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ASSESSING THE CO-BENEFITS OF HOUSEHOLD ENERGY TECHNOLOGY CARBON OFFSET PROJECTS

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The research for this book has been carried out under the ‘Scaling up low carbon household technologies in the lower Mekong Subregion’. The project commenced in 2012 and has been funded by the Nordic Climate Facility (NCF), which is financed by the Nordic Development Fund (NDF) and administrated by Nordic Environment Finance Corporation (NEFCO). All views presented in the text are those of the research team and do not represent the views of the financier or the project partners.

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ABBREVIATIONS

ARMI	Association for Rural Mobilisation and Improvement
BCC	Biogas Construction Company
BUS	Biogas User Survey
CCBS	Climate, Community and Biodiversity Standard
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CFL	Compact Fluorescent Lighting
CWP	Ceramic Water Purifier
DNA	Designated National Authority
DOE	Designated Operational Entity
ER	Emissions Reduction
GERES	Groupe Energies Renouvelables, Environnement et Solidarités
GHG	Greenhouse Gas
GS	Gold Standard
GS SD Matrix	Gold Standard Sustainable Development Matrix
IAP	Indoor Air Pollution
ICOPRODAC	Improved Cookstove Producers and Distributors Association of Cambodia
ICS	Improved Cookstove
LSC	Local Stakeholder Consultation
LDC	Least Developed Country
MAFF	Ministry of Agriculture, Forestry and Fisheries
MATA-CDM	Multi-Attributive Assessment of CDM
MR	Monitoring report
MUS	Monitoring User Survey
NLS	New Lao Stove
NBP	National Biodigester Programme
ODA	Official Development Assistance
PoA	Programme of Activities
PD	Project Developer
PDD	Project Design Document
SD	Sustainable Development
SNV	Netherlands Development Organisation
tCO_2e	Ton of Carbon Dioxide Equivalent
VCM	Voluntary Carbon Market
VCS	Verified Carbon Standard
VER	Voluntary Emission Reduction

EXECUTIVE SUMMARY

There has been an increase of carbon finance in recent years to offset projects in developing countries that claim to produce significant local development benefits, also called co-benefits. Household energy technology projects are an example of carbon offset projects that are claimed to both mitigate climate change and create development co-benefits. This report uses case studies from household energy technology projects in Cambodia and Lao PDR to examine how the co-benefits of household energy technology carbon offset projects are assessed and what possible gaps there are in current academic assessment approaches.

This research has its premise in a project called 'Scaling up low carbon household technologies in the lower Mekong Subregion'. The project commenced in 2012 and has been funded by the Nordic Climate Facility (NCF), which is financed by the Nordic Development Fund (NDF) and administrated by Nordic Environment Finance Corporation (NEFCO). The aim of the project is to scale up the production, distribution and use of household energy technologies, primarily ceramic water purifiers, in Lao PDR and Cambodia. The project partners, social enterprises TerraClear in Lao PDR and Hydrologic in Cambodia, and a cooperative of development organizations called Nexus - Carbon for Development have a significant role in advancing this aim. In addition, the project contains an independent research component carried out by Finland Futures Research Centre, University of Turku, on the different academic approaches to measuring and monitoring the sustainable development impacts of household energy technology carbon offset projects. This report is the main product of the research. All views presented are those of the authors, and do not represent the views of the project financier or the other project partners.

We address three gaps in current approaches to assessing the co-benefits of carbon offset projects. First, there is a lack of analyses on household energy technologies and their co-benefits, although it is one of the project types that has most rapidly increased its share in the voluntary carbon markets. Second, there is a gap between document analysis on the potential development impacts and field work on the realized development impacts. Third, there is little research on the different assessment frameworks developed to assess the sustainable development impacts of offset projects. We aim to address these gaps by analyzing how three different indicator sets developed to analyze the co-benefits of carbon offset projects (Crowe 2013; Nussbaumer 2009; Subbarao & Lloyd 2011) capture the co-benefits of five specific household energy technology projects.

The research has been carried out primarily in Cambodia and Lao PDR, where there are several household energy technology projects at various stages of the carbon finance cycle. This enables an examination of the various stages and processes along the development of a carbon project. Our research material consists of project documents (for a full list, see Annex 1), site visits and interviews (n=68) with technology users, project developers and manufacturers. We look specifically at five different household energy technology projects located in Cambodia and Lao PDR that are applying for, receiving or have received financing from carbon offsetting. The household energy technologies we examine are improved cookstoves, ceramic water purifiers and biogas digesters.

The findings suggest that evaluating a decentralized offset project, such as a household energy technology project, differs significantly from evaluating a point-source offset project that has been implemented in one location. The impacts of a point-source offset project are often visible once the plant or factory is built and has started operating or improvements in processes have been installed. With a decentralized project it often takes a long time for a number of end users to adopt the technology and benefits to realize.

Household energy technology projects perform well on existing indicators on employment, income generation, local economy and technology transfer due to their local production. The projects we examined did not have any significant negative impacts on local development and generally had wide stakeholder participation. We did, however, find some discrepancies between project documents and information from site visits. These information asymmetries worked in both the positive and negative directions: knowledge from the field visits could improve the image or highlight some challenges the project faced.

The frameworks we used for assessing the projects contained some indicators that were suitable for assessing the local development impacts of household energy technology projects, such as those on the use of local resources and employment generation. Other indicators were clearly targeted at projects where the core function is not the sale of a product and additional strategies for delivering benefits to the local community have to be created. These included indicators on issues such as provision of services or education. Our findings suggest four aspects are especially influential on the local development impacts of the type of household energy technology carbon offset projects we examined. These are the product and its qualities, the value chain of production, and the scale and sustainability of the project.

The beneficial impacts on local development were highly dependent on whether the projects succeeded in creating a business model for the technology. In a successful project local manufacturing, distribution and retail networks can reach a large number of people that will benefit from the value chain of the technology. The long-term sustainability of the project itself can ensure that the delivery of the benefits is not dependent on external financing or vulnerable to fluctuations in the price of carbon. There is still a need for more research on the gaps identified in this report and specifically on the discrepancies between desk reviews and field studies as well as on the differences between existing assessment frameworks.

INTRODUCTION

Concern over climate change has led to the development of several market-based approaches that attempt to manage anthropogenic greenhouse gas emissions. Carbon offsetting is one of these mechanisms through which emissions released in one place are compensated by reducing emissions elsewhere. At the same time, carbon offsetting has been presented as a tool to finance and contribute to sustainable development in developing countries (Bumpus and Liverman 2008). In addition to emissions reductions, carbon offset projects are claimed to create co-benefits, which can include community development, biodiversity conservation or improved health (Lovell et al 2009). There are no strict requirements on how to define sustainable development in carbon offset projects or what indicators to use to assess local development impacts (Peskett et al 2012). In the voluntary carbon market some standards have defined and assigned indicators to measure co-benefits but the definitions vary across the standards (Wood 201). The extent to which carbon markets are able to deliver on these two goals of emissions reductions and local sustainable development has been questioned (Alexeew et al 2010). It has been claimed that emissions reductions have been the main focus of offset projects and the provision of co-benefits to local communities has been sidelined (Boyd et al 2009). In response, several academic assessments have attempted to evaluate how and to what extent carbon offset projects actually contribute to sustainable development (e.g. Sutter and Parreño 2007; Olsen and Fenhann 2008). This report analyses the applicability of three such approaches (Crowe 2013; Nussbaumer 2009; Subbarao & Lloyd 2011) to household energy technologies. One of the main objectives of this study is to assess how analysis based on project documents differs from on-site analysis of projects. Another aim is to assess how different assessment frameworks evaluate the sustainable development impacts of household energy technology projects.

This research has its premise in a project called 'Scaling up low carbon household technologies in the lower Mekong Subregion'. The project commenced in 2012 and has been funded by the Nordic Climate Facility (NCF), which is financed by the Nordic Development Fund (NDF) and administrated by Nordic Environment Finance Corporation (NEFCO). The aim of the project is to scale up the production, distribution and use of household technologies, primarily ceramic water purifiers, in Lao PDR and Cambodia. The project partners, social enterprises TerraClear in Lao PDR and Hydrologic in Cambodia, and a cooperative of development organizations called Nexus - Carbon for Development (henceforth Nexus), have a significant role in advancing this aim. In addition, the project contains an independent research component carried out by Finland Future Research Centre (FFRC) on the different approaches to measuring and monitoring the sustainable development impacts of household energy technology offset projects. This report is the main product of the research.

The research has been carried out primarily in Cambodia and Lao PDR. These two countries were selected since the project partners are currently implementing projects in the countries, and FFRC has previous experience of conducting research in Lao PDR and Cambodia. This facilitated carrying out the research, and the selection of two countries was also influence by the feasibility of conducting field research with a limited time period. Lao PDR and Cambodia have several household energy technology projects at various stages of the carbon finance cycle, enabling an examination of diverse questions along the development of a carbon project.

The first gap identified is the lack of research on household energy technology carbon offset projects' development impacts. Household energy technology projects can broadly be defined as projects that reduce emissions caused directly by households and communities in activities of their daily life. These technologies create emissions reductions either through increasing energy efficiency (e.g. improved cook stoves, ICS) or using renewable energy (e.g. biogas digestors). Emissions reductions produced by household energy technologies can be distinguished from other project types due to their decentralized nature (Bumpus 2011; Lambe et al 2015). Another distinguishing element of household energy projects is their framing by project proponents as 'win-win' technologies that can deliver on a variety of climate, development and environment goals (cf. Simon et al 2012). While there have been specific assessments on the sustainable development contributions of a variety of project types, such as forestry (Olsen 2007), hydropower (Karakosta et al. 2014), bioenergy (Lee and Lazarus 2013), and mining (Uddin et al 2015), there is a lack of assessments on the sustainable development impacts of household energy technology offset projects. Analysis on household energy technology projects as carbon offset projects has primarily focused on how carbon finance is changing the landscape of previously development financed initiatives and what new risks and opportunities this presents (e.g. Simon et al 2012; Buysman and Mol 2013; Lambe et al 2015).

Household energy technologies are, however, one of the most rapidly growing project groups in the voluntary carbon markets, with for example, improved cookstoves increasing their market share from near zero in 2010 to 24% in 2013 (Peter-Stanley et al 2011; Peters-Stanley and Gonzalez 2014). At the same time, there is lack of analysis on how, when and if these co-benefits are realized. The aim of this report is not to offer a systematic review of all household energy technology projects in the carbon offset markets due to limits in the amount of projects studied. Rather, we aim to provide an in-depth analysis of three of the most popular household energy project types: improved cookstoves, biogas digesters and water purification technologies. This analysis brings forth some of the challenges posed in attempting to assess projects' sustainable development contributions with current assessment systems.

The second gap noted is the lack of in-depth assessments on development impacts of offset projects, including site visits. A majority of the current literature assessing sustainable development impacts of carbon offset projects has focused on the Clean Development Mechanism (CDM) and evaluating whether or not it is delivering on its dual objective of producing both emissions reductions and local sustainable development benefits. These studies have largely been portfolio analyses of sustainable development impacts. All of them have been limited to analyzing the Project Design Documents (PDDs) and have therefore been restricted to assessing only the potential sustainable development impacts of the projects. Assessing the realized impacts and changes in risks for those affected by the projects has been less common, and only few studies have carried out on-site sustainability analysis. The need for ex-post verifications of whether and how sustainable development claims have been realized has been repeatedly pronounced (e.g. Subbarao & Lloyd 2011; Boyd et al 2009).

A third noted gap in the literature is the lack of research on the different approaches through which the sustainable development impacts of offset projects are evaluated. The need to identify the differences between assessment methods, however, is pronounced because the extent to which the different methods capture sustainable development impacts has not received much attention so far.

Specifically, we ask: what challenges and gaps arise in evaluating household energy technology offset projects with existing sustainable development assessment frameworks? We approach this question by conducting a desk review and on-site analysis of five household energy technology offset projects using three different assessment frameworks. The findings suggest that the analysed household energy technology offset projects perform well in terms of sustainable development impacts, but there are information asymmetries between the project documents and information from site visits. The assessment frameworks evaluated may not be most suitable for analyzing decentralized offset projects.

The report is structured as follows. The **first chapter** introduces the central themes of the report, focusing on carbon offsets and co-benefits in offset projects. The **second chapter** presents household energy technologies and their current standing in carbon offset markets, focusing specifically on improved cookstoves, ceramic water purifiers and biogas digesters. The **third chapter** reviews the methodological literature on measuring and assessing the sustainable development impacts of offset projects and presents the methodology used and selected case studies. The **fourth chapter** presents the results from the assessments. The **fifth chapter** concludes and raises questions for future research, followed by a bibliography and annexes.

1. AN INTRODUCTION TO CARBON OFFSETS AND CO-BENEFITS

Carbon offsets have emerged as one of the methods for responding to climate change. Carbon offsets are often presented as a tool for contributing to sustainable development in the global South. Offsetting is a process whereby emissions reductions in one place can be used to compensate for releasing emissions elsewhere. The rationale of offsetting is based on the idea that emissions reductions in developing countries are cheaper, quicker and easier than reducing emissions in industrialized countries (Bumpus and Liverman 2008). Carbon offset projects in the global South are an example of how developing countries are enrolled into participating in climate change mitigation efforts (Mathur et al 2014). The incentive to participate in climate mitigation is fostered in developing countries through promises of mitigation projects contributing to poverty reduction and local development (Käkönen et al 2014). Such local development benefits are referred to as co-benefits or side benefits, and include, for example, community development, biodiversity conservation or improved health, created in addition to the global emissions reduction (Lovell et al 2009). This chapter briefly introduces the reader to carbon offset markets and the different standards used. We then proceed to discussing questions related to the sustainable development impacts of offset projects.

There are two main types of carbon offset markets: the regulated compliance markets and the voluntary markets. The compliance markets are based on international agreements on emission reductions that have set country-specific targets. To date, the most significant compliance markets were created with the Kyoto Protocol, an international agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC). The most relevant carbon offset mechanism for the developing countries is the Clean Development Mechanism (CDM). The idea of the mechanism is offsetting some of the emissions generated in the industrialized Annex-1 countries of the Kyoto Protocol with emissions reductions produced in non-Annex 1, i.e. developing, countries (UNFCCC 2006). Parallel to the compliance markets, voluntary carbon markets have emerged from initiatives that have not been related to official emissions reduction obligations. Voluntary offsetting arose from frustration with slow and bureaucratic governmental action (Bumpus and Liverman 2008). The voluntary carbon market is a term used of all carbon credit transactions that are made outside government regulation and it covers initiatives implemented in both industrial and developing countries. In this report, we focus solely on offset projects in developing counties. The following section outlines some of the key similarities and differences in the compliance and voluntary offset markets.

The CDM has evolved rapidly since the Kyoto Protocol entered into force in 2005. By the end of 2014, 1 493 billion CERs had been issued through 2 666 CDM projects, representing the mitigation of over 1 493 billion tonnes of CO2e (UNFCCC 2014)1. The CDM has experienced changes in its governance structure (UNFCCC 2014) as well as the plummeting of carbon credit prices from the peak year of 2008. The projects

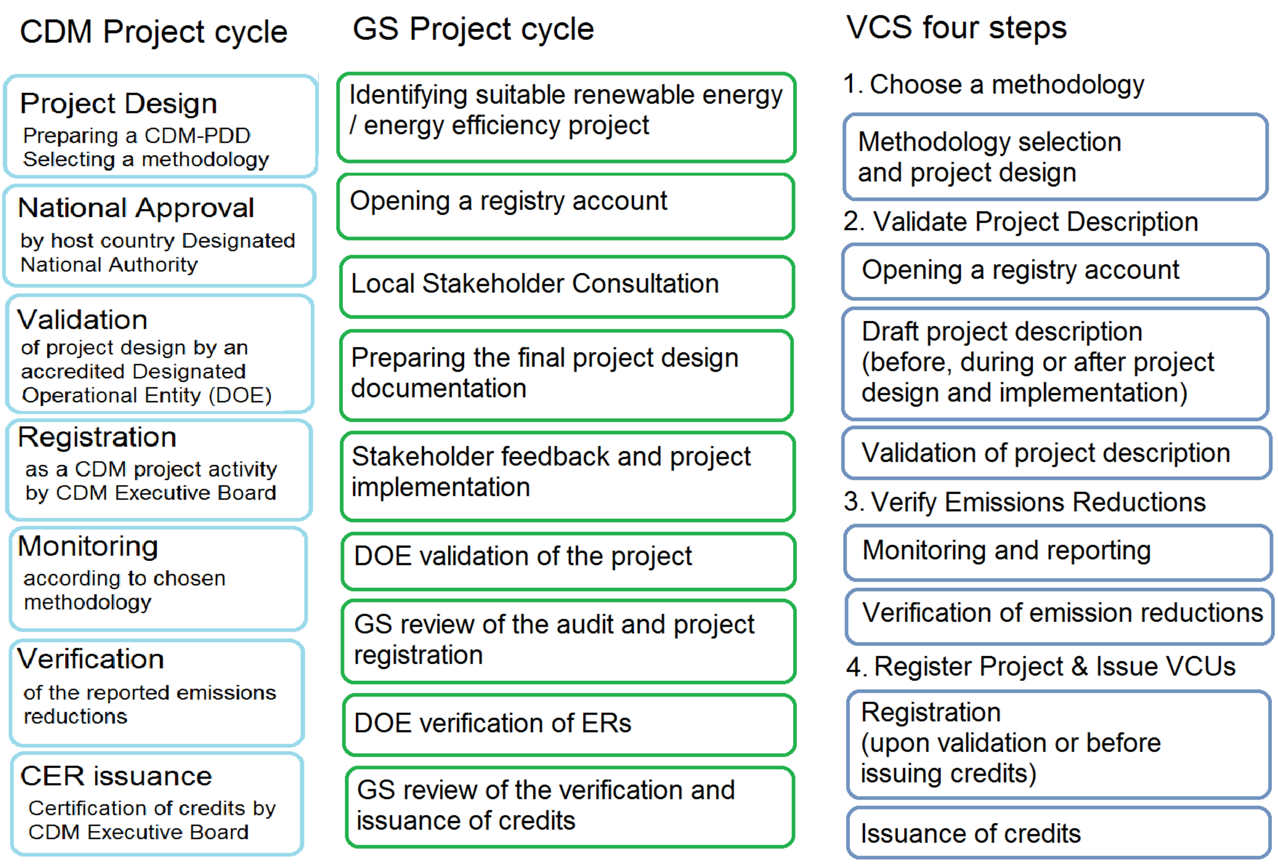
[1] 1 CER represents the mitigation of 1 tonne of CO_2e.

selling offsets in the voluntary market get a price premium on average compared to compliance market. While the prices of carbon credits are greater in the voluntary carbon market, the total amount of traded tCO_2e is greater in the compliance market. In 2011-2013 the average VER price fell from \$6.2 /tCO_2e to \$4.9/tCO_2e but remained still high compared to CDM's offset price of \$1/tCO_2e on average (Peters-Stanley and Yin 2013, Peters-Stanley and Gonzalez 2014). The CDM still remains the largest offset program by volume in the world. In comparison, the voluntary carbon markets account for 28.5% of the traded volume of the CDM with 76 million tonnes of CO_2e traded in 2013 (Peters-Stanley and Gonzalez 2014; UNFCCC 2014).

The UNFCCC and the CDM Executive Board are responsible for the governance of the CDM, whereas in the voluntary carbon markets governance depends on the standard through which the offsets are produced (cf. Wood 2011). The buyers in the voluntary market have been companies, NGOs and individuals that want to reduce their emissions for reasons such as corporate social responsibility or the anticipation of regulation (Kaisti 2013). Since the voluntary carbon market is not regulated and many of the transactions occur bilaterally, there is no centralized body collecting statistics on the projects developed or market transactions for the market as a whole. However, Ecosystem Marketplace and Bloomberg New Energy Finance publish a yearly report based on a market survey that provides statistics on VCM (Peters-Stanley and Yin 2013, Peters-Stanley and Gonzalez 2014). While in the beginning there were no verification mechanisms for offset projects in the voluntary carbon markets, nowadays buyers prefer carbon credits that are verified by some standard. There are two different types of standards in the voluntary carbon market: stand-alone and quality add-on. Stand-alone refers to standards that verify emissions reductions whereas add-on standards do not verify emissions reductions but ensure the deliverance of some additional benefits, such as those related to biodiversity. In the voluntary carbon market, the Verified Carbon Standard (VCS) and the Gold Standard (GS) are stand-alone standards. Climate, Community and Biodiversity Standard (CCBS) and Social Carbon, on the other hand, are add-on standards. The largest standards are the Verified Carbon Standard alone or combined to CCBS or Social Carbon standard, Gold Standard, and CDM CERs (Peters-Stanley and Gonzalez 2014).

The Verified Carbon Standard (VCS) is the leading standard in the voluntary carbon market. It was founded by a group consisting mainly of carbon offset industry actors in 2005 (Kollmuss et al. 2008). Its objective is to verify the accuracy of emissions reductions with less focus on the sustainable development contributions of projects. VCS and combinations of it with the CCBS or Social Carbon account for slightly less than half of the voluntary market (Peters-Stanley and Gonzalez 2014). The Gold Standard was founded in 2004 by a group of environmental and social non-profit organizations (e.g. World Wildlife Foundation, Helios International and South South North). It was established to grant certification to projects that deliver high sustainable development co-benefits. The Gold Standard operates in both the compliance and voluntary carbon markets. In the compliance markets it covers only a marginal share but in the voluntary markets it occupied a 16% market share in 2013 making it the second biggest standard in the market after the VCS (Peters-Stanley & Gonzalez 2014). Compared to the market overall, Gold Standard projects tend to get a price premium. Despite a decrease in GS carbon credit prices, the average price of \$8.5/tCO2e for a GS project well exceeded the market average of \$4.9/tCO2e in 2013 for voluntary offset projects (Peters-Stanley and Gonzalez 2014).

Picture 1 outlines the CDM project cycle, the Gold Standard cycle and the steps of the VCS. While the illustration demonstrates a linear process, the practice is often more complex and various stages can proceed simultaneously. Critical points for carbon projects the validation by a designated operation entity (DOE)[2], the verification of emissions reductions by the standard, DOE or the UNFCCC and the issuance of credits.



Picture 1. Carbon offset project cycles.

Sustainable Development and the Clean Development Mechanism

Sustainable development in the context of the carbon markets has been mostly debated with regards to CDM projects. The majority of studies that have conducted sustainable development impact assessments for carbon offset projects have been done on CDM projects. Although voluntary carbon market projects, the focus of this study, do differ from CDM projects, many of their characteristics are similar and many of the questions raised in the studies are relevant for discussing the sustainable development contributions of voluntary carbon market projects.

[2] A designated operational entity (DOE) is an independent auditor who validates project proposals or verifies whether implemented projects have achieved the planned emissions reductions.

The CDM has the dual objective of producing emissions reductions and local sustainable development (UNFCCC 2006). The debate on the sustainable development impacts of carbon projects surfaced as the objective of delivering sustainable development benefits was questioned by academics and activists. While there are detailed requirements on how to verify emissions reductions prior to obtaining carbon credits, there are no requirements on how to monitor, report or verify the sustainable development benefits. The assessment of sustainable development benefits is seen as a sovereign matter of the host country of the CDM project (UNFCCC 2002). As a result carbon projects have clear incentives and structures to monitor realized emissions reductions, but lack such a framework for the monitoring of sustainable development benefits (hence SD benefits). In addition, the designated national authorities (DNAs)[3] , especially in the least developed countries, can often lack resources for monitoring SD impacts (Olsen 2012a; Käkönen et al 2014). This imbalance has provoked several researchers to study whether projects deliver the promised SD benefits for the host countries. The consistent conclusion of the studies has been that even the potential positive sustainable development impacts of CDM projects are limited (Sutter and Parreño 2007; Olsen and Fennhan 2008; Watson and Fankhauser 2009; Alexeew et al 2010). Several authors have suggested there is a trade-off between emission reductions and sustainable development impacts (Olsen 2007; Sutter and Parreño 2007; Kollmuss et al. 2008; Alexeew et al 2010) since the former is valued in the CDM project cycle but the latter is not. Especially projects switching industrial gases were found to produce extensive amounts of emissions reductions (Boyd et al 2009) with few sustainable development benefits (Olsen and Fenhann 2008; Watson and Fankhauser 2009). On the other hand, smaller community-based projects have faced difficulties in entering the market. Another debated topic has been the uneven regional distribution of CDM projects with emerging economies such as India, China and Brazil having attracted a lion's share of CDM projects due to their larger emissions reduction potential (Kreibich et al 2011).

Several suggestions to improve the sustainable development record of CDM projects have been made. One of them has been promoting sustainable development focused carbon standards to increase SD benefits, or at least to identify the projects with higher SD benefits (Nussbaumer 2009; Drupp 2011). Other researchers have called for reforms to the mechanism such as a policy-based adjustment favoring certain project types (Boyd et al 2009) or implementation of an international standard to ameliorate the poor SD performance of CDM projects (e.g. Olsen and Fenhann 2008; Boyd et al 2009). Increasing reporting requirements of SD impacts in the Project Design Documents (PDDs) has also been suggested to ease the assessment of SD benefits (Olsen and Fenhann 2008; Killick 2012). In 2011, as a reaction to the critique, the CDM Executive Board launched a call for input with the aim of improving the methods to document co-benefits and negative impacts of carbon projects, and assessing the role of different actors and stakeholders in the process. Instead of implementing a new screen for all projects, it was decided that the host countries' right to define their own criteria was to be maintained and projects willing to go further could use a new tool, called the voluntary SD tool. The influence of the SD tool has remained limited since it ended up being a taxonomy evaluating only

[3] Designated national authorities (DNAs) are the carbon project host country organizations that have the responsibility to authorize and approve participation in CDM projects.

positive co-benefits, which are not monitored or verified, and does not require the involvement of local or global stakeholders (Olsen 2012b). In October 2014, only 15 CDM projects (four of them Programmes of Activities, PoAs) had used the tool (http://cdm.unfccc.int/SDTools/index.html).

Co-benefits and the Voluntary Carbon Market

The voluntary carbon market does not have a formal objective to produce sustainable development benefits; rather, the delivery of sustainable development benefits differs in each of the voluntary standards used. Standards were developed to respond to the initial lack of quality control that resulted in the production of low quality carbon credits in the voluntary carbon market (Kollmuss et al 2008). In the voluntary carbon markets, there is no obligation to employ a standard to verify emissions reductions. However, having one is nowadays a mainstream practice since most offset buyers require that the carbon credits are verified by a carbon standard. With regards to the sustainable development impacts, there is no widely used international regulation for valuing and monitoring the co-benefits of voluntary offset projects (Wood 2011).

It has been argued that the voluntary carbon market has a greater ability than the compliance market to deliver local development benefits due to projects' smaller size, stronger sustainable development focus and lower transaction costs (HoC Environmental Audit Committee 2007, quoted in Lovell and Liverman 2010). The more local development benefits a voluntary carbon project can claim to produce, the higher a price it tends to generate in the markets (Hamilton et al. 2012). This is due to the high demand for projects that are presented as visibly contributing to local sustainable development. Credits from such projects are often sought by, for example, corporate buyers who are interested in improving their public image (Lovell et al. 2009). This has led some to argue that since the primary buyers of voluntary carbon credits have altruistic rather than compliance motivations, they are more likely to deliver local development benefits (Chapple, 2008; Peters-Stanley and Gonzalez 2014). However, the limited amount of analysis on the sustainable development impacts of voluntary carbon markets presents a mixed picture. In a comparison of the CDM and the voluntary market, Corbera et al (2008) suggest that the production of co-benefits does not depend on the scheme, but is rather context-specific and dependent on, for example, the project size and technology choice. Similarly, studies on labeled offsets, such as the Gold Standard (GS), suggest that labeled projects do not differ greatly from non-labeled projects of a similar type (Drupp 2011; Nussbaumer 2009). Crowe (2013) also finds that the most pro-poor benefits[4] are produced in projects that are developed by not-for-profit organizations or governmental entities, as well as those projects that have a high level of stakeholder participation. These results suggest that the delivery of sustainable development benefits through the voluntary carbon market projects is not automatic but requires more detailed analysis.

In 2013, the volume of offsets from projects associated with co-benefits was at all-time high in the voluntary carbon market (Peters-Stanley and Gonzalez 2014). Alongside the increased demand for co-benefits

[4] Crowe (2013) has developed a set of seven criteria based on previous literature to analyze whether projects are pro-poor, including economic, social and environmental indicators.

has been an increased interest to verify these co-benefits through measurement and monitoring practices. A news provider on the voluntary carbon market stated that 2013 could 'expect a continued emphasis on carbon projects' social and other "non-carbon" co-benefits' (Ecosystems Marketplace 2013). A market survey from 2011 by Crowe (2013) finds that carbon offset actors are generally interested in the co-benefits of projects, with co-benefits as the second most important criterion for project selection following project additionality.

In the debate on carbon project sustainable development impacts, standards have been one of the suggestions to improve the situation, since standards require monitoring and provide assessment frameworks that can be used to make distinctions between projects in terms of their sustainable development record. Especially the Gold Standard has been seen to hold this promise (Schneider 2007, Sutter and Parreño 2007). Proponents of mainstreaming standards have claimed that identifying projects with higher sustainable development impacts and rewarding them with higher price on carbon credits would lead to an increase of such projects in the markets. However, the evidence on whether standards have achieved this is mixed (Sterk et al 2009 p.131–132, Corbera et al 2009, Wood 2011, Peskett et al 2012).

The approach of the Gold Standard has been characterized as a 'positive exclusion' (Sterk et al 2009) since it employs several screens that projects need to pass in order to be eligible for the standard. The project type screen restricts eligible projects to renewable energy and energy efficiency projects. The additionality and baseline screen assesses additionality with conservative estimates, addressing the debated matter that carbon projects should be additional projects that would not be implemented without the carbon funding. The sustainable development screen consists of a do-no-harm assessment, a Sustainable Development matrix and sustainability monitoring plan, and Local Stakeholder Consultation (LSC). An environmental impact assessment is conducted if considered necessary. Negative impacts have to be neutralized with mitigation measures in order for the project to be eligible for the standard, and all non-neutral sustainable development impacts in the GS Passport be monitored and verified. This requirement has been found to create an incentive to report fewer co-benefits to minimize the monitoring requirements (Sterk et al. 2009 p. 130).

How, when and if carbon offset projects create co-benefits is a question that will remain at the centre of research on carbon offsetting in the future. There is a need to bridge the gap between document analysis and insights from analyses of implemented projects. As carbon offset projects have matured and the financing period of some has even ended, there is a possibility to analyze the realization of co-benefits in projects and what occurs to offset projects once financing from the carbon markets has ceased.

2. HOUSEHOLD ENERGY TECHNOLOGIES AS CARBON OFFSET PROJECTS

In the following chapter we will present the thematic surrounding household energy technology carbon offset projects and discuss specifically three household energy technologies: improved cook stoves (ICSs), biodigesters and ceramic water purifiers (CWPs). The three household energy technology project types have been financed through traditional aid interventions, but have in the recent years received increased financing from carbon credit revenues. Due to their position at the climate-development interface, household energy technology projects have been lauded with expectations of delivering 'win-win' outcomes to both climate and development objectives (cf. Simon et al 2012) and have become highly demanded in the voluntary carbon markets.

Household energy technologies have a long history as projects in development cooperation (cf. Kshirsagar & Kalamkar 2014). The focus and scope of household energy technology projects has shifted throughout their history. For example, improved cookstove projects in India in the 1980s first emphasized slowing deforestation, and projects focused less on indoor air pollution (Simon et al. 2012). In recent years, the focus of large financiers has shifted to rural market transformation (e.g. Shell Foundation 2005). It on this landscape of several decades of development finance and practice that carbon market formalities and practices are overlaid. Carbon finance differs from traditional donor assistance in being paid only upon the delivery of emissions reductions. This results-based mode of financing raises questions for project inception, design, monitoring and continuance that differ from traditional donor assistance (cf. Simon et al. 2012). For example, the finance required to commence an offset project may be a significant barrier for smaller communities or projects to set up offset projects. Other challenges related to access to carbon markets include technical complexity, uncertainties, and the process and procedures of carbon accounting (Howard et al 2015).

In the carbon offset markets, household energy technology projects can be defined as "projects that reduce emissions caused directly by households and communities in activities of their daily life and where these households and communities are actively involved in implementing the project" (Müller et al 2010; 5). The distinctive characteristic of household energy technology projects is that they are targeted at households instead of being established in just one or a couple of industrial units or sites. Household projects are decentralized projects targeting a high number of emission sources that are dispersed over a larger area (Wood 2011; Bumpus 2011). These technologies create emissions reductions either through increasing energy efficiency (e.g. improved cook stoves, ICS) or using renewable energy (e.g. biogas digestors). The concept of 'suppressed demand' is also often applied to household energy technology projects that affect poor populations. Since the emissions of poor populations are often minimal to begin with, the concept of 'suppressed demand' takes into consideration that their emissions would be higher if they had better access to energy and goods (UNFCCC 2012). Projects using suppressed demand methodologies do not mitigate existing emissions but rather avoid future emissions by provide cleaner alternatives. Finally, household energy technology projects produce emissions reductions only when the technologies are used appropriately and not discarded. This means that how the technologies are adopted and used by the households is of importance for the delivery of emissions reductions (Lambe et al 2014).

The most common household energy technology types in the carbon markets are improved cook stoves (ICSs), biogas digesters (biodigesters), water filters or purifiers, solar water heaters, solar cookers and energy efficient lamps and bulbs (Peters-Stanley and Gonzalez 2014). Müller et al (2010) have included also projects promoting pico-hydropower, irrigation systems (pumps), composting and insulation in this definition, but all these technology types are very marginal in the carbon markets and therefore will not be referred to in this report. Out of the abovementioned technologies the most common technology types in the CDM are biodigesters, ICSs, CFL light bulbs, solar cookers and solar water heaters, and in the VCM ICSs, water filters, biodigesters and solar cookers. The exact share of household energy technology projects in the carbon markets is difficult to estimate since neither the UNFCCC nor carbon standard databases separate projects by technology, but rather by sectoral scope or methodology.

The voluntary market has been the principle market for household technologies. The success of household projects in the voluntary carbon market is often attributed to the voluntary carbon markets' sensitivity to perceptions on sustainable development co-benefits (Lovell and Liverman 2010). The more co-benefits a project can claim to produce, the higher a price it tends to generate in the voluntary carbon markets (Hamilton et al. 2012). From the State of the Voluntary Carbon Market reports, estimations can be established on the share of transacted offset volumes (Table 1). REDD+ and forest and land management related projects have remained the largest project type in the voluntary carbon markets in all the years examined, covering around a 50% share of the voluntary offset market (Peters-Stanley and Gonzalez 2014). With regards to household energy technologies, the statistics show that ICSs and CWPs, to a lesser extent, have broken through in the recent years. The rise in cookstove projects has been especially marked and they are projected to be the second largest project type (after REDD+) in 2013–2020 (Peters-Stanley and Yin 2013). 2013 marked a peak year for the market share of ICS, which have since declined. The only other household project type that reaches a 1 per cent share is household biodigesters. The three technologies are the only household technologies that are identified as separate categories in the State of the Voluntary Carbon Market reports, and were thus chosen as representative of household energy technologies, albeit the total shares being rather small.

Table 1 Voluntary carbon market share of ICSs, CWPs and biodigesters in transacted offset volume 2010–2013.

Market share in 2012–2013	**VCM**		
Year	ICS	Water filters	Biodigester
2010	n/a*	n/a*	n/a*
2011	4 %	n/a*	n/a*
2012	8 %	2 %	1 %
2013	24 %	4 %	1 %
2014	4%	2%	1%

Source: State of Voluntary Carbon Market Reports 2011 – 2014 (Peters-Stanley et al. 2011, Peters-Stanley and Hamilton 2012, Peters-Stanley and Yin 2013, Peters-Stanley and Gonzalez 2014)
* shares of marginal project types are in 'other' category and not specified in the report

In the CDM and also with the Gold Standard, household energy technology projects can be developed as individual projects or as part of Programme of Activities (PoA). Instead of going through the bureaucratic registration process project by project, the PoA establishes a framework project under which several similar projects can be developed (CDM methodology booklet 2013).This is intended for reducing transactions costs and facilitates the scale-up of projects. The aim of developing the PoA was to make the replication of successful projects easier and increase the number of decentralized projects (Kreibich et al 2011). The uptake of the PoA approach by their intended target group of decentralized technologies seems to have suited household projects particularly well, since their share of the PoAs reaches over 40 per cent (Table 2). However, it must be noted that the figures in Table 2 refer to registered PoAs. While there have been a large amount of registered PoAs, very few have yet been able to issue credits. In the traditional, stand-alone CDM, household projects have remained more marginal. Table 2 presents the share of household energy technologies in the stand-alone CDM in comparison to the Programme of Activities. Data to estimate household project shares of transacted offset volume in the CDM is not easily available, but based on a UNFCCC database search done for this research (in October 2014) we approximated that biodigester, ICS, CFL and solar appliance projects account for 2 per cent of all registered CDM projects (Table 2). This is supported by recent research, which claims that improved cookstoves account for 1% of all registered CDM projects (Lambe et al 2015).

Table 2 Share of registered CDM projects and PoAs for different household project types.

	ICS	**CWP**	**Biodigester**	**CFL**	**Solar appliances**	
					SWH	Other solar
PoA*	34 PoAs (12.5 %)	8 PoAs (2.6 %)	20 PoAs (7.4 %)	27 PoAs (10.0 %)	9 PoAs (3.3 %)	8 PoAs (2.9 %)
CDM*	39 projects (0.5 %)	n/a	46 projects (0.6 %)	39 projects (0.5 %)	26 projects (0.3 %)	

Source: data compiled from UNFCCC database in Sep-Oct 2014, only registered projects
Figures in brackets are shares of registered projects (out of 7572 registered CDM projects and 272 PoAs in October 2014), Note: Number of CPAs ranges from 1 to 73, most have 1

The requirements of carbon finance for household projects with their dispersed nature and wide array of stakeholders have restricted their number, especially in the CDM. The traditional design of the CDM has been more suitable for large emitters than household projects targeting smaller emission sources due to the project by project approach, high transaction costs, bureaucratic procedures and need for upfront finance since carbon finance is obtained ex-post (Müller et al 2010, Kreibich et al 2011). In recent years, however, several changes have been made to address some of the difficulties. The situation has somewhat improved and the share of household projects in the carbon markets has increased. In both the CDM and voluntary carbon markets, methodologies for small-scale projects and new technology types have been developed. In 2011, the Gold Standard introduced new rules for micro-scale projects that simplified the PDD form itself, the requirements to demonstrate additionality (GS micro-scale Scheme Rules 2011) and mandated to assess only potential negative impacts on SD goals (GS requirements 2012). Declining prices in both the compliance and voluntary carbon markets, however, mean that household energy technology projects can still struggle with financing.

There is a limited, albeit growing, amount of research on the impacts of carbon finance on household energy technologies, especially improved cookstoves (Simon et al 2012; Simon 2014; Lambe et al 2015). Household projects have in common that they aim to get a large number of people to use a low-carbon product but there are differences between projects on how this is done. There is limited research on how distribution networks affect carbon offset projects (see Hyman 2015). The main differences in distribution strategies are whether the products are given for free, subsidized or purchased at full price, and whether they are manufactured locally. Traditionally many development interventions promoting household technologies have imported the technologies and given them out for free, resulting in a debate on technology dumping (cf. Simon et al 2014). In the carbon markets, free distribution with imported technologies has been employed at least with improved cookstoves and water purification technologies. The proponents of free distribution have advocated their strategy due to the low purchasing power of the poor or the easiness compared to establishing retail distribution channels, which will also need upfront finance (Müller et al 2010). Critiques have pointed out that due to a limited infrastructure for the technology maintenance, free distribution can lead to high dropout rates. In addition, users may place limited value on the technology if they have not desired it in the first place.

Another approach is covering some of the costs using carbon finance, which can result in a discounted price for the technology or money transfers sent out later after the developer has received the details of the customer, for example. Proponents see subsidies as necessary to promote equal distribution of the product by making it affordable also for the poor (Simon et al 2012). A complementary or optional approach to increase affordability is cooperation with micro credit institutions, which is being done by several household projects. Some projects might give out the technology as a loan that would be paid in monthly installments with only a fraction of the cost paid up front (Peskett et al 2012). More elaborate ideas include households paying instalments only if the technology is functional, or implementing household projects through a micro credit network offering financial and also technical support to the households (Müller et al 2010). Projects working with biodigesters, which have higher upfront financial costs compared to other household project types, emphasize the necessity of subsidizing the product price with carbon funding (Peskett et al 2012; Buysman & Mol 2013)

Another debate in household energy technology offset projects relates to whether the technologies are locally manufactured or imported (Simon et al 2014). This can often be related to the above discussions on the chosen distribution method and local manufacturing can support local distribution networks. Importing the technology, on the other hand, has been justified with claims on superior quality of imported equipment that would ensure more emissions reductions (Jetter et al 2012; Simon et al 2014). According to critiques importing the technology can harm the local markets and livelihoods of manufacturers of the technology (or similar technologies, and benefits the mainly project developer since they have been able to obtain the carbon credits immediately instead of waiting for the project to scale up. Therefore proponents of local manufacturing have advocated creating a sustainable sector by building the capacity of local producers and establishing distribution channels to market the product. Since some years the number of such market-driven projects has been increasing in the carbon markets.

In the carbon markets, household projects are sometimes distinguished from other project types by describing them as containing 'intrinsic' benefits, where the technology itself has beneficial livelihood impacts compared to 'extrinsic' carbon projects[5] with few direct positive livelihood impacts (Peskett et al. 2012). Such a distinction, however, should be applied cautiously as project design and implementation strongly influences how and what type of impacts projects produce (cf. Simon et al 2012; Lambe et al 2015). The technologies discussed in this report (ICS, biodigesters and ceramic water purifiers) have been argued to provide several beneficial impacts on issues such as health, livelihoods and climate change, which are summarized in the table below (Table 3). Since the realization of co-benefits is one of the key questions of this report, the following table should be read as a list of the different expectations and possible impacts the technologies can have according to actors promoting the technologies.

Table 3 Identified potential impacts of household technologies, adapted from GACC (2011); Bond and Templeton (2011); Bartram et al (2014).

Issue	Potential impacts
Human health	- reduction in indoor air pollution (ICS, CWP, B) - reduction of harm from indoor fires (ICS, CWP, B) - improved potable water quality and quantity (CWP)
Economic development	- reduced time for fuelwood collection (ICS, CWP, B) - reduced money spent on fuelwood, charcoal or other energy purchases (ICS, CWP, B) - increased time for other economic activities (ICS, CWP, B) - bio-slurry can be used as fertilizer (B) - possible employment generation for distribution or manufacturing (if local) (ICS, CWP, B)
Air pollution	- reduction of outdoor air pollution (ICS, CWP, B)
Forest protection	- decreased pressure on forest resources (ICS, CWP, B)
Climate change	- reduction of carbon monoxide, methane and nitrous oxide emissions (ICS, CWP, B) - reduction of black carbon emissions (ICS, CWP, B)
Gender	- reduced drudgery for fuelwood collection (ICS, CWP, B)

Many of the challenges household projects face with carbon finance are related to their dispersed nature compared to the more typical point-source carbon projects, such as industrial projects carried out on one site. First, as carbon finance is results-based, projects require upfront financing from other sources to be able to upscale their size (Simon et al 2012). Upscaling is important, as the most significant impacts of household energy projects occur only once the technologies have been adopted by a large group of households (Simon

[5] Such 'extrinsic' projects may be required to developed plans to provide additional benefits for the local community. For example, the World Bank Community Development Carbon fund requires projects to do this (Peskett et al 2012).

2014). Since projects obtain revenue from carbon finance only afterwards, they need upfront finance for transaction costs and project implementation. These include costs of designing the project, fees, implementing the project itself and monitoring, to name the most important. This is common for all carbon projects but household projects face extra barriers because they become truly profitable only in the long run when they have scaled up the distribution enough to exceed their costs (NEXUS 2012). Second, household projects often face high transaction costs related to carbon market practicalities (Müller et al 2010). Third, related to the previous point, carbon offset projects often contain complicated and bureaucratic procedures. For example, while it is possible to measure the direct emissions reductions from one point-source, it is currently impossible to do so for several, dispersed sources of emissions reductions. Therefore current methodologies rely on estimates from samples of technology use that attempt to extrapolate the data to apply to the wider, heterogenous population of technology users (Bumpus 2011). Also the designated operational entities (DOEs) verifying the project may be inexperienced with decentralized, household-based projects (Gatti & Bryan 2013). A recent study has found that validation and verification processes might be burdensome processes if criteria for point-source industrial projects are applied to decentralized household projects (Gatti & Bryan 2013).

In addition to project design, household projects face difficulties with the monitoring requirements to obtain carbon credits since they need to be able to track their products sold in the market. Unlike point-source projects they need to gather and make available for auditors the data on their decentralized customer base. For this, projects have to develop often complex and costly monitoring systems. Monitoring costs make up a large share of the ongoing costs for decentralized projects, which acts as a disincentive to monitor any other impacts beyond emissions (Peskett et al 2012). Often the more robust and complex methodologies are also more expensive to implement (cf. Howard et al 2015). In the context of distributing household energy technologies, there are several challenges in terms of monitoring. Firstly, market stalls selling the technologies lack an incentive to keep a record of people purchasing the household energy technology product (GERES 2009). Some project developers, such as GERES in Cambodia, have attempted to solve the problem by visiting retailers more frequently to collect the data and provide incentives to register purchase of the technology, such as warranties (GERES 2009). The second hindrance is collecting and recording data on the use of the product after purchase. For decentralized projects with customers spread over a large geographical area this is mostly done with technology user surveys, which are expensive and burdensome for the project developers, and especially for the technology users.

Improved Cookstoves

In developing countries traditional cookstoves, such as stone and clay cookstoves, are widely used technologies. Over half of the world's population use traditional biomass burning cookstoves for cooking and heating purposes (WHO 2009). The use of traditional cookstoves produces toxic fumes and small particles that lead to health problems, including respiratory illness (Simon 2014). Improved cooks stove projects have existed long before carbon finance: ICSs were suggested as a solution for the fuel wood crises in developing countries already in the 1970s (Kshirsagar and Kalamkar 2014). There have been large ICS programs in many developing countries, especially in China (Arens et al 2011). The success of previous ICS programs in the 1980s and 1990s has been criticized due to implementation strategies and the lack of user perspectives (cf. Kshirsaga and Kalamkar 2014).

Since the beginning of the 2000s, ICS projects have received financing from the carbon markets, however, it is only in the last five years or so that ICS projects have increased their share in both the CDM and the voluntary carbon market. In 2013, ICSs comprised 0.5 per cent of CDM projects and 12.5 per cent of CDM PoAs (Table 2) and accounted for 24 per cent of offset transactions in VCM (Peters-Stanley and Gonzalez 2014) (see Table 1). The figures in the voluntary carbon markets have decreased since to 8%, but ICS still remain a relevant technology in offset markets. Carbon finance has been seen as a new source of finance that is useful for scaling up projects, particularly in the voluntary market (Simon et al 2014). In 2012, project developers reported to have distributed already 4 million "cookstoves or other 'clean' household devices" (Peters-Stanley and Yin 2013).

There is plenty of variety among improved cookstoves. They can be designed to be used with, for example, charcoal, wood or briquettes, depending on the market. With the energy efficiency improvements improved cookstoves reduce emissions to an extent but do not eliminate them completely. The term clean cookstoves is often used for more sophisticated technologies such as LPG-burning stoves that aim to reduce emissions and indoor air pollution further than improved cookstoves (Simon et al 2014). Biomass-burning ICSs are often a cheaper option than the LPG-burning stoves and affordable for a larger number of people in developing countries.

Picture 2 Improved cookstoves at a manufacturing site in Kampong Chhnang Cambodia, ©Outi Pitkänen

Since carbon financed projects need to generate additional emissions reductions, carbon-financed ICS projects are implemented in areas with demonstrable depletion of forest resources where the main fuel for cooking is non-renewable biomass, in other words, biomass from forest sources that are depleted at such as high rate they can be considered non-renewable. Improved cookstoves have received a lot of attention in the recent years in discussions on the health hazards from improved air quality. The sustainable development benefits identified for ICSs mostly include health benefits from improved indoor air quality, less pressure on forests and savings of time and money due to reduced fuel wood or charcoal consumption (GACC 2011). The health benefits from reduced indoor air pollution and the reduction in provision of wood or charcoal are cited to benefit especially women and children. The impact of biomass stoves on reducing indoor air pollution and health risks created by it is however, under debate (Simon et al 2014).

Some researchers emphasize the sustainable development benefits of manufacturing in host countries such as employment creation and the use of local resources whereas others have found imported or centrally manufactured stoves to perform better in terms of fuel efficiency and emissions reductions (Simon et al 2014). Projects that manufacture the stoves locally need to establish a production network, which is often done by introducing the technology to existing production facilities. Other researchers have brought forth how the entrance of larger international companies into the cookstove sector has opened the market for higher-quality stoves (Lambe et al 2015).

Domestic biogas digesters

Domestic biogas digester (biodigester) projects have existed already for decades and there have been large programs since the 1970s. In India and China there are approximately 4 and 27 million biogas digesters respectively (Bond & Templeton 2011). Many of the early domestic biogas digesters programs failed and up to half of the units have become dysfunctional partly because the programs lacked a proper maintenance component (Bond & Templeton 2011).

In carbon markets, the biogas technology for large animal farms was among the first project types in the CDM but domestic biodigester projects have made their breakthrough somewhat more recently in the CDM and voluntary carbon markets. Their share of transacted offset volume is approximately 1 per cent in the voluntary carbon markets (Peters-Stanley and Gonzalez 2014), and they account for roughly 0.6 per cent of registered CDM projects and 7.4 per cent of registered CDM PoAs. Governments have often been involved with the implementation of biogas programs in terms of both the provision of subsidies and the operation of the program itself (Bond & Templeton 2011).

There are different types of household biodigesters: some are fixed and built with bricks while others can expand and are made of plastic (Bond & Templeton 2011). Usually there are several size options that are matched to the number of livestock the customer has. The biodigester is fed with animal manure and other organic residues and in anaerobic conditions a fraction of the influent is converted to biogas that can be used through an outlet coming from the digester. The rest of it leaves the digester as 'bioslurry', a nutrient-rich effluent with reduced pathogen content (Bond & Templeton 2011). Bioslurry is used as a fertilizer. Biodigesters work more efficiently in tropical conditions although they can be used also in colder climates or high altitudes. Biogas can be used with several appliances such as cookers or stoves, lamps, refrigerators or engines for electricity generation. There is variation between studies but biodigesters have been found to reduce usage of wood and coal up to around 70 per cent (Remais et al 2009).

Picture 3 Feeding the input into a biodigester in Cambodia, © Visa Tuominen

Biodigesters have been associated with several different co-benefits. Most often cited benefits are the provision of cheap energy for the daily cooking and lighting needs of a family, replacement of wood with biogas that contributes to reducing deforestation, improved health conditions due to a reduction in indoor air pollution, enhanced nutrient preservation of soil due to applying organic bioslurry as fertilizer, monetary savings from the displacement of fuels and synthetic fertilizers that were previously bought, and local production and training of masons that contribute to economic development. Women are often identified as beneficiaries of biodigesters due to better air quality in the kitchen, faster cooking and reduced drudgery from provisioning of fuel wood or charcoal, and less work cleaning the kitchen since the dirt from burning wood or charcoal would be reduced. Some claim a reduction of health hazards from poor sanitation since the yards can be kept cleaner when the animal manure is deposited to the digester. Apart from the maintenance issues, few downsides have been identified with the technology, besides the possibilities of increased water consumption and problems with poorly built units (Peskett et al 2012).

Compared to other household technologies such as ICSs and CWPs, biodigesters require a considerable investment from the user. In spite of the subsidies the poorest households are not likely to purchase a biodigester because they might not have enough cattle to have sufficient amounts of manure and the upfront investment cost is too high for poor farmers (Bond & Templeton 2011). Some biodigester projects have addressed this problem by building smaller digesters in poorer regions with the help of a tiered subsidy scheme (e.g. Nepal; Peskett et al 2012).

Ceramic water purifiers

Water-borne diseases are a primary cause of illness in developing countries (Bartram et al 2014). Specific water filtration devices have been developed to provide access to clean water for people in developing countries. Water filters have often been previously distributed via NGOs that have subsidized them or given them out for free. Ceramic water purifiers are a rather new project type in the carbon offset markets. Water treatment projects in the CDM have been aimed at a small number of facilities, but there have been no dispersed household water purifier projects. After the launch of PoAs, they emerged and account for 2.5 per cent of registered PoAs (Table 2). In the voluntary market, on the other hand, they have increased their market share in recent years reaching 4 per cent in 2013 (Table 1).

There are several types of water filters such as porous ceramic water filters and biosand filters. As carbon offset projects, ceramic water purifier projects create emissions reductions only if in the baseline drinking water was previously boiled using non-renewable biomass. Emissions reductions are then created through the saving that results from the users of the water filter no longer boiling their drinking water. The ceramic water filter purification technology is rather simple: the water is poured into the ceramic filter and is slowly distilled through to the container where it can be stored safely without being contaminated again. The filters remove bacteria, parasites, dirt and suspended solids but heavy metals and chemicals cannot be filtered. The technology requires maintenance by the user by unclogging the pores in the ceramic filter element every once in a while.

Picture 4 Two ceramic water purifiers manufactured by TerraClear, © Outi Pitkänen

Ceramic water purifiers can have direct impacts on the health of the users through reducing water-borne illnesses. The direct benefits most often identified for CWPs are health benefits from the increased quality and quantity of potable water, enhanced indoor air quality, decreased expenditure in terms of both time and money in acquiring wood or water, reduced deforestation, and local employment creation, for example, in manufacturing, assembly, distribution, sales or marketing. Furthermore, the filters can improve the users' capacity to adapt to floods and droughts (WHO and UNICEF 2012).

3. RESEARCH METHODOLOGY AND CASE SELECTION

This report aims to respond to the gaps in knowledge identified in previous research approaches. In the following chapter, we first outline the methodologies used in previous assessment frameworks and identify shortcomings before proceeding to the methodology used in the report.

Methodologies for assessing the sustainable development impacts of offset projects

The aim of a majority of prior studies on the sustainable development impacts of offset projects has been to evaluate whether the CDM is delivering on its dual objective of climate mitigation and enhancing local sustainable development. A review of prior assessments on the different sustainable development evaluation approaches is summarized in Table 4. The following section draws on the same sources, summarizes the data and methods used in these approaches, highlights some of the key questions that have arisen and presents the methods we have selected to apply.

Table 4 Comparison of different approaches to assessing sustainable development impacts of offset projects (adapted from Lee & Lazarus 2013)

Research	**Approach**	**Scoring**	**Standards analysed in the study**	**Sample size of analyzed projects**	**Number of indicators**
Sutter (2003)	MATA-CDM	Range from -1 to 1	CDM	6	12
Nussbaumer (2006)	MATA-CDM	Range from -1 to 1	CDM, GS	5	12
Sutter and Pareño (2007)	MATA-CDM	Range from -1 to 1	CDM	16	3
Olsen and Fenhann (2008)	Taxonomy	Yes / No	CDM	296	13
Boyd et al (2009)	Qualitative assessment	Direct benefits (small/big impact) Indirect benefits (small/big impact)	CDM	10	7
Nussbaumer (2009)	MATA-CDM	Range from -1 to 1	CDM, GS	39	12
Watson and Fankhauser (2009)	Taxonomy	Yes / No	CDM	409	8
Alexeew et al (2010)	Multi-criteria assessment	Range from -1 to 1	CDM	40	11
Drupp (2011)	MATA-CDM	Range from -1 to 1	CDM, GS	46	12
Subbarao and Lloyd (2011)	Own taxonomy / multi-criteria assessment	Yes / No; Low/medium/high impact	CDM	500	10, with 30 sub-indicators
Killick (2012)	MATA-CDM	Range from -1 to 1	CDM, GS	80 (40 GS, 40 non-labelled CDM)	12
Peskett et al (2012)	Taxonomy, sustainable livelihoods focus	Yes / No	CDM / JI	85 World Bank projects	14
Crowe (2013)	Multi-criteria assessment, pro-poor focus	Range from -1 to 1	CDM; GS; CCBS; SC	114	7

Fernandex et al (2014)	Taxonomy	Positive / neutral / negative	CDM, focus on hydropower projects	46	30
Gold Standard (2009, 2012)	Multi-criteria assessment	Range from -1 to 1	n/a	n/a	12
UNFCCC (2011)/CDM Sustainability tool	Taxonomy	Partly / Slightly / Highly	n/a	n/a	13

There are three kinds of data that can be used for SD impact assessment: ex-ante documents (design phase documents), ex-post documents (monitoring reports and surveys) and data collected during interviews and site visits. The majority of academic sustainable development impact analyses (hence SD impact analyses) of carbon projects have been conducted as desk reviews of project documents (e.g. Sutter and Parreño 2007, Olsen and Fenhann 2008, Boyd et al 2009, Watson & Fankhauser 2009, Alexeew et al. 2010; Lee and Lazarus 2013). Most of these studies have used Project Design Documents (PDDs), while some research has complemented the analysis with other documents, such as the validation reports of the Gold Standard (GS) (Killick 2012; Crowe 2013).

Using design phase documentation has several drawbacks. First, the analysis is based on only the potential contribution to sustainable development stated in the documents instead of realized development benefits (Olsen and Fenhann 2008; Sterk et al 2009). Second, the main focus of PDDs is not on sustainable development but on emissions reductions calculations (Peskett et al 2012) and therefore they do not contain homogenous standardized data and few, if any, quantifiable data with regards to sustainable development benefits (Nussbaumer 2009; Crowe 2013). Third, as PDDs are often the main documents through which sustainable development impacts are presented, they will tend to highlight the positive aspects of projects and avoid mentioning the negative impacts (Alexeew et al 2010). Assessing sustainable development contributions only through project documents can also conceal important information on the projects at a local level, such as local resource struggles (Boyd et al 2009).

Document analysis has, however, been commended as allowing the researcher to familiarize oneself with the context in which the impacts take place (Peskett et al 2012; Watson and Fankhauser 2009). The use of PDDs over other documents has been justified with better availability and reliability of data: PDDs are the most likely document to be available at the online registry of the respective standard (Olsen and Fenhann 2008), the documentation of the expected impacts is presented "in a relatively standardized way" (Peskett et al 2012, pp. 31) and they have been assumed to contain verified information that has been reviewed (Nussbaumer 2009).

Data for SD impact assessments has also been collected by interviews and field visits. For example, Sterk et al (2009) interviewed project developers, DOEs and civil society representatives of five GS projects. Similarly, Subbarao and Lloyd (2011) exchanged e-mails and phone calls with project developers and stakeholders and made field visits to two project sites out of a sample of five cases. The few on-site analyses of offset projects have found discrepancies between the stated development impacts in the documents and the observed impacts at the project location (Subbarao and Lloyd 2011).

Academic assessments of development co-benefits have used various sets of indicators that have had different takes on what should be considered sustainable development. All indicator sets reviewed (see Table 4 Comparison of different approaches to assessing sustainable development impacts of offset projects (adapted from Lee & Lazarus 2013)Table 4) encompass the three dimensions of sustainable development including social, economic and environmental indicators (cf. Olsen 2007). Some of the indicators are widely used: all frameworks have considered employment and improvement in services on either a general level or specifically as improvements in health or education, and almost all have included impacts on air, water and land. Other popular criteria have been energy access or depletion of fossil fuel resources and technology transfer. Other than that, the frameworks have been more diverse. Somewhat prevalent has been considering whether the project has benefited the end users or local communities in terms of income or benefits from carbon credits (MATA-CDM[6]; Crowe 2013; Subbarao and Lloyd 2011). Stakeholder participation in the project has also been included in some frameworks (Peskett et al 2012; Nussbaumer 2009; Alexeew et al 2010). Only a few indicator sets have included the impact on women (Peskett et al 2012; Crowe 2013) or biodiversity (Olsen & Fenhann 2008, Gold Standard 2012). Assessment frameworks have qualitative, semi-quantitative and quantitative indicators. Data availability varies especially with quantitative indicators, and documents rarely contain figures related to the sustainable development impacts of projects (Watson and Fankhauser 2009, Peskett et al 2012).

The methods to score or evaluate the indicators have included checklists, multi-criteria assessments and taxonomies (Olsen and Fenhann 2008). Other alternatives brought up have been benchmarking and proxy measures, and minimum requirements such as do-no-harm principles and local stakeholder consultations. Box 2 highlights some of the previous studies that have employed checklists and multi-criteria assessments. Checklists are simple lists of criteria comprising usually of several social, economic and environmental aspects of sustainable development that project developers need to answer. Checklist approaches have been popular with government officials, and had also other proponents (Boyd et al 2009), but they have been criticized for oversimplifying complex issues (Peskett et al 2012). Taxonomies evaluate whether there is an impact on a given indicator, rating each indicator with a 'yes' or a 'no' (Olsen and Fenhann 2008). The drawback of taxonomies is that they do not consider negative impacts or the extent of the impact, which could lead to overvaluing projects that have a minor impact on multiple indicators over ones that contribute significantly to a few chosen ones.

The most prominent method among academic assessments of co-benefits has been multi-criteria assessments (MCAs) (cf. Olsen 2007). One group of multi-criteria assessments are frameworks based on Sutter's (2003) MATA-CDM (Sutter & Parreño 2007; Nussbaumer 2006, 2009; Drupp 2011; Killick 2012). The MATA-CDM approach attempts to evaluate the extent of the impact: whether it is positive, neutral or negative. Multi-criteria assessment approaches are more demanding in terms of data requirements (Olsen and Fenhann 2008) and manual work required to score the projects on each of the indicators, which has kept

[6] We use the term 'MATA-CDM' to refer to all work that has been based on the MATA-CDM approach developed by Sutter (2003). For a list of the approaches based on MATA-CDM, see Table 4.

sample sizes rather low for a majority of the studies (Killick 2012). Considering the application of the methods for project practitioners, the amount of work is a barrier of the MATA-CDM. Interviewing a range of carbon market stakeholders including both organizations and project developers, Wood found that MATA-CDM is seen as “rigid and difficult to implement” (2011, p.12). The adapted MATA-CDM (e.g. Nussbaumer 2009; Drupp 2011) method is also very ambitious with respect to quantitative parameters: apart from savings of fossil energy resources it requires a numeric estimate of internal rate of return and employment generation and places the value in a utility function. Finding such figures can pose a significant challenge, which is further discussed in the results section of this report. Further, there is a difference of opinion whether both positive and negative impacts can be accounted for in a document analysis since overstating the sustainable development benefits “is cheap and of no negative consequence” (Olsen & Fenhann 2008). In a similar vein, information provided in the PDDs is often insufficient for distinguishing the extent of the impact, and the process is often reliant on the subjective view of the evaluator.

Box 2: Examples of different sustainable development assessment methods for carbon offset projects:

Taxonomies

- Olsen and Fenhann (2008): a taxonomy with four indicators in the social and environmental dimension, three economic ones and two other benefits (sustainability tax and corporate social responsibility). Analyze 296 PDDs (out of 744 that existed in 2006) using a keyword search and manually coded the SD benefits found in the PDDs.
- Watson and Fankhauser (2009): eight indicators, for example, on employment, technology transfer, livelihoods and environment. Conducted a keyword search with first and secondary keywords for 409 CDM projects, 10% of the projects in the pipeline in October 2008.
- Peskett et al (2012): Conducted a keyword search for the selected project documents of 85 World Bank carbon projects. In addition to the keyword search, they reviewed the whole PDD for context and decide whether the impact exists of each indicator.
- The voluntary CDM SD tool was launched in April 2014 and contains a checklist of 12 indicators, much similar to Olsen and Fenhann (2008).

Multi-criteria assessments (MCAs)

- Sutter (2003): Developed the Multi-Attributive Assessment of CDM (MATA-CDM) that has social, economic and environmental dimensions, each represented with four indicators. 123 experts from 24 countries were consulted to develop the set of criteria. Apart from qualitative indicators also quantitative indicators are employed, for example, fossil fuel resources, employment generation and microeconomic efficiency. Uruguay has adopted MATA-CDM as the national definition of sustainable development (Olsen and Fenhann 2008).
- Sutter and Parreño (2007): Analysis for 16 registered CDM projects using MATA-CDM, limiting the SD criteria to three indicators (employment, equal distribution of CER returns and local air quality) to reduce the amount of manual work in conducting the analysis

- Nussbaumer (2006): examined SD impacts of five Gold Standard and Community Development Carbon Fund projects using the full MATA-CDM set of criteria.
- Drupp (2011): compared regular CDM and Gold Standard projects using Nussbaumer's adapted version of MATA-CDM.
- Crowe (2013): developed a multi-criteria assessment with seven indicators, for example, employment, equitable revenue sharing, improved services for the poor. Evaluated 114 CDM projects
- The Gold Standard SD Matrix uses MCA methods, and both qualitative and quantitative indicators that are scored from -1 (negative impact) to 1 (positive impact). All non-neutral impacts have to be monitored according to the method specified in the GS matrix.

It is difficult and opaque to assess sustainable development contributions without specific, clear and concrete parameters. If no parameters have been defined or no instructions on the scoring have been provided, the reliability of the assessment is low (Killick 2012). The Gold Standard SD Matrix is a good example of a SD assessment framework that has defined parameters for the indicators and shared them for the public. However, most carbon project SD assessment frameworks do not make available the information on parameters for the public.

A distinction can be made on whether the indicator is assessed relative to a baseline or on an absolute scale (Sutter 2003). The most accurate way to assess the change in a given indicator would be to compare the expected project impacts to the constructed baseline scenario that takes into account 'what would have happened without the project'. For example, the baseline scenario for a renewable power project generating electricity could be the amount of electricity generated by a power station that uses a traditional fuel (Alexeew et al 2010). For emissions reductions this exercise is done in the additionality assessment included in the PDDs, but for SD impacts even reflecting on the impacts of the project itself is not given and therefore what is mostly done in SD impact assessment is comparing the situation before the project to the scenario of what the project would achieve. Comparisons to a 'zero alternative' have been identified as a problem due to inconsistency with other comparison efforts (Sterk et al 2009 p.117).

Apart from the issues with baseline, there are other difficulties related to allocating scores on the different indicators. Many researchers argue that a general statement of an impact is not enough to score a project positively but a 'concrete example' (Olsen and Fenhann 2008), 'specific information' explicitly stating the impact (Crowe 2013) or 'a clear mechanism' to deliver the benefit (Watson and Fankhauser 2009) is needed. However, as documents often lack concrete examples, the extent of how 'specific' the information is, is often left to the decision of the evaluator.

Projects can be compared with a single aggregate score, adding up the scores on the chosen criteria. Adding the scores on different indicators enables simple comparisons of projects' sustainable development contributions (e.g. Alexeew et al 2010). This has become a standard practice in previous studies (Alexeew et al 2010), including both taxonomy (Olsen and Fenhann 2008) and multicriteria methods (e.g. MATA-CDM). Aggregating scores on different indicators has been criticized, as no criteria take into account all possible SD impacts. Taxonomies, for example, evaluate whether SD impacts exist and are not able to assess their extent, and therefore the aggregation should not be considered a measure of sustainability in itself. For multicriteria methods that take into consideration also negative impacts, a drawback of aggregating positive and negative scores is value trade-offs: a bad performance in one indicator can be compensated by a good score in another (Nussbaumer 2009, Killick 2012). Moreover, with a single value a lot of information is lost on which aspects of sustainable development the project contributes to most. Aggregate scores are prone to being affected more by the amount of impacts. For example, a project that had a dramatic effect on one criterion will not compare well with a project that has numerous but only moderately positive impacts on various criteria. Another option to aggregating the scores into one figure has been to compare projects by presenting them separately in graphs. Radar graphs allow comparing the relative strength of the indicators of one project as well as the variation of the indicator across projects (Nussbaumer 2009; Drupp 2011).

In addition to the approaches presented here, there are qualitative assessments that do not score projects and may not have specified any criteria for the assessment. For purely qualitative evaluations, the findings are mostly presented as project descriptions that may or may not include homogeneous information. Thus the comparison is rather at the project level than at the aggregate level. The downside for the qualitative assessment is that the evidence for the impacts might be more anecdotal and exclude the aspects that are not especially worth mentioning. Wood (2011) warns that this might lead to comparing projects in positive ways but failing to identify negative comparisons. On the other hand qualitative descriptions could give a clear picture for readers experienced with carbon projects and carbon markets and therefore serve their purpose well.

Selection of indicators

Our analysis is based on a comparison of three different indicators sets, which are highlighted in Table 4. More details on the specific indicators in the different assessment frameworks can be found in Table 5. The three indicator sets were selected since all of them emphasized small-scale, premium or pro-poor projects in the design of the assessment frameworks and/or in the selection of the analysed projects. Since household energy technology projects also fit the criteria of small-scale and are often described as 'premium' or 'pro-poor', the indicators were considered suitable for this type of projects, in comparison to indicators that were aimed at assessing a wider range of CDM projects (such as Olsen and Fenhann 2008). The chosen indicator sets also had enough differences to make their comparison interesting. They differed from each other with respect especially to the indicator criteria. Most indicators were qualitative, and only Nussbaumer (2009) included quantitative indicators. All of them used some sort of a multicriteria method, where it was attempted to capture the extent of the impact.

Table 5 Overview of indicators used by Crowe (2013), Subbarao & Lloyd (2011) and Nussbaumer (2009)

Crowe (2013)	Subbarao & Lloyd (2011)	Nussbaumer (2009)
EC1. Local employment and/or income generation	Employment generation	SOC1 Stakeholder participation
EC2. Access to clean, affordable energy	Migration	SOC2 Improved service availability
EC3. Equitable revenue sharing	Access to electricity	SOC3 Equal distribution
EN1. Improved air, soil and/or water quality	Education	SOC4 Capacity development
EN2. Sustainable use of natural resources improved	Health	ENV1 Fossil energy resources
SOC1. Improved services for the poor	Socio-economic and human development	ENV2 Air quality
SOC2. Gender inclusive/improved equality	Distribution of benefits	ENV 3 Water quality
	Use of local resources	ENV4 Land resource
	Environmental aspects	ECO1 Regional economy
	Stakeholder comments and perceptions	ECO2 Microeconomic efficiency
		ECO3 Employment generation
		ECO4 Sustainable technology transfer

The first set of indicators by Crowe (2013) focuses on assessing pro-poor development impacts specifically, which differs from most previous approaches that focus more generally on sustainable development. Crowe developed her own set of criteria based on previous sustainable development impact assessments and conducted a multi-criteria assessment on 114 CDM projects. The second set of indicators by Subbarao and Lloyd (2011) focuses on small-scale rural CDM projects. They had 10 indicator groupings, which included 30 sub-indicators. They scored 500 PDDs on the potential sustainable development contribution using a keyword search. The contribution to each specific indicator grouping was calculated by calculating the average of the indicator sub-sets. The third set of indicators was based on the framework developed by Nussbaumer's (2009). It is an adaptation of the Multi-Attributive Assessment of the CDM (MATA-CDM) method developed by Sutter (2003). Although the set of indicators was developed by Nussbaumer (2009), we referred also to Drupp's (2011) work on extending the application of the indicators, which contained detailed description and examples.

Selection of cases

Five case studies of household energy technology projects in Lao PDR and Cambodia were selected for the analysis. The search for case studies was limited to two neighbouring countries to make the field visits possible with limited time and financial resources. We had already identified the 'Scaling up low carbon household technologies in the lower Mekong Subregion' project partners, Terraclear and Hydrologic, as possible case studies. In addition to the two ceramic water purifier projects, we sought for projects working with different household energy technology types in the two countries. Finally, we chose for analysis all the household energy technology projects that were applying for, receiving, or had received financing from carbon offsets. This included two ceramic water purifier projects (CWP) (Hydrologic Social Entreprise and TerraClear), two improved cook stove projects (GERES Cambodia and SNV's ICS project in Lao PDR) and one biodigester project (National Biodigester Project Cambodia), presented in Table 6. More detailed descriptions of the projects are presented in Box 3.

The case studies vary in terms of size, scale, starting year, carbon standard and availability of documentation online. This heterogeneity is a reality for anyone attempting to assess the sustainable development impacts of carbon offset projects (cf. Killick 2012). The projects are also in different phases of the carbon finance cycle. The Cambodian ICS project by GERES was one of the first carbon financed ICS projects, and its carbon finance cycle with the Verified Carbon Standard (VCS) ended in 2013. As of spring 2015, the two other projects in Cambodia (Hydrologic, NBP Cambodia) have issued emissions reductions. The water purifier project in Lao PDR (TerraClear) is registered and validated by the Gold Standard, but has not yet issued emissions reductions. Finally, the ICS project in Lao PDR has recently been submitted to the Gold Standard and is starting validation. The different phases of the projects have been considered when conducting the analysis on the cases.

Table 6 The selected case study carbon offset projects

Project title	**Production and dissemination of Ceramic Water Purifiers by Hydrologic, in the Kingdom of Cambodia**	**TerraClear Ceramic Water Purifier Project in Lao PDR**	**Fuel-Wood Saving with Improved Cookstoves in Cambodia**	**Improved Cook stove Programme Lao PDR**	**National Biodigester Programme, Cambodia**
Project developer	Hydrologic Social Enterprise	TerraClear	Groupe Energies Renouvelables, Environnement et Solidarités (GERES) - Cambodia	ARMI, Association for Rural Mobilisation and Improvement, SNV Laos	Biodigester Programme, SNV Cambodia
Host country	Cambodia	Lao PDR	Cambodia	Lao PDR	Cambodia
Standard	Gold Standard	Gold Standard	Verified Carbon Standard	Submitted to Gold Standard	Gold Standard
Project type	Ceramic water purifier	Ceramic water purifier	Improved cookstove	Improved cookstove	Biodigester
Estimated amount of annual GHG reduction (tCO2e)	89,474	37,097	310,058	75,174	156,581
Product first sold in	2010[7]	2010	2002	2013	2006
Crediting period (estimated in documents)	2010-2017 (PDD 2014)	2013-2020 (PDD 2013)	2003-2012 (PDD 2009)	2014-2020 (PDD 2015)	2006-2013 (PDD 2011)

[7] Ceramic water purifiers were first introduced to Cambodia by iDE (formerly International Development Enterprises) in 2002.

Box 3: Five household energy technology projects in Cambodia and Lao PDR

Hydrologic social enterprise

Hydrologic is a social enterprise that manufactures and distributes ceramic water filters in Cambodia. It started in 2010 as a project of iDE Cambodia and was funded by the USAID WaterSHED public-private partnership. In 2011, Hydrologic won the IMPACT Business Award by German Development Organization GIZ, in 2012 the Ashden Award for sustainable energy and in 2013 the Energy Globe National Award for Cambodia.The CWPs by Hydrologic use gravity filtration. Water poured in the filter is distilled through a porous ceramic pot, removing micro-organisms from the water. The capacity amounts up to 3 liters of potable water per hour. By 2013 more than 300,000 filters had been sold in Cambodia.

Hydrologic is a Gold Standard project in the voluntary market and has undergone emission reductions verification twice, issuing Voluntary Emission Reductions (VERs) in December 2012 and December 2013. In the latter verification the project crossed the 180 GWh threshold to qualify as a large-scale project because unit performance and sales had exceeded expectations. The aim of the project is to create a sustainable market for the water filters by establishing a supply chain, a local production facility, and sales force.

Terraclear: Ceramic Water Purifiers

Terraclear is a social enterprise that produces and markets ceramic water filters with the aim of scaling up the business and establishing a viable sector in water filters in Lao PDR. It was founded in 2005 as a consulting engineering company and has been selling ceramic water purifiers since 2010. The capacity of the filter is up to 55 liters of purified water per day with a storage capacity of 36 liters. The CWPs are sold in urban and rural areas in the Southern and Central parts of Laos and manufactured in a village in Champasak province. Altogether the project employs over sixty workers locally and provides a source of income for approximately 85 artisanal workers. TerraClear is in the process of being registered to the Gold Standard and therefore has not yet issued carbon credits. The majority of filters are sold directly to villages, but a small percentage of filters are distributed through the aid of development organizations.

GERES Cambodia: Improved Cookstoves

GERES is a French non-profit organization that established a unit in Cambodia in 1994 to promote the sustainable management of natural resources. GERES Cambodia was the first actor to introduce an improved cookstove project (the New Lao Stove, NLS) to the voluntary carbon market in 2006. The NLS project has received recognition from the Partnership for Clean Indoor Air (PCIA) several times, the Ashden Award for sustainable energy in 2006 and the Energy Globe National Award in 2012.

Ever since the project started its operations in 2003 it has scaled up extensively, crossing the benchmark of 2,000,000 sold units in December 2012. The NLS is targeted to urban areas selling at US$ 3.50 to US$ 5.00 whereas the cheaper Neang Kongrey Stove (NKS) project receives other external funding to provide a more affordable product for rural populations. The project applied for retroactive carbon crediting for the first years from 2003 to 2007 and afterwards issued carbon credits several times. The carbon crediting period was fixed for 10 years and finished in May 2013. The stoves are locally manufactured and the project creates employment in production, distribution and sales providing the main income generating activity to over 3,000 people (with 1,100 people directly employed). The project has supported the establishment of ICOPRODAC, the Improved Cookstove Producers and Distributors Association of Cambodia.

SNV & ARMI: Improved Cookstoves

The Netherlands Development Organization (SNV) and ARMI (Association for Rural Mobilisation and Improvement), a Laotian not-for-profit association formerly known as Normai, are implementing a project in Lao PDR manufacturing and distributing Tao Payat, an improved cookstove. The programme has recently submitted a project design document to the Gold Standard and is in the process of validation. Prior to this the programme received funding funding from European Commission's SWITCH-Asia Programme that aims to promote sustainable products, processes and services. The medium-term target of the project is to cover the costs with sales revenue and carbon credit funding. The main goal is to reach the distribution of 100,000 high-quality improved cookstoves by the end of 2016. In late 2013 and early 2014 the production has reached a total of 1,600 units approximately every month, produced in the provinces of Vientiane, Savannakhet and Champassak. The project will later expand to Vientiane Capital and Khammouane province. The stoves are manufactured by 15 small and medium-sized enterprise stove producers, thus creating employment. The project organizes 'multi-stakeholder meetings' and village workshops to present the project and raise awareness. In these activities they have received support from Lao Women's Union.

National Biodigester Program (NBP) Cambodia: Biodigesters

The National Biodigester Programme (NBP) is a national programme to promote the construction of biodigesters, coordinated by the Cambodian Ministry of Agriculture, Forestry and Fisheries (MAFF) and supported by the Netherlands Development Organization (SNV). The NBP is a large-scale nationwide project that in the first phase until 2012 had facilitated the construction of over 19,000 units with an estimated 100,000 direct beneficiaries. In the second phase they aim at establishing a self-sustaining biodigester sector to provide clean energy directly to households. Biodigesters diminish the use of fossil fuels and non-renewable biomass by converting manure into biogas that can be used for cooking or lighting instead of wood or kerosene. The biodigesters are produced by local masons. The users receive a subsidy from the project mediated by local microfinance institutions. Sources: Project websites, brochures and interviews with project developers.

While containing many differences, all of the projects had similar features that enable comparisons. First, all of the projects sell the respective technology to the end-users. There were differences by project whether subsidies (direct or indirect) were applied. The debate on subsidizing household energy technologies is extensive (see e.g. Bailis et al 2009; Simon et al 2014) and beyond the scope of this report. However, the affordability of the technology and its uptake can be significantly influenced by the provision of subsidies in developing country contexts. Second, all of the technologies were locally manufactured in Cambodia and Lao PDR and most of the materials were also locally sourced. The projects focused on supporting local employment and skills development. A contrasting approach in the carbon markets has been the dissemination of imported technologies, which in the case of improved cookstoves has been demonstrated to perform better in terms of emissions reductions and efficiency (Jetter et al. 2012). Third, all projects targeted a wide geographic user base, covering several provinces in the host countries. The majority of the users of the technology are rural households with limited incomes in Cambodia and Lao PDR. There is variation by project type, however, with biogas users generally being wealthier than ICS users, for example. Another exception is the ICS project by GERES, whose main target area has been urban and peri-urban households. Finally, all of the projects were expected to perform well in terms of delivering sustainable development benefits. This expectation was based on prior information we had on the projects, for example, the awards they had achieved in different competitions. The projects do not represent the whole spectrum of small-scale household energy technology projects but rather a sample of "well performing" projects. Focusing the analysis on "well performing" projects was directed by the feasibility constraint of conducting the on-site research in only two neighbouring countries. At the same time, critical issues arising from the sample of "well performing" projects can shed light on what other small-scale projects may struggle with.

Desk review of project documents

We first conducted a desk review, where the available project documents (see full list in Annex 1) were scored with the three indicator sets. We based the scorings on all documents the project developer had made available online, including documentation additional to the PDD (cf. Peskett et al 2012; Crowe 2013; Killick 2011; Sterk et al 2009). The project documents were retrieved from the GS registry[8], the UNFCCC CDM database[9] and VCS registry[10] in April 2014[11]. Some documents missing from the databases were recovered using search engines. In case there were several versions of the documents, the newest one was chosen for analysis. Keyword searches of the documents were made to locate the impact, but in order to have a more complete understanding of the context, all of the documents were reviewed by one researcher. Separate sheets on the scorings, containing a synthesis of the relevant text passages and justifications of the allocated scores, were compiled by the same researcher. The allocated scorings and justifications were evaluated by another researcher after which the results were discussed by the two researchers. Any disagreements with the scorings were discussed and in some cases, modifications to the original scorings were made.

Allocating scores for the projects is a subjective process, where the judgment of the individual researcher can have a significant role (Crowe 2013; Lee and Lazarus 2013). We acknowledge this, and have aimed to open the process of how the scores were allocated through writing narrative justifications, which describe why

[8] http://www.goldstandard.org/about-us/project-registry
[9] https://cdm.unfccc.int/Projects/projsearch.html
[10] http://www.vcsregistry.com/
[11] Due to the time limit, the PDD of the ICS Lao project was not available for analysis but the project was evaluated using other preparatory documents that are outlined in Annex 1.

a certain score was allocated (see Annex 2). In conducting the literature review of previous approaches, we found few explicit examples of how scores were allocated and based on what assumptions (with the notable exceptions of Nussbaumer 2006; Drupp 2011). Generally, we attempted to follow the scoring methodology described in each of the three chosen approaches. In Nussbaumer's (2009) approach, the methodology description was comprehensive and aided by Annexes A-H of his doctoral dissertation. In some of the indicators of Nussbaumer (2009) and Crowe (2013), the level of detail in the documents is one of the determining factors for applying a specific scoring. In contrast, the methodological approach of Subbarao and Lloyd (2011) contained very limited details on how the scores were allocated and how the extent of the impact was judged from 'low' to 'high'.

Field studies

In addition to the desk review, we conducted field visits to all projects in September and October 2014. The aim was to collect data from relevant stakeholders of the case study projects. Interviews were sought with three types of stakeholders: project developers, end users and manufacturers or producers. The total amount of interviewees during the three week field visit period added up to 68, out of which 40 were end-users, 15 involved in the manufacturing of the product and 13 project developers. The distinction between project developer and manufacturer may not always be clear in household energy technology projects, however, we have interpreted those primarily working with the carbon offset processes as project developers and those with the development of the technology as manufacturers. Interviewing technology users made verifying the co-benefits claimed in the project documents possible and increased reliability, compared to restricting the interviews to only project developers. It also aided understanding how co-benefits were created in the actual context. The end-user interviews were conducted as semi-structured focus group interviews or household visits. The end-user visits are not a representative sample of end-users and the problems and benefits associated with the technologies. Rather, there is a bias in the households we were able to visit, as the visits were organized by the project developers. This was acknowledged from the beginning and as such the visits' to end-users are a small sample of successful cases. Even so, the visits provided information that was not present in the project documents, discussed in the results section. The interviews with end-users and production workers focused on questions related to the perceived co-benefits or negative consequences, whereas interviews with project designers included questions also on project implementation, monitoring and assessment of sustainable development impacts.

4. RESULTS

This section presents the results of the deskstudy and fieldwork carried out in 2014 on the local development impacts of the five household energy technology carbon offset projects presented in Table 6 and Box 3. While we have used three different assessment frameworks to score the projects, the aim is not to judge the success or failure of the individual offset projects. Rather, we aim to highlight gaps in current assessment approaches. In the first part of the results discussion, we focus on the identified gaps in current assessment frameworks, specifically through looking at the process of scoring; which indicators were consistently rated highly in household energy technology projects; and which indicators changed from the desk assessment to the field assessment. In the second part of the results discussion, we present four key points through which the local co-benefits of household energy technology carbon offset projects are created. These are the product itself, the value chain of the product, and the scale and sustainability of the whole project. Chapter 6, in turn, highlights some of the open questions we encountered in the research process that could be addressed in future research.

The process of scoring the projects with the indicator frameworks of Crowe (2013), Nussbaumer (2009) and Subbarao and Lloyd (2011) based on project documentation (see Annex 1) involved numerous challenges both at the desk study as well as the field study phase. It was especially difficult to make the distinction between a moderate and a significant impact for several of the indicators. This was due in part to lacking information in the documents but also due to lacking description in the assessment frameworks of what constituted a difference between 'moderate' and 'significant'. Many of the analyzed documents lacked information on some of the aspects mentioned in the indicators or lacked explicit statements of impact. In the cases of missing or insufficient impact descriptions, we gave a score of '0', representing no impact. This was also the case when the impact of the project was described at a very general level, for example, as 'the project decreases pressure on forests'. In the scoring, we required specific descriptions of impacts for the project to receive a positive score (cf. Crowe 2013).

We encountered problems with the quantitative indicators (ENV1, ECO2 and ECO3) of Nussbaumer (2009). We decided not to use the indicators ENV1 'fossil energy resources'[12] and ECO2 'microeconomic efficiency'[13]. The main reason was that the figures were mostly not available in the documents. With the amount of assumptions that we would have had to make, we did not see the benefit of using a quantitative indicator. For the indicator ECO3 'employment generation', we employed a qualitative assessment of the projects' employment effects based on the figures provided by the projects on the number of people working

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[12] The calculation method used by Nussbaumer was not suitable for our means. All of the figures used by Nussbaumer in the calculations were readily available in PDD's for the projects that we looked at. With these figures our calculations for all of the projects exceeded the value 1, which is the maximum utility for Nussbaumer. The project we analyzed do not replace production, but reduce emissions through more efficient use of resources. As such, PDD's usually state project emissions as zero or close to zero. The baseline emissions are always higher than project emissions. CERs from the projects are always lower than baseline emissions minus project emissions. With these figures the result is always higher than the maximum utility of 1 as used by Nussbaumer.

[13] Figures of microeconomic efficiency were not available in the documents

at manufacturing, distribution and retail. We also evaluated whether the people working in the supply chains of the projects were international experts or from the local population.

The results of the document and field visit scorings are presented in Table 7. We have converted the figures to a five-point scale, where 1 is the lowest and 5 is the highest[14]. The table highlights those indicators that improved (green) or worsened (red) from the document scoring to the field work scoring. In the results discussion, we focus on those indicators that were constantly rated highly and those indicators that changed. These areas highlight four key findings that are discussed below.

[14] Crowe (2013) and Nussbaumer (2009) use a five-point scale from -1 to 1, which was converted to 1-5. Subbarao and Lloyd (2011) use a four-point scale from -1 to 2, which we converted as 2= 5, 1= 4, 0=3 and -1=2. The differences in the scales are not significant in this case, as none of the projects had negative scorings.

Table 7 Desktop study and field study scorings of projects

	Hydrologic		TerraClear		Geres		ICS Lao		NBP	
	Doc	Field	Doc	Field	Doc	Field	Doc	Field	Doc	Field
Crowe (2013)										
EC1. Local employment and/or income generation	5	5	4	5	5	5	4	4	5	5
EC2. Access to clean, affordable energy	3	3	3	3	3	4	3	4	5	5
EC3. Equitable revenue sharing	4	5	4	5	4	5	3	5	5	5
EN1. Improved air, soil and/or water quality	5	4	5	4	4	3	4	3	5	5
EN2. Sustainable use of natural resources improved	4	3	4	3	4	4	4	4	4	4
SOC1. Improved services for the poor	5	5	5	5	3	3	3	3	4	4
SOC2. Gender inclusive/improved equality	4	5	3	4	5	5	4	5	4	4
Subbarao & Lloyd (2011)										
Employment generation	4	5	4	5	4	5	4	4	4	5
Migration	/	/	/	/	/	/	/	/	/	/
Access to electricity	3	3	3	3	3	3	3	3	3	3
Education	3	3	3	3	3	3	3	3	3	3
Health	5	5	5	5	4	3	4	3	5	4
Socio-economic and human development	3	5	3	4	4	4	3	4	4	5
Distribution of benefits	4	5	4	5	5	5	4	5	5	5
Use of local resources	5	5	5	5	5	5	5	5	5	5
Environmental aspects	4	4	4	4	4	4	4	4	4	4
Stakeholder comments and perceptions	5	5	5	5	4	5	3	5	5	5
Nussbaumer (2009)										
SOC1 Stakeholder participation	5	5	5	5	4	5	4	5	5	5
SOC2 Improved service availability	5	5	5	5	3	3	3	3	5	4
SOC3 Equal distribution	4	5	4	5	5	5	5	5	5	5
SOC4 Capacity development	4	5	4	5	5	5	4	4	5	5
ENV1 Fossil energy resources	/	/	/	/	/	/	/	/	/	/
ENV2 Air quality	4	3	4	3	4	4	4	4	5	5
ENV 3 Water quality	5	5	5	5	3	3	3	3	4	3
ENV4 Land resource	3	3	3	3	3	3	3	3	4	5
ECO1 Regional economy	5	5	5	5	5	5	5	5	5	5
ECO2 Microeconomic efficiency	/	/	/	/	/	/	/	/	/	/
ECO3 Employment generation	5	5	4	5	5	5	4	4	4	5
ECO4 Sustainable technology transfer	5	5	5	5	5	5	4	5	5	5

Range from 1–5, where 5 is the highest possible score.

First, all of the projects scored consistently high on indicators related to the use of local resources, regional economy, sustainable technology transfer and employment generation. This should be interpreted with caution, as it merely indicates that the analysed projects fulfilled the parameters set by the assessment frameworks. For example, in the case of the 'regional economy' indicator by Nussbaumer (2009), all projects fulfilled the highest requirement by being located in an economically disadvantaged area, i.e. in a least developed country.

The high scorings are largely based on the business models adopted by the projects, which stressed local manufacturing, sourcing and distribution of the products. The use of local resources was evident in the support of local supply chains and markets for the products. All of the projects used largely local resources and employment. In the projects examined, the main materials needed for the production were locally available and also sourced locally, which is not necessarily always the case. For example, suitable clay is not available everywhere which makes some regions more suitable for the ceramic water purifier (CWP) production than others. Furthermore, nearly all of the production facilities and equipment have been procured locally in all of the projects we looked at. One of the projects we looked at had invested a great amount of resources and effort to modify some of the machinery to be suitable for the production, when otherwise they would have needed to purchase the equipment and spare parts from Vietnam.

Sustainable technology transfer was considered high since all five projects aimed at local market creation and building the capacity of local actors. The technologies were new in the local markets and the capacity to manage the manufacturing process either existed locally or was targeted in terms of capacity building. However, the indicator should be viewed with caution, as it does not incorporate aspects of sustainable technology transfer that relate more specifically to household energy technologies such as what are the breakage and repurchase rates of the technologies, how satisfied are users with the technology and what type of maintenance systems exist.

Out of the projects, the ceramic water purifier is a more sophisticated technology compared to improved cookstoves and biodigesters in the sense that the manufacturing process is more delicate and requires more knowledge, equipment and expertise. The majority of the employees at both CWP production facilities were from the respective regions and had been trained for the work by the enterprises in question. The National Biodigester Programme also has a training program for masons who build the biodigester according to quality standards. Cookstoves, on the other hand, have been manufactured earlier in both Cambodia and Lao PDR. With the introduction of the ICS, the production and quality standards have been upgraded, but the manufacturing process, broadly speaking, remains very much the same. The ICSs are produced by a number of small enterprises, most of which have produced cookstoves before. The ICS has been a new product line for the enterprises and many continue to manufacture the traditional stoves alongside the ICS. The production of the ICS takes a longer time; however, they can be sold at a higher price. The workers producing ICS also received a higher wage.

Second, none of the projects received negative scorings in any of the indicators. The reason for this stems from household energy technologies as a project type that is sold to end-users. Participation in the carbon offset project is conditioned by the purchase of the technology, and is voluntary in nature. This differs greatly from other carbon offset project types, such as forestry (cf. Larson 2011) or large-scale dams (Käkönen et al

2013), which both can have significant displacement impacts and where participation may not always be voluntary. Another contributing factor is that the production of household energy technologies does not entail significant negative social or environmental impacts, especially if compared to larger scale projects.

Third, the indicator scorings reveal data asymmetries between project documents and field visits. This was to be expected based on previous literature (e.g. Subbarao and Lloyd 2011) and since in some of the cases a lot of time had lapsed since the first project documents were written. The asymmetries were realized in several ways with indicators either improving or worsening from the desk review to the field analysis. Generally, as is visible from Table 7, most of the scorings improved after conducting the field visit. This indicates that the project documents did not grasp all the beneficial impacts of the projects, and that some of the impacts were visible only after some time had passed. Scorings that improved from the desk review to the field were due to limited data in the documents, which was complemented by a more nuanced picture from the field. One indicator that was difficult to judge based solely on the documents was gender inclusiveness, which was not stressed in all the project documents, leading to low initial scorings. Field visits, however, indicated that projects often had women not only as users and beneficiaries of the technologies, but also involved in the production of the technologies. This increased the scoring of the indicator. Another indicator that improved due to increased information was employment generation, as the field visits shed more light on the local impacts of the projects on employment. The wider range of local actors involved in all stages of the supply chain became evident only through the interviews with project developers and manufacturers, who described in more detail the supply chains of their products. Changes in a negative direction occurred with some indicators since the documents overemphasized the benefits. For example, in ICS projects, documents tend to emphasize improved indoor air quality created by use of the ICS and the possible health implications of this. However, the field visits and discussions with project developers highlighted that ICS are not completely clean cooking methods and only decrease the amount of indoor air pollution.

The gap between document analysis and field visits was in our sample rather small and the field visits mainly improved the image of the projects. This differs from, for example, analysis on CDM projects in Cambodia (Käkönen et al 2013) or small-scale CDM projects in India (Subbarao and Lloyd 2011), who both found that documents tended to overstate impacts and found also negative consequences of projects with site visits. In our analysis, the sample of well-performing projects explains the high scorings and the limited difference between document analysis and field visits. As the projects market themselves with producing co-benefits, they are more likely to pay attention to co-benefits in project documentation, reducing the gap between document analysis and site visits. Another explanatory factor is the assessment frameworks themselves. As discussed above, the analysed projects scored highly in some indicators due to the parameter definitions in the indicators. For example, projects scored highly on ‘regional economy’ merely by being located in an LDC. In the CDM, where the distribution of offset projects has been skewed towards the larger developing economies of China, India and Brazil, this may be considered a merit, but in the context of the voluntary offset market, such an indicator tells little about the impact on the regional economy.

Fourth, the process of scoring revealed the incompatibility of many of the indicators and the methodologies for decentralized carbon offset projects. For example, if the indicator contained many sub-indicators, as the indicators of Subbarao and Lloyd (2011), the scoring was difficult to make. In the case of employment generation, Subbarao and Lloyd (2011) included six sub-indicators, some of which were difficult to find information on in project documents, such as whether employees had previously worked in the farming sector. This lead to low scorings on employment generation with the Subbarao and Lloyd (2011) indicators whereas the other two indicator sets (Crowe 2013 and Nussbaumer 2009) had positive employment impacts, as the indicators referred mostly to the amount and quality of employment generated. The field visits further highlighted the inappropriateness of the Subbarao and Lloyd (2011) indicator on employment to a rural developing country context, where it is common to have several sources of income and to engage in farming activities on top of principal employment.

A larger question seems to be that some of the indicators appear to be developed for what Peskett et al. (2012) call 'extrinsic' projects, i.e. projects that do not create direct benefits to the local population but have to create specific strategies, such as CSR, for ensuring that the local population benefits from the offset project. In contrast, household energy technologies can be described as 'intrinsic' projects, since the use of the technology as well as its production and distribution create direct benefits for the local population. The indicator sets that we used had some indicators which were clearly aimed at evaluating CSR strategies, such as Subbarao and Lloyd's indicator on education and Crowe's and Nussbaumer's indicators on the provision of services in one way or another. Decentralized projects, such as household energy technologies, rarely have such extensive additional strategies or programs that could make them score positively on these indicators.

In the second part of the results discussion, we present four key areas through which the co-benefits of household energy technology carbon offset projects could be viewed in contrast to the indicator sets evaluated above. Our aim is not to present an exhaustive new assessment framework, but rather to highlight the areas that we saw as most significant for assessing the co-benefits of household energy technology projects. We argue that the co-benefits that the product itself creates for the end users, the co-benefits created in the value chain (production, distribution, retail) and the scale and sustainability of the activities can be viewed as four central areas to focus on in assessment of the co-benefits of household energy technology projects.

The household energy technology itself and its features create many of the co-benefits of household energy technology offset projects. The assessment frameworks we focused on, however, had few indicators that directly captured the co-benefits created by the product. For household projects to be successful, the product needs to produce benefits that are meaningful for the end users, which usually are related to the main function of the product, be it water purification or the provision of biogas. Therefore, even when talking about co-benefits, the focus on the core function of the product should not be forgotten and a lack of desirable features in the product can lead to users discarding the product. For the end users we interviewed the reasons to buy the product were related to the main functions of the technology. Water filters were bought because they provided users with clean water, improved cook stoves because they made cooking easier and biodigesters because they provided users with bio-slurry and biogas. The purchase decision was often made because the users knew someone who had tried out the product and had been satisfied with it. Although these seemed to be the main reasons, also co-benefits were mentioned in several occasions. Most prominent of these were savings in time and money. Health considerations were more relevant for the water filter end-users.

Time savings seem to be a core benefit for the end-users of water purifiers and ICS, but not so much for biodigesters since they require some work on the maintenance of the product. The indicator sets we evaluated, however, hardly account for time savings, which seem significant for household energy technology projects. Furthermore, the existing indicator sets consider mainly income generation opportunities, not savings generation. End users of ICS and CWP projects seemed to be less aware of the monetary savings whereas biodigester end users, who also pay a higher price for the technology, seemed to be more aware of the monetary savings. All the same, monetary savings created through spending less time and money on sourcing firewood is a key sales argument for household energy technologies.

The second way household energy technology projects create co-benefits is through the product's value chain. From this perspective employment generation is one of the most important impacts. For point-source carbon offset projects, calculating the impact on employment is easier because employment effects can mostly be narrowed down to specific plants or sites. For household projects this is not as straightforward as they are decentralized projects, where also the distribution and production of the technology can be decentralized, presenting a challenge for quantifying the employment impacts. First, they create employment not only in the specific production facilities but also in the distribution and retail of the products and potentially even improve the income generation abilities of the end-users through created savings. The employment and income generation impacts concern several group of stakeholders, which makes it very challenging to evaluate and especially quantify them. Secondly, the number of people employed by household projects depends highly on how much the project manages to scale up, which cannot be known at the time the project documents are written. A third consideration making it harder to assess employment impacts is decentralized production, which is not a common feature of all household projects but employed in some. Evaluating the employment effects of the production of the technology is easier if there is a centralized production plant. This is the case, for example, with water filter projects whose factories are purpose-built and the number employees working on production of the product can be established as the number of people working in the factory. For projects that are implemented in existing dispersed businesses estimating the employment impacts from production is more complicated. This is the case in some improved cookstove projects, where the production is often integrated in the existing production networks so the employment created is more scattered and few producers at least in the beginning focus only on the production of the improved cookstove but work also on other products, such as traditional cookstoves. In our sample of case studies, employees of such businesses were also more likely to be employed part-time. Therefore the number of employees working for the production facilities is not an accurate representation of people employed in production.

A third important factor in analyzing household energy technologies is their ability to scale up. The five projects we analyzed were all at very different phases, and their emphasis and strategies differed. At the early stages, the focus is on designing the product to fit the market and branding it to increase demand, while at the same time establishing production, distribution and sales networks. This was the case with the improved cookstove project in Lao PDR. After the early stages the central question shifts to how to expand the project while maintaining quality control and monitoring activities. Both ceramic water filter projects (TerraClear, Hydrologic) as well as the biodigester project (NBP) were considering these questions. Expanding production at the same pace as sales can be an issue for certain projects. At the final stage the question is mostly about the sustainability of project activities by local actors, assuming the project developer is not a local entity. GERES's improved cookstove project was considering these questions with regards to the functioning of the local producers association, ICOPRODAC.

Scaling up is a very central concept for household energy technology projects because obtaining large-scale distribution is the ultimate goal of the household projects that aim to develop a local market of production and distribution. For carbon finance purposes, projects need to estimate the amount of emissions reductions created but for household projects it is difficult to estimate how much and for how long people will buy the product. Yet the scale the project manages to create is highly relevant in evaluating the sustainable development impacts, since it presents the full picture of the extent of impacts a household project can achieve.

A fourth important consideration especially for household energy technology offset projects is the sustainability of the projects. In this context we use the term sustainability to refer to what extent the project and the sale of the product can continue without external assistance, be it from carbon finance or development assistance. All the projects we investigated were market creation oriented projects, which instead of giving the technology out for free were oriented to establishing a functioning market in the host country for the specific product and building the capacity of local market actors. The sustainability of the project can determine over how long a time period the sustainable development impacts of the technology occur. . For whatever reason, if the project does not have a sustainable business model in terms of financing, production, distribution networks and marketing with a desirable product that end-users will want to buy again, the benefits of a household technology project will be short-lived as the life span of a household technology is usually significantly shorter than one of an industrial size of a plant. Project sustainability is, however, a very difficult concept to evaluate since it cannot be estimated for projects that are in their early stages. At the same time, there are limited financial incentives in carbon offset structures to ensure the sustainability of the project once carbon funding has ceased. This issue was raised in one of the only carbon offset projects that has finished its crediting period, the ICS project of GERES. Also the biodigester project, NBP, is considering how to create a long-term strategy for the biogas sector in Cambodia (Buysman & Mol 2013).

5. CONCLUSIONS AND AREAS FOR FUTURE RESEARCH

This study had as its premise three gaps identified in the literature on the local development impacts of carbon offset projects. The first gap relates to a lack of assessments on the development impacts of household energy technology projects. While the technologies, especially improved cook stoves, have been studied (e.g. Simon 2014; Lambe et al 2015), these studies have focused on how carbon finance has altered the previously development-financed projects. This is understandable, as many projects are only commencing and therefore difficult to research. At the same time, pioneers in carbon financed household energy technologies, such as GERES's ICS programme have already ended their carbon finance period and offer a wide variety of lessons learned (see also: GERES 2009). The second gap we identified in the literature is the lack of assessments of realized development impacts of offset projects. These require more time, effort and money than document analysis to be realized. Yet our analysis echoes the claims of previous researchers who have conducted field visits (e.g. Subbarao and Lloyd 2011; Käkönen et al 2013) that documents do not reveal everything. In the case of household energy technologies, we did not find raging discrepancies between the documents and the field visits. Instead, we found that the site visits often confirmed information in the documents or could even improve the image of the project through more information. This can be largely attributed to the sample of well-performing projects and should not be generalized to all carbon offset projects or even all household energy technology projects. Instead, there is a need for more analysis on projects that are not expected to deliver significant co-benefits and what sort of discrepancies arise in such project between document analysis and site visits. The third gap in the literature we identified was the lack of research on the different approaches for assessing the sustainable development impacts of offset projects. Our analysis does not intend to provide a full comparative research on the merits and pitfalls of the different assessment frameworks. Rather, we identified a significant amount of similarities in the three assessment approaches, especially with regards to their limited applicability in assessing dispersed offset projects, such as household energy technology projects. The analysed assessment frameworks are in many ways targeted to assessing offset projects that have one or few locations and contain specific strategies, such as explicit CSR strategies, for creating extrinsic benefits to the local populations involved in or affected by the carbon offset project. This was present specifically in indicators targeted at assessing contributions to education and services, which are not necessarily the most suitable for household energy technologies.

The results indicate that evaluating a decentralized offset project differs significantly from evaluating a point-source offset project. The impacts of a point-source offset project are often visible once the plant or factory is built and has started operating or improvements in processes have been installed. With a decentralized project it often takes a long time for a number of end-users to adopt the technology. We did note that decentralized projects where the end-users buy the technology, and production or manufacturing is carried out locally, consistently performed well with some of the indicators used (employment generation, use of local resources, distribution of benefits, stakeholder participation). However, these are all dependent on a successful business model for the technology. If the end users do not buy the technologies produced or manufactured, the benefits will not materialize. The more desirable and affordable the technology is, the more end users it can have. The more end users there are, the more significant are the benefits associated to the project. Even if there is an outstanding product which would bring significant benefits on a number of indicators, if for one reason or another the end-users will not buy the technology, there will be no benefits associated to the use of the technology.

Four further lines of research are suggested by this study. First, there is a need for wider assessments of the hundreds of household energy technology projects receiving financing from the compliance or voluntary markets. This research has carried out an in-depth analysis of five household energy technology projects. Even so, we encountered wide discrepancies in the amount and quality of the data we could assess. This is due to a wide range of reasons, including projects' different commencement times, standards used, technologies sold etc. To carry out a larger analysis of household projects is a daunting task that would require more uniform data to avoid the pitfalls of generalizing assumptions from one technology or project type to others, as household projects contain much heterogeneity in their implementation strategies. At the same time, the demands for uniform data also risk missing this heterogeneity. Striking a compromise between these two aspects is difficult. However, the increasing popularity of household energy technologies in carbon offset markets calls for more analysis on them.

Second, more research is needed to bridge the gap between desk reviews and fieldwork. Most current research is based on document analysis of carbon offset projects, which requires less time and financial resources than field work. Most of the frameworks developed for assessing the local development impacts of offset projects are based on theoretical appreciations of sustainable development or pro-poor development. There is a lack of both analysis based on field studies as well as assessment frameworks reflecting the implementation of carbon offset projects. This was especially apparent in the unsuitability of some assessment frameworks to assessing household energy technology offset projects. There is a need to bridge the gap between theoretically-driven assessments and developments of indicator frameworks and the 'on the ground' realities of carbon offset projects.

Third, the actual co-benefits that household energy technology projects claim to produce should be the center of debates on evaluating the local development impacts of carbon offset projects. There is a need for much wider discussion on what actually constitutes a co-benefit and according to whom (cf. Howard et al 2015)? Some co-benefits create something concrete (such as access to clean water) whereas some co-benefits create a saving (e.g. in time or money) or displace previous practices (such as indoor cooking fires). The benefits may accrue to local populations, impact populations further away or benefit only future populations (Howard et al 2015). There is still very little discussion about these differences and how they should be taken into account in evaluating the co-benefits of carbon offsets.

Finally, we would like to highlight the importance of assessing current assessment frameworks that attempt to evaluate the sustainable development impacts of offset projects. The amount of assessment frameworks in academic literature is vast, yet there is little comparative research on the different frameworks. There seems to be lack of analysis and application of already developed assessment frameworks in comparison to creating new frameworks. In highlighting these gaps, we see our contribution as only scratching the surface, and urge other researchers to take on some of the proposed areas for future research.

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Annex 2. Desk study assessments of the five case studies

Hydrologic

Analyzed documents: PDD 2012, PDD 2014, Gold Standard Passport 2012 (GS), Gold Standard Passport 2014, Gold Standard Stakeholder Report 2012 (GS-SR), Validation Report (VaR; 2012), Monitoring report (MR; 2012)

Crowe (2013)

EC1. Local employment and/or income generation Jobs and/or income generation activities created and located within project communities identified as high poverty or clearly directed to poor segments of society.

Both developers and participants agree that the project will have a positive impact on employment (GS p.20). In 2012 they employed 40 people at the factory, 19 at the main office and also independent sales agents (MR p.33). Since Cambodia is classified as an LDC and the factory is located outside the main urban areas (in Trapeang Samrong Village), the employment generation can be regarded to be directed to the poor (PDD p.10). The project developer targets to maintain the factory for 21 years thus creating long-term jobs (PDD p.55). Also the users of the CWP will save time and money (VaR p.31).

Score: 1 "High number (over 25) of long-term jobs created or combination of long-term jobs and short-term jobs"

EC2. Access to clean, affordable energy Project activity provides community population with access to clean and affordable energy services (electricity, heat, or gas for cooking)

Project reduces non-renewable biomass consumption but does not create access to new energy sources (GS p.20).

Score: 0 "No change in access to energy"

EC3. Equitable revenue sharing Equitable share of revenue from CERs is distributed in the project community, with funds reaching the poor and/or marginalized segments

There is no mention of end-users signing a waiver moving the emissions rights to the project developer. Hydrologic states that the enterprise will manage the carbon credits but provide reports on their usage to stakeholders (GS p. 13). Profits will be reinvested in the project mainly to scale up and develop the project (GS p.12), which is justified with the fact that most CWP projects have not been economically sustainable (PDD p.3). This would indirectly benefit the poor given that the project targets to increase distribution of CWPs in rural communities (PDD p.36). No reduction schemes for the poor have been planned although it is mentioned that carbon funds will be used "directly and indirectly" to bring down the price (PDD p.35). Furthermore, there are NGOs that purchase CWPs and resell them at subsidized rates (PDD p.10; VaR p.10&33) and a cooperating microfinance institute that offers loans for the poor (VaR p.10). However, there are no clear parameters for the funds reaching the poor since the clientele is not restricted to the poor. All profits including VER revenue will remain within the project that operates in an LDC and therefore the rating is 0.5.

Score: 0.5 "A share of CER revenue is distributed or pledged locally to high poverty area"

SOC1. Improved services for the poor Essential services other than energy are improved such as roads, health, education, sanitation, or communication

Access to potable water is interpreted as an essential service and a part of health and sanitation. The project improves the access to potable water (VaR p.11) and is described as a "direct investment for the public health" (VaR p.31). Furthermore, CWPs may reduce demand of health services since they reduce the prevalence of water-related diseases (VaR p.30), which are a prevalent cause of sickness (PDD p.4). Since the project has a target of distributing over 325,000 CWPs (PDD p.2), which will have a significant impact on access to potable water, the assigned score is 1.

Score: 1.0 “A significant improvement in one or more area”

SOC2. Gender inclusive/improved equality Marginalized segments of society, in particular women, are intentionally included in processes, stakeholder participation, revenue sharing, and other project activities
Project documents mention “well documented” effects such as reduced time spent provisioning water, reduced morbidity and mortality, and improved school attendance (PDD p.5; GS p.3). The validation report confirms that reduction in indoor air pollution is likely to affect most women and children (VaR p.30) who are traditionally involved with cooking and spend more time in the kitchen. In employment, 17 out of 40 factory staff and 5 out of 19 office staff are women. However, marginalized segments of the society are not specifically targeted in the project planning (GS p.23) nor is their role changed in a significant manner.
Score: 0.5 “Women/marginalized segments targeted for equal inclusion in project activities”

EN1. Improved air, soil and/or water quality The project contributes to decreased air pollution (outdoor or indoor), improved water or soil quality directly within the community of the project location
The water filters contribute significantly to the quality of potable water in households, which has been confirmed with a test run in an independent laboratory (PDD p.4). The amount of people served in the first monitoring period exceeded 400 000 (MR p.32). The project will reduce indoor air pollution from fuel used to boil water but will not impact fuel use on cooking stoves (PDD p.15) and thus the impact will be relatively moderate (PDD p.40; GS p.18). CWPs do not affect other environmental aspects or water quality in general (GS p.18-23). With the rationale of the indicator in question, a detailed account of an important improvement in water quality will be awarded a rating of 1.
Score: 1 “Significant increase in air, soil, and/or water quality”

EN2. Sustainable use of natural resources improved Project contributes to decreased pressure on natural resources or improves sustainable use of natural resources
The validation report identifies the improved sustainable use of natural resources as the main sustainability benefit of the project (VaR p.11). Currently fuel wood in Cambodia can be characterized as a non-renewable resource due to the unsustainable use leading to the depletion of forests (PDD p.22-25). However, the effect on fuel wood collection will most probably stay local because CWPs will affect only a fraction of fuel wood use in households (PDD p.40). Since the effect is stated in general terms and will remain moderate, a score of 0.5 was assigned.
Score: 0.5 “Moderately decreases pressure on natural resources”

Subbarao & Lloyd (2011)

1. **Employment generation**
   a. Number of jobs generated (low/**medium**/high)
      Both developers and participants agree that the project will have a positive impact on employment (GS p.20). In 2012 they employed 40 people at the factory, 19 at the main office and also independent sales agents (MR p.33-34).
   b. Continuity of generated jobs (short-term/**long-term**)
      The aim of the project is to run the factory for 21 years minimum thus creating long-term employment (PDD p.55) in a poor community (PDD p.10).
   c. Jobs generated for young, unemployed and women (low/**medium**/high)
      17 out of 40 factory staff and 5 out of 19 office staff are women (MR p.33).
   d. Jobs generated as supplementary source of income (Yes/**No**)
      Not mentioned
   e. Job switches from farming to project activities sector (**low**/medium/high)
      No mention
   f. Type of jobs created (skilled/**unskilled**)

The issue is not directly addressed although it is mentioned that "employees will be trained in product technology", so the scoring is attributed as a 1=skilled/unskilled (GS p.20).

2. **Migration**
   a. Impact on halting migration (**low**/medium/high)
      Not mentioned
   b. Reversal in migration trend (Yes/**No**)
      Not mentioned

3. **Access to electricity**
   a. Share of electricity generated by the project supplied to the local community (**low**/medium/high)
      Not mentioned
   b. Subsidised electricity to community (Yes/**No**)
      Not mentioned

4. **Education**
   a. Impact on time spent by the children at schools (**low**/medium/high)
      Claimed to increase (PDD p.5) but it is unlikely that the effect would be significant (GS p.23).
   b. Turnaround in number of children attending school (**low**/medium/high)
      It can be inferred that the number would increase (PDD p.5) but it is unlikely that the effect would be significant (GS p.23).
   c. Impact on time spent by children studying (**low**/medium/high)
      It can be inferred that the time would increase (PDD p.5) but it is unlikely that the effect would be significant (GS p.23).
   d. Impact on economic benefits to the family by children through assisting in some income generation activities (**low**/medium/high)
      Not mentioned

5. **Health**
   a. Improved health service delivery in the community (**Yes**/No)
      Access to potable water is an essential service and a part of health and sanitation. The project improves the access to potable water (VaR p.11) and is described as a "direct investment for the public health" (VaR p.31). Furthermore, CWPs may reduce demand of health services since they reduce the prevalence of water-related diseases (VaR p.30), which are a prevalent cause of sickness (PDD p.4). The project has a target of distributing over 325,000 CWPs (PDD p.2), which will have a significant impact on access to potable water.
   b. Reduced exposure to indoor air pollution (**Yes**/No)
      Reduced IAP is one of the main advantages of CWPs. The reduction can be judged to exist at household level although it is recognized that they will affect only a fraction of fuel wood use in households (PDD p.40) and thus the impact is limited (GS p.21).
   c. Improved access to safe potable water (**Yes**/No)
      The water filters contribute significantly to the quality of potable water in households, which has been confirmed with a test run in an independent laboratory (PDD p.4). The baseline study suggests that apart from the quality of water also the average amount people drink is well below the healthy limit and thus the project might have positive health outcomes both in quality and quantity of potable water (PDD p.21; GS p.21-22).

6. **Socio-economic and human development**
   a. Improvement in the socio-economic prospects of the youth in the community as a substitute to conventional farming activities (Yes/**No**)

Not mentioned

b. Impact on number of social associations created (**low**/medium/high)
   Not mentioned
c. Improved income generation (low/**medium**/high)
   Project developers argue this to be one of the main positive impacts through savings in fuel costs and reduced time provisioning fuel (GS p.19&22). However, the savings will be modest so the impact is 'medium'
d. Improved food security (Yes/**No**)
   No mention about food security.

7. **Distribution of benefits:** Impacts on marginalized people in the community in terms of income and employment generation (low/**medium**/high)

There is no mention of end-users signing a waiver moving the emissions rights to the project developer. Hydrologic states that the enterprise will manage the carbon credits but provide reports on their usage to stakeholders (GS p. 13). Profits will be reinvested in the project mainly to scale up and develop the project (GS p.12), which is justified with the fact that most CWP projects have not been economically sustainable (PDD p.3). This would indirectly benefit the poor given that the project targets to increase distribution of CWPs in rural communities (PDD p.36). No reduction schemes for the poor have been planned although it is mentioned that carbon funds will be used "directly and indirectly" to bring down the price (PDD p.35). Furthermore, there are NGOs that purchase CWPs and resell them at subsidized rates (PDD p.10; VaR p.10&33) and a cooperating microfinance institute that offer loans for the poor (VaR p.10). However, there are no clear parameters for the funds reaching the poor since the clientele is not restricted to the poor. All profits including VER revenue will remain within the project that operates in an LDC and therefore the rating is 'medium'.

8. **Use of local resources:** Use of local resources (physical, human and capital) by the project (**Yes**/No)

The stoves will be produced in Cambodia in a poor community, the factory is located outside the main urban areas (in Trapeang Samrong Village) and the employment generation can be regarded to be directed to the poor (PDD p.9-10)

9. **Environmental aspects**
   a. Impact on volume of food/crops grown in the community (**low**/medium/high)
      Not mentioned
   b. Impact on community forests in terms of fuelwood saved or increased forest area (low/**medium**/high)
      Although the fuel wood saved will represent only a portion of household usage (PDD p.40), CWPs do decrease the demand for fuel wood (GS p.22), which might lead to decrease in deforestation.
   c. Impact on quality and quantity of water (low/medium**/high**)
      CWPs are vital for access to potable water but they do not affect water quality or quantity in the surrounding environment (GS p.23). However, by increasing the quality and quantity of potable water the impact for users will be significant (PDD p.21; GS p.21-22).
   d. Impact on local air pollution (including indoor pollution) (low/**medium**/high)
      Reduced IAP is one of the main advantages of CWPs. The reduction can be judged to exist at household level although it is recognized that they will affect only a fraction of fuel wood use in households (PDD p.40) and thus the impact is limited (GS p.21).

10. **Stakeholder comments and perception**
    a. Wide range of stakeholders consulted for the project sustainability benefit discussion (**Yes**/No)

There were three stakeholder consultations to cover rural users, rural non-users and representatives of various related organizations. The participants included local people impacted by the project, local policy makers, government officials, and representatives of local authorities, NGOs and International Organisations. For the second phase also the general public was invited on top of those present in the first consultation. Approximately 20 face to face interviews were conducted (GS-SR p.19). The documents from stakeholder consultations were made available online (GS p.13). The factory site community was not consulted (Trapeang Samrong village).

b. Stakeholder perception of the project activity contribution to sustainable development of community (low/medium/**high**)
According to reports in the GS Passport, the stakeholders agree about the benefits of CWPs although there are concerns about their price and the use of carbon credit revenue. They did not find any potential negative impacts (GS-SR p.47). It should be noted again that there is no mention about consulting the factory site community.

c. Adequate mitigation measures proposed by the project developer on stakeholder concerns (**Yes/**No)
Hydrologic states that all concerns had been anticipated and no modifications are needed (GS-SR p.36). Concerns with price were replied with the stated goal to keep the price as low as possible. On top of that Hydrologic stated it will make efforts to cooperate with microfinance institutions and brought up the possibility that carbon finance would bring the prices down. VER revenue would be reinvested in scaling up and developing the project. (GS p.12)

Nussbaumer (2009)

1. Stakeholder participation

There were three stakeholder consultations to cover rural users, rural non-users and representatives of various related organizations. The participants included local people impacted by the project, local policy makers, government officials, and representatives of local authorities, NGOs and International Organisations. The factory site community was not consulted (Trapeang Samrong village). For the second phase also the general public was invited on top of those present in the first consultation. Approximately 20 face to face interviews were conducted (GS-SR p.19). The documents from stakeholder consultations were made available online (GS p.13). Moreover, the locals have the choice whether to participate in the project by buying the CWP.
Score: 1 “Stakeholders can participate actively in the decision process”

2. Improved service availability

Access to potable water is interpreted as an essential service and a part of health and sanitation. The project improves the access to potable water (VaR p.11) and is described as a “direct investment for the public health” (VaR p.31). Furthermore, CWPs may reduce demand of health services since they reduce the prevalence of water-related diseases (VaR p.30), which are a prevalent cause of sickness (PDD p.4). The project has a target of distributing over 325,000 CWPs (PDD p.2), which will have a significant impact on access to potable water. They will not affect primary education (GS p.23).
Score: 1 “Moderate increase in the availability of important services”

3. Equal distribution

There is no mention of end-users signing a waiver moving the emissions rights to the project developer. Hydrologic states that the enterprise will manage the carbon credits but provide reports on their usage to stakeholders (GS p. 13). Profits will be reinvested in the project mainly to scale up and develop the project (GS p.12), which is justified with the fact that most CWP projects have not been economically sustainable

(PDD p.3). This would indirectly benefit the poor given that the project targets to increase distribution of CWPs in rural communities (PDD p.36). No reduction schemes for the poor have been planned although it is mentioned that carbon funds will be used "directly and indirectly" to bring down the price (PDD p.35). Furthermore, there are NGOs that purchase CWPs and resell them at subsidized rates (PDD p.10; VaR p.10&33) and a cooperating microfinance institute that offers loans for the poor (VaR p.10). There are no clear parameters for the funds reaching the poor since the clientele is not restricted to the poor. However, since all profits including VER revenue will remain within the project (a host-country owned social enterprise; GS-SR p.4) that operates in an LDC, the rating is 0.5.
Score: 0.5 "if the largest fraction of the profits from CER revenues flows to the host-country population (e.g. the owner is a corporation of the host-country, a host-country owned entity)"

4. Capacity development

The project aims at developing a distribution network (PDD p.10) and conducting R&D activities (GS p.25), and the factory workers and technicians will be trained in product technology (GS p.20). Yet they claim that apart from product technology training, the impact on human and institutional capacity is insignificant enough not to monitor it (GS p.20). This is contrasted by the fact that establishing institutions for the continued supply of CWPs is one of the three objectives of the project (PDD p.6). There is a contribution to opportunities in capacity development and the score is 0.5.
Score: 0.5 "Moderate increase in opportunities for capacity development"

5. Fossil energy resources

The calculation method used by Nussbaumer was not suitable for our means. All of the figures used by Nussbaumer in the calculations were readily available in PDD's for the projects that we looked at. With these figures our calculations for all of the projects exceeded the value 1, which is the maximum utility for Nussbaumer. The project we analyzed do not replace production, but reduce emissions through more efficient use of resources. As such, PDD's usually state project emissions as zero or close to zero. The baseline emissions are always higher than project emissions. CERs from the projects are always lower than baseline emissions minus project emissions. With these figures the result is always higher than the maximum utility of 1 as used by Nussbaumer.

6. Air quality

The reduction in indoor air pollution (IAP) can be judged to exist at the household level although it is recognized that they will affect only a fraction of fuel wood use in households (PDD p.40) and thus the impact is limited (GS p.21). Even so, reduced IAP is an advantage of CWPs and therefore the score is 0.5.
Score: 0.5 "Moderate decrease of air pollutant emissions"

7. Water quality

CWPs are vital for access to potable water but they do not affect water quality or quantity in the surrounding environment (GS p.23). However, by increasing the quality and quantity of potable water the impact for users will be significant (PDD p.21; GS p.21-22).
Score: 1 "Significant decrease in pressure on the water supply"

8. Land resource

The project will "contribute to the preservation of woody vegetation cover by reduced fuel wood consumption" but will not "directly contribute to any changes in the pollution level of soil" (GS p.22). No change is claimed, therefore no change compared to baseline is assumed.
Score: 0 "No change compared to the baseline"

9. Regional economy

The project states to target rural populations and argues that without carbon finance CWPs would not otherwise be sold in rural areas (PDD p.35). It is mentioned that the manufacturing would create a source of income to poor communities (PDD p.10). The factory also is located in rural areas, so the score is 1.
Score: 1 "Project location economically disadvantaged"

10. Microeconomic efficiency

Figures of microeconomic efficiency were not available in the documents

11. Employment generation

Employment generation was evaluated qualitatively. Both developers and participants agree that the project will have a positive impact on employment (GS p.20). In 2012 they employed 40 people at the factory, 19 at the main office and also independent sales agents (MR p.33). Since Cambodia is classified as an LDC and the factory is located outside the main urban areas (in Trapeang Samrong Village), the employment generation can be regarded to be directed to the poor (PDD p.10). The project developer targets to maintain the factory for 21 years thus creating long-term jobs (PDD p.55).
Score: 1

12. Sustainable technology transfer

The promise of the technology and the low market penetration (less than 20%; GS p.8) would give grounds to claim it to be innovative. R&D will be conducted to improve the quality of CWPs to remove more viruses and chemicals (GS p.25). The materials are locally available and training will be provided but still the impact of technology transfer is acknowledged to be rather insignificant to monitor it (PDD p.21).
Score: 1 "The technology is innovative and the capacity exists locally to maintain and manage it"

Terraclear

Analyzed documents: PDD 2013, Gold Standard Passport 2013, Gold Standard Stakeholder Report (GS-SR; 2013)

Crowe (2013)

EC1. Local employment and/or income generation Jobs and/or income generation activities created and located within project communities identified as high poverty or clearly directed to poor segments of society. The project will create employment in manufacturing, promotion, distribution and monitoring (GS p.32). The first crediting period is 7 years but TC plans to continue for 2 additional periods totaling 21 years (PDD p.46) and therefore the employment is long-term. Since Lao PDR is classified as an LDC and the factory is located in a rural area (in Lomsaknuea Village), the employment generation can be regarded to be directed to the poor. It is unclear how many jobs are created and therefore a score of 0.5 is attributed.
Score: 0.5 "Low to medium number (less than 25) of jobs or only short-term jobs generated"

EC2. Access to clean, affordable energy Project activity provides community population with access to clean and affordable energy services (electricity, heat, or gas for cooking)
The project claims to improve access to affordable and clean energy services (GS p.31), which could be contested by the fact that it does not create access to new energy sources but reduces the current consumption of non-renewable biomass. Therefore it is assigned a score of 0.
Score: 0 "No change in access to energy"

EC3. Equitable revenue sharing Equitable share of revenue from CERs is distributed in the project community, with funds reaching the poor and/or marginalized segments
There is no mention of end-users signing a waiver moving the emissions rights to the project developer. It is stated that VER revenue will be used to scale up the project (GS p.13), which will indirectly benefit the poor given that the project targets to increase distribution of CWPs in rural communities (GS p.2) CWPs will save

money and time in the consumption of wood/charcoal (PDD p. 4; GS p.31), so the revenue could be seen to benefit the poor indirectly. Equitable sharing is justified also by presenting scaling up the project benefiting more people since users of CWPs will save money and time in consumption of wood/charcoal (PDD p. 4; GS p.31). No reduction schemes for the poor have been planned and there are no parameters for targeting the funds for the poor. There are no parameters for targeting the funds for the poor but since the project operates in an LDC the rating is 0.5.
Score: 0.5 "A share of CER revenue is distributed or pledged locally to high poverty area"

SOC1. Improved services for the poor Essential services other than energy are improved such as roads, health, education, sanitation, or communication
Access to potable water can be interpreted as an essential service and a part of health and sanitation. CWPs will improve significantly the quality of potable water (GS p.29). Apart from the quality also the quantity of potable water available for the household members might increase (GS p.30). Furthermore, CWPs may reduce the demand of health services since water-related diseases are a prevalent cause of sickness (e.g. PDD p.5). Since the project has a target of distributing over 100,000 CWPs (PDD p.2), which will have a significant impact on access to potable water, the assigned score is 1.

Score: 1.0 "A significant improvement in one or more area"

SOC2. Gender inclusive/improved equality Marginalized segments of society, in particular women, are intentionally included in processes, stakeholder participation, revenue sharing, and other project activities
Project documents mention "well documented" effects such as reduced time spent provisioning water, reduced morbidity and mortality, and improved school attendance (PDD p.5; GS p.3), which are likely to affect most women and children who are traditionally involved with cooking and spend more time in the kitchen. However, benefits for women or other marginalized segments of the society are not highlighted nor is there mention about specifically targeting them in the project planning.
Score: 0 "No change from baseline in role of women/marginalized segments"

EN1. Improved air, soil and/or water quality The project contributes to decreased air pollution (outdoor or indoor), improved water or soil quality directly within the community of the project location
CWPs will improve significantly the quality of potable water and reduce indoor air pollution from fuel used to boil water (GS p.29). Apart from the quality also the quantity of potable water available for the household members might increase (GS p.30). Both the access to potable water and the improved indoor air quality might translate into health benefits (GS p.33). CWPs do not affect other environmental aspects or water quality in general. A detailed account of an important improvement in water quality will be awarded a rating of 1.
Score: 1 "Significant increase in air, soil, and/or water quality"

EN2. Sustainable use of natural resources improved Project contributes to decreased pressure on natural resources or improves sustainable use of natural resources
Firewood and charcoal in Laos can be characterized as a non-renewable resource (PDD p.4) and thus diminishing the consumption of firewood and charcoal will reduce deforestation (GS p.34). CWPs will affect the usage of non-renewable biomass for boiling water but will not affect its use for cooking (PDD p.14). Since the effect is stated in general terms and will remain moderate, a score of 0.5 was assigned.
Score: 0.5 "Moderately decreases pressure on natural resources"

Subbarao & Lloyd (2011)

1. **Employment generation**
   a. Number of jobs generated (low/**medium**/high)

The project will create employment in manufacturing, promotion, distribution and monitoring (GS p.32). There is no information on the amount of people hired and therefore the score is medium.

b. Continuity of generated jobs (short-term/**long-term**)
   The first crediting period is 7 years but TC plans to continue for 2 additional periods totaling 21 years (PDD p.46).
c. Jobs generated for young, unemployed and women (**low**/medium/high)
   Not mentioned
d. Jobs generated as supplementary source of income (Yes/**No**)
   Not mentioned
e. Job switches from farming to project activities sector (**low**/medium/high)
   Not mentioned
f. Type of jobs created (**skilled/unskilled**)
   The issue is not directly addressed although it is mentioned that training will be provided for factory personnel, technicians and sales staff, therefore the scoring is 1 = skilled/unskilled (PDD p.10).

2. Migration

a. Impact on halting migration (**low**/medium/high)
   Not mentioned
b. Reversal in migration trend (Yes/**No**)
   Not mentioned

3. Access to electricity

a. Share of electricity generated by the project supplied to the local community (**low**/medium/high)
   Not mentioned
b. Subsidised electricity to community (Yes/**No**)
   Not mentioned

4. Education

a. Impact on time spent by the children at schools (**low**/medium/high)
   Claimed to increase (GS p.6) but it is unlikely that the effect would be significant.
b. Turnaround in number of children attending school (**low**/medium/high)
   It can be inferred that the number would increase (GS p.6) but it is unlikely that the effect would be significant.
c. Impact on time spent by children studying (**low**/medium/high)
   It can be inferred that the number would increase (GS p.6) but it is unlikely that the effect would be significant.
d. Impact on economic benefits to the family by children through assisting in some income generation activities (**low**/medium/high)
   Not mentioned

5. Health

a. Improved health service delivery in the community (**Yes**/No)
   Access to potable water can be interpreted as an essential service and a part of health and sanitation. Furthermore, CWPs may reduce the demand of health services since water-related diseases are a prevalent cause of sickness (e.g. PDD p.5). Since the project has a target of distributing over 100,000 CWPs (PDD p.2), which will have a significant impact on access to potable water, the score is 'Yes'.
b. Reduced exposure to indoor air pollution (**Yes**/No)
   Reduced IAP is one of the main advantages of CWPs (GS p.32).
c. Improved access to safe potable water (**Yes**/No)

The water filters contribute significantly to the quality of potable water in households (GS p.33). The baseline study revealed that most rural households boil water or drink it untreated, whereas wells, water tanks and bottled water are more prevalent in urban households (PDD p.3)

6. **Socio-economic and human development**
    a. Improvement in the socio-economic prospects of the youth in the community as a substitute to conventional farming activities (Yes/**No**)
    Not mentioned
    b. Impact on number of social associations created (**low**/medium/high)
    Not mentioned
    c. Improved income generation (low/**medium**/high)
    Project developers argue improved livelihoods to be one of the main positive impacts through savings in fuel costs and reduced time provisioning fuel (GS p.31&35). However, the savings will be modest so the impact is 'medium'
    d. Improved food security (Yes/**No**)
    Not mentioned

7. **Distribution of benefits:** Impacts on marginalized people in the community in terms of income and employment generation (low/**medium**/high)

There is no mention of end-users signing a waiver moving the emissions rights to the project developer. It is stated that VER revenue will be used to scale up the project (GS p.13). CWPs will save money and time in the consumption of wood/charcoal (PDD p. 4; GS p.31), so the revenue could be seen to benefit the poor indirectly. There are no parameters for targeting the funds for the poor but since the project operates in an LDC the rating is medium.

8. **Use of local resources:** Use of local resources (physical, human and capital) by the project (**Yes**/No)

The filters will be manufactured using local physical and human resources (PDD p.2) although the plastic parts will be imported from Thailand (PDD p.8).

9. **Environmental aspects**
    a. Impact on volume of food/crops grown in the community (**low**/medium/high)
    Not mentioned
    b. Impact on community forests in terms of fuelwood saved or increased forest area (low/**medium**/high)
    Firewood and charcoal in Laos can be characterized as a non-renewable resource (PDD p.4) and thus diminishing the consumption of firewood and charcoal will reduce deforestation (GS p.34). CWPs will affect the usage of non-renewable biomass for boiling water but will not affect its use for cooking (PDD p.14) so the impact is 'medium'.
    c. Impact on quality and quantity of water (low/medium/**high**)
    CWPs will improve significantly the quality of potable water (GS p.29). Apart from the quality also the quantity of potable water available for the household members might increase (GS p.30).
    d. Impact on local air pollution (including indoor pollution) (low/**medium**/high)
    CWPs will reduce particulate emissions from fuel used to boil water (GS p.29). The improved indoor air quality might translate into health benefits (GS p.33). CWPs will affect the usage of non-renewable biomass for boiling water but will not affect its use for cooking (PDD p.14) so the impact is limited.

10. Stakeholder comments and perception

a. Wide range of stakeholders consulted for the project sustainability benefit discussion (**Yes**/No) Terraclear has conducted an Environmental Monitoring Plan (EMP) during which stakeholder interviews have been conducted (PDD p.46). The GS Stakeholder Consultation process took place both in Vientiane and in Khammouane province where the CWPs have been piloted (GS-SR p.14). The meeting in Vientiane included representatives of various ministries, intergovernmental organizations, international NGOs and local NGOs (GS-SR p.6-10). In Khammouane present were local NGO representatives and inhabitants of the region (GS-SR p.11). There is no mention about consulting the factory site community (Bachiengchaluensouk).

b. Stakeholder perception of the project activity contribution to sustainable development of community (low/medium/**high**)
There were extensive stakeholder consultations (see above). Stakeholder perceptions of the project are generally positive (GS-SR p. 27-28). However some concerns were raised about the price of the product for the poorest. Since the perceptions were generally positive, a scoring of 'high' is attributed. It should be noted again that there is no mention about consulting the factory site community.

c. Adequate mitigation measures proposed by the project developer on stakeholder concerns (**Yes**/No)
All the questions stated in the documentation were replied to but it is hard to identify whether there have been adequate mitigation measures since most questions were clarifying in nature rather than stated concerns. To one stated concern about the use of VER revenue the reply was that the revenues will be reinvested in scaling up and developing the project.

Nussbaumer (2009)

1. Stakeholder participation

Terraclear has conducted an Environmental Monitoring Plan (EMP) during which stakeholder interviews have been conducted (PDD p.46). The GS Stakeholder Consultation process took place both in Vientiane and in Khammouane province where the CWPs have been piloted (GS-SR p.14). The meeting in Vientiane included representatives of various ministries, intergovernmental organizations, international NGOs and local NGOs (GS-SR p.6-10). In Khammouane present were local NGO representatives and inhabitants of the region (GS-SR p.11). There is no mention about consulting the factory site community (Bachiengchaluensouk).
Score: 1 "Stakeholders can participate actively in the decision process"

2. Improved service availability

Access to potable water is an essential service and a part of health and sanitation. CWPs will improve significantly the quality of potable water (GS p.29). Apart from the quality also the quantity of potable water available for the household members might increase (GS p.30). Furthermore, CWPs may reduce the demand of health services since water-related diseases are a prevalent cause of sickness (e.g. PDD p.5). Since the project has a target of distributing over 100,000 CWPs (PDD p.2), which will have a significant impact on access to potable water, the assigned score is 1.
Score: 1 "Significant increase in availability of important services"

3. Equal distribution

There is no mention of end-users signing a waiver moving the emissions rights to the project developer. It is stated that VER revenue will be used to scale up the project (GS p.13), which will indirectly benefit the poor given that the project targets to increase distribution of CWPs in rural communities (GS p.2) CWPs will save money and time in the consumption of wood/charcoal (PDD p. 4; GS p.31), so the revenue could be seen

to benefit the poor indirectly. Equitable sharing is justified also by presenting scaling up the project benefiting more people since users of CWPs will save money and time in consumption of wood/charcoal (PDD p. 4; GS p.31). No reduction schemes for the poor have been planned and there are no parameters for targeting the funds for the poor. Terraclear is a host-country owned social enterprise (GS-SR p.4) and the project operates in the rural parts of an LDC, so the rating is 0.5.
Score: 0.5 "if the largest fraction of the profits from CER revenues flows to the host-country population (e.g. the owner is a corporation of the host-country, a host-country owned entity)"

4. Capacity development

Training will be provided for factory personnel, technicians and sales staff (PDD p.10). The users are trained in the operation of CWPs and community trainings in water, sanitation and hygiene are organized (PDD p.10). Still the overall impact is regarded not significant enough to monitor (GS p.31). As the project creates opportunities to capacity development it receives a score of 0.5.
Score: 0.5 "Moderate increase in opportunities for capacity development"

5. Fossil energy resources

The calculation method used by Nussbaumer was not suitable for our means. All of the figures used by Nussbaumer in the calculations were readily available in PDD's for the projects that we looked at. With these figures our calculations for all of the projects exceeded the value 1, which is the maximum utility for Nussbaumer. The project we analyzed do not replace production, but reduce emissions through more efficient use of resources. As such, PDD's usually state project emissions as zero or close to zero. The baseline emissions are always higher than project emissions. CERs from the projects are always lower than baseline emissions minus project emissions. With these figures the result is always higher than the maximum utility of 1 as used by Nussbaumer.

6. Air quality

CWPs will reduce particulate emissions from fuel used to boil water (GS p.29). CWPs will affect usage of non-renewable biomass for boiling water but will not affect its use for cooking (PDD p.14) so the impact is limited.
Score: 0.5 "Moderate decrease of air pollutant emissions"

7. Water quality

CWPs will improve significantly the quality of potable water (GS p.29). Apart from the quality also the quantity of potable water available for the household members might increase (GS p.30).
Score: 1 "Significant decrease in pressure on the water supply"

8. Land resource

Diminishing the consumption of firewood and charcoal will reduce deforestation (GS p.34). However, since the CWPs will affect usage of non-renewable biomass for boiling water but will not affect its use for cooking (PDD p.14) the impact is limited.
Score: 0 "No change compared to baseline"

9. Regional economy

The CWPs are locally made (PDD p.2) and the factory is located in a rural area (Bachiengchaluensouk). The manufacturing will create a source of income to poor communities (GS p.2).
Score: 1 "Project location economically disadvantaged"

10. Microeconomic efficiency

Figures of microeconomic efficiency were not available in the documents

11. Employment generation

Employment generation was evaluated qualitatively. The project will create employment in manufacturing, promotion, distribution and monitoring (GS p.32). The first crediting period is 7 years but TC plans to continue for 2 additional periods totaling 21 years (PDD p.46) and therefore the employment is long-term. Since Lao PDR is classified as an LDC and the factory is located in a rural area (in Lomsaknuea Village), the employment generation can be regarded to be directed to the poor. It is unclear how many jobs are created and therefore a score of 0.5 is attributed.
Score: 0.5

12. Sustainable technology transfer

The technology could be claimed to be innovative due to its promises and low rate of adoption (varying between 0 and 1,8 %; PDD p.26; GS p.5). The CWPs will be locally manufactured (PDD p.2) and training is provided for the manufacturers, technical staff and users (PDD p.10). However, the impact is not deemed big enough to monitor (GS p.32). The technology is still deemed innovative, so the score is 1.
Score: 1"The technology is innovative and the capacity exists locally to maintain and manage it"

Geres
Analyzed material: PDD (PDD 2007: PDD 2009), Monitoring reports (2009; 2013), Verification reports (VR 2013; VR 2011)

Crowe (2013)
EC1. Local employment and/or income generation Jobs and/or income generation activities created and located within project communities identified as high poverty or clearly directed to poor segments of society. The majority of the employment benefits are realized for small-scale businesses and retailers, which also created some jobs (PDD 2009 p.6). The lifetime of the project was 10 years (PDD 2009 p.16), thus it created long-term employment. The production of ICSs is said to employ more people than that of traditional stoves (MR 2013 p.26). Furthermore, income generation of the users will be improved with reduced expenditure on fuel wood or charcoal in times when their prices have risen (MR 2013 p.25). There are no specific estimates of the amount of jobs created but since 420,000 stoves were sold in 2011 (MR 2013 p.24), the impact is likely to have been high.
Score: 1 "High number (over 25) of long-term jobs created or combination of long-term jobs and short-term jobs"

EC2. Access to clean, affordable energy Project activity provides community population with access to clean and affordable energy services (electricity, heat, or gas for cooking)
There will be an indirect improvement on access to energy. Firstly, the livelihoods of the households are improved, because with reduced consumption of charcoal or fuel wood the funds disposable for energy purchases will increase (MR 2013 p.25). Secondly, deforestation has caused the Cambodian poor to switch to inferior fuels (PDD 2009 p.13) and thus the reduced pressure on forest resources could benefit the poor (MR 2013 p.27). Since the effect is stated in general terms and no direct provision of energy occurs, the score is 0.
Score: 0 "No change in access to energy"

EC3. Equitable revenue sharing Equitable share of revenue from CERs is distributed in the project community, with funds reaching the poor and/or marginalized segments
VER revenue is used for project development and scaling up, i.e. for R&D, training, technical follow-up, quality control, market development, structuring the supply chain with fair trade values, energy policy work and advertising (MR 2013 p.1). There are no subsidy schemes (MR 2013 p.1). There are no explicitly stated parameters for the funds reaching the poor but since the project operates in an LDC, many of the ICS users are likely to be poor, so a share of the revenue is assumed to benefit the poor with a score 0.5.
Score: 0.5 "A share of CER revenue is distributed or pledged locally to high poverty area"

SOC1. Improved services for the poor Essential services other than energy are improved such as roads, health, education, sanitation, or communication
ICSs do not affect health service delivery per se although they may affect their reduced demand in case reduced cooking time and less exposure to smoke leads to health benefits (MR 2013 p.26). The health impacts have not been monitored. Therefore the impact is deemed not very significant and a score of 0 is assigned.

Score: 0 "No noticeable improvement in any areas"

SOC2. Gender inclusive/improved equality Marginalized segments of society, in particular women, are intentionally included in processes, stakeholder participation, revenue sharing, and other project activities
The ICSs will reduce time and money spent provisioning fuel wood, which will affect women who comprise 98% of stove users (MR 2013 p.27). Therefore women are identified as key beneficiaries of the project (PDD 2009 2009 p.5; MR 2013 p.27). Although the reduction is not substantial it is targeted at the funds mostly controlled by women (PDD 2009 p.5; MR 2013 p.28). It is mentioned that 34 % of the production workers are women (MR 2013 p.28). Since the impact on women is demonstrated and they are explicitly identified as beneficiaries, a score of 1 is assigned.
Score: 1 "Role of women/marginalized segments enhanced through the project activities"

EN1. Improved air, soil and/or water quality The project contributes to decreased air pollution (outdoor or indoor), improved water or soil quality directly within the community of the project location
There is evidence that the ICSs have replaced traditional inefficient stoves and thus have created permanent emissions reductions (MR 2013 p.20). With reduced fuel wood and charcoal consumption the ICSs contribute to efforts to preserve forests (MR 2013 p.21). The benefits are stated in very general terms and therefore the score is 0.5.
Score: 0.5 "Noticeable improvement in air, soil and/or water quality"

EN2. Sustainable use of natural resources improved The project contributes to decreased pressure on natural resources or improves sustainable use of natural resources
ICSs will reduce fuel consumption, which has been confirmed with tests in laboratory and field (PDD 2009 p.13). The reduced consumption of charcoal or fuel wood will reduce pressure on forest resources, which are considered a non-renewable resource with the current consumption levels (MR 2013 p.21). Deforestation has already caused the Cambodian poor to switch to inferior fuels (PDD 2009 p.13). The benefits are stated in very general terms and therefore the score is 0.5.
Score: 0.5 "Moderately decreases pressure on natural resources"

Subbarao & Lloyd (2011)

1. **Employment generation**
   a. Number of jobs generated (low/medium/**high**)
   The majority of employment benefits are realized for small-scale businesses and retailers but also some jobs will be created (PDD 2009 p.6). The production of ICSs is said to employ more people than that of traditional stoves (MR 2013 p.26). There are no estimates of the amount of jobs created but since 420,000 stoves were sold in 2011 (MR 2013 p.24), the impact is likely to have been high.
   b. Continuity of generated jobs (short-term/**long-term**)
   The lifetime of the project was 10 years (PDD 2009 p.16), thus it created long-term employment.
   c. Jobs generated for young unemployed and women (low/medium/**high**)
   It is mentioned that 34 % of the production workers are women (MR 2013 p.28), which is a high amount in the given context.
   d. Jobs generated as supplementary source of income (Yes/**No**)
   Not mentioned
   e. Job switches from farming to project activities sector (**low**/medium/high)

No mention

f. Type of jobs created (**skilled/unskilled**)
   The workers will be trained but there is limited discussion on the level of skills, so the score 1 'skilled/unskilled' is given.

2. Migration

a. Impact on halting migration (**low**/medium/high)
   Not mentioned
b. Reversal in migration trend (Yes/**No**)
   Not mentioned

3. Access to electricity

a. Share of electricity generated by the project supplied to the local community (**low**/medium/high)
   Not mentioned
b. Subsidised electricity to community (Yes/**No**)
   Not mentioned

4. Education

a. Impact on time spent by the children at schools (**low**/medium/high)
   Not mentioned in the project documents
b. Turnaround in number of children attending school (**low**/medium/high)
   Not mentioned in the project documents
c. Impact on time spent by children studying (**low**/medium/high)
   Not mentioned in the project documents
d. Impact on economic benefits to the family by children through assisting in some income generation activities (**low**/medium/high)
   Not mentioned in the project documents

5. Health

a. Improved health service delivery in the community (Yes/**No**)
   ICSs do not affect health service delivery per se although they may affect their reduced demand in case reduced cooking time and less exposure to smoke leads to health benefits (MR 2013 p.26). As the impact is indirect, the scoring is 'No'.
b. Reduced exposure to indoor air pollution (**Yes**/No)
   ICSs may provide less exposure to indoor cooking smoke (MR 2013 p.26).
c. Improved access to safe potable water (Yes/**No**)
   Not mentioned.

6. Socio-economic and human development

a. Improvement in the socio-economic prospects of the youth in the community as a substitute to conventional farming activities (Yes/**No**)
   Not mentioned
b. Impact on number of social associations created (low/medium/**high**)
   A professional association of stakeholders along the ICS supply chain, called Improved Cooking Stove Producers Distributors Association of Cambodia (ICOPRODAC), has been founded (MR 2013 p.28). During the meetings members discuss pricing issues and share information to produce better quality stoves (MR 2013 p.28).
c. Improved income generation (low/medium/**high**)
   Income generation of the ICS users will be improved with reduced expenditure on fuel wood or charcoal in times when their prices have risen (MR 2013 p.25). The income of the producers of ICS

is estimated to be four times higher than of those producers making traditional stoves (MR 2013 p. 26).

d. Improved food security (Yes/**No**)
It is claimed that reduced fuel wood demand leads to less competition over the resource and improves energy access and food security (MR p.27) but the impact is indirect.

7. **Distribution of benefits:** Impacts on marginalized people in the community in terms of income and employment generation (low/medium/**high**)

VER revenue is used for project development and scaling up, i.e. for R&D, training, technical follow-up, quality control, market development, structuring the supply chain with fair trade values, energy policy work and advertising (MR 2013 p.1). There are no subsidy schemes (MR 2013 p.1). The ICSs will reduce time and money spent provisioning fuel wood, which will most affect women who comprise 98% of stove users (MR 2013 p.27). Therefore women are identified as key beneficiaries of the project (PDD 2009 p.5; MR 2013 p.27). Although the reduction is not substantial it is targeted at the funds mostly controlled by women (PDD 2009 p.5; MR 2013 p.28). It is mentioned that 34 % of the production workers are women (MR 2013 p.28). There are no explicitly stated parameters for the funds reaching the poor but many of the ICS users are likely to be poor since the project operates in an LDC, therefore scaling up the project would probably benefit the marginalized segments.

8. **Use of local resources:** Use of local resources (physical, human and capital) by the project (**Yes**/No)

The stoves are produced locally in various provinces of Cambodia (MR p.28).

9. **Environmental aspects**
    a. Impact on volume of food/crops grown in the community (**low**/medium/high)
    Not mentioned
    b. Impact on community forests in terms of fuelwood saved or increased forest area (low/**medium**/high)
    ICSs will reduce fuel consumption, which has been confirmed with tests in laboratory and field (PDD 2009 p.13). The reduced consumption of charcoal or fuel wood will reduce pressure on forest resources, which are considered a non-renewable resource with the current consumption levels (MR 2013 p.21; PDD 2009 2013 p.12). The benefits are stated in very general terms so the rating is 'medium'.
    c. Impact on quality and quantity of water (**low**/medium/high)
    Not claimed to increase.
    d. Impact on local air pollution (including indoor pollution) (low/**medium**/high)
    There is evidence that the ICSs have replaced traditional inefficient stoves and thus have created permanent emissions reductions (MR 2013 p.20). With reduced fuel wood and charcoal consumption the ICSs contribute to efforts to preserve forests (MR 2013 p.21). The benefits are stated in very general terms and therefore the score is medium.

10. **Stakeholder comments and perception**
    a. Wide range of stakeholders consulted for the project sustainability benefit discussion (**Yes**/No)
    The institutional stakeholders have been consulted as well as the stove producers, distributers and retailers. The VCS does not require stakeholder consultations for the end-users, so there are no documented stakeholder consultations. "The stakeholders in the field are not formally consulted … [t]heir views and comments are integrated in the baseline studies and monitoring studies (user surveys, etc.)" (PDD 2009; 2007 p.26).

b. Stakeholder perception of the project activity contribution to sustainable development of community (low/**medium**/high)
   User surveys have reported positive effects, but there is limited information otherwise.
c. Adequate mitigation measures proposed by the project developer on stakeholder concerns (Yes/**No**)
   VCS does not require stakeholder consultations so this has not been addressed in the PDD.

Nussbaumer (2009)

1. Stakeholder participation

The institutional stakeholders have been consulted as well as the stove producers, distributers and retailers. The VCS does not require stakeholder consultations for the end-users, so there are no documented stakeholder consultations. "The stakeholders in the field are not formally consulted … [t]heir views and comments are integrated in the baseline studies and monitoring studies (user surveys, etc.)" (PDD 2009 2007 p.26). Since some of the stakeholders are involved, the scoring is 0.5.

Score: 0.5 "Stakeholders are invited to give inputs and raise concerns"

2. Improved service availability

ICSs do not affect health service delivery per se although they may affect their reduced demand in case reduced cooking time and less exposure to smoke leads to health benefits (MR 2013 p.26). There will be an indirect improvement on access to energy. Firstly, the livelihoods of the households are improved, because with reduced consumption of charcoal or fuel wood the funds disposable for energy purchases will increase (MR 2013 p.25). Secondly, deforestation has caused the Cambodian poor to switch to inferior fuels (PDD 2009 p.13) and thus reduced pressure on forest resources could benefit the poor (MR 2013 p.27). However, since the impacts are indirect and limited, the scoring is 0.

Score: 0 "No change compared to baseline"

3. Equal distribution

GERES is not a host-country owned entity, however, the producer's association ICOPRODAC is a local association. Carbon funding was designed to be used on scaling up the project and increasing the involvement of the local producers' association, which will benefit local population, therefore the scoring is 1.

Score: 1 " The largest fraction of the profits from CER revenues flows to the poorer 50% of the host-country population (e.g. the project owner is a small producer, local association)"

4. Capacity development

The training for the production workers of ICS could be classified under capacity development. Also the formation of the producers' association ICOPRODAC is capacity development, so the score is 1.

Score: 1 "Significant increase in opportunities for capacity development"

5. Fossil energy resources

The calculation method used by Nussbaumer was not suitable for our means. All of the figures used by Nussbaumer in the calculations were readily available in PDD's for the projects that we looked at. With these figures our calculations for all of the projects exceeded the value 1, which is the maximum utility for Nussbaumer. The project we analyzed do not replace production, but reduce emissions through more efficient use of resources. As such, PDD's usually state project emissions as zero or close to zero. The baseline emissions are always higher than project emissions. CERs from the projects are always lower than baseline emissions minus project emissions. With these figures the result is always higher than the maximum utility of 1 as used by Nussbaumer.

6. Air quality

There is evidence that the ICSs have replaced traditional inefficient stoves and thus have created permanent emissions reductions (MR 2013 p.20). The stoves have reduced cooking time (MR 2013 p.27). There is a moderate decrease in emissions, so the score is 0.5.

Score: 0.5 "Moderate decrease of air pollutant emissions"

7. Water quality

The project claims no increase in water quality and there is no reason to believe water quality or quantity would decrease either.

Score: 0 "No change compared to baseline"

8. Land resource

The reduced consumption of charcoal or fuel wood will reduce pressure on forest resources, which are considered a non-renewable resource with the current consumption levels (MR 2013 p.21; PDD 2009 2013 p.12). The effect is indirect, therefore a score of 0.

Score: 0 "No change compared to baseline"

9. Regional economy

The ICSs are manufactured in Cambodia and are sold mainly in urban and peri-urban areas (MR 2013 p.31). Since the country is an LDC, a score of 1 is justified.
Score: 1" Project location economically disadvantaged"

10. Microeconomic efficiency

Figures of microeconomic efficiency were not available in the documents

11. Employment generation

Employment generation was evaluated qualitatively. The majority of the employment benefits are realized for small-scale businesses and retailers, which also created some jobs (PDD 2009 p.6). The lifetime of the project was 10 years (PDD 2009 p.16), thus it created long-term employment. The production of ICSs is said to employ more people than that of traditional stoves (MR 2013 p.26). Furthermore, income generation of the users will be improved with reduced expenditure on fuel wood or charcoal in times when their prices have risen (MR 2013 p.25). There are no specific estimates of the amount of jobs created but since 420,000 stoves were sold in 2011 (MR 2013 p.24), the impact is likely to have been high.
Score: 1

12. Sustainable technology transfer

The project is highly oriented to technology transfer: "By including the local producers and merchants in the project activities a technology transfer is achieved" (PDD 2009 p.5). The technology transfer is achieved by three means: "Firstly, traditional cook-stove producers are attracted for the production of the new stoves and are assisted in the production itself. Secondly, an awareness program for wholesalers, retailers and mobile sellers guarantees that the products are really sold and networks between producers, merchants and users are

created. Thirdly, a campaign on the utilization of the new stoves builds up the users' knowledge about the technology". (PDD 2009 p.7)
Score: 1 "The technology is innovative and the capacity exists locally to maintain and manage it"

ICS Lao PDR
Analyzed material: Annual report (AR; 2011), Satisfaction survey report (SSR; 2013)

Crowe (2013)
EC1. Local employment and/or income generation Jobs and/or income generation activities created and located within project communities identified as high poverty or clearly directed to poor segments of society. The stoves will be produced locally (AR p.16). There are at least 36 people employed in the manufacturing facilities where the stoves will be produced (AR p.17). It is however, unclear if they will work only for ICS Laos. There is no record of the duration of the employment. The income generation of ICS users improves as time and money is saved (SSR p.4). With the general description of impacts the score assigned is 0.5.
Score: 0.5 "Low to medium number (less than 25) of jobs or only short-term jobs generated"

EC2. Access to clean, affordable energy Project activity provides community population with access to clean and affordable energy services (electricity, heat, or gas for cooking)
The analysed documents do not mention any impacts.
Score: 0 "No change in access to energy"

EC3. Equitable revenue sharing Equitable share of revenue from CERs is distributed in the project community, with funds reaching the poor and/or marginalized segments
Documents do not mention how the VER revenue will be used, therefore a scoring of 0 is assigned.
Score: 0 "No CER revenue is distributed locally"

SOC1. Improved services for the poor Essential services other than energy are improved such as roads, health, education, sanitation, or communication
ICSs do not affect health service delivery per se although they may affect their reduced demand because reduced exposure to indoor air pollution might lead to health benefits (AR p.11). Also the awareness of the health implications of indoor air pollution will be improved (AR p.15). The benefits are described on a very general level and they have not yet been verified so the score is 0.

Score: 0 "No noticeable improvement in any areas"

SOC2. Gender inclusive/improved equality Marginalized segments of society, in particular women, are intentionally included in processes, stakeholder participation, revenue sharing, and other project activities
Empowering women is a stated goal of the project (AR p.18). The production facilities outlined in the 2011 annual report employ more women than men (AR p.17). The project cooperates with Lao Women's Union. The benefits are stated in general terms so the score is 0.5.
Score: 0.5 "Women/marginalized segments targeted for equal inclusion in project activities"

EN1. Improved air, soil and/or water quality The project contributes to decreased air pollution (outdoor or indoor), improved water or soil quality directly within the community of the project location
With reduced fuel wood and charcoal consumption the ICSs enhance indoor air quality (SSR p.4). Since pollution is diminished rather than eliminated and the effect is stated in general terms, the score is 0.5.
Score: 0.5 "Noticeable improvement in air, soil and/or water quality"

EN2. Sustainable use of natural resources improved Project contributes to decreased pressure on natural resources or improves sustainable use of natural resources

The reduced consumption of charcoal or fuel wood will reduce pressure on forest resources, which are considered a non-renewable resource with the current consumption levels (SSR p.4). The benefits are stated in general terms so the score is 0.5.

<u>Score</u>: 0.5 "Moderately decreases pressure on natural resources"

Subbarao & Lloyd (2011)

1. **Employment generation**
   a. Number of jobs generated (low/**medium**/high)
   The stoves will be produced locally (AR p.16). There are at least 36 people employed in the manufacturing facilities where the stoves will be produced (AR p.17). It is however, unclear if they will work only for ICS Laos.
   b. Continuity of generated jobs (short-term/**long-term**)
   There is no record of the duration of the employment, but it can be assumed to be long-term due to default employment of ICS.
   c. Jobs generated for young unemployed and women (low/**medium**/high)
   Current producers have employed women and there is potential to increase the amounts (AR 2011, p. 17-18).
   d. Jobs generated as supplementary source of income (Yes/**No**)
   Not mentioned
   e. Job switches from farming to project activities sector (**low**/medium/high)
   Not mentioned
   f. Type of jobs created (**skilled/unskilled**)
   There is training (AR 2011, p.7), so the type of jobs is assumed to be skilled/unskilled.

2. **Migration**
   a. Impact on halting migration (**low**/medium/high)
   Not mentioned
   b. Reversal in migration trend (Yes/**No**)
   Not mentioned

3. **Access to electricity**
   a. Share of electricity generated by the project supplied to the local community (**low**/medium/high)
   Not mentioned
   b. Subsidised electricity to community (Yes/**No**)
   Not mentioned

4. **Education**
   a. Impact on time spent by the children at schools (**low**/medium/high)
   Not mentioned
   b. Turnaround in number of children attending school (**low**/medium/high)
   Not mentioned
   c. Impact on time spent by children studying (**low**/medium/high)
   Not mentioned
   d. Impact on economic benefits to the family by children through assisting in some income generation activities (**low**/medium/high)
   Not mentioned

5. **Health**
    a. Improved health service delivery in the community (Yes/**No**)
    ICSs do not affect health service delivery per se although they may affect their reduced demand because reduced exposure to indoor air pollution might lead to health benefits (AR p.11). Also the awareness of the health implications of indoor air pollution will be improved (AR p.15). However, as the impacts are indirect, the scoring is 'No'.
    b. Reduced exposure to indoor air pollution (**Yes**/No)
    ICSs reduce exposure to indoor air pollution (AR p.11).
    c. Improved access to safe potable water (Yes/**No**)
    Not mentioned

6. **Socio-economic and human development**
    a. Improvement in the socio-economic prospects of the youth in the community as a substitute to conventional farming activities (Yes/**No**)
    Not mentioned
    b. Impact on number of social associations created (**low**/medium/high)
    Not mentioned
    c. Improved income generation (low/**medium**/high)
    With ICSs users' income generation improves as time and money is saved (SSR p.4).
    d. Improved food security (Yes/**No**)
    Not mentioned.

7. **Distribution of benefits:** Impacts on marginalized people in the community in terms of income and employment generation (low/**medium**/high)

Empowering women is a stated goal of the project (AR p.18). The production facilities outlined in the 2011 annual report employ more women than men (AR p.17). There is also intended cooperation with the Lao Women Union, therefore the score is 'medium'.

8. **Use of local resources:** Use of local resources (physical, human and capital) by the project (**Yes**/No)

The stoves will be produced locally (AR p.16).

9. **Environmental aspects**
    a. Impact on volume of food/crops grown in the community (**low**/medium/high)
    Not mentioned
    b. Impact on community forests in terms of fuelwood saved or increased forest area (low/**medium**/high)
    The reduced consumption of charcoal or fuel wood will reduce pressure on forest resources, which are considered a non-renewable resource with the current consumption levels (SSR p.4).
    c. Impact on quality and quantity of water (**low**/medium/high)
    Not mentioned
    d. Impact on local air pollution (including indoor pollution) (low/**medium**/high)
    With reduced fuel wood and charcoal consumption the ICSs enhance indoor air quality (SSR p.4) but the effect is limited as wood or charcoal will still be used.

10. **Stakeholder comments and perception**
    a. Wide range of stakeholders consulted for the project sustainability benefit discussion (Yes/**No**)
    In 2013 they conducted a user satisfaction survey where 44% of users registered in the database were interviewed (SSR p. 5) however no wide consultations have yet been made.

b. Stakeholder perception of the project activity contribution to sustainable development of community (low/**medium**/high)
   The survey revealed that most users perceived ICS had created benefits in cooking time, lower costs and reduced exposure to smoke (SSR p.6) therefore the score is 'medium'.

c. Adequate mitigation measures proposed by the project developer on stakeholder concerns (Yes/**No**)
   The survey was about satisfaction to the product, not to other project activities and there have not been mitigation measures as of yet.

Nussbaumer (2009)

1. Stakeholder participation

In 2013 they conducted a user satisfaction survey where 44% of users registered in the database were interviewed (SSR p. 5). The survey revealed that most users perceived ICS had created benefits in cooking time, lower costs and reduced exposure to smoke (SSR p.6). The survey, however, asked only about satisfaction to the product, not to other project activities so the score is 0.5.
Score: 0.5 "Stakeholders are invited to give inputs and raise concerns"

2. Improved service availability

ICSs do not affect health service delivery per se although they may affect their reduced demand because reduced exposure to indoor air pollution might lead to health benefits (AR p.11). Also the awareness of the health implications of indoor air pollution will be improved (AR p.15). The effects are demonstrated on a very general level and the impacts are indirect, therefore a score of 0.

Score: 0 "No change compared to baseline"

3. Equal distribution

The program is situated in an LDC and implemented by a Lao non-profit association for rural mobilizations and improvement (Normai). It is therefore assumed CER revenue will eventually benefit the poor.

Score: 1 "The largest fraction of the profits from CER revenues flows to the poorer 50% of the host-country population (e.g. the project owner is a small producer, local association)"

4. Capacity development

Training will be provided for producers and retailers (AR p.8). Although the project will need external help in the beginning, "the goal of the program is to build the capacity of the different actors involved to a level where they are able to properly self-manage the program's activities." (AR p.7). Therefore some opportunities will be available and the score is 0.5.

Score: 0.5 "Moderate increase in opportunities for capacity development"

5. Fossil energy resources

The calculation method used by Nussbaumer was not suitable for our means. All of the figures used by Nussbaumer in the calculations were readily available in PDD's for the projects that we looked at. With these figures our calculations for all of the projects exceeded the value 1, which is the maximum utility for Nussbaumer. The project we analyzed do not replace production, but reduce emissions through more efficient use of resources. As such, PDD's usually state project emissions as zero or close to zero. The baseline emissions are always higher than project emissions. CERs from the projects are always lower than baseline emissions minus project emissions. With these figures the result is always higher than the maximum utility of 1 as used by Nussbaumer.

6. Air quality

With reduced fuel wood and charcoal consumption the ICSs enhance indoor air quality (SSR p.4) but the effect is limited as wood or charcoal will still be used. Therefore a score of 0.5 is given.

Score: 0.5 "Moderate decrease of air pollutant emissions"

7. Water quality

No effect is mentioned.

Score: 0 "No change compared to baseline"

8. Land resource

No effect is mentioned.

Score: 0 "No change compared to baseline"

9. Regional economy

The stoves will be produced locally (AR p.16). The locations of the named production facilities are not provided but the producers distribute the stoves in Champon, Outhomphon, Paksong, Atsaphongthong, Kaysone, Thakhek, Xaibouri, Xaiphouthong, Phin, which apart from Thakhek are outside the main cities of the country and therefore can be considered economically underprivileged in the LDC country.

Score: 1 "Project location economically disadvantaged"

10. Microeconomic efficiency

Figures of microeconomic efficiency were not available in the documents.

11. Employment generation

Employment generation was evaluated qualitatively. The stoves will be produced locally (AR p.16). There are at least 36 people employed in the manufacturing facilities where the stoves will be produced (AR p.17). It is however, unclear if they will work only for ICS Laos. There is no record of the duration of the employment. With general descriptions, the score is 0.5

Score: 0.5

12. Sustainable technology transfer

The technology is new and innovative for Laos (AR p.10). Other (international) ICS organizations will be consulted with the establishment of the production and distribution (AR p.8) and Thai experts will provide training in product technology (AR p.16). Although the project will need external help in the beginning, "the goal of the program is to build the capacity of the different actors involved to a level where they are able to properly self-manage the program's activities." (AR p.7). Since technology transfer takes place but external aid is still required, the score is 0.5.

Score: 0.5 "The technology is innovative but external assistance is require to develop local skills"

National Biodigester Programme Cambodia

Analyzed material: PDD (2011), PDD2 (2013), Gold Standard Passports (GS=2010; GS2=2012), Gold Standard Stakeholder Reports (GS-SR=2010; GS-SR2=2012), Monitoring report (MR; 2013), Verification report (VR; 2013), Validation Report (VaR 2011 & 2013), Biogas User Survey 2009 (BUS 2009), Biogas User Survey 2012 (BUS 2012)

Crowe (2013)

EC1. Local employment and/or income generation Jobs and/or income generation activities created and located within project communities identified as high poverty or clearly directed to poor segments of society. Biodigester construction will provide employment for materials producers and construction workers (PDD p.13) and both skilled and unskilled employment will be created (PDD p.5). The expected operational lifetime of 20 years (PDD p.74) was extended to 25 years (PDD2 p.67) thus providing long-term employment. The users will accrue savings after the biodigester has paid back the investment in approximately three years (PDD p.28). Expenditure on fuel for cooking and lighting decreases since biogas produced in the biodigester is free (PDD p.4; GS p.25). The use of bio-slurry will improve the soil quality and increase the amount of organic matter in the soil (GS p.19), which could affect income through higher yields (VaR p.85). The number of people employed with the help of the project is not stated but will be more than 25 due to the scale of the project. Although the project is not explicitly directed at the poorest segment in Cambodia, both the users and producers are located in an LDC and therefore a score of 1 was assigned.
Score: 1 "High number (over 25) of long-term jobs created or combination of long-term jobs and short-term jobs"

EC2. Access to clean, affordable energy Project activity provides community population with access to clean and affordable energy services (electricity, heat, or gas for cooking)
The project will create access to new cleaner energy (biogas) as well as provide the means to use it and reduce the use of non-renewable fuels (PDD p.4). Each biodigester will be accompanied by a number of biogas lamps, a number of biogas stoves and a toilet (PDD p.4). All biodigesters will be subsidized (PDD p.24-25). With the extent of detail and importance of impact, the project received a score of 1.
Score: 1 "Access to energy provided directly to the community and subsidized"

EC3. Equitable revenue sharing Equitable share of revenue from CERs is distributed in the project community, with funds reaching the poor and/or marginalized segments
The NBP will use the carbon revenues to subsidize the biodigesters (PDD p.24-25&28) and subsidies will be handled through banks and microfinance institutions (PDD p.7). The cost of a biodigester is higher in remote areas due to transportation costs (GS-SR2 p.34). The people purchasing a biodigester do not represent the poorest households in Cambodia since the target groups are economically better off than average rural inhabitants (BUS 2012 p.14; Baseline survey p.48): according to one study the investment is more than twice the annual income per capita (PDD p.25). However, the NBP still is a local not for profit organization (PDD p.30) functioning in an LDC. With the subsidy scheme implemented there is evidence that the funds will reach the poor and a score of 1 is allocated.
Score: 1 "A significant share of CER revenue is distributed or pledged locally, with clear parameters for funds reaching the poor"

SOC1. Improved services for the poor Essential services other than energy are improved such as roads, health, education, sanitation, or communication
The project will reduce health hazards by improving sanitation and reducing indoor air pollution (PDD p.4; GS p.22). Secondly, the accompanying lamps and biogas as their fuel will enhance the quality of life (GS p.24) through, for example, enabling various activities in the evenings (GS p.28). Finally, it will provide the users with a free, natural fertilizer (PDD p.3). Thus the aggregate benefits are significant but the impact on the poor is somewhat less significant since the target groups are economically better off than average rural inhabitants (BUS 2012 p.14; Baseline survey p.48): according to one study the investment is more than twice the annual

income per capita (PDD p.25). They estimate that about 25% of the rural population in targeted areas would have the capacity for operation of a biodigester (PDD2 p.75). However, the users live in the rural areas of an LDC country and therefore the benefits will reach the poor by definition of the indicator. Since the impacts besides energy are not that significant, the project is allocated a score of 0.5.
Score: 0.5 "A marked and noticeable improvement in one or more area"

SOC2. Gender inclusive/improved equality Marginalized segments of society, in particular women, are intentionally included in processes, stakeholder participation, revenue sharing, and other project activities
The reduced time in firewood collection is claimed to benefit women especially and increase the school attendance of girls (PDD p.5; GS p. 4). The improved air quality in the kitchen (PDD p.5) would most likely benefit women (BUS 2012 p.32) and children. In the first stakeholder consultations the number of women was very low (GS-SR p.15), but was increased somewhat for the second round (GS-SR2 p.11). There is no record of employing women. Since women are explicitly identified as project beneficiaries but other forms of inclusion are incomplete, a score of 0.5 was allocated.
Score: 0.5 "Women/marginalized segments targeted for equal inclusion in project activities"

EN1. Improved air, soil and/or water quality The project contributes to decreased air pollution (outdoor or indoor), improved water or soil quality directly within the community of the project location
The biodigesters will reduce fuel wood usage and therefore diminish indoor air pollution (PDD p.4) and indirectly reduce the pressure on forests (PDD p.5), although this aspect will not be measured (GS p.23). Soil condition is improved since waste management systems are established and the by-product (bioslurry) will replace chemical fertilizers and thus contribute to soil amendment (PDD p.5). However, follow-up surveys find that only 55% use less chemical fertilizer (BUS 2012 p.32). Water quality is enhanced when human and animal waste are treated in biodigesters and biogas can be used to boil water (GS p.19&23). Since the project will replace activities that cause indoor air pollution and provide other benefits, it will have a significant effect on environmental quality.
Score: 1 "Significant improvement in air, soil, and/or water quality"

EN2. Sustainable use of natural resources improved Project contributes to decreased pressure on natural resources or improves sustainable use of natural resources
The biodigesters will reduce fuel wood usage and indirectly reduce the pressure on forests (PDD p.5). The impact is stated in general terms and therefore a score of 0.5 is assigned.
Score: 0.5 "Moderately decreases pressure on natural resources"

Subbarao & Lloyd (2011)

1. **Employment generation**
   a. Number of jobs generated (low/medium/**high**)
      The number of people employed with the help of the project is not stated but due to the scale of the project can be considered substantial since masons and technicians are locally employed.
   b. Continuity of generated jobs (short-term/**long-term**)
      The expected operational lifetime of 20 years (PDD p.74) was extended to 25 years (PDD2 p.67) thus providing long-term employment.
   c. Jobs generated or young unemployed and women (**low**/medium/high)
      Not mentioned
   d. Jobs generated as supplementary source of income (Yes/**No**)
      Not mentioned
   e. Job switches from farming to project activities sector (**low**/medium/high)
      No mention
   f. Type of jobs created (**skilled**/**unskilled**)

Biodigester construction will provide employment for materials producers and construction workers (PDD p.13) and both skilled and unskilled employment will be created (PDD p.5).

2. **Migration**
   a. Impact on halting migration (**low**/medium/high)
   Not mentioned
   b. Reversal in migration trend (Yes/**No**)
   Not mentioned

3. **Access to electricity**
   a. Share of electricity generated by the project supplied to the local community (**low**/medium/high)
   Electricity generation or displacement of electricity is practiced only by a few biogas users (PDD p.33), therefore it has a low impact. According to the user survey, the share is 2.2% (BUS 2012 p.25)
   b. Subsidised electricity to community (Yes/**No**)
   Not mentioned

4. **Education**
   a. Impact on time spent by the children at schools (**low**/medium/high)
   The reduced time in firewood collection is claimed to increase the school attendance of girls (PDD p.5; GS p. 4), however, due to the indirect impact the effect is low.
   b. Turnaround in number of children attending school (**low**/medium/high)
   The reduced time in firewood collection is claimed to increase the school attendance of girls (PDD p.5; GS p. 4), however, due to the indirect impact the effect is low.
   c. Impact on time spent by children studying (low/**medium**/high)
   The reduced time in firewood collection is claimed to increase the school attendance of girls (PDD p.5; GS p. 4) and the use of biogas lamps is claimed to enable various activities in the evenings (GS p.28), therefore the impact is medium.
   d. Impact on economic benefits to the family by children through assisting in some income generation activities (**low**/medium/high)
   Not mentioned

5. **Health**
   a. Improved health service delivery in the community (**Yes**/No)
   Biodigesters will reduce health hazards from both the untreated waste in yards (PDD p.4) and indoor air pollution (PDD p.5) although it will not improve health service delivery per se.
   b. Reduced exposure to indoor air pollution (**Yes**/No)
   Biodigesters will reduce indoor air pollution (PDD p.5) through decreasing use of fuelwood.
   c. Improved access to safe potable water (**Yes**/No)
   Biodigesters will provide energy that can be used for boiling water, although the impact is indirect an improved access is possible (PDD p.5).

6. **Socio-economic and human development**
   a. Improvement in the socio-economic prospects of the youth in the community as a substitute to conventional farming activities (Yes/**No**)
   Not mentioned
   b. Impact on number of social associations created (**low**/medium/high)
   Biodigester User Networks (BUNs) have been established (GS p.17).
   c. Improved income generation (low/medium/**high**)

The users will accrue savings after the biodigester has paid back the investment in approximately three years (PDD p.28). Expenditure on fuel for cooking and lighting decreases since biogas produced in the biodigester is free (PDD p.4; GS p.25). The monthly saving on energy costs with the biodigester is estimated to be US$ 14.39 per month (BUS 2009 p.iv). The use of bio-slurry will improve the soil quality and increase the amount of organic matter in the soil (GS p.19), which could affect income through higher yields (VaR p.85). Biodigester construction will provide employment for materials producers and construction workers (PDD p.13) and both skilled and unskilled employment will be created (PDD p.5). Biodigesters will not always generate savings if people are collecting wood, for example (VaR p.85). However, due to the extent of the other impacts the scoring is 'high'.

d. Improved food security (**Yes**/No)
The use of bio-slurry will improve the soil quality and increase the amount of organic matter in the soil (GS p.19), which could lead to higher yields (VaR p.85).

7. **Distribution of benefits:** Impacts on marginalized people in the community in terms of income and employment generation (low/medium/**high**)

NBP will use the carbon revenues to subsidize the biodigesters (PDD p.24-25&28) and subsidies will be handled through banks and microfinance institutions (PDD p.7). The cost of a biodigester is higher in remote areas due to transportation costs (GS-SR2 p.34). NBP is a local not for profit organization (PDD p.30) functioning in 19 provinces of Cambodia (an LDC). The project will both provide employment locally and subsidize the purchases, therefore a ranking 'high' is given.

8. **Use of local resources:** Use of local resources (physical, human and capital) by the project (**Yes**/No)

Masons and technicians are locally employed and trained. Also stoves are produced locally (PDD p.5).

9. **Environmental aspects**
   a. Impact on volume of food/crops grown in the community (low/**medium**/high)
   The use of bio-slurry will improve the soil quality and increase the amount of organic matter in the soil (GS p.19), which could lead to higher yields (VaR p.85).
   b. Impact on community forests in terms of fuelwood saved or increased forest area (low/**medium**/high)
   The project will indirectly reduce the pressure on forests through reduced fuel wood collection (PDD p.5) although this aspect will not be measured (GS p.23).
   c. Impact on quality and quantity of water (low/**medium/**high)
   Water quality is enhanced when human and animal waste are treated in biodigesters and biogas can be used to boil water (GS p.19&23). This will be monitored with the amount of toilets attached to the biodigester (GS p.26). Furthermore, biodigesters will provide energy for boiling water (PDD p.5). However, the user survey indicates that water collection time has increased and few have attached a toilet to the biodigester, therefore the score is medium (BUS 2012).
   d. Impact on local air pollution (including indoor pollution) (low/medium/**high**)
   The biodigesters will reduce fuel wood consumption and therefore diminish indoor air pollution (PDD p.4), the impact can be significant, therefore a scoring of high.

10. **Stakeholder comments and perception**
   a. Wide range of stakeholders consulted for the project sustainability benefit discussion (**Yes**/No)
   NBP held a great number of stakeholder consultation meetings, both at national, provincial and at village level (GS p.15). The amount of participants for the stakeholder consultations of the first

crediting period totaled over 5100 in village workshops, almost 700 in provincial consultation workshops and almost 300 in national level workshops (GS-SR p.27) and for the second round an equally high number of stakeholders were consulted (GS-SR2 p.19). The number is exceptionally high due to the large scale of the project and many of the consultations being more of workshops than discussions on the pros and cons of the project. NBP also provides a direct communication channel on their website, where they have developed a special page for feedback (GS p.15; GS2 p. 12).

b. Stakeholder perception of the project activity contribution to sustainable development of community (low/medium/**high**)
   In the annual/biannual Biogas User Surveys the sampled users can express their views, which have been mainly positive: 81% of the users had no complaints at all (BUS 2012 p.24). The most important benefits reported are "bioslurry availability", "easiness and fast cooking" and "time savings". p.37
c. Adequate mitigation measures proposed by the project developer on stakeholder concerns (**Yes**/No)
   The Gold Standard Stakeholder Consultation Reports do not have any serious complaints that were not answered to. Complaints in Biogas User Surveys have either been tended to or they have not been brought up again.

Nussbaumer (2009)

1. Stakeholder participation

NBP held a great number of stakeholder consultation meetings, both at national, provincial and at village level (GS p.15). The amount of participants for the stakeholder consultations of the first crediting period totaled over 5100 in village workshops, almost 700 in provincial consultation workshops and almost 300 in national level workshops (GS-SR p.27) and for the second round an equally high number of stakeholders were consulted (GS-SR2 p.19). The number is exceptionally high due to the large scale of the project and many of the consultations being more of workshops than discussions on the pros and cons of the project. NBP also provides a direct communication channel on their website, where they have developed a special page for feedback (GS p.15; GS2 p. 12).
<u>Score: 1</u> "Stakeholders can participate actively in the decision process"

2. Improved service availability

The project will reduce health hazards by improving sanitation and reducing indoor air pollution (PDD p.4; GS p.22). Secondly, the accompanying lamps and biogas as their fuel will enhance the quality of life (GS p.24), through for example enabling various activities in the evenings (GS p.28). Finally, it will provide the users with a free, natural fertilizer (PDD p.3). Thus the aggregate benefits in access to energy, sanitation and fresh water will be significant.
<u>Score:</u> 1 "Significant increase in availability of important services"

3. Equal distribution

NBP is a local not for profit organization (PDD p.30) functioning in an LDC. NBP will use the carbon revenues to subsidize the biodigesters (PDD p.24-25&28) and subsidies will be handled through banks and microfinance institutions (PDD p.7). The cost of a biodigester is higher in remote areas due to transportation costs (GS-SR2 p.34). With the subsidy scheme implemented there is evidence that the funds will reach the poor and a score of 1 is allocated.
<u>Score:</u> 1 "The largest fraction of the profits from CER revenues flows to the poorer 50% of the host-country population (e.g. the project owner is a small producer, local association)"

4. Capacity development

The trainings organized will develop the capacities of the masons and supervisors (GS p.24; GS2 p.20), and it is claimed that the "skills created resulting from the NBP activities have overspill to other sectors" (PDD p.5). "Masons with good skills can become a Biogas Construction Companies (BCC) owner by following additional training on management, entrepreneurship, marketing and accounting. The establishment of a BCC is an example of building human and institutional capacity." (GS p.21). Since there are significant opportunities, a score of 1 is allocated.
Score: 1 "Significant increase in opportunities for capacity development"

5. Fossil energy resources

The calculation method used by Nussbaumer was not suitable for our means. All of the figures used by Nussbaumer in the calculations were readily available in PDD's for the projects that we looked at. With these figures our calculations for all of the projects exceeded the value 1, which is the maximum utility for Nussbaumer. The project we analyzed do not replace production, but reduce emissions through more efficient use of resources. As such, PDD's usually state project emissions as zero or close to zero. The baseline emissions are always higher than project emissions. CERs from the projects are always lower than baseline emissions minus project emissions. With these figures the result is always higher than the maximum utility of 1 as used by Nussbaumer.

6. Air quality
The biodigesters will reduce fuel wood usage and therefore diminish indoor air pollution (PDD p.4-5). The impact can be judged to be high.
Score: 1 "Significant decrease of air pollutant emissions"

7. Water quality
Water quality is enhanced when human and animal waste are treated in biodigesters and biogas can be used to boil water (GS p.19&23). This will be monitored with the amount of toilets attached to the biodigester (GS p.26). However, the user survey indicates that water collection time has increased and few have attached a toilet to the biodigester, therefore the score is 0.5 (BUS 2012).
Score: 0.5 "Moderate decrease of pressure on the water supply"

8. Land resource
Soil condition is improved since waste management systems are established and the by-product (bioslurry) will replace chemical fertilizers and thus contribute to soil amendment (PDD p.5; GS p.19). The project will indirectly reduce the pressure on forests through reduced fuel wood collection (PDD p.5) although this aspect will not be measured (GS p.23).
Score: 0.5 "Moderate decrease of pressure on land resources"

9. Regional economy
Free and locally produced biogas will reduce the demand for imported energy and imported chemical fertilizers (PDD p.5). In the second phase the project doubled the regions where they function and thus will cover the major part of the country (PDD2 p.4; GS2 p. 10), targeting all households owning the proper amount of animals. Since customers will most likely be located in rural areas of an LDC, the score is 1.
Score: 1 "Project location economically disadvantaged"

10. Microeconomic efficiency
Figures of microeconomic efficiency were not available in the documents.

11. Employment generation

Employment generation was assessed qualitatively. The number of people employed with the help of the project is not stated. A positive impact on employment is, however, estimated (GS p.21) and will be measured in masons' working days (GS p.30). Due to the scale of the project a score of 0.5 is estimated.
Score: 0.5

12. Sustainable technology transfer

The model is modified from an Indian biodigester (PDD p.5). The organization will conduct R&D to indigenize the biogas stoves (PDD p.5). The project is first of its kind to disseminate the biodigesters (PDD p.16) and the project developers argue that with the way it is implemented it "is a clear example of technology transfer and technological self-reliance". "Significant capacity building is necessary to establish the new technology in the country" (GS p.28) but efforts are made in training. Therefore the technology can be considered innovative and with the effort to indigenize it and train people in the operation and technology, a score of 1 is given.
Score: 1 "The technology is innovative and the capacity exists locally to maintain and manage it"

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