1 MW Manggani Mini Hydroelectric Project, West Sumatra, Indonesia - CPA)	Indonesia	Combined installed capacity of no more than 15 MW	5,201	-
None (PoA)	Sustainable Small Hydropower Programme of Activities (PoA) in Viet Nam (Song Mien Hydropower Project - CPA)	Vietnam	Installed capacity of up to 30MW	9,624	-
None (PoA)	Vietnam Renewable Energy Development Program (REDP) - PoA (REDP1 - Sung Vui Hydropower Project - CPA)	Vietnam	5 projects with installed capacities between 4 to 18 MW (initially)	31,820	-
2738 (small-scale)	Ping An Yiji 6MW Hydropower Project in Chongqing City	China	3 x 2 MW	20,729	3.45
2729 (small-scale)	5 MW Chirchind Grid-Connected SHP in Himachal Pradesh, India	India	2 x 2.5 MW	16,861	3.37
2692 (small-scale)	Bethlehem Hydroelectric Project	South Africa	3 + 4 MW	32,688	4.67

Table 37: CER estimations of SHP projects/programmes

9.4.2 Financial requirements

The financing of SHP projects has suffered under the trend that funding from government and international agencies has become steadily more difficult to secure, making loans and equity capital from the private sector increasingly important in the financing of both thermal and hydroelectric power projects.

Several of the main cost components involved in developing hydropower projects do not change proportionally with the project size. For a large project the technical feasibility study normally accounts for 1% – 2% of the total costs while for a small project the costs for the feasibility study may be significantly higher.

Furthermore, the costs for required permits (e.g. EIA, land and water rights) vary on average from EUR 10,000 to 30,000 for a request of authorisation and this amount is lost if the authorisation is denied (ESHA 2005a).

On average, investment costs vary in the range of 1,000 – 3,000 EUR/kW. This means that the payback time without financial assistance is between 10 and 20 years (ESHA 2005). Hence many banks regard hydro projects as a risky investment. A positive exception is China: with its extreme efforts to disseminate hydropower, the four major Chinese state banks lend money to hydro projects. Loan conditions usually range between three and five years and financing negotiations take only three months (ESHA 2005b).

To sum it up, the high initial costs combined with a long payback period make SHP projects un attractive for financiers and are therefore the main barrier for SHP projects.

The following cost summary is adapted from an estimation of average costs for a 3 MW hydropower unit. To be on a conservative side, a 10-year crediting period is applied. Of course, due to the long lifetime of such a plant, a renewable crediting period is also possible.

Cost components		Upfront (EUR)	Annual (EUR p.a.)
Fixed costs	Project design and CDM documentation	200,000[112]	30,000
	Monitoring	45,000	1,000
	CDM fees	50,000	30,000
Variable costs	SHP procurement	7,500,000	-
	Permit costs	-	20,000
	Other costs	-	150,000

Table 38: Overview of the fixed and variable costs of the model SHP programme (nominal)[113]

For this specific example, the nominal costs per installed SHP unit (3 MW) would reach EUR 7,546,500 upfront and EUR 156,100 in annual costs. The assumptions lead to the following attractiveness table. The CER generation scenarios represent the following CERs/a resulting from a 3 MW unit and a total programme of 30 MW in a grid connected project.

Annual CERs per SHP unit	CER minimum price for break-even (€)	CER price for IRR of 15% (EUR)
3,000	3.5	58.5
5,000	2.1	34.9
7,000	1.5	25.1

Table 39: Indicative level of CER prices and CERs per SHP required for break-even and IRR of 15 %[114]

[112] Due to the relatively broad experience with single project hydropower activities within the CDM, it can be expected that the total costs for the project design and for CDM documentation may be lower than for the other project types described in this book.

[113] Assumed PoA with 10 CPAs, 3 MW installations, EUR 2,500 per kW installation costs & 2% O&M costs.

[114] Note: Discount rate of 10% for the calculation of the break-even point

The financial information of the model projects allows for the calculation of the critical project size to achieve financial viability. The following CER revenue levels are considered for the analysis, assuming a CER price of EUR 12 and annual numbers of CER per SHP of 3,000, 5,000 and 7,000. Based on the three scenarios for the CER revenue per SHP unit, the critical project size for the break-even and IRR of 15% are summarised in Table 40.

Annual CERs per SHP unit	Critical size (number of SHP units)	
	Break-even	IRR of 15%
3,000	3	Unlikely to achieve
5,000	2	Unlikely to achieve
7,000	1	Unlikely to achieve

Table 40: Critical size of an SHP programme for the break-even point and IRR of 15%[115]

A grid-connected hydropower programme is covers the costs for the Coordinating Entity already with a few installations but is unlikely to achieve a high IRR.

[115] Note: Discount rate of 10% for the calculation of the break-even point

Key points and challenges

1. Small hydropower projects can generate electricity in rural areas and replace diesel generators. Step by step the small units can contribute to a cleaner energy mix of the region or country. With productive use these areas could become independent from rising fossil fuel prices.
2. The high investment and the long and burdensome planning and project realisation time are the main barrier. For grid connected projects the administrative framework of a region or country can also be prohibitive if no access to water or dispatch grids is possible.
3. The programmatic CDM could help overcome these barriers by providing additional revenues from the sale of CERs to support the finances of the project developer.
4. SHP units cost between EUR 1,000 and EUR 3,000 per installed kW. Depending on the achievable plant load factor and the grid emission factor of the host country/region, a 3 MW unit could save between 5,000 and 8,000 t $CO2e/a$.
5. Key Challenge I is the need for financial support as access to finance is limited and cumbersome. Carbon revenue is an additional income stream to the repayment of the loan and provides incentives to the bank to give out loans with more attractive conditions.
6. Key Challenge II is the need for management support during the project set-up and during operation to overcome obstacles that inexperienced hydropower players face.

10. Efficient Chillers[116]

10.1 Background

In many developing countries, cooling requirements contribute significantly to increasing demand for electricity. In India, for example, over 30 % of energy consumption in large buildings and industrial establishments originates from chillers providing the necessary cooling. As the production of electricity accounts for approximately 41% of worldwide CO_2 emissions (IEA, 2007), limiting the demand for electricity through end user energy efficiency is of key importance. Large energy savings and CO_2 reductions could be achieved by replacing old, inefficient chillers by more efficient ones.

Chillers mostly supply the required energy service for process cooling and cooling for commercial and industrial buildings. Chillers are sometimes also used to supply a large number of smaller units with cooling, such as residential units and offices, usually referred to as air conditioning units. The demand for cooling service in small units (residential units, offices and small commercial units) today represents the bulk of the demand for cooling services in most countries.
According to some models (Letschert and McNeil, July 2007) residential cooling already consumes well over 15% of residential electricity use in India (in 2008) and is expected to even exceed 20% of residential electricity consumption beyond 2020. This is confirmed by sales numbers of air conditioning units which are growing at a rate of 20% per year in India (Letschert and McNeil, July 2007). In China, air conditioning already represents 20% of total electricity demand[117]. In Chinese provinces which combine a subtropical climate with a higher than average level of economic development, air conditioning can even consume over 30% of total electricity production as it is the case in the province of Guangdong.[118]

The use of large chillers to provide cooling service to several users is limited, however, by administrative and technical requirements when there is a need for sharing the required infrastructure. For example, for users that are not located in the same building the use of district cooling consisting of a large chiller and a supply network would be required. As a result, split air conditioning (AC) units[119] are still the prevailing solution in the residential sector[120]. This chapter, however, solely

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[116] A chiller in this chapter refers to vapour compression chillers driven by an electric motor.
[117] Greenpeace, October 2008.
[118] China Daily, July 30, 2005.
[119] Although AC units do not fundamentally differ from chillers, their scale is generally limited to 0.5 to 5 TR (Tonnes of Refrigeration). Another key difference is in the way the cooling is provided to end users. In the case of AC units the medium (air) is directly cooled while chillers are generally used to chill a cooling fluid (e.g. chilled water) which is then supplied to the end users.
[120] It should be noted that chillers are also used in the residential sector when a central chiller supplies many building units with cooling service. This is the case in either large scale residential buildings with many units or in cases where the chiller supplies building units which are not all attached through a district cooling network.

concentrates on larger chillers, and more precisely on “vapour compression chillers” also commonly called “electric chillers”[121].

The performance of a chiller is defined by its Coefficient of Performance (COP), also sometimes referred to as Energy Efficiency Ratio (EER). It is defined as the ratio of the heat removed (cooling) per unit of power consumed. In this chapter it is expressed in $kW_{electricity}$ per Tonne of Refrigeration (TR)[122]. New efficient chillers can reach between 0.35 and 0.55 kW/TR while old installed chillers 10 or more years old consume 0.95 to 1.3 kW/TR (World Bank 2009). In turn, replacing chillers 10 or more years old could cut the specific electricity consumption by close to 50% compared to older units in operation[123]. Depending on the technology and surrounding conditions, chillers have an average technical lifetime of between 15 and 30 years[124.] As a result, energy savings over the whole remaining lifetime of inefficient chillers can be substantial. The cost of acquiring new chillers is quite high, with an estimated USD 400 per TR, while no capital cost is required for the continued operation of an existing outdated chiller[125]. Despite the high initial costs, replacing inefficient chillers can be economically attractive due to the substantial electricity savings. By replacing an inefficient chiller with a specific consumption of 1 kW/TR by a modern chiller consuming only 0.45 kW/TR, savings of over USD 100 per TR capacity are possible – equivalent to a simple payback of less than 4 years[126].

Efficient chillers create a win-win situation for many reasons.

- Many countries with a high need for cooling suffer from electricity supply shortages, as is the case in India, for example. The electricity savings can therefore be used for additional energy services and contribute to the economic development of a region or country.
- The demand for cooling is often a major source of peak electricity consumption. Saving chiller energy consumption can therefore reduce the high cost of power generation and the provision of a power transmission and distribution network associated with a high peak load.

[121] Besides electric chillers, heat driven chillers such as absorption chillers also exist. Most of the cooling worldwide, however, is supplied by “vapour compression chillers” driven by an electrical motor.

[122] A Tonne of Refrigeration (TR) is a unit for the cooling power. It is defined as the cooling output required for freezing one metric tonne of water at 0°C within 24 hours.

[123] Depending on the country, the efficiency gap or difference in efficiency to the best available technology is estimated between 40% and 50% based on an ICF study (Chiller Sector Energy Efficiency and CFC phase-out, ICF, Jan 2005) as quoted in the World Bank report (World Bank, project appraisal document, May 29 2009).

[124] The technical lifetime of a chiller depends on many factors, among which are its load factor (in % of its nominal load), its utilisation rate (in hours per day), the type of technology used, the maintenance performed as well as the climatic zone in which it is installed. The standardised lifetime provided in the UNFCCC “Tool to determine the remaining lifetime of equipment” is 15 years

[125] http://www.allbusiness.com/professional-scientific/scientific-research-development/528253-1.html

[126] Based on an operation of 3,000 hours per year, a cost of purchased electricity of 0.08 $/kW and a capital cost of 400 $/TR for acquiring chillers.

- The lower fuel consumption decreases both local and global pollution and reduces the exposure to fluctuating fuel prices on the country or regional market level.[127]
- Finally, the investment in new chillers to replace outdated ones represents an investment with an attractive return on investment and a high business certainty.

Beyond energy efficiency and reduction in GHG emissions, the replacement of outdated chillers can also achieve the objective of the Montreal Protocol of phasing out Ozone Depleting Substances (ODS). A number of chillers operating in Non-Annex I countries currently operate on CFC-11 and CFC-12 refrigerants and are expected to do so until the end of their lifetime. An early retirement of these chillers would reduce the leakage of highly potent ODS which would otherwise have occurred as a result of their continued operation.

Although sufficient statistics do not exist, many inefficient chillers are expected to still be operating in developing countries, despite the benefits of replacing outdated chillers by more efficient ones. Initial field research in two countries, however, has estimated a total potential for inefficient chiller replacement on a scale of hundreds of units[128].

Early retirement before the end of the technical lifetime is called "discretionary retrofit". Discretionary early replacements are rarely observed as there is little awareness of the associated savings. Moreover, the initial investment required often represents a barrier and investments in energy efficiency are often neglected as they are not in what is considered a core business of chiller owners or operators. It has been estimated in the case of India that chiller replacement for the sector as a whole, considered as an investment, is required to produce an IRR of more than 30%.[129]

The CDM/JI could help overcome the barriers associated with the switch to more efficient chillers, especially for the initial cost barrier, by providing additional revenues through carbon emission reductions that can be secured and thus mobilise upfront financing. Additionally, in the frame of a programme the CDM/JI could overcome other major barriers to the early replacement of inefficient chillers such as lack of awareness and expertise. The following sections discuss methodological and financial requirements for a chiller replacement programme and develop a model for chiller replacement implementation, building on the lessons learned from other programmes (e.g. stoves, transformers, CFL, etc.).

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[127] A more energy efficient solution reduces the fuel consumption but increases fixed capital costs. This reduces the risk associated with the price volatility of fuels as less fuel is consumed. Instead the energy efficient solution relies more on predictable capital expenditures.

[128] Around 375 chillers of 100 TR output with a residual lifetime of five years or more have been identified in the Philippines. Among these 375 chillers, roughly 10% are CFC based eligible chillers (independent count for the Philippines). For comparison, around 1,000 to 1,200 CFC based chillers of 100 TR or more capacity are estimated to be operating in India

[129] World Bank, 2002: Sidney F. Thomas, Ph.D. India Chiller Replacement Strategy Study: Report of the Lead Consultant. The World Bank. June, 2002.

10.2 Methodological requirements

Existing methodologies

By October 2010, there were no registered PDDs for efficient chillers, whether for new chillers or for the replacement of existing chillers by more efficient ones. In total, seven prospective projects have been identified at an earlier stage [130]. Three of the identified prospective projects consist in a CDM programme aimed at replacing several chillers.

In order to claim CERs from the replacement of chillers in a programme, the savings from the programme have to be calculated first. Savings include CO_2 savings from energy use as well as, in some cases, the reductions in emissions from refrigerants with global warming potential.

Key parameters for the energy savings calculation, depending on the chosen methodology, include – *inter alia* – the number of chillers replaced, the cooling output supplied by each one, as well as the specific gain in energy efficiency.
In order to claim CERs from an efficient chiller programme, the electricity savings resulting from each CPA have to be calculated. The same level of service should be used in the baseline and the project. This level of service is determined by monitoring the cooling provided by the project chiller (new chiller). While the electricity consumption in the project can be directly metered, the baseline electricity consumption has to be estimated based on what would have been the level of energy efficiency for the conversion, using the baseline chiller.

The determination of the real efficiency of electric chillers is complex as the relation between the cooling delivered and the electricity used is not linear. Instead the efficiency of the chiller is influenced by many parameters[131], inter alia:

(i) the utilisation factor,
(ii) the outside temperature and
(iii) the outlet temperature (related to the desired cooling).[132]

In order to determine what would have been the baseline electricity consumption for the provided cooling output, two broad categories of estimations can be applied:

(i) determination of the exact function between the three parameters listed above and the level of efficiency of the baseline equipment and
(ii) deemed savings approach.

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[130] Source: Point Carbon Project Manager (as found in the database on 7 February 2009) and internal sources.

[131] These parameters have been taken into account in the approach applied for the CDM methodology AM0060, thus the list of parameters to be considered can be found in AM0060

[132] The outlet temperature is the temperature of the cooling medium leaving the chiller. In the literature, the temperature lift (difference between the returning temperature of the cooling medium and the temperature at which it is chilled) is sometimes used.

The main difference between the two approaches is the degree of monitoring requirements. The first approach involves greater monitoring efforts since in the absence of manufacturer data an initial monitoring campaign for the characterisation of the equipment is required before scrapping the baseline chillers. Additionally, this approach requires a precise and continuous monitoring of these three parameters in the project as these are the real conditions under which the baseline chillers would have operated in the absence of the project.

- Key parameters for refrigerant-related emissions include - *inter alia* – the global warming potential of refrigerants used in the baseline and the project, specific leakage rates of the refrigerant in the baseline and the project, the charge of refrigerant in the project chillers, and the charge of refrigerant in the baseline chillers.

The electricity savings are multiplied by the corresponding grid emission factor to calculate the emission reductions from energy savings achieved by the programme. The total emission reductions are calculated by adding the emission reductions from energy savings and the emission reductions from refrigerant (if any).

AMS-II.C. (version 13) is applicable to energy efficient equipment either installed at new sites or as a replacement of existing equipment[133]. It requires the use of Chlorofluorocarbon(CFC)-free refrigerants in the new chillers. The methodology further specifies that only emission reductions from the reduced use of electricity can be credited. The methodology, however, requires the accounting of refrigerant leakages in both the project and the baseline (e.g. through the use of a standard factor). This contradicts the calculation which would in theory also generate CERs from the switch to chillers with a lower leakage of refrigerant in the case of refrigerant with a high Global Warming Potential (GWP).
With the threshold of 60 GWh_{el} maximum savings per CPA and year, a CPA within the programme would be limited to the replacement of a cooling capacity of roughly 40,000 to 50,000 TR.[134]

AMS-II.D. (version 12) is a generic methodology applicable for energy efficiency projects at one or more industrial facilities. The methodology can be used for efficient equipment installed at new sites or as a replacement of existing equipment. The methodology does not include any provision for emissions related to the leakage of refrigerants with GWP. The methodology requires that the "impact of the project implemented can be clearly distinguished from changes in energy use due to other

[133] According to applicability conditions found in AMS-II.C. v. 13 this methodology comprises activities that encourage the adoption of energy-efficient equipment/appliances (e.g., lamps, ballasts, refrigerators, motors, fans, air conditioners, pumping systems) at many sites. These technologies may replace existing equipment or may be installed at new sites."
[134] Based on an assumed operation of 3,000h/year and a gain in efficiency of 0.45 kW/TR assuming an efficiency of 0.55 kW/TR in the project and 1kW/TR in the baseline.

variables not influenced by the project activity". This condition can potentially be seen as critical as many variables influence the real efficiency level of chillers[135].
Most prospective projects for chillers propose the use of AMS-II.D. So far no project for chiller replacement has been formally submitted to the CDM Executive Board (EB). As such, no feedback is available on the precise requirement which would be acceptable for projects using this very generic methodology. The threshold explained for AMS-II.C. (60 GWh_{el} maximum savings per CPA and year) also applies to AMS-II.D.

As of February 2010, two large-scale methodologies exist for efficient chillers: **AM0060 (version 1.1)** and **AM0084.** The methodology **AM0060** only allows for chillers driven by electrical energy. **AM0084** is only applicable to the installation of a new cogeneration plant simultaneously producing chilled water and generating electricity by using absorption chillers. As absorption chillers only represent a small fraction of the installed chiller capacity, the potential for AM0084 is limited.

AM0084 in its version 01 is only applicable if the project is a cogeneration system in which heat is produced to generate both power and cooling using solely heat absorption chillers. Due to the high investment cost and the complicated business model and monitoring, the potential for this methodology is limited. For both, baseline and project chiller, the methodology uses the concept of "power function" initially developed for AM0060 which adds to the methodology complexity.

AM0060 in its version 1.1 is the only large-scale methodology applicable to "power savings through the replacement by energy efficient chillers" for electric chillers. The scope of this methodology, however, is explicitly limited to the replacement of existing chillers by new chillers and will therefore fail to capture the market for new chillers. A key concept of this methodology is the determination of a "power function" expressing the COP as a function of the output, condenser temperature and outlet temperature.
The use of this "power function" is complex due to the data needed to determine the "power function" of the baseline chiller. If such data is not available from the manufacturer, an initial measurement campaign has to be performed in order to determine the "power function" for the baseline chiller.
It also requires the constant monitoring of the same parameters during the operation of the project chiller. This power function essentially consists of a function which links the following three variables: (a) the chiller output, (b) the inlet temperature of the condensing water and (c) the outlet temperature of the chill water. A proposed very stringent alternative in the methodology (referred to as "Option C") is the use of the most conservative COP observed over the range of the operating parameters.

[135] In AM0060 and AM0084, parameters included in the power function which are seen as critical parameters influencing the chiller efficiency level are: (a) the chiller output, (b) the inlet temperature of the condensing water and (c) the outlet temperature of the chill water.

So far only two PDDs applying this methodology could be identified and no project activity has been registered under this methodology yet. Several barriers have been identified which have so far prevented the use of this methodology despite the high potential for emission reductions. In sum, AM0060 is the only methodology specifically dedicated to electric chiller replacement projects as it includes a clear and suited guidance for the determination of the baseline efficiency level through the use of a power function. While accurate, the use of a power function is, however, likely to lead to high monitoring costs. While other methodologies, especially the small-scale methodologies AMS-II.C. and AMS-II.D. also seem to be applicable, no clear guidance exists for establishing the baseline level of the coefficient of performance.

While the monitoring for AM0060 is complex due to the use of the “power function”, it is doubtful whether other less accurate baseline determinations will be allowed in combination with small scale methodologies. The potential gains from a simpler monitoring requirement for COP and electricity usage should be carefully compared against the possible loss in the amount of CERs as well as the risk for registration or approval (in case of a proposed new methodology).
A decision will also depend on the amount of planned chillers in the programme as well as on the registration risk for simplified approaches under small-scale methodologies or a new methodology. On those results the decision for the most appropriate methodology can be taken. While the monitoring for AM0060 is complex, PoA coordinators should take into account the economy of scale linked to the replication of this type of monitoring which, once mastered, can be replicated to many CPAs.

Category	Key methodological differences
Applicability	AM0060: Replacements of existing electric chillers used to chill a cooling fluid (chillers directly cooling a process are excluded). AM0084: Substitution of electric chillers by cogeneration of electricity and cooling via absorption chillers from a source of heat. AMS-II.C: Maximum savings of 60 GWh electricity annually. New projects and replacements AMS-II.D: Maximum savings of 60 GWh electricity annually. New projects and replacements.
Baseline determination	AM0060: Use of either the power function to determine the parametric baseline COP or the lowest COP for any of all the operating parameters. AM0084: same as AM0060. AMS-II.C: Calculated either based on the total energy consumption in the baseline (option 1) or based on the baseline-specific energy consumption per unit of supply (option 2) AMS-II.D: Retrofits: Historical energy consumption – no further guidance. New chillers: estimated energy consumption of the "most plausible baseline scenario
Emissions from refrigerant	AM0060: Leakage of refrigerants in the project and baseline; initial charge of refrigerant (project chiller only) AM0084: same as AM0060. AMS-II.C: Baseline and project leakages of refrigerants. AMS-II.D: no information available
Monitoring	AM0060: Characterisation of the "power consumption function"; monitoring of the cooling output and of the parameters for the application of the power consumption function AM0084: same as AM0060. AMS-II.C: no further information AMS-II.D: no further information

Table 41: Key methodological differences between AMS-II.C (version 13), AMS-II.D (version 12), AM0060 (version 1.1) and AM0084 (version 1)

10.3 Programme design

10.3.1 Lessons from existing programmes

As chiller replacement programmes have so far been limited to two prospective PoAs, elements available from such existing programmes will be compared against other programmes such as CFL, efficient cooking stoves and biogas. The experience gained from other programmes will be used in order to highlight what the key success factors for efficient chiller replacement programmes might be.

The expected key factors of success are the following:

- The identification of a sufficient target group in terms of the number of eligible chillers within the chosen project boundaries;
- Identifying the key institutional players and assisting in strengthening the capacity of these players to effectively carry out their respective roles;

- Securing the commitment and support of financial institutions to work in close partnership, especially if the business model includes the disbursement of an initial grant;
- Securing additional income from appropriate funds (World Bank, GEF, etc.) if the chiller programme also aims at reducing ODS emissions;
- Sufficient resources for promotion and marketing;
- Providing technical and management support to all key players
- Ensuring that the appropriate incentives reach the target groups as owners/operators of chillers might not all have the same upfront capital available.
- Ensuring cooperation with known and reputable actors trusted by the target group, as chiller owners/operators trust their existing chiller types and might be reluctant to change unless the incentive is well communicated.

Regarding promotion and marketing, lack of consumer awareness is a major limiting factor, whether for new units or for the replacement of existing units. In order to overcome this barrier, information and education need to be central to any promotional programme. This is especially true as (i) consumers might be satisfied with their present solution, (ii) mistrust the new solution and (iii) consumers might not understand or know about its economic advantages. Most of the benefit for the consumer comes from decreased monthly electricity costs of which they might have only limited awareness as energy efficiency is not regarded as part of the core business plan.

A lack of familiarity with the CDM in its regulatory framework and technical requirement for the monitoring is another key limiting factor. It explains especially why the CDM, due to its own complexity and transaction costs, has not been able to provide an incentive sufficient to mobilise such projects. By pooling CDM managerial and technical resources, programmes might finally overcome such barriers which for single chiller CDM projects would have outweighed the benefits from the CDM. This is especially expected with the complex monitoring required in CDM large-scale methodologies for chiller replacements.

10.3.2 Business model and institutional requirements

Building on the lessons learnt from other programmes as described above, an efficient chiller replacement programme model is conceptualised in Figure 9. The figure summarises the key actors and their responsibilities. It has to be kept in mind that different options regarding the different actors and their roles and responsibilities are possible. For example, in one analysed CPA-DD, chiller owners can choose between surrendering all CER rights in exchange for an upfront grant or surrendering only a fraction of the CER rights in exchange for participation in the programme (administrative and monitoring costs). Also, the share of the initial investment not covered by the initial grant could be financed either by the chiller owner, by the chiller supplier (in the form of a lease) or by a bank which can also be the project coordinator. The development of the business model should be oriented towards the core competencies of the different actors, especially the core interests and strengths of the PoA coordinator.

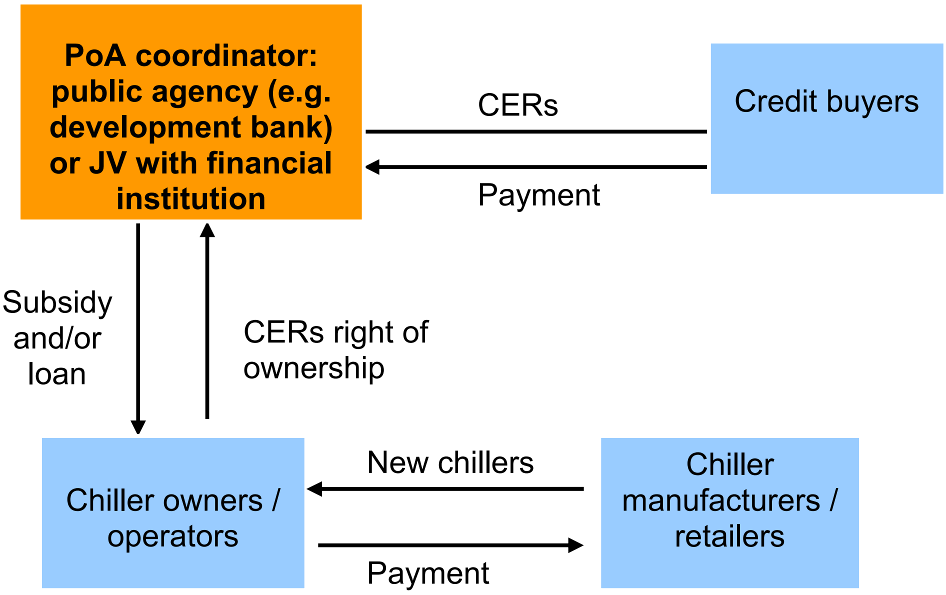

Figure 9: Business model example for a chiller replacement programme

The model strives to address the barriers to efficient chiller replacements in the following manner:

- Initial cost barrier: Provision of grant to chiller buyers to lower the initial costs to a more attractive level. This grant is provided on a basis proportional to the cooling capacity of chillers (in $ per TR). As an alternative to the initial grants, soft loans can also be provided.
- Technology barrier: Ensuring the choice of appropriate chillers and a proper replacement including scrapping of the installed chillers – additionally, technological assistance is provided for the complex monitoring.
- Information/behaviour barrier: Raising awareness through chiller manufacturers/suppliers who have knowledge of installed chillers (scale, efficiency level and age) and an economic incentive to replace chillers. Chiller manufacturers are trusted by customers, have a working relationship with them and an expert knowledge of chillers.

Aim of the PoA: The aim of the PoA is the replacement of outdated chillers, which would otherwise continue operating, by new chillers with a much higher level of efficiency, thus saving electricity. The PoA aims to remove the two main obstacles which are (i) the lack of information and awareness and (ii) the high initial investment. This initial investment barrier has been one of the largest obstacles to the early replacement of chillers. To overcome this barrier the PoA proposes passing on the income from the carbon revenues to incentivise the participation in the programme. The participation of chiller owners could be incentivised through the following instruments:

- An upfront grant paid to chiller owners upon replacement and paid proportionally to the chillers' cooling output (in $ per TR) in exchange for full surrender of CERs rights, or
- An upfront soft loan in order to finance the acquisition of the new chiller in exchange for full surrender of CERs rights, or
- The payment of a substantial share of the CER revenues as they are generated to chiller owners in exchange for a share of withheld CERs by the managing entity in order to cover the administrative and technical costs involved in participation in the programme.

Participation in the programme would lead to a decreased consumption of electricity which would both reduce consumers' electricity demand and greenhouse gas emissions. In addition, this will ease the shortage of power supply in the associated power grid to which the chillers are connected.

Target group: The target group is owners of chillers with a minimum output of 100 TR[136] in a defined geographic area (e.g. country). As the early retirement of inefficient chillers is credited, only chillers with a specific expected remaining technical lifetime are eligible. The target group includes chillers operated for either process cooling or air conditioning.

Managing entity: The PoA coordinator is either (i) a public agency such as a development bank, (ii) a utility company with a very strong logistical capability and excellent local network in areas that are normally not conducive to business activities or (iii) a private consultant with appropriate CDM expertise and capable of supervising the various steps of the programme. The PoA coordinator takes care of, inter alia, (a) developing the business model of the PoA; (b) implementing or supervising marketing operations necessary for the programme; (c) the model for financial transformation (e.g. providing a financial incentive for the switch to an efficient chiller); (d) the availability of setting incentives (whether as a grant or soft loan) to the end user; (e) the technical and administrative support for participating entities or its supervision; (f) supervising the monitoring necessary for the CDM project. In case the managing

[136] As considered in the PoA proposed for the replacement of chillers in the Philippines. Chillers of a lower scale are thought not to reach the required threshold to offset with carbon revenues the cost occurred from their participation to the programme.

entity has no technical capability to perform the monitoring it would need to hire an entity that takes over the monitoring.

Actors involved: Once the business model for the chiller replacement programme has been set up by the coordinating entity, the marketing and communication campaign is to start by explaining and marketing the programme to chiller suppliers. This communication is to ensure active participation of chiller suppliers as main actors of communication and marketing toward the chiller owners based on their economic interest to sell new chillers. As already mentioned, chiller suppliers usually have a sound knowledge of the installed chillers and a working relationship with their owners. Additionally, private or public banks could be involved for the additional need to finance the initial investment, including in association with chiller suppliers. In business models in which the incentive is passed on in the form of a soft loan instead of an upfront grant, banks play an even larger role. The coordinating entity can choose to be the managing entity of the PoA or subcontract the daily management of the PoA to a private entity. Additionally, in case no internal expertise is available for the monitoring, an external entity can be hired.

Programme implementation:

- If additional revenues are expected from the reduction of ODS, the PoA coordinator is to assess potential additional financing from ODS reduction.
- The PoA coordinator needs to conduct an ex-ante random survey in the project area. The key issue for investigation is the detailed census of the cooling capacity eligible for the project in the selected programme boundaries. This requires, among others, knowledge about the cooling output of chillers (expressed in TR) in the target group; their operation load (in hours per year); the estimated efficiency of such chillers; the age of the chillers; the electricity grid(s) to which chillers are connected and the emission intensity of the respective electricity grid(s). Finally, as different technologies have a different expected average technical lifetime, the type of chiller used also needs to be known and documented if the programme is to differentiate the remaining lifetime according to the technology. Based on these, PoA coordinators can determine the potential carbon revenue from the CDM for potential project participants. With additional information on the bulk electricity prices, efficiency for potential replacement models and their costs, the PoA coordinator can estimate the potential electricity savings for potential project participants.
- Based on the results, a business model with a detailed project implementation plan has to be established. Ideally, the model would allow for a maximum mobilisation of the potential for emission reductions.
- The PoA coordinator has to prepare necessary contractual arrangements with the chiller owners. The PoA coordinator organises awareness raising activities for the programme toward chiller suppliers and further assists them in their own

marketing for chiller owners. The PoA coordinator has to publish the requirements for programme eligibility such as a minimum COP or requirements in terms of the remaining technical lifetime of the chillers. The chiller suppliers play a key role in selling and distributing the new efficient chillers and could help in organising the promotion and awareness activities. In case new models are to be introduced in the market, which have not been distributed before, the PoA coordinator has to take care of aspects related to the import of the units and their compliance with national standards.

- The technical process of replacing existing chillers has to be implemented. If AM0060 is used, it includes a measurement campaign for the characterisation of the power consumption function of the baseline chillers according to several parameters. Once the measurement campaign has been performed, the gas charge from the replaced chiller has to be recovered and certified, especially if the refrigerant has a high Ozone Depleting Potential (ODP) or high Global Warming Potential (GWP). This operation is to be performed by adequate and certified experts. The baseline chiller can then be scrapped with documented proof of the scrapping. The chiller supplier will then install the new chiller according to applicable procedure. Additional to the installation of the new chiller, monitoring equipment has to be installed in order to record (i) parameters which will enable the back calculation of what the COP would have been in the baseline for the specific operation parameters, (ii) the power consumption and (iii) and supplied cooling.
- Monitoring should be conducted by the PoA coordinator or by an entity with adequate expertise and be suited to the methodology chosen or developed for the programme. The monitoring process will require the installation of advanced monitoring equipment in order to gather data on operation along with the relevant parameters (load and temperatures) and can be combined with the installation of the new chillers. Test procedures to characterise both, replaced and new chillers, should also be organised by the monitoring entity. Also, the scrapping of retired chillers and the recovery of their refrigerant charge will need to be monitored.

10.4 Carbon revenues and financial requirements

10.4.1 Carbon revenues

Based on specific own assumptions and review chiller replacement programmes[137], key parameters for CER estimations are summarised in Table 42:

[137] The assumption of an average chiller size is derived from multiple source of literature among which reviewed PDDs. The average yearly usage is derived from the drafted PDD from the PoA programme proposed by the Philippines Department of Environment and Natural Resources (DENR).

Equivalent number of 300 TR chillers replaced	Average cooling power of units distributed	Average yearly usage [hours]	Grid emission factor [tCO2e/ MWh]	Baseline average COP [kW/TR]	Project average COP [kW/TR]	Annual amount of CERs	Amount of CERs per 300 TR chiller
400	300 TR	5000	0.6	1.0	0.5	80,000[138]	200[139]

Table 42: CER estimation of a model chiller replacement programme

The CER potential depends on several key factors such as the programme design and the location/region of implementation. It is therefore highly recommendable to conduct an ex-ante survey at the location where the programme is planned. An ex-ante survey would allow the PoA developer to assess the number of chiller units currently installed as well as their specifications (age, efficiency, capacity, efficiency level, etc.). Additionally, the ability to attract the participation of the chiller suppliers in the programme is a key parameter. A project implemented in an area with a low grid emission factor will have a lower CER generation rate compared with the same programme in an area with a higher grid emission factor. In addition, the specific climatic conditions might influence the average yearly usage of chillers. Figures on cooling usage should be gathered in order to predict the amount of expected CERs.
Additionally to energy related carbon revenues, the owner of the CERs in the business model should pay attention to the refrigerant related change in emissions in accordance with the methodology used. For example, under AM0060, the initial charge of the refrigerant is subtracted from emission reductions. There is, in turn, an incentive to select a refrigerant with a GWP that is either low or zero.
One expected feature of efficient chiller programmes is the wide use of private sector financing with the programme only providing an incentive upon replacement. Also, chiller suppliers are largely used in the promotion of the programme as they have an obvious incentive to sell their equipment.

The programme uses an incentive based on chiller output and paid to the owner for a replacement. The indexation of the incentive to the chiller capacity (in TR) prevents any perverse incentive which could, for example, arise if manufacturers had an incentive to artificially inflate the chiller price. Instead chiller owners have an incentive to pay a fair price for chillers.

The programme is generally expected to have a high cost of monitoring if a methodology such as AM0060 uses the “power consumption function”. By capitalising the knowledge for this monitoring through economies of scale achieved by replicating this complex methodology, programmes are expected to be able to cover the transaction costs.

[138] The estimated crediting only lasts for 6 years as a result of the estimated remaining lifetime of the baseline equipment replaced.

[139] The figure is an average for 6 years of crediting and accounts for a negative emission reduction of -550 tCO_2e at the beginning of the crediting period as a result of the emissions accounted for the initial charge.

10.4.2 Financial requirements

High initial costs are the main barrier for chiller replacement projects. According to the literature, the investment costs per TR of new chiller capacity are estimated at roughly EUR 300. This is equivalent to EUR 90,000 for a 300 TR chiller. By providing an upfront incentive equal to 10% of the cost of the chiller, the programme would lead to an upfront cost of EUR 10 per TR equivalent to a EUR 9,000 grant for an average 300 TR chiller.

Overall distribution costs are estimated to be relatively low as the installation of the chiller as well as marketing and commercial operations will largely be performed by the chiller suppliers that can use established distribution procedures.

The carbon revenues for chiller replacement projects can only play a limited role.
Most incentives for the chiller owners to perform retrofits will result from the related savings resulting from decreased electricity consumption. This is especially true in countries with high electricity prices. Assuming EUR 0.08 per kWh, a load factor of 3,000 hours per year and a COP improvement of 0.5 kW/TR, the specific annual savings from decreased electricity consumption would amount to EUR 120 per TR. For an average 300 TR unit this represents EUR 36,000 of savings in electricity costs per year. Despite such high savings it has been shown, however, that such savings from energy efficiency are heavily discounted and thus rarely happen for a return on investment lower than 30%.
For comparison, with an estimated CER price of EUR 12/tCO_2e, the revenue stream generated from emission reductions would only account for roughly EUR 8 per year per TR or 2,400 EUR per year for a 300 TR unit. As such the additional carbon finance is only likely to play a minor role. If well used, however, it could trigger the replacement of chiller units which would otherwise not have happened.

It should be noted that due to the nature of the project, which is to claim emission reductions up to the date at which the baseline equipment would have continued operating, estimates are based on CER generation only during the 5 first years of the crediting period.

In turn, most of the gains of such programmes arise for chiller suppliers, which achieve sales, and from the decreased electricity consumption for both the chiller owner/operator and the country's electricity system, as a result of ancillary effects from electricity savings.

It might be noted that additional costs not accounted for herein might arise from the disposal and destruction of the existing chillers. On the other hand, additional revenues could occur if the recovery and destruction of refrigerants could be taken into account[140].

Cost components		Upfront (EUR)	Annual (EUR p.a.)
Fixed costs	Programme design and CDM documentation	200,000	30,000
	Monitoring	100,000	50,000
	CDM fees	50,000	30,000
Variable costs	Chiller units procurement (for a 300 TR chiller)	9,000 per chiller	-
	Chiller distribution and replacement of existing AC units	-	-
	Other costs	-	-

Table 43: Overview of the estimated fixed and variable costs of the model chiller replacement programme

For the specific example of replacing 450 chillers, the nominal cost per 300 TR chiller unit would reach EUR 9,700 upfront plus EUR 200 annually.
This generates the following attractiveness table for annual CER volumes of 400, 200 and 100 CERs per year per 300 TR chiller unit, respectively. The median assumption of 200 CERs generated per year for a 300 TR chiller replaced is based on an assumption of a 5,000 hours per year load, an efficiency increase from 1.0 kW/TR to 0.5 kW/TR and a grid emission factor of 600 tCO_2e/GWh.

Annual CERs for an equivalent 300 TR chiller unit	CER minimum price for break-even (EUR)	CER price for IRR of 15% (EUR)
400	6	6.8
200	12	13.7
100	24	27.4

Table 44: Indicative level of CER prices and CERs per 300 TR chillers for a 450 chillers programme required for break-even and IRR of 15%[141]

Furthermore, the financial information of the model project allows the calculation of the critical project size to achieve financial viability.

The following CER revenue levels are considered for the analysis, assuming a CER price of EUR 12 and annual CER generation per chiller unit of 400, 200 (as in the reference case) and 100. Based on the three scenarios for the CER revenue per replaced chiller unit, the critical project sizes for the break-even and IRR of 15 % are summarised in Table 45.

[140] AM0060 currently only accounts for the initial charge in the project and not the recovery of the charge in the replaced chiller, thus leading to a loss of emission reduction.
[141] Note: Discount rate of 10% for the calculation of the break-even point.

Annual CERs for an equivalent 300 TR chiller unit	Critical size (equivalent number of 300 TR chillers replaced)	
	Break-even	IRR of 15 %
400	60	70
200	450	3500
100	Unlikely to achieve	Unlikely to achieve

Table 45: Critical size of a chiller replacement programme for the break-even point and IRR of 15%[142]

The analysis shows that chiller replacement programmes are only attractive if a sufficient number of CERs can be generated per chiller and if a sufficient number of chillers can be replaced within the geographic area in which the programme is implemented. Particular attention should be paid to the parameters which influence the specific emission reduction per capacity of chiller output replaced.
Nevertheless, the programme makes generally sense due to the large electricity savings. Due to the very high capital required to be invested in such projects as well as the marginal share represented by the CDM financing, it is essential for such projects to properly market the substantial electricity savings which the chiller owner will enjoy. Because the type of programme has strong ancillary effects as ODS emissions can be reduced and energy shortages can be eased, it is also very well suited for public entities as coordinating entities.

Nevertheless, for chiller owners this type of programme also fulfils a demonstration effect. Because of the information barrier, many private actors will join programmes just for the comfort afforded by being with the peer group, and for not missing out on the informational hand-holding that would be provided. The fact that this type of programme is an environmentally friendly initiative gives impetus for marketing corporates as being environmentally aware and friendly.

[142] Note: Discount rate of 10% for the calculation of the break-even point.

Key points and challenges

1. In many parts of the world, outdated chillers with low efficiencies are still in operation. Replacing these chillers before the end of their technical lifetime could cut the electricity consumption required for cooling by up to 50%. Ancillary benefits of such programmes in terms of reduced electricity shortage or reduction in ODS emissions are strong. As such, chiller programmes are well suited for public entities.
2. Barriers for replacing existing outdated chillers by more efficient ones include the high initial costs of the devices, and mostly a lack of awareness of the energy savings potential.
3. The programmatic CDM could help overcome these barriers by lowering the cost of participation to the CDM, thus offering an attractive incentive.
4. Chiller suppliers are to play a key role in such programmes as they have key information on the cohort of installed chillers, have an interest in promoting the sale of new and more efficient chillers, and are trusted by chiller owners with whom they have a working relationship.
5. A first challenge is a careful investigation of the potential, especially regarding the output, hours of operation and efficiency of chillers found in the baseline of the programme, as well as the willingness to enrol in such a retrofit programme for a defined area. Chiller suppliers can play a key role in providing this information. It is essential to generate a maximum of CERs per chiller units installed. For this reason, programmes should focus on geographic areas with strong cooling demand and high grid emission factors.
6. The second challenge is monitoring costs that can be high for chiller programmes. It is therefore essential to be able to achieve economies of scale for the monitoring.

11. Contracting PoAs: Some legal considerations

(By Moritz von Unger, ClimateFocus)

A PoA differs from classic CDM or JI projects in a number of procedural, substantial and practical aspects. These include, most importantly, the flexible programme size; an extra governance layer; decentralised programme growth; the multitude of stakeholders and actors; the risks associated with the untested pace of implementation; and the specific role the carbon buyer usually assumes in the development and roll-out of PoAs.

As a consistent PoA practice has not yet evolved—only two programmes are registered under the CDM, five under JI—and as the theoretical underpinnings remain barely explored[143], project developers, operators, validators, carbon sellers and, last but not least, carbon buyers will require a robust contractual framework capable of structuring the transaction and minimizing risks as much as possible. Given the diverse nature of PoAs, such a framework will differ from PoA to PoA. However, there are a number of traits common to all programmes. Some of them are identified below.

A Multitude of Contractual Relations

A PoA consists of a multitude of actors and players. At the contractual centre is the coordinating or managing entity (PoA Coordinator). It is contractually linked to all CDM Programme Activities (CPAs) and all JI Programmes of Activities (JPAs), respectively, including entities that are structured within a CPA (households, end-users, others), the CPA/JPA proponents.

In most cases, PoA implementation will require close cooperation with other entities, technology providers, for instance, installation firms, financial operators or maintenance and monitoring service providers. These companies will have contractual relationships among each other and with the CPA/JPA proponents.

Then, in the investor country, the carbon buyer will usually play a key role. Due to the specific needs of PoA development and implementation, it will be rare for PoA developers to implement a programme unilaterally, i.e. without the participation of the investor country and the carbon buyer. Carbon buyers are very often needed to advance payment (seed financing) and to support the PoA with structural, operational, legal and other support. The classic contract in JI and CDM between project owner and investor, the emission reductions purchase agreement (ERPA), in the PoA constellation is either seconded by a number of other contracts (on finance, operational support, monitoring support, other) or it integrates the supplementary

143 Other than this PoA Blueprint Book (first edition 2009) there is a well publicised UNEP/CD4CDM publication (A Primer on CDM Programmes of Activities, 2009) but little else.

aspects. Either way, this contractual relationship is likely to be, and to remain, a complex and dense one.

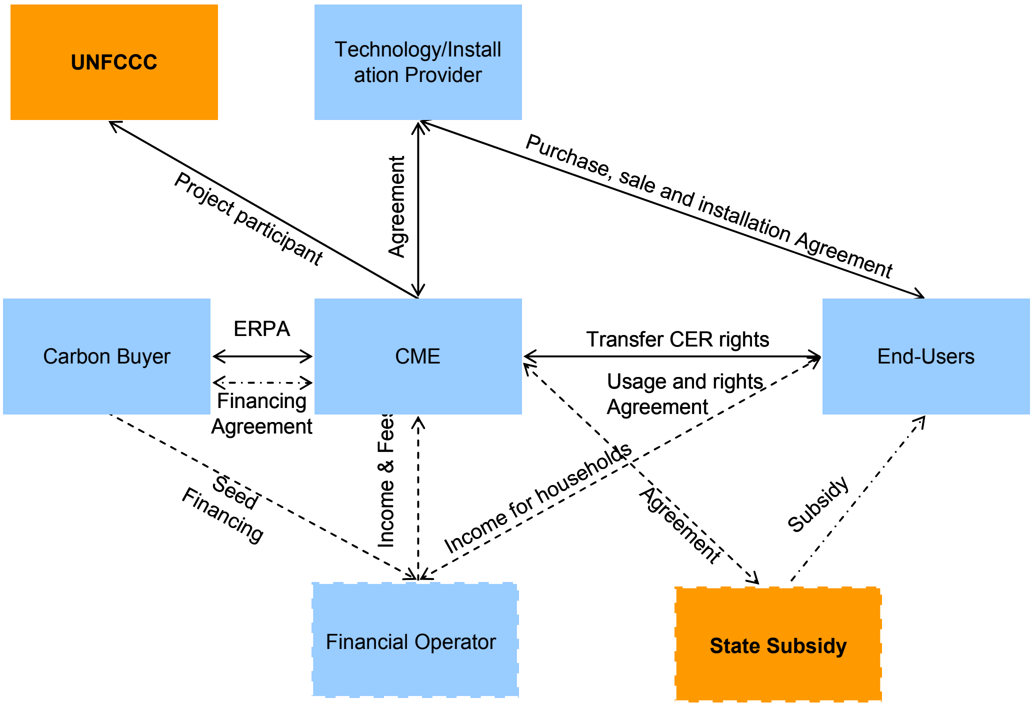

Figure 10: Contractual Arrangements PoA. Source: Climate Focus 2010.

Thus, a PoA normally combines an array of contracts and contractual partners (see figure). This makes it difficult and time-consuming to be set up, and it creates legal risks of its own. Due to the complex relationships, the different partners can control the overall implementation of the PoA only to a limited extent. In addition, if a contract is breached or terminated on one end, this will almost always have implications on the other end without the entities affected always having a contractual tool to remedy the situation. At the same time, it is usually not the most effective solution to set up multi-party agreements so that each party can control—to some extent—the doing of the others. Multi-party agreements are difficult to negotiate, complex in their structure and weak in enforceability. It is also often not recommendable for various types of actors, entities whose role is very limited in scope (technology providers, for instance) or carbon buyers, to have too much contractual exposure to other parties or stakeholders.

The most promising response is to centralise, the bilateral relations as much as possible in one entity, the PoA Coordinator. This is the entity with overall exposure, with full procedural rights in the international framework (Executive Board and Joint Implementation Supervisory Committee), and with operational oversight. The PoA Coordinator is the life-line of any PoA and it is logical to make it the contractual focus point, too.

The PoA Coordinator should, thus, be the entity that has bilateral agreements in place with technology providers, installation and/or monitoring firms, where applicable, third-party subsidy schemes, etc. For practical reasons, this may not be possible in each and every case and there are situations in which the establishment of a contractual relation is not appropriate in the first place. Most importantly, however, the PoA Coordinator should be the direct transferee of the carbon rights of the CPA/JPA proponents and other potential rights holders. For practical reasons it may often be possible that the PoA Coordinator does not engage directly with (all) CPA/JPA proponents. Technology providers, installation firms, financial operators or others may sometimes be the only ones that have the infrastructure to reach all CPA/JPA end users concerned. Then these entities will conclude the necessary contracts with the end users. Nonetheless, the PoA Coordinator should be given direct rights under these contracts so that, should there ever be a compliance issue, the PoA Coordinator can intervene directly. Naturally, the clear allocation of rights and compliance obligations through contracts is not in all circumstances feasible or realistic (in light bulb projects, for instance); general considerations of law then should help close any remaining gaps in the establishment of valid title and authority.[144]

The carbon buyer (and seed financer) will—and should—insist that the PoA Coordinator holds all relevant rights and titles and is operationally capable of implementing the project. If the carbon buyer comes into the programme early on, then it is best advised not only to make reference to the third-party contracts in its contractual arrangements with the PoA Coordinator but to link the different contractual regimes and even to assume a decisive role in drafting and overseeing the conclusion of the relevant third-party agreements.

The PoA Coordinator

The PoA Coordinator is a PoA's central actor throughout the programme's life-cycle. It develops (or commissions) the development of the PDD, it contracts validation, it procures the LoAs from all host countries', registers it in its name, adds CPAs, implements the programme, procures monitoring and verification, and it holds the programme together. At registration level, the coordinating entity is the only mandatory project participant and it is necessary in all communications with the Executive Board (EB).[145] CERs or ERUs from a PoA, thus, can only be obtained procedurally from or through the coordinating entity. It is the natural party to any (primary) PoA ERPA.

Any investor/carbon buyer must therefore contract with the coordinating entity, and as shown above it makes most sense to keep the ERPA a bilateral contract and not to integrate other proponents, especially not those at CPA level.

[144] Note, however, that even in extremely fragmented and small-scale operations it is often possible to allocate rights through contractual or quasi-contractual means (prints on the wrapping, for instance).
[145] For the CDM see EB 47, 29, para 9 (either sole or joint focal point); for JI see JISC 18 (Procedures for programmes of activities under the Joint Implementation Supervisory Committee).

From a project point of view, it is usually not the coordinating entity that operates and runs the project but a multitude of proponents at CPA level. The genuine activity for the coordinating entity in this respect is literally the coordination of activities at CPA/JPA level, while the actual operations occur outside its imminent control. The coordinating entity can thus take up the obligation to put in place an adequate structure of coordination and supervision (in the form of an implementation manual or other); the coordinating entity can—and should—also be put under an obligation to impose compliance obligations on the CPA/JPA proponents and even to secure that the proponents at CPA/JPA level will operate and monitor the units in accordance with the PoA. Once more, this is not feasible in every constellation but it should be seen as the starting point. Deviations of this starting point would need a solid justification. In PoAs where participation of hundreds, thousands or even hundreds and thousands of units, households or other is envisaged, it depends largely on the PoA design, its management, cooperation with other actors such as technology providers, and the incentive structure schemed and maintained by the coordinating entity to eventually trigger success or failure.

As credit output is ultimately a function of a programme's pace of implementation, i.e. CPA/JPA numbers and CPA/JPAs sizes (1 CPA/JPA covering 10 units, 100 units or 1,000 units, for instance) over time, and as these factors ultimately lie outside the control of both the coordinating entity and the investor/carbon buyer, PoA calculations need be to checked with care during due diligence and provisions delivery shortfall and risk allocation, for erroneous emission reduction estimates and operational delays are likely to play an important role in the ERPA negotiations. It is here that diligent contractual coverage comes into play. Great care should be given to the need to list the activities of the coordinating entity and its partners in a clear and detailed way in the ERPA and to protect them with warranties, delivery guarantees and fixed milestones. Mechanisms for early contract termination and recovery of payments (pre-payment, seed financing) should be installed.

The End Users

As shown above, there have to be specific agreements in place between the PoA Coordinator and the CPA/JPA proponents, i.e. a multitude of separate, standardised agreements which set out the terms of cooperation, stipulate the transfer of any rights regarding emission reductions generated with the participation of the proponents, and lay out the form of compensation (revenue sharing). The standard agreement needs to respond to the nature of the PoA, the type of activity and the profile of the CPA/JPA proponents involved. Often, as is the case where CPA/JPA proponents are households or individual end-users, these agreements need to respect consumer-protection law and specific protection under domestic law. In these cases it is usually legally mandatory, and for the purpose of contractual enforcement recommendable, to have the contracts governed by domestic rather than a foreign law. Furthermore, if under these contracts households are required to take any particular action (such as operating equipment and responding to monitoring surveys over several years), the contracts need to respect educational standards and must be in the local language and as simple and as comprehensible for a layperson as possible.

Carbon Title

From the perspective of the carbon buyer, ensuring the smooth and enforceable transfer of the legal title and carbon ownership is of essence for the carbon buyer. The international legal regime does not respond to the question of personal title. The legitimacy that flows from an international registration as project participant and from the right to be forwarded CERs from the EB pending account into the project participant's holding account, or ERUs from a Kyoto Annex I account into the registry account of the JI project participant, is a procedural one.[146] By contrast, the substantial claim to the carbon credits in question is regulated by domestic law. An ERPA, which allocates and transfers legal title emission reduction units, is a legal document recognised by domestic, not international, law.

The specific challenge carbon sellers and carbon buyers are facing in the PoA constellation results from the fact that the original claim to the carbon credits in question may be disputed. In order for the ERPA to successfully allocate and transfer CERs or ERUs, the carbon seller must have full legal title over the credits in the first place. His legitimisation again is defined by domestic law, not the international structure of PoAs.

In the absence of specific domestic regulations on emission reduction claims issues, credits may be claimed under general domestic law by various actors, property owners/technology providers (fructus civiles), operators of installations (product of operational process, ususfructus), or project participants (personal title). Whenever two or more persons or entities can raise a claim under any of these concepts, they are facing a legally unclear, unsorted situation, which needs to be addressed by contractual means. It follows that the ERPA between carbon seller and carbon buyer should not only address the bilateral situation (transfer of rights from seller to buyer) but should integrate or cover, in the best possible way, all other legal relations that may have arisen regarding the carbon rights. While for practical purposes risks are considerably contained with a PoA being validated and registered, exposure remains. It is important to keep in mind that international registration gives a procedural title rather than a substantial right to the credits concerned.

Liability for Validation

A CPA can be included in a registered PoA at any time during the lifetime of a PoA. There is no formal registration at EB or JISC level involved. Rather—under the CDM—a designated operational entity (DOE) scrutinises the CPA for conformity with the PoA Design Document (PoA DD) and, if the assessment is positive, formally includes the CPA by a simple upload on the UNFCCC website. Apart from the power

[146] Cf. Decision 2 CMP.1: "[The] Kyoto Protocol has not created or bestowed any right, title or entitlement to emissions of any kind on Parties included in Annex I." It follows that mediated entities (public or private) are in no better position.

to undertake spot reviews, the EB does not confirm, cross-examine or else interfere in this process. Under JI, the accredited independent entity (AIE) is not involved in the JPA inclusion but retains some scrutiny obligations regarding erroneous inclusion during verification.[147]

Although the general liability of validators for irregular credits was recognised under the Marrakesh Accords[148], the issue has become much disputed only in the context of CPA inclusions. As the EB recently maintained, if a CPA inclusion proves erroneous, validators "shall acquire and transfer, within 30 days of the exclusion of the CPA, an amount of reduced tonnes of carbon dioxide equivalent to the amount of CERs issued to the PoA as a result of the CPA having been included, to a cancellation account maintained in the CDM registry by the Executive Board (EB)".[149]

Wary about their direct, seemingly non-privileged liability[150], validators will usually seek to shift their economic responsibility to their contractual partners, the PoA Coordinator. PoA Coordinators, in turn, will be interested to limit their contractual exposure to fraudulent or grossly negligent behaviour, leaving validators with those risks that could have been detected through diligent scrutiny. Carbon buyers for their part will seek to stay out of this liability issue altogether. In any event, the validation contract needs to be closely looked at and carefully negotiated in order to allocate responsibilities in a fair and sustainable manner and, thus, to facilitate the PoA's implementation.

[147] See JISC 18 – PoA Guidelines, para 46.
[148] For the CDM 1 CMP 3, para 22; for JI 1 CMP 9, para 43.
[149] EB 47, 30, para 11. The JI PoA Guidelines do not contain a similar provision. However, here the JISC is in another role than the EB which issues credits. Under JI, erroneously issued ERUs constitute damage for the issuing State Party and careful scrutiny of the national legislation is needed to assess who could be held liable in what way for any action or omission in relation with a wrongful JPA inclusion.
[150] EB 47, 29, para 22: "any error" causes liability, i.e. arguably including slight negligence.

12. PoA Case Studies

12.1 Solar Water Heaters

Key Facts of the PoA

Title of PoA	South African Solar Water Heater (SWH) Programme
Host country / PoA boundary	South Africa (SA)
PoA/CPA status	Under validation
Programme start date	March 2010
Applied technology/-ies	Solar water heating units (SWH)
Applied methodology and project type category	AMS-I.C. version 16 (Thermal energy production with or without electricity)
Estimated CERs	Approx. 100,000 t CO_2e per year (average); 1,000,000 over the 10-year crediting period.
PoA target group	Domestic, individual households
PoA Coordinating Entity	Unlimited Energy Resources (Pty) Ltd
CPA developers	Unlimited Energy Resources (Pty) Ltd

Table 46: Key facts of SWH case study

Host country

South Africa (SA) has a functional DNA with well developed rules and criteria for project approval.[151] Even though the country has the highest number of registered CDM projects in Africa, limited interest from the business sector and numerous difficulties in developing most project types keep the market activity quite low. As of January 2010, South Africa has 17 registered CDM projects and an additional 5 projects with a Letter of Approval (LoA) issued.[152] The grid emission factors is approximately 1,02 t CO_2/MWh, this is a very high value and is due to an electricity generation based on thermal energy; mainly coal fired power stations[153]. From the point of view of a CDM project or programme, this is very attractive for projects reducing power consumption, enhancing energy efficiency and employing most renewable energies.

[151] Compare Point Carbon, Host country ratings South Africa, January 2009.
[152] Point Carbon, Carbon Project Manager, January 2010.
[153] http://www.eskom.co.za.

PoA design

Objective

The objective of the PoA is the reduction of CO_2 emissions through the substitution of non-renewable for renewable energy for the purpose of heating water in South African (SA) households. Virtually all households in SA use electric geysers even though climatic conditions for Solar Water Heaters (SWH) are very favourable. SA also has one of the highest grid emission factors of >0.90 CO_2/MWh in the world. The PoA also aims to grow and strengthen the SWH market in SA and to increase consumer awareness of the benefits of installing a quality SWH. The PoA's primary target group is the 4 million houses with a formal piped water supply. The PoA applies the small-scale methodology AMS-I.C. version 16 (Thermal energy production with or without electricity).

The PoA does not mention any technological limitation and supports both direct and indirect SWH systems. In direct systems, the water is heated directly by solar panels, whereas in an indirect system a heat exchanger is used to provide protection from cold temperatures. The most frequently installed SWH units have a storage tank capacity of 200 litres and a collector surface area of 4 m^2.

All SWH units under the PoA will be installed by SA companies who have the necessary qualifications, experience and training. All participating SWHs will have been quality approved using the local and trusted authorising authority – SABS (South African Bureau of Standards).

The PoA targets water heating installations where:

(1) solar based technology is retrofitted to existing water heating technology,
(2) SWHs replace existing water heating equipment, and
(3) new builds select SWHs as the preferred alternative to electric geysers.

Additionality determination

Additionality testing is undertaken at both PoA and CPA level. The barrier analysis shows that the PoA overcomes financial, organisational and technological barriers which historically have resulted in the prevailing practice of using electric geysers to heat water. The penetration of SWH systems in SA has remained low and is estimated at less than 100,000 installed systems, compared with nearly 9 million households, of which some 4 million are houses or brick structures on a separate stand or yard that come into consideration for the programme. This low level of penetration is primarily due to low electricity prices, the high capital costs of installation and a lack of consumer awareness regarding the benefits of SWHs.

The PoA is the first programme that considers carbon funding as a mechanism to support a mass national rollout of SWH systems in South Africa.

Baseline determination

The baseline for the programme is the prevailing practice in South Africa for heating hot water through the use of electric geysers and continuation of this practice in the absence of the individual CPAs and the PoA as a whole. The emission baseline is determined as a factor of the amount of electricity that would be required to produce the same level of thermal energy produced by the renewable energy technology (SWH) and the emission factor for the electricity displaced, taking into account transmission and distribution losses.

Sustainability benefits

The implementation of the programme supports South Africa's strategy to increase the contribution of renewable energy sources to final energy consumption as stated in the White Paper on Renewable Energy published by the Department of Minerals and Energy.

Roles of involved institutions and business model

Involved institutions and their roles

One of the PoA participants is Unlimited Energy Resources (Pty) Ltd, a South African project development and consulting firm offering services for emission reduction, renewable and energy efficiency projects and carbon offset. Unlimited Energy will function as the coordinating/managing entity of the PoA and will at the same time function as the only developer of CPAs.

As PoA coordinator, Unlimited Energy will be responsible for ensuring that the emission reduction potential of the PoA is maximised and that households participating in the programme only have quality SWHs installed by suitably qualified installers. Unlimited Energy will identify potential institutional participants (such as insurance companies, banks and property developers) who are able to facilitate the installation of SWHs on a large scale and will actively work with these institutions to encourage them to use the PoA as a platform for their own SWH initiatives. To ensure that only quality SWHs are installed, Unlimited Energy requires that certain quality standards are met before SWHs or installers are included in the PoA. Finally, Unlimited Energy will coordinate and manage consumer awareness programmes to inform households of the benefits of both installing a SWH and of installing a SWH under this PoA.

Later during the progress of the programme the PoA coordinator will perform procedures to determine the operational status and operating hours of installed SWHs and will compile monitoring reports for the CPA(s).

Subsidies will only be paid out to consumers once the coordinating entity has received confirmation from both the consumer and the installer that the SWH has been installed correctly. A sample of all installations will be inspected to ensure both the quality of the installation and that only participating SWHs have been installed.

All consumers installing a SWH unit have to sign legally binding agreements making them aware that they are participating in a PoA and that the SWH installed will be included in a CPA. As the CER revenue should cover the transaction costs of the PoA the ownership of the CERs will be diverted from the household to the coordinating entity.

CER ownership

The PoA is an initiative undertaken by Unlimited Energy. The PoA and each individual small-scale CDM CPA will be coordinated and managed by Unlimited Energy. The CER revenues generated by the PoA will be used as follows:

(1) The majority will be used to significantly lower the cost of installing a SWH,
(2) to cover the initial setup costs and ongoing operating costs of the PoA, and
(3) to fund the consumer awareness programmes undertaken by Unlimited Energy.

Financial contribution of the CDM

The average cost of a 150 l SWH in South Africa was assumed to be about ZAR 15,000 (EUR 1,500)[154]. The PoA-DD estimates that a SWH in South Africa will on average reduce emissions by 1.86 t CO_2e per annum or 18.6 t CO_2e over the crediting period of 10 years. Assuming a CER price of ZAR 100 (EUR 10.0) this 18.6 t CO_2e has a value of ZAR 1,860 (EUR 186) and represents around 12% of the capital cost of installing a SWH. This reduction in capital costs will significantly contribute to overcoming investment barriers.

By conservative estimates that a SWH, including an electrical backup, will consume only 30% of the electricity that an electric geyser needs, and that an average 150 l electric geyser consumes electricity amounting to ZAR 2,300 (EUR 230) of worth per annum, the PoA-DD estimates that an SWH will save ZAR 1,600 (EUR 160) per annum. The payback period for an SWH based on these savings, without taking into account any carbon revenue, will take 9.4 years. Considering the additional carbon revenues the payback period will be shortened by one year to 8.4 years. This is a simplified calculation as inflation or the increases in CER and electricity pricing are not taken into account due to the relative uncertainty of these movements over the crediting period of the CPA.

[154] 1 ZAR approx. 0,1 EUR (April 2010)

PoA implementation

PoA promotion

The activities will include consumer awareness and education, training of installers, quality standards and the marketing of SWH as a desirable alternative to an electric geyser. There are about 4 million houses in SA that have formal piped water supply and would be part of the target market for the programme.

Monitoring concept

Each installed SWH is uniquely identifiable and Unlimited Energy will maintain a database of all SWHs installed under the PoA. Each CPA will be characterised and defined by the unique identifier of the SWHs included in it. The unique identifier of each SWH included in a CPA can be cross-checked against the database to ensure that SWHs are not included in multiple CPAs. Further cross-checking procedures will be undertaken within the databases of other SWH CDM programmes in SA to ensure that a SWH has not already been included in any alternative programme which may be introduced in the future.

De-bundling is not an issue for this PoA as the average SWH is expected to achieve emission reductions of less than 2 t CO_2e, which will exempt the PoA and the individual CPAs from performing a de-bundling check. The latest guidance[155] provides this exemption stating that if the emission reductions generated by each independent subsystem of the PoA (here: a SHW unit) are no greater than 1% of the small-scale threshold defined by the methodology applied (here: 60,000 t CO_2e), then no de-bundling check is required. A sample approach is followed to determine the operational status of the SWHs. A combination of physical inspections and proof of ongoing financial payments (e.g. SWH insurance premiums in the insurance industry) will be used to determine the operational status of the sample SWHs.

To determine the annual operating hours, the average solar radiation for each area published by an official source will be taken. The CO_2 grid emission factor given in the first CPA has been calculated and shall be fixed ex-ante for the crediting period of the CPA. To be eligible for an exemption of leakage emissions, the scrapping process of replaced equipment has to be monitored.

Estimated CER volumes

The PoA is expected to generate around 100,000 t CO_2e per year. This corresponds to electricity savings of around 98 GWh per annum at the applied emission factor of 1.02 t CO_2/MWh.

[155] UNFCCC: EB meeting 47

Lessons learnt

The high number of stakeholders has been identified as a challenge for such programmes. This PoA tries to limit the number of involved stakeholders as the PoA coordinator and the CPA developer are the same. Furthermore, the PoA relies on existing business relations of the Sustainable Energy Society of Southern Africa (SESSA), other regulating bodies and the SABS. These networks could be in favour of the work of the PoA coordinator.

The documents at hand are in a medium stage of the carbon project cycle. So far no other CDM project or programme applying solar water heating systems has reached the registration or issuance stage. Therefore, no statement about the performance rate can be made. The first developed project would be decisive for the future of this project type and the coming years will deliver the experience under the CDM frame.

This PoA received support from the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) via the PoA Support Centre Germany[156] which is headed by KfW Bankengruppe.

[156] See KfW Bankengruppe: http://www.kfw.de/carbonfund

12.2 Efficient Chillers

Key Facts of PoA

Title of PoA	Philippines – Chiller Energy Efficiency Programme
Host country / PoA boundary	Philippines
PoA/CPA status	PoA at pre-validation stage
Programme start date	January 1, 2010
Applied technology/-ies	Modern non-CFC centrifugal chillers
Applied methodology and project type category	AM0060 version 1.1 (Power Saving through replacement by energy efficient chillers)
Estimated CERs	64,000 tCO_2e per year on average; ca. 640,000 tCO_2e over the first 10-year crediting period). (An average of approx. 800 tCO_2e per typical CPA is estimated over the first 10-year crediting period)
PoA target group	All operators of outdated large chillers (over 100 TR) for process and air-conditioning applications in all sectors
PoA Coordinating Entity	Philippines Department of Environment and Natural Resources (DENR)
CPA developers	Project Management Contractor (PMC) under the responsibility of the Coordinating entity on behalf of each CPA (one CPA per chiller owner)

Table 47: Key facts of efficient chillers case study.

Host country

After overcoming initial problems, the Philippine CDM approval process is now running relatively smoothly. However, an unpredictable delay risk is given owing to changes in officials in the DNA. While having a wide potential covering many different project types, most projects taking place in the Philippines are relatively small, but the current pipeline is diversified and accelerating.[157] The Philippines has 40 registered CDM projects as of January 2010, and an additional 40 projects with a Letter of Approval (LoA) received.[158] The latest grid emission factors validated amount to approximately 0.48 t CO_2/MWh[159], which is moderately attractive for projects reducing power consumption and enhancing energy efficiency.

157 Point Carbon, Host country ratings Philippines, January 2009
158 Point Carbon, Carbon Project Manager, January 2010
159 IGES CDM ERs Calculation Sheet: Grid Emission Factors (January 2010)

PoA design

Objective

The objective of the PoA is to replace inefficient large-scale chillers with a scale of 100 Tonnes of Refrigeration (TR)[160] or more by efficient centrifugal chillers. The target group for the whole PoA comprises enterprises that operate large-scale chillers either for process cooling or air conditioning in the Philippines. The direct target group of the PoA comprises 350 to 400 large-scale chillers. A CPA would be developed for each participating chiller owner. The average scale of replaced chillers is expected to be 330 TR.[161] An early replacement of those chillers with more efficient ones would lead to substantial cuts in electricity consumption, thus decreasing CO_2 emissions. Furthermore, the PoA aims at eliminating the consumption of Ozone Depleting Substances (OPD) in line with the terms of the Montreal Protocol.[162]

The PoA is based on the large-scale methodology AM0060 (Power Saving through replacement by energy-efficient chillers). In turn, project and baseline chillers are required to be electrically driven vapour compression chillers. New chillers will have to be of a similarly rated output capacity as baseline chillers (+/-5%) and be CFC-free. Other requirements from the methodology such as the destruction of replaced chillers as well as monitoring requirements apply.

Additionality determination

According to the PoA-DD, additionality testing is undertaken at PoA and CPA level solely by application of barrier analysis showing that the PoA overcomes investment and technological barriers which previously resulted in no “early replacements” of existing chillers. A study carried out by the World Bank in a variety of countries has shown that without an additional incentive early replacements of chillers would not occur, even with short payback periods. The main barriers encountered relate to the upfront financing, expected disruption of activities and knowledge gap. The implicit empirical discount rate for replacing installed chillers has been found to be over 30%. At the CPA level, additionality is determined based on the estimated remaining time until business as usual (BAU) replacement and based on the BAU replacement predicated on daily usage rate

Baseline determination

The applicable baseline scenario is the continuation of using the existing chillers without any replacement of the equipment. The core project idea thereby is early

[160] Commercial refrigeration systems are commonly rated in Ton of Refrigeration (TR). One TR is defined as the cooling power to freeze one short ton of water in 24h. One TR is equal to 3.517 kW.

[161] It is expected that the average chiller capacity will be in line with the population average, which is about 330 tons refrigeration (TR). The number results from an uneven distribution of chillers rated output with the most common type of chiller expected to have a rated output around 230 TR. The difference can be explained by the existence of a limited number of chillers with a scale of 400 TR or more.

[162] The further goal of achieving a reduction in ODP emissions does not lead to additional emission reductions relevant for CDM. It is limited to a small number of eligible chillers.

replacement, which would not be undertaken without external inducement, such as provided by the CDM. Replacement applies only in the case where the old chiller uses CFC refrigerant. Replacement – to convert the chiller to the use of non-CFC refrigerant – is usually only considered for reasons of country compliance with the Montreal Protocol.

Sustainability benefits

The programme contributes to sustainable development in the Philippines by promoting the use of efficient cooling equipment that allows the achievement of considerable power savings. Related benefits are reduced air pollution due to reduced fuel consumption for power generation and reduction of peak demand for power stabilising the power grid and therefore the power supply. Additionally, some of the energy-inefficient chillers targeted under the programme use CFC refrigerants, which are ozone-depleting substances subject to phase out under the Montreal Protocol.

Roles of involved institutions and business model

Involved institutions and their roles

The Philippines Department of Environment and Natural Resources (DENR) is planned to act as PoA coordinator. It has been proposed, however, to delegate the day-to-day operative part of the PoA to a Project Management Contractor (PMC) against a certain fee. This PMC would become the project developer on behalf of chiller owners which agree to enter into a contractual arrangement with the PoA coordinator. This PMC would be selected among competent entities from the private sector based on a bidding process.

The PMC would be in charge of most of the tasks to be performed by the coordinating entity and has the following responsibilities. At first it will organise workshops to encourage the enrolment of chiller owners in the programme. As a next step the PMC will manage the process of application of chiller owners and ensure their compliance with all requirements. This includes, inter alia, the review of proposals, determination of baseline scenarios, and certification of the destruction of replaced chillers. A database would be established in order to keep track of all participating chiller owners and their respective chillers participating in the programme.

In addition, all operations related to validation, registration, monitoring, verification, etc. would be under the responsibility of the PMC. This includes performing spot checks on specific projects. Chiller owners, however, are responsible for the appraisal, procurement, commissioning and installation of new chillers. Finally, the management of the financial flows and carbon flows would be the responsibility of the PMC. The PMC will ensure the eligibility of the CPA to participate in the PoA against a list of eligibility criteria for the inclusion of CPA in the PoA. At present this would require a minimum level of performance of 0.63 kW/TR for new chillers as well as a residual lifetime of at least 5 years for the chiller to be replaced.

CER ownership

The initial financing/subsidy required for the PoA will be supplied by the Global Environment Facility (GEF) and the Multilateral Fund (MLF). Further financing of the incentive will be provided by using the CER revenues of the participating CPAs. The chiller owner of the respective PoA will cede either all CERs or a share of them to the coordinating entity. The procurement of chillers, however, will follow participants' normal commercial practice with investment costs largely or entirely borne by participants.

Each CPA requires passing on the incentive from the carbon revenues in order to alleviate the efforts and costs. Additionally, manufacturers from the new chillers will need to confirm in a letter that they will not claim any CERs either for producing or selling the chillers. Chiller owners will be attracted and incentivised to participate in the Programme by way of two alternative incentive options offered to the Chiller owners:

1) In the first option an upfront financing is proposed to chiller owners in exchange for relinquishing all future carbon finance revenues to the PoA Coordinating Entity (CE). This upfront financing will be directly proportional to the scale of the chillers. Participants who decide to follow this model are required to sign an emission reduction transfer agreement and surrender all expected CERs, and 15% of the estimated USD 400 cost per TR will be paid upfront as a grant.
2) In the second option no upfront financing is proposed. The chiller owner will receive about 80% of the carbon revenue. The remaining fraction of the carbon revenue has to be surrendered in order to cover the costs of the whole PoA service provided by the CE.

In both cases CERs would be received from the UNFCCC by the CE. For CPAs which have opted for the first model, CERs would remain the sole property of the CE as per agreement with the chiller owner in exchange for the upfront grant. For CPAs which have opted for the second model, an Emission Reduction Trading Agreement (ERTA) would specify the amount of CERs eligible to each CPA. This share of CERs would be kept by the CE for the set up of the PoA and management of the CPA. Chiller owners will be made aware of the two options through a direct communication effort.

Financial contribution of the CDM

Providing the mentioned reference price of USD 400 per TR, each CPA opting for the first financing model (no claims on CERs in exchange of an upfront financing) based on a typical scale of 230 TR would receive an upfront financing of USD 13,800. This sum would be disbursed from the seed funding of USD 3,600,000 paid by the Global Environment Facility (GEF) and the Multilateral Fund of the Montreal Protocol (MLF). This seed funding would suffice for roughly 330 CPAs opting for this model. Around 70 CPAs will be attracted to incentive option two.

PoA implementation

PoA promotion

The promotion of each CPA will be done mostly by existing suppliers of chillers as they already have an on-going relationship with chiller owners, are trusted by them and know where likely candidates for chiller replacements are located. Workshops organised by the PMC will support marketing activities. The upfront financing is based on a lump sum proportional to the chiller capacity. The new chillers will be sourced according to normal commercial practices. In turn, there is no incentive for gaming the price of chillers. This set-up allows for a direct participation of chiller suppliers for marketing efforts.

Monitoring concept

Each CPA will start with an own assessment of the subproject design followed by an invitation of proposals to chiller manufacturers. At this point, a pre-approval application to the PoA has to be sent to the PMC. Upon bid award, a final application is to be sent to the PMC and funds will be made available around the time of disbursement for the chillers. The next step of the PoA project cycle is the equipment delivery which includes installation and commissioning. Other steps for a participating CPA include the destruction of the replaced chillers, the recovery of CFC refrigerants as well as activities related to the measurement, monitoring and verification as data are required by the CE in order to claim emission reductions.

Emission reductions are based on the theoretical baseline coefficient of performance of the baseline chillers. This coefficient of performance is derived from a measuring campaign or data to be obtained before its destruction.

Estimated CER volumes

In accordance with AM0060, the measured cooling demand will be used to derive the baseline electricity consumption which would have occurred with the replaced chillers. This in particular requires the use of “power consumption” which expresses the coefficient of performance (COP) for variations in load, inlet temperature and outlet temperature of the chilled water. A data management system will be used to track all chillers as the amount of CERs to be issued is proportional to the cooling service delivered by the project chillers. A continuous data monitoring for the new chillers will be adopted. Further details on the monitoring to be performed, responsibilities and documents are provided in the annexes of the PoA-DD. The PoA is expected to generate approximately 640,000 tCO_2e over the 10-year crediting period.

Lessons learnt

The benefits from the programme can be different according to the CPA: while all chiller replacements provide benefits in terms of emission reductions and local development, specific CPAs provide additional benefits in terms of protection of the ozone layer.

The high complexity of managing such a programme can be delegated to a private entity to act as a project management contractor.

Incentive schemes, if set up properly and well marketed, can possibly lead to the enrolment of chiller owners despite a limited contribution to the initial financing by the coordinating entity. The possible co-financing as an upfront sum proportional to the chiller scale removes the possibility of gaming by artificially inflating the price. This, in turn, allows an active participation of the chiller suppliers in the marketing of the project. So far no standalone CDM project activity has been developed under the methodology AM0060. Reasons for that could be due to a low expected yield in CERs for standalone chiller projects as well as high monitoring requirements compared with other CDM project types. Therefore, pooling CDM transaction costs into a PoA can represent an attractive course of action for large-scale chillers. While the use of the power consumption function is complex, the use of one entity (the PMC) to perform measurement may enable this complex barrier to be overcome as the know-how gained on this measurement can be replicated to a large number of chillers within the PoA.

The first developed projects are decisive for the future of this project type. A success of this project type could pave the way for more projects.

The two main potential threats are a lower than expected participation of chiller owners as well as the monitoring requirements under AM0060.

Apart from the support by the World Bank, this PoA received facilitation by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) via the PoA Support Centre Germany[163] which is headed by KfW Bankengruppe.

[163] See KfW Bankengruppe: http://www.kfw.de/carbonfund

12.3 Compact fluorescent lamps CFL

Key Facts of the PoA

Title of PoA	CUIDEMOS México (Campana de Uso Inteligente De Energía México) - Smart Use of Energy, Mexico
Host country / PoA boundary	Mexico
PoA/CPA status	PoA registered; 1st CPA registered
Programme start date	August 2009
Applied technology/-ies	Compact fluorescent lamps (CFL)
Applied methodology and project type category	AMS-II.C. version 9 (Demand-side energy efficiency activities for specific technologies)
Estimated CERs for the first CPA	24,283 t CO_2e per year (average); 242,838 over the 10-year crediting period.
PoA target group	Low-income households
PoA Coordinating Entity	Cool nrg Carbon Investments Pty Ltd (UK)
CPA developers	Cool nrg likely to be eligible as CPA developer exclusively

Table 48: Key facts of CFL case study

Host country

Mexico counts on significant CDM experience and has 133 registered CDM projects[164]. The grid emission factor of recent projects was around 0.51 t CO_2/MWh and is moderately attractive for projects reducing power consumption. As part of the PoA Cool nrg has established a regional office in Mexico City.

PoA design

Objective

The aim of the PoA is to replace incandescent light bulbs with 1,000,000 compact fluorescent lamps (CFLs) per CPA in low to medium-income households in Mexico, resulting in reduced electricity consumption and thus reduced CO_2-emissions through avoided electricity generation by thermal power plants. CFLs provided to households will have rated power outputs of 15W and 20W (equivalent in lumen output to incandescent bulbs of at least 60W and 75W, respectively). The CFLs will be given away free of charge at selected retail stores where functioning light bulbs have to be exchanged into the same amount (up to four) of compact fluorescent lamps. The PoA applies the small-scale methodology AMS-II.C. version 9 (demand-side energy

[164] IGES Database, 01.10.2010

efficiency activities for specific technologies).

Additionality determination

Testing of additionality is undertaken at PoA and CPA level by application of a simple cost analysis that shows that the PoA without CER revenue would not be attractive to CPA developers as the compact fluorescent lamps are free of charge for the participating households. The economic analysis is supplemented by a barrier analysis at PoA and CPA level that demonstrates that the households also face barriers to the autonomous use of compact fluorescent lamps. The penetration of compact fluorescent lamps into domestic lighting is approximately 10-20%, into low-income households in Mexico it is only 2% mainly due to the significant up-front costs for compact fluorescent lamps.

Baseline determination

The baseline for this PoA is the continued use of light bulbs in the households as prescribed in AMS-II.C. as autonomous replacement is prevented by barriers.

Sustainability benefits

As Mexico is planning to increase its fossil fuel fired power capacity, the PoA will lead to a decrease in local pollutants from these power sources. It also partially reduces the need for new generation capacity and lowers energy infrastructure expenditures. The PoA alleviates the barrier for low-income households to apply compact fluorescent lamps and therefore saves income of these households.

Roles of involved institutions and business model

Involved institutions and their roles

The PoA participants are Cool nrg Mexico SRL de CV of Mexico (Cool nrg Mexico), and Cool nrg Carbon Investments Pty Ltd of the United Kingdom (Cool nrg UK). Cool nrg Carbon Investments Pty Ltd is designated as coordinating/managing entity of the PoA. Cool nrg is the CPA developer in this PoA. In each CPA the retail partners of Cool nrg, Comex and Coppel, run stands in their retail stores where the exchange of the lighting appliances takes place. Comex and Coppel are very suitable distributors for the PoA as they target low to middle-income households and have a wide geographic coverage in Mexico. Coppel is a department store chain with 250 retail stores in Mexico. Comex is the largest paint manufacturer world-wide with 3,000 stores across Latin America. The investment costs for the PoA have reportedly been financed through European investors.

Cool nrg Carbon UK supervises the record keeping and monitoring procedures of Cool nrg Mexico. The latter has a great degree of autonomy and is responsible for the complete data management process from the exchange of appliances at the distribution point until the calculation of CERs.

CER ownership

The PoA-DD specifies that Cool nrg Carbon Investments Pty Ltd intends to sign legal agreements with the distribution partners stipulating that their activities are part of the PoA. The PoA-DD also says that "households will be made aware that they are participating in a climate change action program aiming to reduce greenhouse gas emissions". Cool nrg further assumes that the awareness campaign and the free compact fluorescent lamp sufficiently imply that activity of the household is part of the PoA. The CPA-DDs do not mention how the awareness campaign will be conducted. The topic of legal ownership of CERs is not addressed in the documents. As the PoA Coordinator and the CPA developer are the same entity Cool nrg did not need a CER sharing between the PoA coordinator and CPA developer. The investment is made by Cool nrg Carbon UK through Cool nrg Mexico and the CERs will remain with the coordinating entity Cool nrg Carbon UK for marketing.

Financial contribution of the CDM

Each CPA requires financing the investments in compact fluorescent lamps that can only be recovered through CER revenues, as the CPA does not generate any other revenue (lamps are distributed free of charge to the end-consumer). Assuming the total expenditures provided in the specific CPA-DD of around 2,600,000 EUR (1,35 USD/EUR per April 2010) for the compact fluorescent lamps, additional investments for CDM administrative costs and CER revenues of around 2,400,000 EUR (at a CER price of 10 EUR) over the ten year crediting period, the PoA would not be able to achieve self-financing. However, the cash flow analysis provided in the specific CPA-DD assumes a CER price of 12 EUR/CER and therefore achieves a positive cash flow for the first CPA over the crediting period. It should be noted that operational costs of the PoA and the CPA that will accrue (e.g. labour, transportation, office operation, administration etc.) could not be taken into account as they are not available.

PoA implementation

PoA promotion

Each CPA is promoted through a public education component as well as targeted media campaigns. Cool nrg has selected a media partner, Consejo de la Comunicación, to encourage households to participate in the CPA and to deposit their CFLs in specific locations after the end of their lifetime. Details of the campaign are not available in the PoA/CPA documents.

Monitoring concept

Each CPA starts with the distribution of the target number of 1,000,000 compact fluorescent lamps. Each household representative has to hand in his electricity bill code and the light bulbs to be exchanged. A software-based data management system records the household as well as the total number of substituted lighting appliances. The data management system (DMS) avoids double counting of households. It automatically archives the name, address, electricity bill number, wattage of light bulbs exchanged as well as the date and location of exchange. This enables the PoA coordinator to prove that the single small-scale CPAs are not a debundled component of a large-scale project activity by keeping a 1 km “buffer zone” between the project boundaries of each CPA. This is especially relevant since the size of each CPA needs to be limited to total electricity savings of 60 GWh per year in order to comply with the CDM small-scale project thresholds.[165]

Monitoring of emission reductions takes place at intervals to be chosen by the CPA developer. An integral part of the monitoring procedure is the selection 2 times 240 compact fluorescent lamps that will be randomly sampled from the DMS. The sample groups will be established and fixed for the entire crediting period before monitoring commences. At the first group of 240 CFLs the average operating hours will be measured at the end of every monitoring interval. In the same interval the second group will be checked for ongoing operation of the compact fluorescent lamps. The CO_2-grid emission factor given in the first CPA is publicly available and fixed ex-ante for the crediting period of the CPA. Collection and destruction of light bulbs also needs to be monitored by an independent entity.

Cool nrg is required to monitor progress on the implementation of the compact fluorescent lamp recycling system. An independent entity, Servicios Integrales de Residuos SA de CV, verifies that the light bulbs are collected and destroyed and is also responsible for establishing a recycling system jointly with the Mexican Ministry of Environment.

Estimated CER volumes

The first CPA is expected to generate around 24,283 t CO_2e per year (242,838 t CO_2e over the 10-year crediting period). This corresponds to electricity savings of around 47 GWh per annum at the applied emission factor of 0.514 t CO_2/MWh as given in the first CPA-DD. The total amount of the PoA will be much higher as cool nrg plans to implement 30 CPAs.

Lessons learnt

Cool nrg is a pioneering PoA project developer for CFLs. The company believes in the PoA concept and has invested considerably in the preparation and set-up of the PoA. This PoA can be a role model for future PoAs. Generally, free exchange of light bulbs for compact fluorescent lamps is a very common feature in CDM CFL projects. This demonstrates that the CDM project developers expect their compact fluorescent lamp projects to be economically attractive based only on CER revenues. As the project type requires significant up-front investment, a success story for compact fluorescent lamp projects will be a showcase for other project developers for CFL

[165] Please note that for this type of activities since EB meeting 47 no de-bundling check is needed any more (see Chapter 2).

CDM projects and programmes. A project design that includes the distribution of compact fluorescent lamps at low cost but not totally for free could be an option that enables additional revenues without disregarding the proof of additionality.

13. Overview of current PoA activities

The PoA Pipeline[166] has evolved from an almost constant amount of ca. 10 PoAs in 2008 and 2009 to an actual PoA Pipeline (October 2010) of 58 PoA projects at validation stage and/or beyond, of which so far 5 CDM and 7 JI (track 1) PoAs were successfully registered. The high number of PoAs submitted for validation by the end of 2009 is a result of the possibility to retroactively include CPAs starting between the 22nd of June 2007 and the commencement of validation in a PoA in case of PoA submission for validation until end of December 2009.

Although still a very small population, the now listed publicly available PoA Documentation gives us an insight into the actual market activities and shows for example where the forerunners of the PoA are located and what kind of reduction activity they pursue.

Using the pipeline it is possible to get an idea of the impact the PoA is going to have. To have a look at sectoral and regional trends is especially interesting as they show if the PoA is effectively helping to overcome the often named barriers of the stand-alone CDM and gives answers on the following questions:

- Do PoAs substantially foster the inclusion of dispersed micro- and small scale emission reductions in the CDM?
- Are PoAs able to attract activities in countries where the CDM was not able to gain ground?

The first deliberate answers show that indeed PoAs have the potential to move the market into the above indicated direction. The regional distribution and country wise distribution of the CDM PoAs currently in the pipeline do not follow the same pattern as CDM stand alone project activities do.[167]

PoAs in Africa[168] (16%) outperform the CDM Pipeline (3%) by 13%. Apparently the trend of the PoA is leading to an inclusion of African countries in the CDM. Interesting is the comparison for **Least Developed Countries (LDC):** 10% of the PoAs are located in LDC whereas only 1% of the CDM Projects are located in LDC, the share of PoAs in LDC is considerably higher than in the overall CDM.

As in the regular CDM favoured host countries and regions for PoAs are located in **Asia & the Pacific** reaching up to 64%. This is quite lower as in the CDM in total, where around 9% of the projects belong to this region. For **Latin America** the data reveals that almost the same percentage of PoAs (19%) and CDM projects (16%) take place in Latin America.

[166] PoA Pipeline refers to all PoAs either in validation phase or registered.
[167] For this analysis the total number of CDM Projects on the basis of the UNEP Risø pipeline (www.cdmpipeline.org) is calculated and compared with the PoA Pipeline. Rejected Projects are excluded. Slight variations to data analysis provided in the UNEP Risø data might be possible.
[168] In the statistics Africa includes Egypt and Tunisia.

The differences become clearer, if the Pipeline is not grouped regionally but leaves out the three biggest “CDM countries” China, India and Brasil. Then a considerable regional variation can be noted comparing PoAs in Asia and Pacific (33%) versus CDM Projects in Asia and Pacific (16%) showing that PoAs are more evenly located in the region than CDM projects. Applying this comparison to Latin America it can be seen that PoAs in Latin America (without Brasil) account for 12% of the Pipeline whereas CDM Projects in Latin America (without Brasil) account for only 10% of the Pipeline indicating that the distribution per continent for PoAs is slightly better balanced in comparison to the CDM.

	CDM Projects	PoA
China, India, Brasil	73%	33%
LDCs	1%	10%
Others	26%	57%
Total	100%	100%

Table 49: Regional distribution of PoAs and CDM Projects.
(Source: UNEP Risø, own calculations)

	CDM Projects	PoA
China, India, Brasil	73%	33%
Asia & Pacific	17%	38%
Latin America	7%	12%
Africa	2%	16%
Middle East	1%	2%

Table 50: Regional distribution of PoAs and CDM Projects.
(Source: UNEP Risø, own calculations)

Although the analysis is based upon a very small population (58 PoAs compared to 5,471 CDM Projects) the PoA mechanism appears to activate a promising potential of emission reduction projects in Africa, in LDCs and in other countries where the CDM could not leverage project activities so far.

Project types

In terms of project types, it is interesting that the two registered PoAs are applying project types that are considered as rather complex within the CDM. This implies that the concept of PoAs allows for an overall reduction of CDM transaction costs especially for project types that involve a high number of appliances in dispersed areas. However, the PoAs recently submitted for validation are applying all kind of project types, also renewable energy technologies that have been already frequently used without the concept of PoA in the CDM.

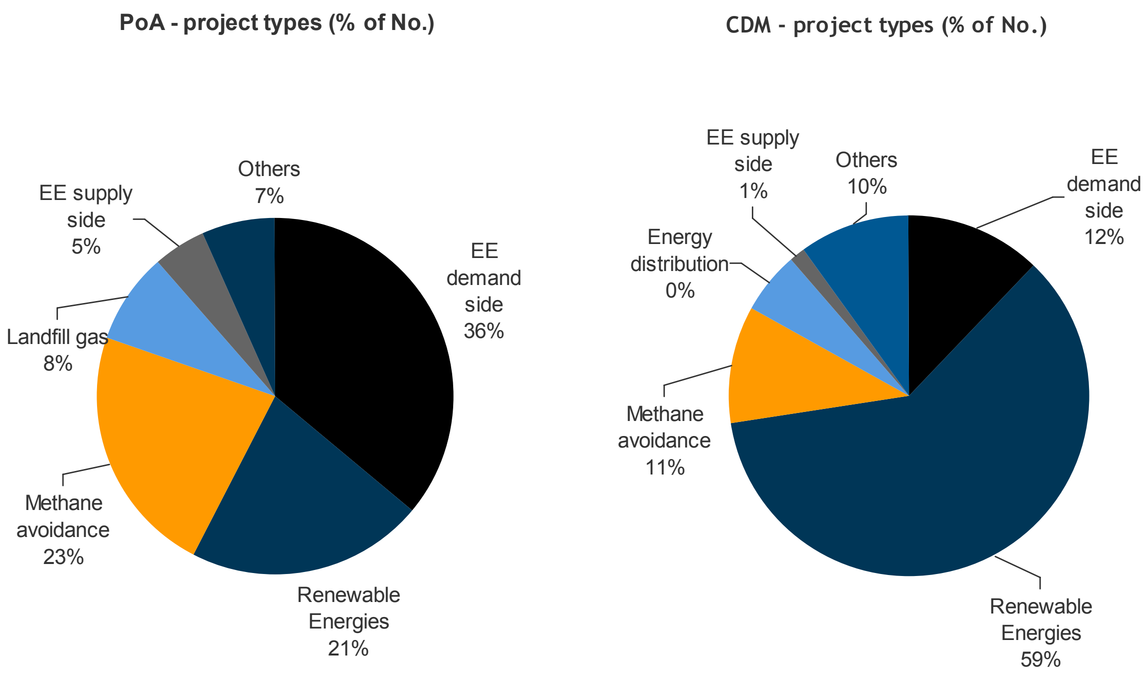

Figure 11: PoA and CDM projects by project types.
(Source: UNEP Risø, own compilation)

Figure 12 illustrates the difference between PoAs and regular CDM projects in terms of applied project types. Among CDM project activities renewable energies are dominating with almost 60% of all projects in the pipeline (5,471 projects[169] at validation and beyond as of October 2010). In comparison among the 58 PoAs renewable energies only comprise 22% of all PoAs. Instead two other types are significantly more important among PoAs as for general CDM project activities: energy efficiency measurement on the demand side and methane avoidance. Energy efficiency (demand) project activities are realised in only 12% of the regular CDM, this project type has been applied to more than a third of all 58 PoAs currently in the pipeline.

Typical projects are efficient lightning (CFL) and improved cooking (stoves). Methane avoidance is applied in 24% compared to 11% among the regular CDM.

The high share of energy efficiency PoAs indicates that the PoA concept is leading to kick off Programmes working with project types that have been underrepresented in the project-based CDM.

Energy efficiency measures on the demand side usually appear in rural or urban **households** or within other **consumer locations** (e.g. commercial buildings). Almost **50%** of all PoAs concentrate on activities in urban and rural households.

[169] UNEP Risø CDM and JI Pipeline, own calculations deducting the PoAs.

PoA Project Activity	**Number of PoAs**	**Percentage**
Solar Home Systems / Solar Water Heater (SWH) for Households	5	9%
Efficient Cooking Stoves	5	9%
Domestic Biogas	6	10%
Efficient Lighting for Households	5	9%
Others: Manure, Waste and waste management	20	34%
Renewable Energy (Minihydro & SWH for SME)	7	12%
Energy Efficiency in the Industry	5	9%
Energy Efficiency in Electricity Distribution	3	5%
Transport	1	2%
Reforestation	1	2%
Total	**58**	**100%**

Table 51: Sectoral distribution of the actual PoA Pipeline.
(Source: UNEP Risø, own compilation)

The above stated data shows the single measures are distributed amongst several locations or even hundreds or several thousands as in case of CFL distribution projects. Since CPAs can be defined in different ways, single activity/location or multiple locations, the PoA concept can be perfectly used to cover these multiple locations, as described in the technology chapters and case studies above.

The character of the first CPA of the current PoA in terms of location and definition of the CPA sheds light on structural differences between the stand-alone CDM project and a PoA. CPAs can be specified only to one location (e.g. hydro power plant) or to multiple places as for instance by applying CFL in thousands of households that are gathered to one single CPA. In some cases single and/or multiple locations are allowed under the PoA, e.g. the CPA can constitute one or more biogas plants.

Most PoAs currently define the CPAs for **multiple locations**, which is in line with the high share of energy efficiency project activities and other small applications. For additional the first CPA is a single location, however the PoA-DD also allows for CPAs including multiple locations.

In terms of size and CERs generated, CPAs in most PoAs are relatively small. The average size reaches approximately 50,000 tCO_2/a. However, there is a huge difference between project types. Whereas all other project types of the current PoA pipeline are well below 20,000 - 40,000 tCO_2/a, CPAs of energy efficiency (power) projects and biomass projects (animal waste) are in some cases achieving more than 120,000 tCO_2/a and even up to 140,000 tCO_2/a.

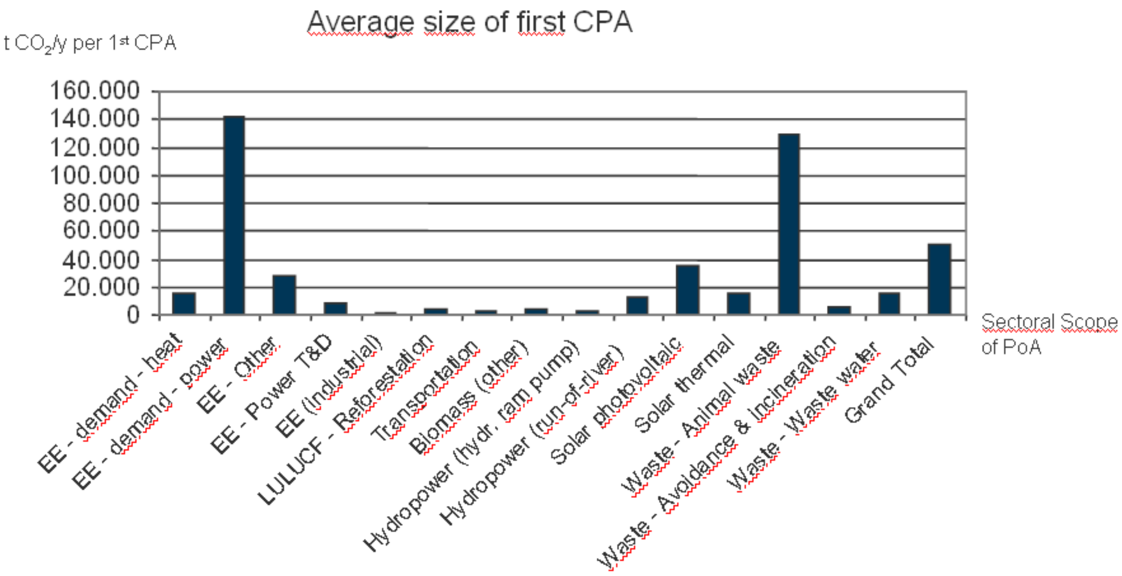

Figure 12: Average size of CPAs (Source: IGES, March 2010)

It has to be mentioned that these figures are estimated for the first CPA. They do not represent the whole PoA and hence are not practical to forecast the overall emission reduction of the whole PoA. The overall success of a PoA relies on the feasibility and practicability of each single CPA, and future CPAs. Eventually, the achievable emission reduction through a PoA in the long run depends highly on the amount of implemented CPAs and the respective implementation schedule and procedures.

Although it is only a small number of PoAs the analysis evidences that the concept of the PoA already changes the sectoral and regional trends of the CDM. For a sound statistical analysis of methodological issues and PDD argumentation lines much more registered PoAs would be needed. This analysis remains to be done in the future counting on more experiences with registered and implemented PoAs.

For an overview of current PoA project activities in the pipeline for both, CDM and JI we recommend to have a look at the information provided at the webpages of the Risoe Centre on Energy, Climate and Sustainable Development (CDM/JI Pipeline Analysis and Database)[170] or the Institute for Global Environmental Strategies (IGES CDM Programme of Activities (PoA) Database)[171].

[170] www.cdmpipeline.org
[171] http://www.iges.or.jp/en/cdm/report_cdm.html

14. Conclusions

As we have seen in the former sections, the development of a Programme of Activity is a promising but nevertheless challenging attempt.

There are an unlimited number of possible variations in the programme design. As stated in the introduction, the business models presented in this guidebook are proposals based on present knowledge and experience. It should be kept in mind that a PoA coordinator should well understand the key barriers to penetration of the concerned technology. The subsequent design should try to overcome these barrier(s) as efficiently and effectively as possible. Methodological choice, incentive instrument, organisational arrangements, and choice of the appropriate Coordinating Entity etc. shall take into account lessons learnt from existing programmes but should also be developed in line with the given pre-conditions in the region/country where the PoA is planned and implemented. The programmatic approach offers flexibility, leaves room for creative solutions and thus provides great opportunities for further scaling up the potential of the CDM/JI.

- A PoA is managed by a Coordinating Entity who has the responsibility for all CDM documentation, monitoring and distribution of CERs. A good coordinator can increase cost-effectiveness of the CDM project cycle through a centralised management structure, and/or integration of monitoring procedures into the normal business operation. As shown in the different business models, various actors may take on responsibilities in the PoA so that coordination efforts need to be undertaken frequently and efficiently. This means, however, that the institutional capacity of a PoA coordinator and its partner agencies has to be very strong. References of successful programme implementation in the past (even without CDM) is surely a helpful indicator to determine the own capacity and capability to structure and implement a CDM PoA in the future. Guidance on CDM specific requirements and advice can be found with the national DNAs, international operating consultant firms in the CDM market, carbon credit buyers or development organisations.
- The PoA should integrate elements that help to promote the PoA and to attract potential project developers to take part in the PoA. The more understandable and transparent the PoA is designed, the more attractive it is for project developers to join. Especially the benefit of creating a template for the CPA-DD for subsequent CPAs bears a huge advantage for potential project participants. This advantage should not be eliminated by designing the PoA in a way which shifts many important elements (e.g. proof of additionality, baseline determination) to the CPA-level or by creating complicated eligibility criteria for the CPA inclusion.

- The right choice of the methodological approach is key to the successful programme implementation. A PoA can use SSC methodologies without any limit to the overall size of the PoA. However, each CPA under a PoA applying SSC methodologies is required to stay below the SSC threshold. As SSC methodologies are generally simpler to apply and more standardised, in most cases it would make sense to go for a SSC-PoA whenever possible. A comprehensive pre-assessment of the right choice of methodology is highly recommended before starting the work on developing the PoA design and preparing the PoA documents.
- Needless to say, the choice of incentives to mobilise projects under the PoA also plays a critical role in its implementation and financial viability. Setting incentives plays also a key role as soon as support is provided by companies/institutions (e.g. for monitoring or maintenance) that do not have a direct profit from the CERs generated.

  This is especially important to ensure optimal procedures of interrelated tasks and hence to generate the expected amount of CERs in the course of the PoA operating life-time (up to 28 years). Furthermore, it is important to carry out capacity building and awareness raising on both the technology supply and demand side of a PoA. On the supply side, training and quality control for providing the technology and to support its continued operation are very important. On the demand side, consumer education and targeted outreach are essential to create sustainable demand for the products offered by the PoA and to transform the market. Not all these requirements lead to costly additional work. Some of them can be integrated into the existing business infrastructure with marginal incremental costs.
- The need for seed funding will apply in many cases of programmes. If the PoA coordinator cannot pre-finance the incentive at the beginning of the programme, he needs to look out for external funding from banks, carbon buyers or other parties. The development of a good business model and a good presentation of the special features and possibilities of the programme will help to attract institutions which can pre-finance the gap to finance the incentive at the beginning of the programme. Nevertheless, the prevailing challenge is that a decent risk assessment is quite difficult to undertake given the uncertainties in the market and the rather limited existing experience. Yet the interest to pre-finance the seed funding exists although the bulk of it might stay in the initial phase with public funds or socially responsible capital investors.

The development of programmatic CDM is a success in the CDM history and represents a substantial change in direction. It can make use of the experiences gained from the vast number of single CDM projects and at the same time allows for simplifications and further improvements in regards to the set up of the CDM instrument. It addresses sustainable change in customs and habits of the different sectors and the whole society and tries to incentivise a low carbon future. It includes countries as possible participants in the carbon market that were not integrated yet. It gives a variety of actors such as banks, utilities, private enterprises and public agencies the opportunity to develop their own ideas to reduce GHG emissions and to market these emissions. However, the instrument of PoAs within CDM and JI can be seen as still being in the fledgling stage. Its potential and possible evolvement for whole sectors and regions needs further assessment and experience.

The current developments within the climate negotiations indicate that PoAs are seen as one central element within the flexible mechanisms to further tap the untapped potential of greenhouse gas mitigation options in Least Developed Countries (LDCs). Together with further streamlining the general rules and procedures of CDM and JI (e.g. through standardized baselines, simplify baseline & monitoring methodologies, allow for suppressed demand) PoAs bear a high potential to overcome typical barriers (high transactions costs, high level of risks, unpredictable amount of emission reductions) for project developers and investors. Beside further streamlining and simplifying the rules and procedures, the environmental integrity of such programmes as well as the overall aim to achieve credible emission reductions must be ensured.

The PoA concept has emerged from the CDM regime and has been so far further developed under these rules. It would even further improve the benefits of PoAs if the rules would allow for a higher flexibility of applying multiple methodologies and multiple technologies. To a certain extent PoAs are already allowed to apply multiple methodologies. However, the application rate of such PoAs is still very low since each combination of methodologies must be justified and get approval from the EB. Subsequent to a successful approval each CPA under the PoA is required to apply exactly the same combination of methodologies. With a higher flexibility it would be possible to apply PoAs for broader multi-technology programmes (e.g. for low-carbon cities) instead of implementing several PoAs for different measures (energy efficient lighting, energy efficient insulation, fuel switch etc.) in parallel.

Other instruments that are extensively discussed, like sectoral crediting or National Appropriate Mitigation Actions (NAMAs), are more detached from the existing flexible mechanisms. The CDM rules will either need to allow for more flexibility for PoAs in certain aspects to further increase the attractiveness of PoAs compared to standard standalone CDM project activities or the PoA development will help to refine the CDM rules in general (e.g. through the development of simplified and more applicable methodologies).

PoAs in many cases aim to target whole countries or even regions (multiple countries) they could serve as a pre-step, at least to a certain extent, to support preparing for developing countries for National Appropriate Mitigation Actions (NAMAs). NAMAs constitute non-binding obligations or targets for developing country Parties to reduce greenhouse gas emissions. PoAs could e.g. serve as a forerunner for NAMAs in specific sectors and would help to quantify the actions taken.

As could be seen in the samples provided throughout the guidebook, PoAs have the potential to overcome existing barriers for greenhouse gas mitigation activities and to scale up the mitigation efforts in a variety of countries and sectors. The opportunities are manifold.

This guidebook presents 8 key types of PoAs – energy-efficient lighting for households, improved biomass stoves, bio-digesters for small farmers, solar water heaters, refurbishment of industrial boilers, improvement of building energy efficiency, small hydropower and energy efficient chillers. However, PoAs are possible for all kinds of CDM project types.

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