การลดต้นทุนการดำเนินโครงการการใช้มาตรการการพัฒนาที่สะอาด (CLEAN DEVELOPMENT MECHANISM) ขนาดเล็กในประเทศไทย

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TRANSACTION COST REDUCTION FOR SMALL-SCALE CLEAN DEVELOPMENT MECHANISM (CDM) PROJECTS IN THAILAND

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แหล่งพลังงานที่เชื่อถือได้ เป็นมิตรต่อสิ่งแวดล้อมรวมถึงการนำไปใช้ถือเป็นองค์ประกอบสำคัญในการสนับสนุนการพัฒนาที่ยั่งยืนในระดับชุมชนท้องถิ่น โดยเฉพาะอย่างยิ่งในประเทศกำลังพัฒนา โครงการที่นำพลังงานกลับมาใช้ใหม่มีแนวโน้มที่จะลดการปล่อยก๊าซที่ก่อให้เกิดปรากฏการณ์เรือนกระจก และให้ทุนผ่านทางกลไกการพัฒนาที่สะอาด (ซีดีเอ็ม) วัตถุประสงค์หลักของวิทยานิพนธ์ฉบับนี้ก็คือการค้นหาวิธีที่จะลดค่าใช้จ่ายที่สูงของการดำเนินโครงการกลไกการพัฒนาที่สะอาดขนาดย่อม การรวมเอาโครงการขนาดย่อมหลายๆ โครงการเข้าด้วยกันและพัฒนาโครงการเหล่านั้นให้เป็นโครงการใหญ่เพียงหนึ่งเดียวนับเป็นอีกทางเลือกหนึ่ง อย่างไรก็ดียังมีคำถามหลักเกิดขึ้นว่าในความเป็นจริง ค่าใช้จ่ายนั้นจะสามารถลดลงได้อย่างไรหากใช้วิธีรวมโครงการเป็นหนึ่งเดียว เพื่อสืบค้นคำตอบให้กับปัญหานี้และเพื่อค้นหาทางเลือกอื่นๆ การค้นคว้าเพื่อการวิจัยนี้จึงได้มุ่งเน้นไปที่โครงการบำบัดน้ำเสียและก๊าซธรรมชาติขนาดย่อมในฟาร์มเลี้ยงสุกรในประเทศไทย

ข้อสรุปสำคัญของการค้นคว้าเพื่อการวิจัยในครั้งนี้คือ ขั้นตอนและวิธีที่ที่ทำให้ง่ายขึ้นของอนุสัญญาว่าด้วยการเปลี่ยนแปลงสภาพภูมิอากาศแห่งสหประชาชาติ (UNFCCC) นั้นไม่ได้ช่วยลดค่าใช้จ่ายในโครงการซีดีเอ็มได้มากพอสำหรับโครงการขนาดย่อมที่มีสุกรจำนวน 10,000 และ 5,000 ตัว ซึ่งช่วยลดการปล่อยก๊าซที่ก่อให้เกิดปรากฏการณ์เรือนกระจกโดยเฉลี่ย 4231 และ 2116 ต่อปี ตามลำดับ แม้ว่าการรวมโครงการเข้าด้วยกันสามารถลดค่าใช้จ่ายในการดำเนินการได้ แต่การรวมโครงการขนาดย่อมกว่ายังคงได้ผลน้อยกว่าโครงการที่ไม่มีกลไกการพัฒนาที่สะอาดและค่าใช้จ่ายในการรับรองการลดก๊าซเรือนกระจก (ซีอีอาร์) ยังเป็นจำนวนที่สูงสำหรับการรวมโครงการทั้งหมด ข้อสรุปประการที่สองก็คือการรวมโครงการโดยตัวมันเองนั้นไม่สามารถลดค่าใช้จ่ายของโครงการซีดีเอ็มได้มากพอ ด้วยทางเลือกทางนโยบายที่เพิ่มขึ้น การรวมโครงการได้รับการเพิ่มจำนวนให้อยู่ในระดับที่มากพอแม้ว่าราคาของการรับรองการลดก๊าซเรือนกระจกจะอยู่ในระดับที่ต่ำ ดังนั้นข้อสรุปที่สามก็คือค่าใช้จ่ายในการดำเนินการนี้สามารถลดลงมาอยู่ในระดับที่สามารถปฏิบัติได้อย่างน้อยก็ใช้ได้กับบางโครงการที่ถูกนำมารวมกันเพื่อลดค่าใช้จ่าย แต่ทว่า เมื่อการสนับสนุนเทคโนโลยีการใช้ก๊าซธรรมชาติของรัฐบาลปัจจุบันได้มีขึ้น ความเสี่ยงทางเทคโนโลยีและค่าใช้จ่ายที่พ่วงมาด้วยจึงต้องได้รับการพิจารณา ทั้งนี้สามารถสรุปได้ชัดเจนว่ามีเพียงโครงการเลี้ยงสุกร 10,000 ตัวเท่านั้น ที่อยู่ในโครงการรวมที่สามารถนำมาปฏิบัติได้จริง ด้วยเหตุนี้ จึงสามารถสรุปในตอนท้ายสุดได้ว่าโครงการเลี้ยงสุกร 10,000 ตัว และ 5,000 ตัว อาจไม่สามารถทำให้เป็นโครงการซีดีเอ็มขนาดย่อมได้เว้นเสียแต่ว่าค่าใช้จ่ายในการดำเนินการจะลดลง แต่บางโครงการที่กล่าวมานี้ก็ยังไม่สามารถดำเนินการได้เนื่องจากไม่สามารถพัฒนาภายใต้ซีดีเอ็มขนาดย่อมด้วยความพยายามที่เพิ่มขึ้นเพียงเล็กน้อย ดังนั้น บทสรุปส่งท้ายก็คือการลดค่าใช้จ่ายในการดำเนินการนั้นเป็นหัวใจสำคัญที่จะนำไปสู่การสร้างโครงการซีดีเอ็มขนาดย่อมเหล่านั้นให้เป็นจริง ยิ่งไปกว่านั้น โครงการซีดีเอ็มขนาดย่อมยังอาจนำมาซึ่งผลประโยชน์ของท้องถิ่น หรือสามารถแก้ไขปัญหาท้องถิ่นในความเป็นจริงได้ในขณะที่มีการเรียกร้องให้มีการใส่ใจสิ่งแวดล้อมโลก หากมีความพยายามที่จะพัฒนาศักยภาพก็สามารถทำให้การลดค่าใช้จ่ายเป็นจริงขึ้นมาได้

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KEY WORD: SMALL-SCALE CLEAN DEVELOPMENT MECHANISM PROJECT/ TRANSACTION COST REDUCTION/ LOCAL BENEFITS/ THAILAND

SANNA SALMELA: TRANSACTION COST REDUCTION FOR SMALL-SCALE CLEAN DEVELOPMENT MECHANISM (CDM) PROJECT IN THAILAND: ASSOC. PROF. SITANON JESDAPIPAT, PH.D., 123 PP., ISBN 974-14-3504-5.

An environmentally friendly, reliable source of energy, and access to it, can be seen as a critical element in supporting sustainable development at the local community level. Additionally, for developing countries in particular, e.g. renewable energy projects have the potential to reduce greenhouse gas emissions and provide finance through the clean development mechanism (CDM). The main objective of this thesis is to explore how the high transaction costs of small-scale CDM projects can be reduced. Bundling several small-scale CDM projects together and developing them as one larger CDM project bundle is one option. The key question remains, however, how such a transaction is reduced through bundling in reality. To investigate this and other policy options, this research study focuses on small-scale wastewater and biogas projects at Thai pig farms.

One main conclusion of this research study is that the UNFCCC simplified modalities and procedures do not reduce the CDM project cycle transaction costs sufficiently for the single small-scale projects of 10,000 pigs and 5,000 pigs, which generate in average 4231 tCO_{2e} and 2116 tCO_{2e} of emissions reductions annually. Bundling per se can reduce these transaction costs further, however, the smaller project bundles stay less viable than the projects without CDM and the transaction costs per CER remain in a high range for all bundles. The second main conclusion is therefore that bundling per se does not sufficiently reduce the CDM project cycle transaction costs. With the additional policy options the viability of the bundles is increased to a sufficient level even with the low price of CER. Therefore, the third main conclusion is that the transaction costs can be reduced to a viable level at least for some project bundles with these transaction costs reductions. Yet, when the current government biogas technology subsidies, technology risk and cost of bundling are considered, it becomes clear that only the project of 10,000 pigs in bundles can possibly be viable enough in reality. Therefore, finally, it can be concluded that the projects of 10,000 pigs and 5,000 pigs would never be realized as small-scale CDM projects unless the transaction costs were reduced. And yet, some of these projects are not so unviable that they could not be developed under small-scale CDM with some additional effort. Therefore, the last main conclusion is that transaction cost reduction is central to the realization of these small-scale CDM projects. Moreover, these small-scale CDM projects could bring about local benefits, or in fact solve local problems, while addressing global concerns, if effort is put in developing capacities that enhance the realization of the transaction cost reductions.

Field of Study International Development Studies Student's Signature: ....

Academic Year 2006.............................. Advisor's Signature: ....

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CONTENTS

LIST OF ABBREVIATIONS

BAU	Business As Usual
CBA	Cost-Benefit Analysis
CER	Certified Emission Reduction
CDM	Clean Development Mechanism
COP/MOP	Conference of the Parties/ Meeting of the Parties
DNA	Designated National Authority
DOE	Designated Operational Entity
DRE	Danish Royal Embassy
EB	UNFCCC Executive Board
EIA	Environmental Impact Assessment
IEE	Initial Environmental Evaluation
IRR	Internal Rate of Return
MONRE	Ministry of Natural Resources and Environment
NCUNFCCC	National Committee on the UNFCCC
NEB	National Environmental Board
NPV	Net Present Value
ONEP	Office of Natural Resources and Environmental Policy and Planning
PDD	Project Design Document
SHS	Solar Home System
SPP	Small Power Producer
RET	Renewable Energy Technology
UNFCCC	United Nations Framework Convention on Climate Change
UASB	Up-flow Anaerobic Sludge Blanket
VSREPP	Very Small Renewable Energy Power Producer

CHAPTER I

INTRODUCTION

1.1 Background of the Study

An environmentally friendly, reliable source of energy, and access to it, can be seen as a critical element in supporting sustainable development at the local community level. Additionally, for developing countries in particular, renewable energy projects have the potential to reduce greenhouse gas (GHG) emissions and provide finance through the clean development mechanism (CDM). Yet, these countries often lack the financial and technical resources to develop projects that could hypothetically exploit the economies of scale promised by large projects, for small-scale industries are main features of their economies. Having not the best practices for environmental protection, these industries often present themselves as problematic, and at times, such as during the economic downturn, managers and officers do not want to address the problems squarely for social reasons. Therefore, small-scale CDM projects can be an important mechanism to protect local environment, and furthermore, an important part of the CDM potential.

Thailand's energy needs are growing and the country imports much of the energy in order to supply it for economic activities. Yet, in the rural areas, where major part of the poor live, most used fuel-type is still fuel wood and charcoal. Also as small and medium sized enterprises (SMEs) are the backbone of the Thai economy still today, making use of the abundant renewable energy potential through a much wider use of renewable energy technologies (RETs) could be part of the solution toward a more sustainable energy future in Thailand. These projects can also lead to other significant local benefits, such as in the case of wastewater treatment and biogas production at Thai pig farms. In the renewable energy sector SMEs can produce and sell the energy they produce, or the SMEs can use RETs to satisfy their own energy needs. Additionally, it is worth emphasizing that the high renewable energy potential can often be more sustainably exploited through small-scale projects for both industrial and domestic uses. The small-scale CDM projects can play a part in ensuring that sustainable economic development and environmental protection policies can be pursued to further ensure that significant negative environmental impacts are not emerging and positive impacts are enhanced, both locally and globally.

1.2 Statement of the Problem

The CDM is a new form of a development model[1] that came out of the Kyoto Protocol [2] negotiations in 1997. Developed countries can support the development needs of developing countries via investments made through the CDM and in return receive certified emission reductions (CERs) to help meet their own targets. Therefore, the CDM encourages private sector to invest in development projects that result in CERs revenues. Projects under the CDM have two objectives. First, they seek to enhance the sustainable development of the host countries. Second, they aim to assist developed countries in reducing GHG emissions in a cost-efficient manner. However, because CDM projects are distributed through market mechanisms, which by their nature result in search of least-cost carbon credits, the realized CDM projects are not likely the kind that deliver many sustainable development benefits. Especially small-scale CDM projects are in disadvantaged position due to their high transaction costs per CER. And therefore, there is a threat that this opportunity for supporting local sustainable development is lost.

There is also other inconsistency in formulating a "normal" investment project, and a small-scale CDM project. Small-scale CDM project should start from the needs of the local communities in response to local needs, not from the amount of CERs the developed country wishes to buy. Small-scale CDM projects would generally yield

[1] Formally it is stated that under the CDM, Annex I countries may implement projects in non-Annex I countries that reduce emissions and use the resulting certified emission reductions (CERs) to help meet their own targets. However, in reality the CDM model has evolved toward a unilateral CDM model, in which the projects are actually implemented without Annex I country assistance, and the emission reduction purchase agreements (ERPAs) are signed in much later stage, even after registration with the Executive Board (EB). (UNFCCC, 2006)

[2] Kyoto Protocol went into force on 16 February, 2005. As of 30 August 2006, 164 countries have ratified Kyoto Protocol to date. Of these 35 and EC are required to reduce their GHG emissions below the levels specified in the treaty. The individual targets add up to a total reduction of at least 5% from 1990 level in the commitment period 2008-2012. The targets cover six main GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). (UNFCCC, 2006)

little of this anyhow. Hence, it is difficult to justify the merit of a small-scale CDM project purely on its CERs benefits.

Given the reality of developing countries as mentioned above, small-scale CDM projects should be also allowed to co-exist along large-scale CDM projects by recognizing that sustainable development goal was the other original main goal for designing the CDM, and that they should be seen as cost-effective ways to deliver sustainable development outputs, and improve environment at the community level in developing countries. This point seems to be well-recognized at the international level. To address these concerns, there already is a special guideline of simplified modalities and procedures to reduce transaction costs for small-scale CDM projects. In practice, however, still the majority of CDM investments and financial flows from CERs are flowing into large-scale projects, even though the simplified modalities and procedures for small-scale CDM projects exist. In Thailand, only two out of twelve CDM projects currently in the CDM pipeline are small-scale projects. The fixed costs are still significant for small-scale CDM projects compared to the amount of CERs they are able to produce. On the other hand, making use of all the simplified modalities and procedures have not been fully exploited yet.

It has been discussed especially in the Indian context that one way to reduce transaction costs can be done through bundling several small-scale CDM projects together and developing them as one larger CDM project. Under the current rules, if the size of the bundled CDM project stays under the limits defined for small-scale CDM projects, it can benefit from reduced transaction costs associated with fast tracking procedures and the spreading of costs across the several smaller projects. However, the current rules are still seen too restrictive by many and successful bundling can be a challenge itself. The key question remains, however, how such a transaction is reduced through bundling in reality. This research study presents an analysis of how the potential reduction of transaction costs can be done especially through bundling individual projects into a larger CDM project, which still remains eligible to be developed as a small-scale CDM project.

The purpose of this research study is to provide a framework for clarifying the relevant issues surrounding small-scale CDM projects and provide answers to the questions raised – mainly the issue of high transaction costs associated with promoting small-scale projects for CDM. First, this research study will focus on clarifying the general potential of small-scale CDM projects in Thailand. Second, it will focus on the issue of bundling small-scale CDM projects as ways to reduce the high transaction costs involved in small-scale CDM projects. Specifically, the focus will be on small-scale biogas projects at Thai pig farms and providing recommendations in that specific context. Third, the aim is at assessing what other policy options there are and how they can enhance further the transaction cost reduction for small-scale CDM projects. Moreover, the aim is at providing recommendations in that particular context. The key hypothesis is that small-scale CDM projects could bring about local benefits, while addressing global problems – a win-win investment. Presently, this rationale does not seem to be clearly defined, deliberated, explored and promoted in Thailand. Currently conditions that enable small-scale CDM projects to flourish do not exist.

1.3 Objectives and Research Questions of the Study

1.3.1 Objectives

1. To understand issues surrounding small-scale CDM projects and to assess the small-scale CDM potential in Thailand.
2. To explore local benefits of small-scale CDM projects in Thailand.
3. To estimate and quantify transaction costs for a small-scale CDM project in Thailand.
4. To assess the possibility to reduce transaction costs through bundling small-scale CDM projects in Thailand.
5. To explore other policy options, how the high transaction costs could be reduced further particularly for small-scale CDM projects in Thailand, but also in general.

These objectives translate into a set of research questions that guide the research process.

1.3.2 Research Questions

1. What is the small-scale CDM potential in Thailand?
2. How transaction costs can be reduced through bundling of small-scale biogas CDM projects in Thailand?
3. How other policy options could enhance the reduction of transaction costs particularly for small-scale CDM projects in Thailand?

1.3.3 Hypothesis to be Tested

Because the key concern relating to CDM projects is that they do not generally succeed well in bringing about local sustainable development benefits, this research focuses specifically on small-scale CDM projects which have the potential to succeed in that, if the high transaction costs do not prevent them from being developed. Therefore, besides the key hypothesis that small-scale CDM projects could bring about local benefits, while addressing global problems – a win-win investment, the issues described above lend themselves especially well to empirical investigation and testing of a specific hypothesis. Therefore, the specific hypothesis to be tested in this research is: **Reduction of transaction costs is central for the realization of small-scale CDM potential in Thailand.**

1.4 Analytical Framework

The small-scale CDM potential is assessed through the general technical and institutional CDM potentials, and furthermore, in more detail through case-studies. To explore the transaction cost reduction through bundling and other policy options, this research study focuses on small-scale wastewater and biogas projects at Thai pig farms. Transaction costs for small-scale CDM biogas projects are estimated and quantified. An externality analysis describes the negative externalities that originate in pig farming and the positive externalities that originate in biogas production at pig farms. The emissions reductions are estimated and calculated through using the UNFCCC small-scale methodology for methane recovery and replacing grid electricity in order to estimate the fixed transaction costs and global benefits. This way the transaction costs and environmental and social benefits are defined through a clear framework, which allows them to be included later in the cost-benefit analysis (CBA), which estimates the net benefits under different scenarios and options using internal rate of return (IRR) and net present value (NPV). At this stage, all the relevant costs and benefits are included for projects of 10,000 pigs and 5,000 pigs. Besides analyzing the data, this operationalizes the guiding Article 12 of Kyoto Protocol. Three scenarios are established: a project without CDM, a single CDM project and a bundled CDM project. The first scenario is a benchmark scenario to the latter ones. And the second scenario is a benchmark for the third scenario. Within the bundled project scenario different options for bundles are identified. After the ´bundling per se´ is analyzed, other transaction cost reduction enhancing policy options, major risks and ´cost of bundling´ are included into the analysis.

1.5 Methodology

This research report is a result of a combination of field research and desk-study. Two types of data was required and used in this research study: primary data on biogas system costs and revenues, number of pigs, electricity savings/revenues, fertilizer revenues, transaction cost data and data relating to small-scale CDM potential in Thailand, and secondary data on biogas system costs and revenues, number of pigs, price of electricity, transaction cost data, negative and positive environmental and social impacts and data relating to small-scale CDM potential.

Data was collected through literature reviews, telephone and internet communication, through participating to a relevant seminar and a workshop, through field interviews and discussions. The informants in this research study are local project proponents such as pig farmers and CDM proponents from international and national consultant and development agencies, local institutes and government agencies.

This research study starts from analyzing the general small-scale CDM potential in Thailand, from which it finds its way to a case-study approach. The first part of the research study is mainly qualitative and descriptive in nature and it relies on literature and databases, which are supplemented with insights from different local CDM proponents. Case-studies are examined in order to attain in-depth information and data, to explore the theoretical possibilities, and to test the theory in real cases. The specific case-study sites are located in Ratchaburi province. The case study A consists of three large-sized pig farms, which are project proponents in an existing small-scale CDM project. They were contacted and on-site interviews were scheduled with the pig farm/biogas plant managers. However, finally only two of the farms were visited in person. Other relevant stakeholders such as consultants were contacted and data collected mainly through e-mail. Also the other case-study is situated in Ratchaburi province. No field visits were done in this case, because the data used in analysis was received from the project documents. The case-study B is a demonstration project of manure management and biogas production at medium-large sized pig farms, which is one of the demonstration projects included in the Livestock Waste Management in East Asia –project, which is still in early stage. The case-studies are described in detail in chapter 4.

1.6 Scope and Limitations of the Study

This research study focuses on small-scale CDM potential and projects in Thailand, especially on wastewater and biogas projects at pig farms. It does not explore extensively other types of possible small-scale projects. The analysis of the case-studies stems from their characteristics; therefore, the approach is partly case-specific and does not lend itself to wide generalization of the research results.

Even though this research uses case-studies, making several simplifications has been necessary. The cost and revenue data used in this research study are quite simple, not all the existing costs and revenues have been included, because collecting those was out of scope of this research study. The aim has been however to confirm from as many sources as possible that the data used in this research are alike those that are used in other studies.

This introductory chapter explained the relevant issues of this research, of which one strongly standing out is transaction costs. However, the estimated transaction costs are mainly seen as means in the transaction cost reduction analysis, not a core issue. [3] Therefore, this study does not try to extensively and comprehensively study the absolute transaction costs related to small-scale CDM projects. The necessary quantity of data for empirical survey of transaction costs is not abundantly available in Thailand. Specifically, it has to be mentioned that this study does not estimate or quantify search costs, negotiation costs or transfer costs. These are real CDM transaction costs, however, likely to be very dependent on the type of CDM model. These would have been difficult to estimate without the Danish Royal Embassy (DRE) enclosing this information for the case-study project. Additionally, the focus of this research study is merely on transaction costs of unilateral CDM projects. The aim of this research study is to estimate and quantify the CDM cycle –related transaction costs for a specific type of small-scale CDM project, in a reliable manner. These are then further used in the cost-benefit analysis as mentioned.

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[3] For a detailed transaction cost research study see Krey (2004) and Ahonen (2005).

Also, while analyzing negative and positive externalities in this research study, the aim is not to attempt to quantify or put a monetary value on the actual externalities, because it is not possible within this research. Moreover, local benefits in this research study refer mainly to community level benefits, however also national or even regional level sustainable development benefits are seen in contrast to global benefits that follow e.g. from reducing GHG emissions.

Additionally, due to the fact that people are still currently questioning whether the Thai government will take the CDM seriously in the future, there is certain hesitation in discussions, and real strategic planning which would relate CDM to the bigger picture seems to be missing in Thailand currently.

1.7 Significance of the Research

Research on the CDM, particularly on the small-scale CDM and transaction cost reduction, is scarce in Thailand. Therefore, this study attempts to contribute to this scarce body of literature with an emphasis on local benefits, specifically, on an issue which is considered increasingly significant in Thailand, namely, the negative impacts of pig farming on local environment and the cumulative effects also at the regional scale. There seems to be a real need to find additional ways to replicate the existing and planned demonstration projects in Thailand. CDM finance can possibly provide part of the solution. This study aims at providing a framework and useful insights to the issue within its scope.

While the existing Ratchaburi Farms Biogas CDM Project can show that carbon finance can be most likely generated through small-scale CDM projects, it cannot be used as an example for replication, because of the decision[4] of the UNFCCC Executive Board (EB) in its 24th meeting in May 2006 to put a cap on the

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[4] III.D category is currently applicable for project activities resulting in annual emission reductions lower than 25,000 tCO_{2e}. If the emission reduction of a project activity exceeds the reference value of 25,000 tCO_{2e} in any year of the crediting period, the annual emission reduction for that particular year is capped at 25,000 tCO_{2e}. Before May 2006 there were no limits in the III.D category. (EB, 2006)

total CERs that can be generated from the methane recovery by this type of projects. Therefore, in order to use the simplified modalities and procedures fully, this research looks also into medium-large sized pig farms with wastewater treatment and biogas production. In Thailand, there are no small-scale CDM projects involving medium-large sized pig farms yet and besides the Racthaburi Farms Biogas CDM Project there are no other bundled projects to date.

1.8 Structure of the Report

This study is structured into 6 main chapters. The following chapter 2 outlines the conceptual and theoretical issues in this research. Chapter 3 describes and analyses the general CDM potential in Thailand, and emphasizes the most attractive cases of the small-scale CDM potential. Chapter 4 sets out with a background description to the case-studies, describes the specific case-studies and also discusses the negative and positive externalities. The transaction cost estimation and quantification based on the Ratchaburi Farms Biogas Project is presented and applied to smaller projects. The GHG emissions reductions are also calculated for projects of 10,000 and 5,000 pigs according to the specific small-scale CDM project methodologies. In Chapter 5 the previous findings are included to the CBA, which forms the core of this research study. The framework of analysis is presented in detail. In CBA, the effects of bundling per se and other policy options to reduce transaction costs further are investigated. Findings of the CBA are presented and discussed. Chapter 6 ends the report with main conclusions and recommendations for project developers, policy makers and further study.

CHAPTER II

LITERATURE REVIEW

This chapter introduces the relevant literature to the underlying theoretical and conceptual framework in this thesis research. The purpose of this chapter is to provide a framework for analyzing the issues surrounding the small-scale CDM projects in Thailand through two lenses: international and local.

2.1 The Clean Development Mechanism

Perceived mainly from the international perspective, the CDM is a project-based mechanism of the Kyoto Protocol by which developing countries (non-Annex I Parties) assist developed countries (Annex I Parties) in reducing greenhouse gas (GHG) emissions. Certified emissions reductions (CERs) can be created through investing in GHG mitigating activities and implementing projects in developing countries. Furthermore, the CDM can be seen as an institutional arrangement established by the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) that encourages governments, international organizations, local businesses and civil society actors to work together to reduce GHG emissions. More simply put, the idea is to engage the private sector in investing in development projects and reducing GHG emissions, which would produce additional revenues from selling the produced carbon credits. The Article 12 of the Kyoto Protocol governs the CDM. “The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I countries in achieving compliance with their quantified emissions limitation and reduction commitments under Article 3” (UNFCCC, 1997). This means that the advancement of sustainable development goal through the CDM projects in the host-countries is critical, besides allowing Annex I countries to reduce GHG emissions cost-effectively.

The CDM exploits the efficiency gap between industrialized countries and developing countries. In order to understand the potential of the CDM, one needs to consider that emission reductions through a CDM project are not assessed in absolute terms since developing countries have no reduction commitments, but in relative terms: every new project is compared to a forecast of future emissions, the baseline. (CdmWatch, 2006)

2.1.1 The Potential Flow of CDM Transactions

According to Niederberger and Saner (2005) the flow of CDM transactions to a country is based on three main factors: scope for CDM (potential for GHG emissions reductions), CDM capacity and business environment. Furthermore, Hanh, Michaelowa, and de Jong (2006) concentrate on potential supply size, business climate and CDM institutions and experience in a country when determining the overall competitiveness for CDM of a particular country. Jung (2005) clarifies the often stated simplistic assumption that CDM flows follow in general the same path as FDI flows. According to her this only considers the business climate factor, whereas determining CDM attractiveness of a country requires consideration of all above mentioned factors.

2.1.2 The CDM as an Element toward a Carbon-free Economy

Agarwal and Narain (1999) provide welcome contrast to the language in the official documents. They remind about the controversy that is embedded into the CDM: in principle, Kyoto Protocol assigned legally binding emissions reduction targets on the developed countries, and also for developing countries later, after an unspecified timeline. And yet, the CDM is a mechanism that allows emissions to be externalized by developed country partners instead of being internalized, exactly as the Article 12 states. Agarwal and Narain also emphasize the logic behind a market-based mechanism, i.e. improving competitiveness through lowest-cost emissions reductions. However, Agarwal and Narain are not against the CDM if its ´emissions trading´ provides a transition toward a carbon-free economy, but it means that non-carbon energy has to be factored into the mechanism. They actually explain in detail how the world could do this with solar power. The rule, therefore, is: "no trade can take place unless it involves a transition to the use of non-carbon or biomass energy instead of trading being the cheapest alternative". The above-described framework is a perfect sidetrack, because the rest of this literature review will continue to focus on how to make the best of the current CDM, which has not quite followed the action plan outlined by Agarwal and Narain. This also means that CDM is not likely to be a mechanism for technology transfer in its current form, because technology transfer requirements are not strongly "factored into the mechanism".

2.1.3 Sustainable Development in the CDM

Sustainable development is agreed to be country and project specific. This was well recognized in the negotiations, because the group of developing countries is diverse. The host-countries themselves define guidelines and criteria, which determine whether a planned project is eligible for host-country support, and furthermore, possibly for carbon finance if it complies with all other CDM-specific modalities and procedures. Whether a particular project finally will be implemented is determined by its attractiveness for carbon finance. Therefore, to realize the CDM potential there is a need to "carefully integrate two different sets of objectives: those of private sector guided by the bottom line, and those of developing countries guided by their development priorities and emphasis on poverty eradication" (Cosbey et al., 2005). Therefore, the concern about the CDM is quite uniform, however, different proponents emphasize different issues to be included into the sustainable development requirement.

Sutter (2003) endorses strong sustainable development criteria. And in his opinion developing countries do need help in developing such criteria, because in reality, the existing sustainable development criteria for CDM projects are often rather general and they do not really make a difference between projects contributing a lot to sustainable development and projects contributing the minimum requirement. This is often for the reason that besides CDM being a market-based mechanism, it is also emphasized as such, i.e. as a market mechanism representing new models of governance, in which the need for institutional flexibility and private sector involvement are recognized in reducing GHG emissions (Streck, 2004), and therefore strong sustainable development criteria are not necessarily emphasized in its application. This repetition basically describes the situation, where some countries have stricter sustainable development criteria than others, but end up having fewer projects, and others who don't have much of criteria, end up with projects with less sustainable development benefits.

Yet another approach is to emphasize the meaning of scale to the sustainable development benefits, because it is believed that small-scale CDM projects can deliver sustainable development outputs cost-effectively, and improve environment at the community level in developing countries – as local participation is required. (Bhardvaj et al., 2004; Peters & Brunt, 2004; Sutter, 2001) However, small-scale CDM projects are in disadvantaged position due to their unattractiveness for obtaining carbon finance, because they produce small amounts of CERs revenues annually and they still have to absorb the high transaction costs per CER. Reduction of the transaction costs for small-scale CDM projects would, therefore, automatically ensure that the host-country would benefit also from projects that potentially contribute significantly to host-country's sustainable development.

2.2 Methods for Sustainable Development

Munasinghe´s (2002) Sustainomics framework provides an overarching and trans-disciplinary design for analysis and policy making. Furthermore, it aims at supporting the concept of sustainable development in the real world, because hugely diverse real world problems affect all dimensions of sustainable development. Energy for example is one key resource whose use affects the economic, social and environmental dimensions of sustainable development. Therefore, methods that can be used to bridge the economy-society-environment interfaces are important. Methods that just seek to make development more sustainable might make more sense, than insisting on defining what sustainable development is precisely. Concentrating on recognizing and eliminating unsustainable activities may be more practical. Therefore, whichever way the argument for the sustainable development is stated, practical methods are the tools toward it.

Bruyninckx (2006) discusses in detail the institutionalization of sustainable development, the history and the debates around the concept. Also, he rightly points out that the policy translation of sustainable development often has a strong environmental bias. The ecologicalization of sustainable development in this research study is also one point of departure, as ecosystems are seen as an essential precondition to human functioning in its social and economic dimensions.

2.2.1 Externalities

Environmental problems result from inefficient market conditions or from market failure, in other words. This means that the market does not take into account the damage outside the market transaction. A useful way to model these external effects is through the use of externality theory. (Callahan & Thomas, 2000) Pigou´s original theory of externalities is well known. The theory examines cases where the welfare of a party depends not only on his/her activities, but also activities of another party. In Pigou´s thinking environmental problems are conceptualized as externalities or physical effects between agents, for which no price is paid and no compensation is received. (Paavola & Adger, 2005)

Environmental economics has followed Pigou´s suggestion that the solution is to impose a tax, among others, on the generators of negative externalities, or subsidies on generators of positive externalities. However, when Coase argued against Pigou, people were convinced to believe his view of externalities. First, he argued that externalities do not simply exist, because one party imposes a cost to another party. According to Coase, it depends on decisions of both parties. The pig farms[5] decide to pollute and the villagers decide to live where the pig farm is polluting, is the fact that produces the cost. Additionally, Coase argued that the existence of externalities does not necessarily lead to an inefficient result; Pigouvian taxes do not in general lead to the efficient result; and most significantly, instead of externalities the problem arises from transaction costs. However, Coase does recognize that the Pigouvian analysis of the externality problem is correct under special circumstances, such as in situations in which transaction costs are high, so that transactions between the parties do not easily happen. And more importantly, in regard to the externality imposed by e.g. a pig farm, in which the agent deciding which party is to be held liable already knows who can prevent the problem with lower cost. Therefore, above mentioned taxes or subsidies to the pig farms can be analyzed from this perspective. Furthermore, it can be concluded that the conventional theory of externalities provides an important theoretical starting point to this research. (Friedman, 2001)

Therefore, suppose a pig farm and a village are located nearby each other and a river or a canal, as they traditionally are. The first produces pork and as a by-product pig manure. Most of the excess pig manure ends up to the river from the farm. This poses a cost at the people in the village in the form of health effects and bad odor. Additionally, the manure deteriorates the ecological state of the river, which has wide ranging impacts. Therefore, an externality exists. Pig farming inevitably involves producing pollution as well as pork. However, the market price for pork does not capture all the production costs, namely the cost of pollution, therefore, pollution

[5] Pig farms are used as an example, because of further emphasis in case-studies.

persists. Therefore, pork production is a classic case of production externalities. (Callan & Thomas, 2000)

2.2.2 Abatement Equipment Subsidy

The next section covers Pigouvian subsidies, because instead of using taxes it is sometimes preferred to pay to the polluters not to pollute through an environmental subsidy. Especially abatement equipment subsidies are important in the context of this research study and therefore introduced here. The aim of abatement equipment subsidies is to reduce the costs of abatement technology. And because subsidies are “negative taxes” they work as incentives the similar way as taxes working to penalize “wrong-doers”, however they reward for not polluting. Taxes penalize for engaging in polluting activities.

From theoretical perspective however, it can be argued that abatement equipment subsidies attempt to internalize the positive externality that originates in the abatement activities. If a subsidy were offered for the implementation of specific abatement equipment, e.g. biogas production plant at a pig farm, the effect would be to encourage a higher quantity to be demanded of this kind of equipment by artificially lowering its price. (Callan & Thomas, 2000)

2.2.3 Cost-Benefit Analysis

Cost-benefit analysis (CBA) is not a philosopher's stone; however, it can be a useful tool for analysis. CBA is an investment appraisal technique for public sector projects and other aspects of public policy, also such as the implementation of policies for the control of specific type of pollution. (Bowers, 1997) Munasinghe and Swart (2005) also discuss the CBA widely while they introduce analytical tools for climate change adaptation and mitigation. Therefore, CBA can also be used to analyze CDM projects, because it emphasizes different issues than private investment appraisal does alone. Under CBA the total social benefits expected from a project are compared with the social costs and a decision is taken on the project by using a rule: invest if the present value (PV) of benefits exceeds the costs. Therefore, if the decision rule is satisfied, the project will result in potential Pareto improvement, i.e. the gainers have the chance to compensate the losers and still be better off.

A private investor will ignore the externalities if they are not internalized to the decision-making for some reason, such as taxes or subsidies. But from the society's point of view these externalities are internal and have to be taken account in CBA: the environmental costs of a project are compared with the non-environmental benefits. (Bowers, 1997) In the context of CBA of CDM projects, environmental and social effects are also included among the costs and benefits to be differentiated from private costs and benefits. Additionally, for CDM projects in particular, the local benefit side is supposed to stand out in the decision-making. The CDM projects ´cannot´ result in negative local effects.

Even though, the CBA attempts to put values on all the externalities, often no meaningful monetary valuations can be produced for environmental or social effects. As an alternative to valuation, one possible solution is the application of the so-called extended Leitch guidelines by using environmental impact assessment (EIA) as database. A non-monetary assessment could serve as useful filter in the analysis. (Bowers, 1997)

A comparison to a private investment appraisal is useful, because private investors are involved in CDM projects. A private investors starts out with the investment appraisal with a slightly different rule, which can be stated: discount the anticipated profits at the opportunity cost of the capital (the interest rate, r) and invest if the PV of the discounted profit stream exceeds the capital cost. On the other hand, when the profit stream is estimated, the discount rate, which makes the PV of that profit stream equal to the capital cost, can be found. Then the investment rule is based on the internal rate of return (IRR), i.e., the rule follows: invest, if the IRR is greater than the interest rate. The result is obviously the same by following either rule. (Bowers, 1997) The private investment appraisal corresponds to a situation of perfect competition, whose conditions are far from the real world conditions (Munasinghe & Swart, 2005). CBA is an equivalent to private sector investment appraisal; however, it differs from it mainly as explained above. Additionally, the used discount rates are not based on the costs of borrowing or lending, they are rather based on arguments on what is the opportunity cost of the investment to the society. (Bowers, 1997)

2.2.4 Application of CBA to CDM Projects

When CBA investment appraisal is done for CDM projects, the different steps in the analysis have to be given consideration, because the issue of additionality is important in CDM. A CDM project activity is additional if anthropogenic emissions of GHGs by sources are reduced below those that would have occurred in the absence of the registered CDM project activity. However, the additionality has to be proved through additionality testing. Therefore, in theory the NPV and IRR should be negative for a project without CDM revenues. And it is argued that financial additionality can provide a strong argument in favor of the CDM project (Shrestha, 2006), however “a positive NPV or high IRR do not automatically mean non-additionality”. The project proponents can also choose the barrier test; however, the designated operational entity (DOE) has the right to ask for a NPV or IRR assessment if the barrier tests are not perceived sufficient. The important question is how “high” these barriers are. This is subjective issue and has to be discussed transparently when proposing a project. (Kamel, 2005)

For small-scale CDM projects this has been made simpler. The additionality can be explained by describing at least one of the following barriers: investment barrier, technology barrier, prevailing practice barrier, or other barriers. Therefore, there is no requirement for investment analysis. Investment barrier means that there is a financially more viable alternative available, which would have lead to higher emissions. Technology barrier means that there is a less technologically advanced option available, with fewer risks, which would lead to higher emissions. Barrier due to prevailing practice means that prevailing practice or existing regulatory or policy requirements would have resulted into an implementation of another project, which would have led to higher emissions. Other barriers refer to such as institutional barriers or limited information, managerial resources, organizational capacity, financial resources, or capacity to absorb new technologies, and therefore, emissions would have been higher without the project activity identified by the project proponents. (URC, 2006; IGES, 2005)

This basically confirms that the NPV or IRR do not have to be negative without the CDM revenues. Then, in reality, the analysis is project specific. If the barriers can be proved, the purpose of the CBA is to show the overall net benefits to the society and give an idea when the projects are likely to be attractive to private investors, who are constrained by their limited resources. Furthermore, CBA can also provide useful information for involved governments who are concerned of the environmental and social costs and benefits of the projects. In the case the projects are highly beneficial, but do not quite attract private sector, how could they be turned into more viable from the private sector’s point of view? As discussed earlier, the small-scale CDM projects are likely suffer from high transaction costs, which prevent them from being developed by the private sector, therefore, these considerations are highly relevant.

2.3 Small-scale CDM Projects

Additionally, small-scale CDM projects have rules, which constrain and guide them. Project participants may use the simplified modalities and procedures for small-scale projects or small-scale CDM project activities meeting the criteria specified in decision 17/CP.7 (UNFCCC, 2001) and relevant decisions by the Conference of the Parties or the Meeting of the Parties (COP/MOP). These are presented below. As mentioned, the objective of this fast track mechanism is to enable small-scale projects to be pursued without the need for going through the more detailed and expensive approval and assessment processes as required for larger scale projects.

Three eligible types (table 1) and a number of eligible categories (table 2) for small-scale CDM projects have been defined by the EB. The eligible types are renewable energy projects, energy efficiency improvement projects and other project activities. Small-scale CDM project activities include project activities that remain under the decided limits every year during their crediting period. Projects falling within these limits are eligible for the modalities and procedures of small-scale CDM projects.

Table 1 Eligible Types of Small-scale CDM Activities

The specific limits for different types of activities are:
A. Type (i) project activities: renewable energy project activities with a maximum output capacity equivalent to up to 15 MW (or an appropriate equivalent).
B. Type (ii) project activities: energy efficiency improvement project activities which reduce energy consumption, on the supply and/or demand side, by up to the equivalent of 15 GWh/year.
C. Type (iii) project activities: other project activities that both reduce anthropogenic emissions by sources and directly emit less than 15 kilotonnes of carbon dioxide equivalent annually.

Source: UNFCCC, 2002

Table 2 Eligible Categories of Small-scale Activities

Project Types	Project Categories
Type (i): Renewable energy projects	A. Electricity generation by the user/ household
	B. Mechanical energy for the user/ enterprise

	C. Thermal energy for the user
	D. Electricity generation for a system
Type (ii): Energy efficiency improvement projects	E. Supply-side energy efficiency improvements – transmission and distribution activities
	F. Supply-side energy efficiency improvements –generation
	G. Demand-side energy efficiency programmes for specific technologies
	H. Energy efficiency and fuel switching measures for industrial facilities
	I. Energy efficiency and fuel switching measures for buildings
Type (iii): Other project activities	J. Agriculture
	K. Switching fossil fuels
	L. Emission reductions in the transport sector
	M. Methane recovery
Types (i)-(iii)	N. Other small-scale project

Source: UNFCCC, 2002

2.3.1 Simplified Modalities and Procedures for Small-scale CDM Projects

In order to reduce transaction costs associated with preparing and implementing a CDM project activity, the simplified modalities and procedures provide small-scale CDM projects for the following simplifications:

1. A simplified project design document.
2. Simplified methodologies for baseline determination and monitoring plans.
3. Bundling of project activities at various stages in the small-scale CDM project activity cycle, however occurrence of debundling of larger project activities has too be checked in the case of bundling.
4. A simplified environmental impact analysis (EIA).
5. Revised registration fee calculation.
6. Shorter review period for the registration of small-scale CDM project activities.
7. The same DOE can validate as well as verify and certify emissions reductions for a specific small-scale CDM project activity. (UNFCCC, 2006)

2.3.2 Principles for Bundling of Small-scale CDM Projects

In principle any small-scale CDM project can be bundled with another project if certain limits are not exceeded. However, bundling makes sense only when it reduces transaction costs. Several small-scale CDM projects can be bundled into a portfolio during different stages of the project cycle. Project activities can be divided into one or more sub-bundles the way that their distinctive characteristics will remain specified, such as technology/measure, location, and application of simplified baseline methodology. Project activities within one sub-bundle need to be of the same type. Furthermore, the sum of the output capacity of project activities within a sub-bundle cannot exceed the allowed maximum output capacity limit for the particular type.

Other rules concerning bundling state that if project activities are bundled there has to be an indication of this at the time of the registration; the project activities that are bundled for a project cycle stage cannot be debundled for this stage; the composition of bundles cannot be changed over time; the crediting periods for all project activities need to be the same length and starting date the same; and a specific form for bundling needs to be included for submission that cover issues such as title of the bundle, general description, project participants, locations, types and categories, estimated amount of emission reduction, crediting period and monitoring plans. It needs to be also demonstrated that the bundle will not exceed the allowed maximum output capacity limit for the type every year during the crediting period. The estimated emission reduction for the crediting period needs to be also submitted and further monitored. This will be the allowable maximum in case the bundle will go beyond the limits for the selected type.

The principles applying to bundling of small-scale project activities of the same type, same category and same technology/measure differ from the principles applying to bundling of small-scale projects activities of the same type, same category, but different technology/measure and of the same type, but different category and different technology/measure and for different types in the context of a monitoring plan. In the last three there are requirements for different monitoring plans for the bundle and separate monitoring reports, whereas for the first, one overall monitoring plan and one monitoring report are sufficient. (UNFCCC, 2002)

2.4 Transaction Costs

2.4.1 Rationale of CDM Project Cycle

To generate CERs, a CDM project needs to go through the so-called 'CDM project cycle', which is guided by decisions of Marrakech Accords and thereafter the EB. The CDM is governed by four key entities, the COP/MOP, the EB, the DOEs and the Designated National Authorities (DNAs). Separated by their tasks and responsibilities, each of these institutions is essential for the smooth functioning of the CDM. Under the authority and guidance of the COP/MOP, the EB supervises the CDM. (UNFCCC, 2006)

The detailed CDM project cycle also stems from the fact that only developed countries have binding emission reduction targets, and they can use CERs to help meet these targets. However, these reductions have to be real and measurable and would not have occurred in the absence of the CDM project. Therefore, the CDM project cycle with detailed steps was designed for ensuring that the projects would not be business as usual (BAU) and that only real reductions that occur are credited. On the other hand all this insurance is costly and burdens the project financing. This is true especially for small-scale CDM projects as was mentioned above and it was decided in that simplified modalities and procedures are needed in order to reduce the transaction cost burden on small-scale CDM projects. The rational comes from the thinking that small-scale projects are more likely to be additional in nature, and because the project emissions and reductions are smaller, also the errors in crediting unreal reductions would not be significant. Therefore, the requirements in the small-scale CDM project cycle are simplified in many steps. (UNFCCC, 2002)

2.4.2 Transaction Costs Categories

The detailed modalities and procedures of the CDM result in transaction costs additional to those of investments in general. The impact of transaction costs in general is that they increase the costs that incur to the participants of the transaction, and therefore, they reduce the total trading volume, and if they are high enough, they prevent some transactions from happening.

Krey (2004) quantified empirically transaction costs of 15 potential unilateral CDM projects in India. He makes an important distinction between market transaction costs and CDM project cycle transaction costs (table 3). On the other hand, Ahonen and Hämekoski (2005) estimate empirically transaction costs for 6 small-scale CDM projects absorbed by a CDM Pilot Programme. Therefore, they emphasize the transaction costs, which incur to the carbon credit buyer.

This study will follow the division of transaction costs of the unilateral CDM and modify it to fit the context of this research study and specifically the context of small-scale CDM projects and bundled projects. However, because the case-study A is not a unilateral CDM project, a combination of these approaches is applied. Furthermore, this study focuses on estimating and quantifying the CDM project cycle transaction costs, because those can be assigned to any one of the project proponents. In other words, the market transaction costs, namely, search costs, negotiation costs and transfer costs, are not quantified in this research study. The transaction costs related to the bundling itself are also discussed and quantified to some extent.

Generally transaction costs of the CDM project cycle consist of the cost components such as project design document (PDD) costs, approval costs, validation costs, registration costs, monitoring costs, verification and certification costs and costs accruing from the adaptation fee and administration (as presented in table 3).

Table 3 CDM Transaction Cost Categories

Market Transaction Costs	CDM Project Cycle Transaction Costs	
	Pre-Implementation Transaction	Implementation Transaction

	Costs	Costs
Search Costs: - Costs for finding a Potential Project Investor/Buyer - Search Activity Costs	PDD Costs: - Baseline Costs - Monitoring Plan Costs - EIA or IEE Costs - Stakeholder Consultation - Other PDD Costs, such as documentation costs.	Monitoring Costs: - Monitoring System Costs - Training
Negotiation Costs	Approval Costs: - Letter of Approval(s)	Verification & Certification Costs
	Validation Costs	Adaptation Fee Costs
	Registration Costs	Administration Costs

Source: Krey, 2004

2.4.3 Small-scale CDM Project Cycle Costs

Small-scale CDM projects can have lower costs in several stages of the project cycle. Because the EB has defined standardized baseline methodologies to project categories, the project developers do not need to submit methodologies, if the standardized methodologies are sufficient. The EB has also given recommendations on what kind of data is needed to calculate the baseline. Therefore, the baseline costs are likely to be lower for small-scale CDM projects, if project developers can avoid hiring external consultants to determine baseline methodologies, and instead apply the standardized baselines in the context of the project. However, this cannot be assumed for all projects, because some consultant help may be necessary. The EB has also defined standardized monitoring methodologies and recommendations on which kind of data should be monitored and included in the monitoring plan. Therefore, monitoring plan costs are also likely to be lower for small-scale projects.

The small-scale rules require documentation on EIA of the project activity only if it is required by the host-country. In Thailand, EIA is not required for projects under capacity of 10 MW (IGES, 2006). However, an initial environmental evaluation (IEE) is required by the Thai DNA for the others. Therefore, the environmental impact documentation costs can be assumed lower for many small-scale projects and depend on the complexity and surrounding area of the project. Stakeholder consultation costs are also likely to depend on the project type and size, as it is assumed that the more local impacts the project has the more stakeholders are interested in engaging in the stakeholder comments process. Therefore, the costs of stakeholder consultation are likely to be lower due to the smaller size of the project compared to larger projects.

Because the same DOE which validates a project is also allowed to verify and certify the emission reductions for a specific small-scale CDM project activity, the verification and certification costs can be assumed to be significantly lower, because the DOE already is familiar with the project, and therefore, verification and certification require less time and resources.

Furthermore, the registration costs and adaptation fee costs will be lower for small-scale CDM projects due to the fact that the small-scale CDM projects are likely to generate less emissions reductions than large-scale CDM projects. In addition, it is assumed that validation and monitoring costs depend on how complex the project is. Therefore, the simplified modalities and procedures for small-scale CDM projects do not really affect these costs.

2.5 Bundling Literature Review

Due to the fact that utilizing the UNFCCC simplified modalities and procedures, and especially the rules for bundling are a major issue in this research, a literature review on earlier, significant studies which address these issues is conducted. First, results from greater number of small-scale CDM case-studies are important in the context of this research, because the primary data availability is limited in Thailand. Second, these studies give theoretical guidance to this research study to some extent; however, the conceptual framework of this research study mainly follows its own path that is relevant to the Thai context and to the planned research.

Especially in India there has been much interest to build local capacities to bundle small-scale CDM projects. A few publications have resulted from those experiences. Mariyappan et al. (2005) provide probably the most extensive piece of document on bundling small-scale CDM projects to date. They guide a project developer through the whole process of making use of the simplified modalities and procedures for small-scale CDM projects. Their study originates in India, like so many other studies relating to CDM projects as the empirical data is abundantly available there, as India hosts the highest amount of CDM projects in the world to date.

Besides presenting a business plan for a bundling organization, a study by Mariyappan et al. (2005) provides insights to bundling three types of small-scale CDM activities, namely, biomass gasification power plants (project activities in one state), solar home systems (SHSs) and solar lanterns (project activities in one region), and energy efficiency in water heating using LPG based water heaters (project activities distributed nation-wide). Only similar technologies were bundled in these examples. They concluded that the highest transaction costs were with a bundle of energy efficiency activities due to the need to develop different baselines for different geographical areas, and contractual difficulties because the project involved several technology distributors and high number of end-users. The high number of stakeholders also increases the risk of the project not running as smoothly as planned.

The bundled energy efficiency and solar projects also suffer from very high monitoring and verification costs, because they are non-metered and the geographical range is wide. Additionally, the emissions reductions are made by the end-users, therefore, giving additional incentives in form of lower technology or maintenance costs may be required. Of these three examples, the bundled biomass gasification (5 x 1 MW power plants) and energy efficiency projects are viable, while the solar project would require a much higher CER price than the others to be viable, approximately $US 20 per CER. The bundle can however utilize a standardized baseline.

The study by Bhardvaj et al. (2004) conclude that small project that generates only up to 10,000 tCO_{2e} reductions per year does not benefit enough from the simplified modalities and procedures for small-scale CDM projects. The transaction costs of this type of project are 21% of total CER revenues, which is well above the normally acceptable 10% threshold. Through bundling small-scale projects that are metered, the share of the transaction costs in total CER revenues decreases to 9.9%, which means that the bundled project can attract investors to bring it under CDM. Furthermore, they found that bundling without a meter results in too high transaction costs (up to two-thirds of CERs value), because of high annual verification costs. These kinds of bundles need to be verified more seldom, i.e. every two years or once in five years or only in the end of the crediting period.

Mariyappan (2003) provides a quite extensive background description on small-scale CDM and on the work and discussions that went on in India relating to e.g. choosing a bundling organization through which bundling of small-scale CDM projects could be done efficiently and with expertise. Therefore, in India the focus has been on identifying institutional and managerial approaches. Mariyappan stresses on building the bundling capacity of specific organizations, because according to him the success depends on the capacity and ability of such an organization. He defines that the role of bundling organization is to be an intermediate between project developers and CERs buyers. According to him, the results from studies on bundling in Africa, the bundling resulted in moderate, maximum three percent increases in IRRs, and did not have much impact on SHSs and micro-hydro projects. Also worth noting is that diversification of the bundle may increase the transaction costs.

The results from the Indian and African case-studies are very valuable also from the Thai perspective, because they give guidance on where the technical potential for bundling of small-scale CDM projects may exist, and what the specific issues which need to be considered in successful bundling are. Therefore, the results from the case-studies presented above are used as guidelines in this research, where appropriate. However, the emphasis on similar bundling organization may be too early and it has to be remembered that the scale of CDM project development is totally at a different level in India, as mentioned. Also considering the size of projects that are aimed to be bundled is decisive, because if the bundle consists of tens or hundreds or even thousands of projects, it is natural that the emphasis on an organization to carry out this has to be greater. Therefore, another approach might be taken for establishing institutional capacity for bundling in Thailand especially in the early stage.

Solis (2005) presents another study on bundling from the Peruvian point of view. She bundles micro-hydro and SHSs in order to determine whether CDM can be a mechanism for rural electrification in Peru. Her study originates from the local needs in Peru, where in the rural areas electrification is still low. She looks at the issue from the user's point of view and compares the costs of CDM projects to the costs of using typical sources of energy: kerosene, candles, battery charging and mini-grid diesel. She comes to the conclusion that micro-hydro can be viable option from the user's point of view. The paper relating to her PhD study further carries out a sensitivity analysis in order to identify how many projects are needed to overcome the transaction costs. It considers cases without CDM, with low and high CERs prices. She concludes that more than 80 micro-hydro installations are needed into the bundle, or then they should be bundled with projects which result to higher amount of CERs, or the price of CER should be even higher than used in the sensitivity analysis ($US 3 and $US 10). Yet, she importantly asks whether bundling more than 80 micro-hydro projects is possible within the same crediting period. She concludes that it is unlikely that micro-hydro bundle with lower than 12 MW capacity attracts private investors.

A Peruvian comparison to Thailand as a case study is not very relevant, because as Shrestha, Kumar, Martin and Limjeerajarus (2006) emphasize, Thailand is a particularly interesting developing country from the perspective of renewable energy technologies (RETs). This is especially because the biomass and solar resources are abundant in the country; for more than 25 years RETs, especially solar photovoltaic based technologies, have been promoted by the Thai government, and the level of electrification is high in Thailand. Only 1.5 % of the villages are not electrified, though at a household level 83.5 % of the households have access to electrification. However, Solis confirms the case of SHSs and micro-hydro for CDM through an extensive analysis.

CHAPTER III

SMALL-SCALE CDM POTENTIAL IN THAILAND

This chapter describes the small-scale CDM potential in Thailand, which originates in the same technical and institutional potentials as the large-scale CDM potential; therefore, it is not attempted to artificially differentiate the small-scale potential until the analysis shifts to the specific renewable energy potential. The general CDM potential is explored first through the "top-down" potential for energy and emissions reductions, and also through the institutional potential, which clearly enhances the realization of the technical potential from the "bottom-up".

3.1 Technical potential

3.1.1 Comparative Technical Potentials in ASEAN Countries

Technical potentials are explored besides Thailand also for Cambodia, Indonesia, Lao PDR, Malaysia, Philippines and Vietnam in order to better analyze Thailand's position in the CDM pipeline and development within the Southeast Asian countries. These are supplemented with some additional specific trends and indicators for Thailand.

Primary energy consumption (table 4) in these ASEAN countries and indicators related to energy consumption describe quite well the level of their economic and industrial development. Thailand ranks high in both absolute and per capita energy consumption compared to all the other countries. Therefore, the potential to reduce emissions can be considered high. Energy intensity can potentially indicate how much the energy efficiency can be improved in a country. There is likely to be room for improvement in all the countries, except in Cambodia currently. In Cambodia, the energy consumption and CO_2 emissions from the energy sector (table 5) are minimal compared to other countries. In Lao PDR, the energy consumption and CO_2 emissions from energy sector are a little bit higher than in Cambodia, therefore, the relatively high value for energy intensity is likely to indicate quite inefficient use of energy in Lao PDR.

Table 4 Primary Energy Consumption in 2004 in ASEAN Countries

Country	**Primary Energy (Million Btu)**	**Per Capita (Btu)**	**Energy Intensity (Btu per 2000 $US)**
Thailand	**218,59**	**53,7**	**6 767**
Cambodia	**0,58**	**0,6**	**349**
Indonesia	**307,68**	**19,7**	**5 377**
Laos	**1,07**	**8,3**	**4 606**
Malaysia	**153,64**	**107,1**	**9 635**
Philippines	**74,68**	**15,2**	**5 081**
Vietnam	**57,48**	**11,5**	**4 080**

Note: Btu = British thermal unit. (3,412 Btu = 1 kWh electricity)

Source: EIA, 2006

Table 5 CO_2 Emissions from the Energy Sector

Country	**CO_2 Emissions (Million tons)**	**Per Capita CO_2 (tons)**	**CO_2 Intensity (tons per 2000 $US)**
Thailand	**218,59**	**3,43**	**0,43**
Cambodia	**0,58**	**0,04**	**0,02**
Indonesia	**307,68**	**1,29**	**0,35**
Laos	**1,07**	**0,18**	**0,10**
Malaysia	**153,64**	**6,53**	**0,59**
Philippines	**74,68**	**0,87**	**0,29**
Vietnam	**57,48**	**0,70**	**0,25**

Note: CO_2 emissions from the consumption and flaring of fossil fuels

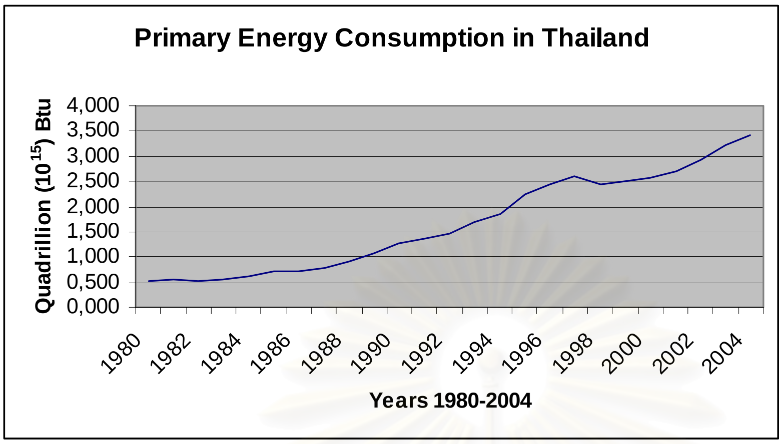
Source: EIA, 2006

Carbon dioxide (CO_2) emissions from the energy sector (table 5) describe quite well the potential to reduce emissions from the energy sector by switching to low carbon fuels or renewable energies. Thailand's absolute emissions are quite high, though the per capita emissions are very high compared to the other ASEAN countries, except Malaysia.

The comparison indicates that Thailand is among those countries in the ASEAN, which have high technical potential to generate emission reductions and also still increase energy efficiency. Therefore, the technical potential for CDM projects can be considered high in Thailand according to the above indicators. And furthermore, Thailand has high economic incentives to increase the share of renewable energies and increase savings through improved energy efficiency. In Thailand, fossil fuels account for about 80 percent of the total energy supply, and imported petroleum and petroleum products account for about 40 percent of total supply, which equals about 10 percent of GDP (JGSEE, 2005). Therefore, increasing the use of domestic renewable energies in Thailand seems crucial from the perspective of economic development as the energy consumption keeps rising, which means also that quite high incentive for CDM project development exists naturally in Thailand.

Primary energy consumption in Thailand has steadily risen over the last decades (figure 1) with the economic development. Only after the 1997 economic crisis for a few years the energy consumption did not keep rising in Thailand due to the drastic slowdown in economic development.

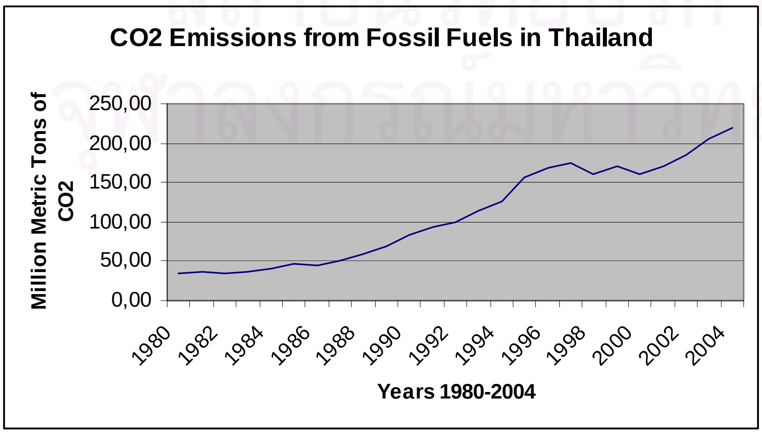
Figure 1 Primary Energy Consumption in Thailand



Source: EIA, 2006

Also CO_2 emissions from fossil fuels have steadily risen in Thailand over the last decades (figure 2). The curves in the figures look very much alike. The same decrease as above can be naturally seen in CO_2 emissions after the 1997 economic crises, because the consumed energy is produced mainly from fossil fuels as mentioned. Therefore, if energy consumption is reduced, the CO_2 emissions are reduced. However, if the carbon-free future is the ultimate goal for all countries, the CO_2 emissions from fossil fuels cannot keep following the same trend curve as energy consumption. Renewable energies have to increasingly replace the use of fossil fuels.

Figure 2 CO_2 Emissions from Fossil Fuels in Thailand



Source: EIA, 2006

Additionally, for example methane emissions from livestock in Thailand have also steadily increased and are also expected to continue rising in the next decades. Total methane emissions are estimated to grow from 473 Gg from the year 1990 to 1.13 Tg in the year 2020, which represents an average increase of about 4.6 % per annum. In 2020, pigs farms are expected to generate 70 percent of methane released from livestock manure in Thailand. (ADB, 1998)

3.1.2 Renewable Energy Potential and RETs in Thailand

In Thailand there is potential for over 5000 MW of solar electricity, 1000 MW micro-hydro power, 7000 MW of biomass power, and 1600 MW wind power. (DEDE, 2006) These potentials can be realized through renewable energy technologies (RETs). Shrestha, Kumar, Martin and Limjeerajarus (2006) discuss extensively on the status of RETs in use in Thailand and the existing barriers. Furthermore, in the context of this research study, it is also important to consider the different categories within different types of renewable energies and also the potential installation sizes of the different renewable energy projects. The small-scale RETs to be discussed in detail are solar photovoltaic (solar PV), micro-hydro, biomass and biogas technologies.

3.1.2.1 Solar Photovoltaic

Solar energy is abundant in Thailand, therefore, solar PV technology has received increasing attention in recent decades especially due to its high potential for small-scale, rural electricity generation and steadily decreasing costs. Thai government has installed over 200 000 new SHSs with output capacity of 120 W_p each to off-grid areas since 2003. However, there are also some commercial installations in use.

There are no manufacturers for solar PV modules in Thailand; although the imported solar cells are assembled in the country. The price is around \$US 7/W_p. In the near future a Thai company is planning to start manufacturing solar cells and the price is expected to become 20-30 percent lower. PV based technology is currently used for electricity in stand-alone systems, grid-connected systems, and in hybrid systems. Water pumping systems, battery charging stations, solar home systems, roof top solar modules and solar thermal technologies are all fairly widely used especially in rural areas in Thailand. Most of the systems have been installed with government subsidies (DEDE, 2006; Shrestha, Kumar, Martin & Limjeerajarus, 2006). Therefore, even though solar energy is abundant in Thailand, technical barriers, relatively high price for the electricity produced (Greacen, 2005) and low output capacity per installation prevent solar electricity from becoming a feasible option for CDM.

The transaction costs seem to be very high per CER, therefore, it is not a feasible option for private project investors. Only bundling large amounts of solar installations could produce enough GHG emissions reductions, however, installing those simultaneously in order to have the required same crediting period could be difficult. (ref. Mariyappan et al., 2005) Additionally as the large government SHS project to provide electricity to rural areas is already installed in Thailand (Shrestha, Kumar, Martin & Limjeerajarus, 2006; Greacen, 2005), similar size projects are not likely to be implemented in near future. Those over 200 000 SHSs equal in output capacity to 2 small-scale CDM projects. Therefore, solar electricity is part of the small-scale CDM potential in Thailand, however, the likelihood of realization of such projects is currently still low. In the future, as the PV industry matures further, the cost of solar energy will likely to become more competitive. The possible increase in the price of CER and possibility of sectoral CDM (URC, 2006) are also developments, which may enhance the realization of the abundant solar energy potential in Thailand as solar energy is considered to have an important role in providing decentralized energy in the future.

3.1.2.2 Micro-hydro

The potential for micro-hydro is quite high in Thailand; however it is not seen as an attractive source of electricity. Many micro-hydro plants have been abandoned when electricity from the grid has become available. (Greacen, 2004) Additionally, micro-hydro does not either seem to be a feasible option for CDM currently (ref. Solis 2005). Making bundling feasible would require a high number of micro-hydro plants to be bundled and implemented for the same crediting period. Currently, in Northern Thailand some micro-hydro plants are constructed jointly by the villagers and NGOs. They supplement the government's rural electrification program. Micro-hydro is still considered as a positive alternative for electricity production in off-grid areas, because it is cheaper and more reliable than solar electricity, especially when the villagers participate in the construction and maintenance. (Greacen, 2004)

3.1.2.3 Biomass and Biogas

The recoverable biomass and biogas can be classified to five types, which are agricultural residue, animal dung, municipal solid waste, waste water and feasible wood production from plantation. These are classified as either biomass or exploitable biogas (table 6) with values for recoverable energy potentials.

Table 6 Recoverable Biomass and Biogas Types

Types	Biomass (kton)	Exploitable Biogas (Mm^3/year)	Recoverable Energy Potential (REP) (TJ/year)
Agricultural residue	**42,494**	**-**	**604,821**
Animal dung	**-**	**560**	**11,751**
Municipal solid waste	**7,324**	**1,184**	**112,047**
Waste water	**-**	**435**	**10, 448**
Feasible wood production from plantation	**22,500**	**-**	**337,500**
Total	**72,318**	**2,179**	**1,076,567**

Source: Shrestha, Kumar, Martin & Limjeerajarus, 2006

The amount of energy that can be generated from the agricultural residues is high in Thailand. The four major agro industries which have commonly utilized biomass as fuel for cogeneration in Thailand are sugar, rice, palm oil and wood industries. Direct combustion has been the most important process in converting biomass to other useful form of energy. (Srisovanna, 2004) The cogeneration plant output capacities are suitable for large-scale or small-scale CDM projects[6] (Lacrosse, 2004). Generating electricity from agricultural residues is an attractive option, especially in the context of small-scale projects, because it is suggested that many of the future biomass power plants should be small in size in order to make use of the rest of the exploitable biomass potential. For certain types of residues, the remaining potential can be best exploited through small-scale energy generation plants, because the residue needs have to be satisfied from nearby areas for it to be feasible.[7] Additionally, the size of output capacity for a biomass plant is determined by the capacity possessed to handle the whole operation.[8] Managing a biomass plant is different from conventional energy production. It involves greater risks, higher uncertainties and special considerations for different seasons, unofficial contracts, etc.

Biomass gasification has not attracted much the private sector in Thailand yet. It is reported that there is only two rather large sized – 22MW and 10 MW – and no small size biomass gasification plants in Thailand. The small size biomass gasification is popular in many other Asian countries, where the grid is not as extensive as in Thailand. However, it can be expected that the number biomass gasification plants will increase in future as the technology and research matures further in Thailand. The BOSCH of Energy for Environment Foundation in Thailand is specialized in biomass gasification demonstration projects. (Shrestha, Kumar, Martin & Limjeerajarus, 2006)

Biogas is mainly produced at livestock farms and large wastewater producing factories such as tapioca scratch factories. Since mid-1980´s Thailand started to implement biogas technologies at pig farms as a result of Thai-German technology

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[6] The additionality may be more difficult to prove in the case of large-scale CDM projects.
[7] Communication with a Senior Expert from Energy for Environment organization on July 6, 2006.
[8] Personal communication with a rice-husk plant manager on July 6, 2006.

cooperation. For some years now also foreign biogas companies have been working with industries producing large quantities of wastewater in Thailand and several such plants are already running. However, these newer kinds of technologies for factories seem to be suitable for the large-scale CDM projects. The biogas produced in digesters is used to produce heat with e.g. a boiler or mechanical energy with a gas engine.

The recoverable energy potential from animal manure is not huge compared to agricultural residues or even biogas production from municipal waste (table 6), however, it can still be significant source of energy at the farm level. Cattle and pig farms represent the biggest potentials in Thailand (table 7). Besides, the wastewater treatment and biogas production systems with nutrient recycling have extensive positive effects on the local environment. Furthermore, local villagers usually support these kinds of projects, because they also benefit from them. New power plants, also renewable energy power producers, face often resistance from the local communities in Thailand.

Table 7 Potential of biogas production from different livestock activities in Thailand

Animal Dung	Heads (thousand heads)	Manure Production (kg/head/day)	Biogas yield (Mm^3/yr)	REP (TJ)
Cattle	5,208	5.6	239	5,018
Pig	7,761	1.1	135	2,828
Buffalo	1,702	8.0	97	2,036
Chicken	172,247	0.03	82	1,713
Others	N/A	N/A	7	156
Total	N/A	N/A	560	11,751

Source: DEDE, 2003 in Shrestha, Kumar, Martin & Limjeerajarus, 2006

3.1.3 Most Attractive Small-scale CDM Projects

The general suggestion that the CDM trend and potential in Thailand are especially in biomass and biogas projects (DEDE, 2005; Bratasida, 2006) seems to be supported by this overview, and it also fits to the small-scale CDM potential. Biomass projects may be developed under small-scale CDM, when the size of the output capacity remains under 15 MW. Bundling of these kinds of projects is possible, when the total capacity still remains under the limit. However, if methane recovery from decaying agricultural residues is included as a project activity, the new 25 000 tCO_{2e} annual limit has to be taken into consideration (UNFCCC, 2006). The amount of methane recovery needs to be calculated for each residue type. Biomass projects therefore seem to be viable even with lower electricity generation output capacities. This can be observed also from the current world CDM pipeline (CD4CDM, 2006).

Producing biogas from animal manure is also an attractive option for small-scale CDM. The issues to be considered are similar as with agricultural residues, however, the size of the biogas production usually depends on the number of livestock units at the farm. The output capacity of biogas generators is relatively small, namely around 1 MW for large-scale pig farms (ERM, 2005), and therefore, the limiting factor is again the amount of methane recovery. However, because the biogas can be produced at very different sized farms, of which even the large ones seem to fit the small-scale CDM category, the main potential seems to fit to the small-scale CDM project category.

3.2 Experience with CDM in ASEAN – Projects and Methodologies in Pipeline

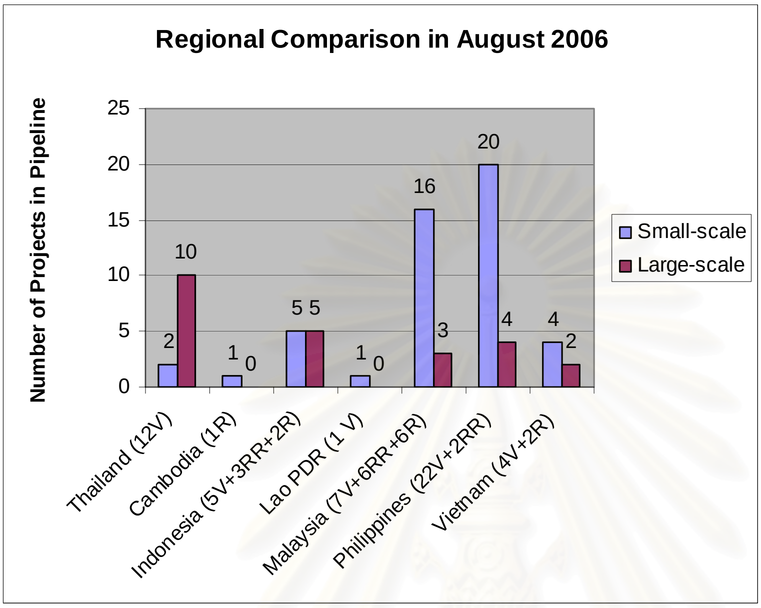
As of August 9, 2006, there are 12 CDM projects in the pipeline in Thailand, of which two are small-scale projects (CD4CDM, 2006). One small-scale CDM project is a biomass project, which generates energy from empty fruit bunches. The other is a bundled small-scale project, which consists of three pig farms, which produce biogas from pig manure. Both of them are at the validation stage. (UNFCCC, 2006) The methodologies currently used in these two small-scale CDM projects are thermal energy for the user (AMS-I.C), renewable electricity generation for a grid (AMS-I.D), methane recovery (AMS-III.D) and avoidance of methane production from biomass decay through controlled combustion (AMS-III.E) (CD4CDM, 2006). The other 10 CDM projects are categorized as large-scale projects. They are two biomass projects, one landfill gas projects and seven biogas projects. They are also all at validation stage.

In the ASEAN region, the Philippines has the highest overall number of CDM projects in the pipeline currently (figure 3). The Philippines has also the highest number of small-scale projects. Most of the projects are small-scale methane recovery projects. There are also wind power, mini-hydro power, wastewater, biogas and geothermal projects. However, none of those 20 small-scale or 4 large-scale projects have been registered yet; only 2 projects have requested to be registered.

Whereas, Malaysia has the highest number of registered projects and highest number of projects that have requested to be registered, i.e. 6 each. The number of small-scale projects in the pipeline is also high, i.e. 16 small-scale, compared to the 3 large-scale CDM projects. Most of the Malaysian projects are small-scale biomass projects, which can generate fairly high amount of CERs annually. There are also a few industrial energy-efficiency and landfill gas projects.

Indonesia has 5 small-scale and 5 large-scale projects of different types (also one solar cooker project) in the pipeline, of which 2 have been registered, 3 have requested registering and the rest are at validation stage. Vietnam is developing and implementing currently 4 small-scale and 2 large-scale projects, of which two are already registered. Most of Vietnam's projects earn CERs from hydro-power, however, the highest number of CERs are generated by one fugitive gas project. Cambodia and Lao PDR have each one small-scale project in pipeline. The Cambodian 1.5 MW rice-husk project has requested to be registered and the Laotian energy efficiency project is at validation stage.

Figure 1 Regional Comparison of CDM pipeline in ASEAN



Note: V = Validation, RR = Requested Registration, and R = Registered

Source: CD4CDM, 2006

The other ASEAN countries besides Thailand are clearly developing mostly small-scale CDM projects; therefore, the same concern about lost opportunities for supporting local sustainable development does not quite extend to them. Malaysia for example has a special guideline for developing small-scale CDM projects. Besides, having a gap on the small-scale CDM project side, another fact is striking for Thailand: as of August 9, 2006 all the Thai projects have received a pre-validation report, however, none have been approved by the Thai DNA.

3.3 Institutional Potential

3.3.1 Institutional and Policy Framework for CDM in Thailand

Thailand's participation to international and national climate change and CDM policy making has varied from very active to rather passive over the years. Thailand ratified the UNFCCC in December 1994 and the Kyoto Protocol in August 2002 (ONEP, 2006). The UNFCCC went into force in March 1995, and the Kyoto Protocol in February 2005. When the Thai Cabinet ratified the Kyoto Protocol, it also appointed the first national focal point. However, a few institutional changes and shifts were needed before the Cabinet passed a resolution to assign the Ministry of Natural Resources and Environment (MONRE) to be the designated national authority (DNA) for the CDM in July 2003, which seems to be a resolution that will guide the long-term structuring of CDM operations in Thailand. Furthermore, after initially assigned to another governmental agency under MONRE, the Office of Natural Resources and Environmental Policy and Planning (ONEP) was assigned to be the Secretariat to Thailand's DNA and act as the National focal point to the UNFCCC and the CDM. The ONEP is responsible for coordinating and structuring the CDM operation and management in Thailand. Within the ONEP, the climate change coordinating unit is responsible to great extent for drafting national CDM policies, institutional framework, CDM project procedures and criteria. The Cabinet, the National Environmental Board (NEB), and the National Committee on the UNFCCC (NCUNFCCC) are involved mainly in granting official approval on the suggested national policies and approval procedures. (IGES, 2006 & ONEP, 2006)

Besides ratifications and institutional arrangements, Thailand has engaged increasingly actively in international climate change policy making in the recent years and made specific contributions for example in the COP/MOP 1 in Montreal in the end of the year 2005 (IGES, 2006; [9]) Climate change is recognized in Thailand as a

[9] Personal communication with senior policy advisor.

significant issue, therefore, engaging into discussion of future climate regimes and mitigating national emissions is important according to many. However, it is still currently unclear whether the Thai Cabinet perceives the CDM as useful mechanism for Thailand. The Cabinet is still delaying its CDM approval process. It may start still this year (ONEP, 2006), however, there are no guarantees.[10] Therefore, Thailand's participation to international and national CDM policy making cannot be seen as active. Thailand is lagging behind very much in developing its CDM business experience compared to other countries in the region with similar institutional capacities. However, since the Kyoto Protocol went into force in the beginning of 2005, there has been recognizable change toward more emphasis in also engaging into the CDM development in Thailand, at least in the capacity development field.[11]

Thailand's national climate change strategy framework includes the CDM scheme. The CDM policy in Thailand is indeed quite special in the sense that it is required that the Cabinet will give final approval for CDM projects case by case. The current CDM guidelines are quite broad, which also must depend on this case by case approach. According to the guidelines, the CDM projects need to contribute to Thailand's sustainable development goals, create technology transfer and capacity building. It is also stated that the priority is given to projects in the energy sector and to those which benefit local communities. (ONEP, 2006) ONEP has also ranked preferred CDM project sectors and categories in order to give guidance to project developers (table 8).

[10] Gazelle (2006) predicted first Thai CDM project to be approved in 2007.
[11] Personal communication with ONEP.

Table 8 Preferred CDM Project Sectors and Categories in Thailand

Energy Sector I. Production of Energy • Project for the use of bio-energy such as ethanol and bio-diesel, and-biogas from farm and industrial wastewater. • Project for the conversion of industrial waste into energy. • Project for the use of renewable energy sources such as solar, wind, and small hydro-power systems. II. Increasing Energy Efficiency • Project for increasing the efficiency of combustion and steam generation. • Project for improving the efficiency of cooling systems. • Project for improving the efficiency of energy usage in buildings. • Project for changing the types of fuel used to produce energy.
Environmental Sector • Project to convert residential waste into energy. • Project to convert residential wastewater into energy.
General CDM Projects • Project to increase transport efficiency.
Industrial Sector • Other projects that can lead to the reduction of greenhouse gas emissions.

Source: ONEP, 2006

3.3.2 CDM Draft Approval Procedure

ONEP has also drafted an approval procedure that is planned to be in place when the Thailand Greenhouse Gas Management Organization (TGM) is established. The TGM is planned to act as the DNA for CDM projects in Thailand. The draft includes the approval procedure for reviewing CDM projects, required documents and guidelines for sustainable development requirements to be used in the review. The determination whether a project supports Thailand's sustainable development will be done in several steps. The main issues to be screened are: voluntary nature of the project, technical concepts, local sustainable development components and their impacts within a timeframe, reduction of environmental impacts and overall legal compliance. TGM will first forward the relevant required documents (table 9) to experts and relevant government ministries within 3 working days from the day the proponent submitted them. The experts and ministries are to provide comments back to the TGM within 15 working days, after which the TGM will compile a summary of comments within 20 days and submit it to be reviewed by the TGM Board. Within 3 working days the TGM Board will review and respond to the project proponent. If the project is approved, a Letter of Approval will be issued and the NCUNFCCC will be notified. (ONEP, 2006) Again, it should be recognized that these approval procedures are yet to be tested.

Table 9 Required Documents to Complete the Approval Process

- Application form;
- Project Design Document (PDD);
- Qualifications of project developer;
- Calculation of GHGs under normal operating conditions;
- Timeline for trading CERs;
- Initial Environmental Evaluation (IEE);
- Fee
- (Approval from relevant ministries);

Source: ONEP, 2006

Apart from the local sustainable development criteria, ONEP is not planning to draft criteria to guide the technologies used in CDM projects. The plan is rather to leave as much room as possible for the "creativity" of the private sector in designing CDM projects in Thailand. According to ONEP, the private sector should not be constrained with specific requirements, besides providing and updating technology guidelines is considered also to be time-consuming. Additionality testing is considered to be the responsibility of the DOEs and the EB.[12] The concern is also that by requiring new technology transfer through the CDM might hamper the efforts to enhance local technology production, if the technologies were bought from abroad, because after they become outdated the benefits are lost, unless the technology transfer includes transfer of technology development capacities as well.[13] These seem to be the main reasons why new technology transfer is not stressed in the context of CDM, and is mentioned only vaguely in the guidelines. Additionally, it is thought that because Thailand is at such initial stage, there are no plans for technology requirements, however if the government takes the CDM seriously, maybe there will be.[14]

[12] Personal communication with ONEP on August 1, 2006.
[13] Personal communication with senior policy advisor, UNEP Riso Centre, on August 1, 2006
[14] Personal communication with a senior research advisor, AIT, on August 2, 2006

3.3.2 Renewable Energy Policy

Compared to the ´CDM sector´, the renewable energy sector has received much attention in recent years, and the discussion around it remains quite lively in Thailand. The rising fossil fuel prices, energy security, and imported energy costs are issues, which receive attention from an increasing range of stakeholders in Thailand, such as key ministries and government agencies, large to small-scale industries, and even sellers on the streets of Bangkok. Thai and international NGOs are concerned about local environmental problems arising from fossil fuel based energy production, especially from coal plants.

The Thai government has also set a target to increase the share of renewable energy within all commercial energy from 0.5% to 8% by 2011 (Greacen, 2005). The target is aimed to be reached with a combination of Small Power Producer (SPP) Program, Very Small Renewable Power Producer (VSREPP) Program and other incentives to small renewable energy power producers. It is also suggested that in Thailand the strongest candidates for CDM are renewable energy projects, which plan to sell energy to the grid due to the existing SPP and VSREPP legislation (Todoc, 2003). The SPP Program was established by the Thai government already in 1992, however, the subsidy scheme for SPPs was initiated in 2001. SPPs receive price support, if their production output capacity is under 90 MW and if they use biomass residues or waste. In 2002, the Thai government launched a very small renewable energy power producers program (VSREPP) which allows sales to distribution utilities from producers whose capacity is less than 1 MW. (Todoc, 2003; PalangThai, 2006; BCSC, 2005) The producers whose capacity is less than 6 MW will also be included in the VSREPP most likely in the future, when the Thai government has a chance to consider the proposal from the Energy for Environment Foundation.

At the same time it is recognized that the current plans are not enough in order to meet the increasing energy demand, and improvements needed to reach the proposed target are lacking. The share of sources of renewable energy has rather decreased from 2002 to 2005. Therefore, if this trend will continue, Thailand will not achieve its target to increase the renewable energy share target. (Greacen, 2006)

3.3.3 Potential Small-scale CDM Project Proponents

In the renewable energy power production sector, there is wide potential left especially for smaller renewable power plants. Therefore, anyone attempting to enter the sector with appropriate technology, which has implementation barriers, has the possibility to search for CDM finance. So it can be assumed that e.g. some power producers who would fit into the SPP or VSREPP categories could also develop CDM projects, if they had the specific knowledge and capacity to do that. The additionality testing is done case-by-case, therefore, even if there are e.g. rice-husk plants which have been developed without CDM finance or other subsidies, such small-scale plants may prove to be additional, if the barriers can be proved.

The project proponents of the Ratchaburi Farms Biogas Project informed that other pig farmers in the area are also interested in implementing biogas plants at their farms with the help of CDM finance; however, they are waiting to see first how the first project will proceed. [15]

It has also been proposed that actors in the NGO sector could facilitate or be involved in small-scale CDM project development. This could be likely also in Thailand, because the NGO sector has a strong background in being involved in improving the local social and environmental conditions. It is reported that there are five active Thai NGOs that promote renewable energies, i.e. Energy Conservation Center of Thailand, Energy for Environment Foundation, Thailand Environment Institute and Appropriate Technology Association and Palang Thai (Shrestha, Kumar, Martin & Limjeerajarus, 2006). However, the Thai NGOs have not been very

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[15] Personal communication with biogas plant manager on July 27, 2006.

interested in being involved in CDM activities or capacity development, even though they have been invited to participate in different events. Therefore, WWF Thailand is perceived as one of the only active NGO participant in CDM policies in Thailand.[16] But for local level involvement in CDM there does not seem to be many probable candidates yet. This may of course change as the CDM in Thailand matures.

In the renewable energy sector, there are a few NGOs such as Palang Thai involved in promoting and implementing renewable energy projects in Thailand, however, many of these projects or installations are rural micro-size projects or smaller size installations (Palang Thai, 2006), therefore, they may not have the capacity or intentions to develop and construct larger installations due to several reasons. Because even the small-scale CDM requires some volume in order to produce enough GHG emission reductions and absorb the related transaction costs. As mentioned before, in case these small installations could be replicated and bundled into a larger package, the practical question remains how they can be constructed the way that the crediting period is the same for all installations.

In Thailand, the biomass project developers, many of which are small to medium size, are also finding it difficult to provide the finance needed for the projects. Technologies, equipment and processes that could efficiently use biomass as fuel are available commercially and many of them offer viable economic returns. Yet, not many of such projects are being implemented compared to what can be potentially achieved. Therefore, in project development, the national financial institutions are very important. In Thailand, the Thai Military Bank (TMB) is the main proponent of the CDM within the banking sector. There are several TMB officers and analysts who are already very knowledgeable about the CDM project development and finance. They possess good capacities to easily disseminate their knowledge to Thai project developers.[17]

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[16] Personal communication with ONEP on August 1, 2006.
[17] Personal communication with TMB on August 3, 2006.

Other interested and relevant parties in CDM project development are several public and private organizations, such as Thai electricity generating authorities, electric companies, other Thai banks, airlines, several governmental agencies, which potentially will be involved in CDM projects in the future. Some industries have also recognized that being prepared for the future by lowering the emissions of their key operations is crucial. [18]

3.3.4 Capacity Development

The main actors in the field of capacity development for both CDM policies and project development in Thailand are Royal Danish Embassy (or Danida), Institute for Global Environmental Strategies (IGES), UNEP Riso Center and Asian Institute of Technology (AIT). ONEP is the collaborating agency from the Thai government and is involved in organizing capacity development workshops and seminars with these international organizations. All these international organizations are involved in capacity building activities in region wide; therefore, they have a good understanding what is the status of CDM capacities in Southeast Asia. They have also disseminated this information well to ONEP. Therefore, ONEP knows very well the different institutional structures of CDM in other Asian countries.

Todoc (2003) reminds how Thailand hit the world headlines as country who declared that it will not take part in the CDM, which was however later clarified that the government was only rejecting CDM forestry projects and would consider other CDM investments on project-by-project basis. The point to be made is that as the CDM was welcomed with some suspicion by most of the developing countries, Thailand made a decision that every project is to be screened carefully at the higher policy level. As her answer to the question when the first CDM project will be approved in Thailand, the head of ONEP announced on August 1, 2006 that capacity development for CDM is also currently being done at the Cabinet level, which emphasizes the fact that CDM knowledge is not general knowledge and special

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[18] Personal communication with senior level manager on August 2, 2006.

emphasis has to be put in learning, also at the Cabinet level. UNEP´s approach to enhancing the capacities of the Thai officials is to take them on study tours to other countries to East Asia in order to share their enthusiasms, good experiences and success stories on how the countries may benefit from the CDM.[19]

3.4 Conclusion

The development of alternative energy sources is critical to Thailand's energy sustainability and energy security, and Thailand has great economic incentives to attempt to shift away from using fossil fuels as extensively as it does currently. Thailand's renewable energy potential is considered high, therefore, the development of renewable energy sources is given quite high status in the national policy making, even though there are still barriers to efficient development. At the same time the CDM development, which could enhance the development of renewable energies, is lagging behind in Thailand compared to many other ASEAN countries. However, besides the DNA approval process, institutional potential can be perceived already as CDM enhancing, because there are no other major barriers that would affect Thailand more than other ASEAN countries, and several supporting factors already exist such as the SPP and VSREPP legislation, which make the use of some currently important renewable energy technologies attractive, because of the wide grid availability in Thailand.

The small-scale CDM development has received less attention in Thailand, however, when the possibilities are screened, Thailand is in position to make use of the most viable small-scale CDM possibilities, i.e. biomass and biogas projects. In the renewable energy sector, it is only small-hydro, which other ASEAN countries tend to use more, because it is a financially viable small-scale CDM option.

Furthermore, the real small-scale potential is not in the true small-scale renewable energy technologies such as solar PV and micro-hydro. Excluding solar PV

[19] Personal communication with senior policy advisor, UNEP Riso Centre, on August 1, 2006.

and micro-hydro from the small-scale CDM potential does not mean that they are not considered as an important part of the RETs. They should be promoted, however, it seems that the CDM framework does not promote them currently enough. Small-scale biomass and biogas projects, which in some circumstances could happen without CDM, present the greatest potential. However, to which extent the small or medium sized installations of these types of renewable energy technologies are viable as CDM projects is an interesting question and explored through case-studies, which focus on exploring the potential to bring biogas projects at medium-large sized Thai pig farms under the small-scale CDM. As it is believed that workable examples can be used as encouragement, this is attempted.

CHAPTER IV

TRANSACTION COST ESTIMATION AND QUANTIFICATION

This chapter presents the case-studies in more detail. It also assesses the negative and positive externalities involved in pig farming and biogas production. The analysis starts from transaction cost estimation and quantification. In order to quantify the transaction costs for different sized projects, the relevant emissions reductions have to be estimated by using the specific small-scale CDM methodologies. Moreover, transaction costs for bundled projects are estimated and quantified, and the effect of bundling per se on transaction costs is analyzed.

4.1 Background to the Case-studies

Traditional pig farms were integrated into communities along the waterways and riverbanks in Thailand. This enabled the farms to run their business with lower costs, because it was efficient for them to transport the products via waterways, and the water intensity of pig farms is high as well. Because this practice has been rooted in the culture (Jesdapipat, 1998), the problems that have come along modern pig farming, which was introduced to Thailand in the 1970´s (GEF, 2006), have not been solved easily, cheaply or fast. Additionally, for Thailand especially, the economic prosperity created a huge demand also for livestock products, and therefore, these industries grew (Jesdapipat, 1998) and expanded exponentially. The livestock sector is also able to generate high tax revenues for the government through its large-scale industrial farms, and help contribute to poverty alleviation through income generation at the household level (Changchui, 2006). These are clear benefits, but they also came with a price tag in another form. Intensive livestock farming created large-scale waste management problems in Thailand (Jesdapipat, 1998), which have resulted in negative environmental and social externalities. The pig industry produces more unprocessed waste and discharges more nutrients than the neighboring land can absorb. It is estimated that almost fifty percent of the estimated excess phosphorus on agricultural lands originates from animal waste and ends up in water supplies or coastal waters. Human health and biological diversities of all drainage waters are under threat. (Changchui, 2006) Due to weak environmental regulations, intensive modern pig farmers generally do not have to pay for the negative externalities they create, although recently attention is increasingly being paid to mitigating and preventing these negative externalities (GEF, 2006). Subsidies, legal enforcement and R&D are the current agro-environmental policy instruments in Thailand (DLD, 2003). Pig farming is considered the most important form of agricultural point source pollution, and identified as such according to the Enhancement and Conservation of National Environmental Quality Act 1992. The effluent standards of wastewater treatment system for pig farms have been enforced since 2002; however, they are not successfully implemented yet. Besides, a pig farm standard was established for environmental protection and food safety in 1999, but the standards are voluntary and do not have real impact on practices. Furthermore, manure management at pig farms by using biogas technology is encouraged according to the Energy Act 1992 in order to reduce energy consumption and seek for alternative sources of energy. (CMS, 2005) Therefore, wastewater treatment with the use of biogas technology is identified as ways to deal with the growing problem (outlined below). However, doing so is not forced by law, and therefore, the projects are additional from this perspective.

In 2002, pig farms were counted to be the second most important livestock with about 7.761 million pigs in Thailand. These Thai farms generate around 879.95 million kg of dry dung per year, which can be used to produce 134.67 Mm^3 of biogas[20]. (Shrestha, Kumar, Martin & Limjeerajarus, 2006). At the world scale, Thailand with China and Vietnam produce over fifty percent of world's pigs. (GEF, 2002) The pig stocks are expected to increase four percent during the coming decade in Thailand (table 10) (GEF, 2006).

[20] This amount corresponds to about 2,828 TJ of recoverable energy (DEDE, 2003).

Table 10 Estimated pig stocks until 2014

	Annual growth rate 1990 to 2000	Estimated stock (millions)		
		2004	2009	2014
Thailand	4.0 %	8.27	10.07	12.26
Vietnam	4.9 %	23.96	30.46	38.74
Guangdong (China)	4.6 %	23.19	28.99	36.24

Source: GEF, 2006

Since mid-1980´s Thailand started to implement biogas technologies. In the mid-1990´s, the Thai government began to promote local biogas technology in pig farms; however, it is not yet fully mature. The locally designed and manufactured technology still needs further development to overcome some operation and maintenance problems. In 2004, total volume of installed digesters equaled to 142,527m^3.

In Thailand, the main use of biogas is for electricity generation, although also heat can be produced[21]. (Shrestha, Kumar, Martin & Limjeerajarus, 2006) Large and medium-large sized, industrial pig farms are dominant in Thailand and it has been estimated that 50% of pig stocks are in industrial systems (table 11). Additionally, 80% of future pig stock growth is assumed to take place in industrial systems. (GEF, 2006)

Table 11 Estimated pig stocks in industrial production systems

	Estimated share of pig stock in industrial systems	Estimated stock in industrial systems (millions)		
	2004	2004	2009	2014
Thailand	50.0%	4.14	5.58	7.33
Vietnam	25.0%	5.99	11.19	17.81
Guangdong (China)	25.0%	5.80	10.44	16.23

Source: GEF, 2006

[21] Case-study A consists of two pig farms, which use biogas for electricity generation and one, which uses biogas for both electricity and heat production.

4.2 Case-studies

4.2.1 Case-study A: Ratchaburi Farms Biogas CDM Project

Ratchaburi Farms Biogas CDM Project is an existing small-scale CDM project in Thailand, in which the government of Denmark [22] is a project proponent and the CERs buyer. The other project proponents are three very large-sized pig farms in Ratchaburi province[23], which have altogether approximately 205 000 pigs. The CDM project activity involved installation of systems to treat manure flushing water and production of biogas at the three pig farms. The purpose is to treat this wastewater in anaerobic processes, which generates biogas, and furthermore, this biogas will serve as fuel for heat and/or electricity generation, which replaces the electricity brought in earlier from the Thai electricity grid. The three farms have therefore invested in closed anaerobic treatment reactors, which have replaced the traditional open lagoon treatment systems. Previously, the produced biogas was emitted directly to the atmosphere. Moreover, the system results also in reductions of GHG emissions. In return, the farms have agreed to sell the generated emission reduction credits to the Danish government and earn carbon revenues, with which they cover the technology investment costs. The three farms employ so-called Upflow Anaerobic Sludge Blanket technology (UASB technology), which has been further developed to fit the Thai needs by the Biogas Technology Centre (BTC) of Chiang Mai University since the late 1980´s. It originated in Thai-German technology development cooperation.

Additionally, the farms benefit from either electricity savings[24] or revenues from selling the produced biogas[25] or electricity. The manure is also used to produce organic fertilizer. This provides additional income and directly reduces the production cost of crops, because the price is comparatively lower than chemical fertilizer.

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[22] or DRE.
[23] See map in Appendix.
[24] 2,32 Baht/kWh or $US 0,058/kWh used in case-study B to calculate revenues from biogas production.
[25] at price of 3,5 Baht/kWh, personal communication with biogas plant manager on July 27, 2006.

The DRE absorbs all the transaction costs related to the project development, except the monitoring cost[26] and share of proceeds, i.e. adaptation costs and administration costs, which are deducted from the carbon revenues, and therefore, absorbed by the farms. The possibility of additional carbon revenues prompted the farms to become CDM project proponents. The cost of biogas technology is still considered so high that investments do not occur without good incentives. However, the pressure from the society around the farms due to the local environmental impacts also pushed the farms to make the decision in favor of implementing the CDM project.[27]

The project has received a pre-validation report from the DOE, however, due to the delay in the host-country approval process and due to the new methodologies rule decided by the EB, the project may have to be taken through the validation process again with a new methodology. This small-scale CDM project is used as a base-case for the positive and negative externalities and the transaction cost estimation and the emissions reduction estimation in this research study.

4.2.2 Case-study B: Kanchana Farm – A Demonstration Project

The Livestock Waste Management in East Asia Project (the LWMEA Project) includes Thailand, because the Thai livestock rearing activities have significant impacts also on the international waters besides its own rivers and coastal areas. The Project supports several technology demonstration projects, which focus on environmental impact abatement technologies at pig farms. Not all the technology demonstration projects aim at maximizing the biogas production, however, especially in Thailand, this is also considered, if the produced biogas can be utilized extensively. The biogas maximizing demonstration project at medium-large sized Kanchana farm (10,000 pigs) in Ratchaburi province is used also as a base case for the negative and

[26] Personal communication with the Royal Danish Embassy and the Project proponents.
[27] Personal communication with the Farms on July 27, 2006.

positive externalities and for reducing CDM transaction costs through bundling and other policy options.

The LWMEA Project and the possible replication projects of the demonstration projects aim at reducing land-based pollution from livestock production in Thailand and in the international waters. Therefore, the objective of the LWMEA Project is to reduce the major negative environmental and health impacts on water bodies and people from rapidly increasing and intensive livestock production that is concentrated to certain areas. Furthermore, the LWMEA Project is seeking a win-win approach by developing livestock waste management systems through nutrient recycling, biogas production, and sustainable utilization of scarce land resources through waste management technology improvement and adoption of more efficient waste disposal methods. The aim is to provide the agencies concerned with land and water pollution with specific guidelines on the mitigation of the environmental effects of intensive livestock production.

The Thai EIA report highly encourages the implementation of the demonstration projects: “the proposed project activities, if implemented successfully, and if the recommended mitigation and control measures, presented in this report are adopted, the impacts will be highly positive on long-term environmental and social environments” (CMS, 2005).

4.2.3 Case-study Site

In Thailand, pig farms are concentrated especially in Tha Chin and Bang Pakong river basins, and the Ratchaburi province is among the highest pig producing province. In 2003, some 1 174 344 pigs were raised at 853 pig farms in the province. This represents approximately 15 % of the total pigs in Thailand. It is also reported that there are 144 large farms, 580 medium farms and 129 small farms in the province. (CMS, 2005) Ratchaburi province, about 100 km west from Bangkok, is characterized as still having dynamic growth in pig production. It is also reported that the manure management projects are supported strongly by Provincial Governor as well as district government, (GEF, 2006) and only a few farms have proper manure management practices so far (CMS, 2005).

4.2.4 Negative and Positive Externalities

The negative externalities stem from pig farming without proper manure management. It is therefore a situation ´without´ the project. The major causes of environmental problems from pig farming are such as wastewater, pig-generated solid and liquid waste. The problems to humans, animals and nature arise from water pollution, odor, water borne and zoonotic diseases, and proliferation of insects. Without manure management projects, the excess nutrients, mainly nitrates and phosphates, and the biological oxygen demand (BOD)[28] and chemical oxygen demand (COD) [29] cause increased eutrophication, fish kills, destruction of freshwater ecosystems, natural mangrove and coral reef ecosystems of the coastal zone of the gulf of Thailand and South China Sea. The odor is produced from gases which could have direct effects on the lungs of farm workers and even the health of pigs. Publicly the odor is mainly an annoyance problem.

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[28] BOD aims at measuring the amount of organic carbons that bacteria can oxidize. It is a standardized means of estimating the degree of contamination of water supplies, especially those which receive contamination from sewage and industrial wastes.

[29] COD is the total measurement of all chemicals in the water that can be oxidized. It refers to the amount of oxygen, consumed under specific conditions in the oxidation of the organic and oxidizable inorganic matter contained in industrial waste water.

Next, the situation ´with´ the project is considered. It is reported that negative impacts from the projects are negligible, and the improved manure management and biogas technologies produce rather positive externalities, which occur from a successful implementation of the projects. There are a few possible aspects which need to be considered. Even though the anaerobic lagoon and UASB system are designed to remove more than 90% of organic matter from the pig wastewater, the effluent from both systems is still rich in nutrients. A post treatment system of final ponds is required before the effluent can be discharged, even if the farms plan to use the treated wastewater for barn flushing. Overflow during the rainy season is possible, however, the effects are likely to be minimal, because it can happen ´with the project´ only from the final treatment ponds. The possibility of groundwater pollution is determined by the soil permeability; however, the construction of the UASB system reduces this possibility significantly in any case. As solid waste is treated and turned into fertilizer the positive nutrient recycling is enhanced and excess nutrients in water and agricultural lands are reduced. Additionally since large quantities of methane are captured, safety issues need to be considered. It is reported that gas explosion is unlikely.[30]

Therefore, with proper treatment ponds and nutrient recycling in addition to biogas production process, the surface and ground water pollution and their effects on human and ecosystem health can be reduced significantly. The annoying odor and emitted methane, which is a significant GHG, are reduced by proper treatment of pig manure and wastewater. Reduction of the odor and improvement of the surrounding environment can reduce conflicts between the farm owners and the surrounding communities. Moreover, it can be concluded that environmental aspects are expected to improve with the implementation of the UASB systems. Cumulative impacts from replicating these projects may be significant in the national and regional level. (ERM, 2005; CMS, 2005)

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[30] However, an explosion in a biogas system is still possible as was learned through local media in the end of August, 2006. An accidental explosion at Nong Bua Farm, one of the Ratchaburi Farms Biogas CDM Project, was lethal to 5 persons.

4.3 Transaction Cost Estimation and Quantification

The transaction costs are estimated and quantified for the case-study A, i.e. the Ratchaburi Farms Biogas CDM Project as a bundled small-scale CDM project. (See table 13 for summary.) According to the estimation, the transaction costs for this project consisting project activities from three farms lie around $US 142,431. However, this is a sub-total before the annual transaction costs which occur after the first CERs are allowed to be transferred. The total transaction costs are estimated to be $US 442,095. Yet, the total transaction costs depend very much on the real emission reductions, and are determined based on those eventually, when the reductions are monitored and the results are verified. The next section discusses the estimation of transaction costs of a bundled small-scale CDM project in detail.

The application of the small-scale CDM standard baseline methodology to baseline study with calculation of emissions reductions and monitoring plan costs are estimated to be approximately $US 20,000 each[31], i.e. altogether $US 40,000, when done by 2 consultants, one local and one foreign. The cost of the three half-day stakeholder consultations and the IEE are estimated to be $US 10,000 [32] for this small-scale CDM project, without a requirement for a more extensive and comprehensive EIA. All the estimated PDD related costs are assumed to include the documentation cost of PDD. Approval costs for such a bundled project are 15,000 Thai Baht according to the Thai DNA. Therefore, the approval cost is approximately 375 US dollars.[33] The validation costs are estimated to be $US 30,720, including all

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[31] Estimated by a local consultant. Personal communication on August 16, 2006.

[32] Estimation takes results from other studies into consideration. The project consultant did not enclose this information. However, another Thai consultant firm, which has experience in conducting EIAs for biogas projects at pig farms estimated (on Sept 7, 2006) the cost to be approximately 300,000 baht per project, which equals approximately $US 7500. This is however considered too high especially for bundled projects, because the IEE only requires simple information (ref. ERM, 2005 & ONEP´s IEE Guidelines, 2005).

[33] 1 $US = 40 Thai Baht assumed.

DOE costs. The cost to validate a normal single small-scale project is estimated to be $US 12,620 [34], including all costs (table 12).

Table 12 Estimated Costs of DOE Accreditation

Validation $US 12,000 per project,
Validation of bundled 6 projects $US 55,000
1st Verification and Certification $US 6000 per project,
for following turns, Verification and Certification $US 4500
Travel cost approximately $US 500,
and daily cost $US 60

Source: DOE, 2006

Registration costs are quantified according to the estimated emission reductions. The total estimated reductions are 1,003,797 tCO_{2e}. [35] The average estimated reductions are 100,380 tCO_{2e} per year.[36] Therefore, the registration cost is calculated to be $US 18,576. [37] Monitoring cost is estimated to be $US 12,000 to each farm.[38] This is the cost of the monitoring system. In total, the monitoring cost is $US 36,000. Adaptation fee cost is 2 % of the CERs. This equals to the annual average of 2007,6 CERs in this project. Therefore, the adaptation cost depends on the price of the CER paid. For example, with $US 4.25 price of CER, the annual adaptation cost is $US 8532,3. Verification and certification costs are much lower than validation costs due to using of the same DOE. This is assumed to be $US 6000 per a single small-scale project for the first verification and certification.

[34] Estimated according the information received from the DOE. Personal communication on 2 September, 2006.

[35] This figure is based on the Ratchaburi-PDD, not own calculations.

[36] See Annex A for the estimated annual emission reductions for the Project.

[37] The administrative expenses are (a) $US 0.10 per certified emission reduction issued for the first 15,000 tonnes of CO_2 equivalent for which issuance is requested in a given calendar year; (b) $US 0.20 per certified emission reduction issued for any amount in excess of 15,000 tCO2 equivalent for which issuance is requested in a given calendar year. The registration fee shall be the share of proceeds applied to the expected average annual emission reduction for the project activity over its crediting period. The registration fee shall be deducted from the share of proceeds for administrative expenses. The registration fee is an advance payment of the administrative expenses for the emission reductions achieved during the first year.

[38] Estimated by a farm/ plant manager. Personal communication on July 27, 2006.

Table 13 Estimated Transaction Costs for Ratchaburi Farms Biogas CDM Project

Number of Farms in Bundle	3	Total Transaction Costs absorbed by Royal Danish Embassy (RDE)
CERs per year	100 379,7	153 591
Total CERs	1 003797	Total Transaction Costs absorbed by the farms
CERs Revenues w $4.25	4 266137	288 504
CERs Revenues w $12	12 045564	
Up-front transaction costs/ CER	0,1418922	
Transaction Costs / CER	0,4404227	
CDM transaction	Transaction Costs	Party absorbing Transaction Costs
PDD Costs:		RDE
Baseline determination	20 000	
Monitoring plan determination	20 000	
Stakeholder consultation & IEE	10 000	
Validation	30 740	RDE
Host-country Approval (LoA)	375	RDE
Monitoring cost	36 000	Farms
Registration cost	18 576	RDE
1st Verification and Certification	6 740	RDE
Up-front TC Sub-total 1	142 431	
Verification & Certification		
2nd turn	5 240	RDE
3rd turn	5 240	RDE
4th turn	5 240	RDE
5th turn	5 240	RDE
6th turn	5 240	RDE
7th turn	5 240	RDE
8th turn	5 240	RDE
9th turn	5 240	RDE
10th turn	5 240	RDE
Adaptation cost 2% of CERs annually US$ 8532	85 320	Farms
Administration cost annually US$ 18 576	167 184	Farms
TC Sub-total 2	299 664	
Total	442 095	

However, for the following turns, \$4500 per a single project is assumed. In addition, the travel cost for the site-visits is approximately \$US 500 per trip for a round-trip from the DOE office. The daily costs are \$US 60.[39] (See table 12 for a summary of estimated costs of DOE accreditation.) The RDE plans to verify and certify the emission reductions every year.[40]

4.4 Emission Reduction Estimation for Small-scale CDM Projects

In order to estimate transaction costs for possible future small-scale CDM projects, the emission reductions have to be estimated according to the approved small-scale methodologies, therefore, the methodologies corresponding types I.D and III.D in the Ratchaburi Farms biogas CDM Project are applied (ref. ERM, 2005). If these methodologies are applied for a pig farm of 10,000 pigs and 5,000 pigs (case-study B), the following are the corresponding results. The total emissions reductions delivered in year 2006 by the projects are estimated to be 4273,15 tCO_{2e} (see table 14) and 2136,59 tCO_{2e} (see table 29 in Appendix A), respectively. The annual average for emission reductions are estimated to be 4231,2 tCO_{2e} and 2115,6 tCO_{2e}, respectively (see tables 30 and 31 in Appendix A).

[39] Estimated according information received from the DOE. Personal communication on 2 September, 2006.
[40] Personal communication with the Royal Danish Embassy, Danida-section on August 29, 2006.

Table 14 Emission Reduction Estimation for a Project with 10,000 pigs

$ER_{PROJECT} = BL_{PROJECT} - E_{PROJECT}$ $ER_{PROJECT}$ = Emissions reductions delivered by the project (tCO_2/yr) $BL_{PROJECT}$ = Project baseline (tCO_2/yr) $E_{PROJECT}$ = Project emissions (tCO_2/yr) – equals Zero
$BL_{PROJECT} = CO_{2e\ AVOIDED,CH4} + CO_{2\ AVOIDED,E}$
$CO_{2e\ AVOIDED,\ CH4} = CH_{4\ AVOIDED} * GWP_{CH4}$ (equation 1) $CH_{4\ AVOIDED} = Q_{G,CH4} * D_{CH4} * t$ (equation 2) $Q_{G,CH4}$ = Methane flow (m^3/d), estimated from $Q_{G,CH4}$ = pig heads * VS_{PROD} * Bo * MCF_{LAGOON} * f_{LAGOON} * $E_{CAPTURE}$ (equation 3) $Q_{G,CH4}$ = 10000 * 0,34 kg/d * 0,29 m^3/kg * 0,90 * 1,00 * 0,85 = 754,29 m^3/d (result eq.3) $CH_{4\ AVOIDED}$ = 754,29 m^3/d * 0,67 kg/m^3 * 365 d/yr = 184,461 tCH_4/yr (result eq.2) $CO_{2e\ AVOIDED,\ CH4}$ = 184,461 tCH_4/yr * 21 = 3873,69 tCO_{2e} (result eq.1) GWP_{CH4} = Global warming potential of methane (= 21) D_{CH4} = Density of methane (= 0.67 kg/m³) VS_{PROD} = Volatile solids production per head (= 0,34 kg/d) Bo = Maximum methane production (= 0,29 m^3CH_4/kg VS) MCF_{LAGOON} = Methane conversion factor – lagoon (= 0,90 (%)) f_{LAGOON} = Fraction of pig manure treated in lagoon system (= 1,00 (%)) $E_{CAPTURE}$ = Methane capture efficiency in biogas plant (= 0,85 (%))
$CO_{2\ AVOIDED,E} = KW_{E,GENERATED} * t * CEF_{THAI\ GRID}$ (equation 4) $KW_{E,GENERATED}$ is estimated from, $KW_{E,GENERATED} = Q_{G,CH4} * CV_{CH4} * t * E_{E,\ GENERATED}$ (equation 5) $KW_{E,GENERATED}$ = 754,29 m^3/d * 35MJ * 0,28 = 2,0533 MWh/ d (result eq.5) $CO_{2\ AVOIDED,E,2006}$ = 2,0533 MWh/d * 365 d/yr * 0,533 tCO_2/MWh = 399,47 tCO_2/yr (result eq.4) $CEF_{THAI\ GRID}$ = Average weighted carbon emissions factor for the Thailand electricity grid ($kgCO_2$/kWh or tCO_2/MWh) CV_{CH4} = Calorific value of CH4 (35 MJ/ m³) $E_{E,\ GENERATED}$ = Electrical conversion efficiency of biogas generation sets (= 0,28 (%))
Therefore, the project farm with 10000 pigs would result in reducing in year 2006: **$BL_{PROJECT}$ =** **$CO_{2e\ AVOIDED,CH4} + CO_{2\ AVOIDED,E,2006}$ = 3873,69 tCO_{2e}/yr + 399,47 tCO_2/yr = 4273,15 tCO_{2e}/yr**

Source: Small-scale CDM methodologies adopted from Ratchaburi Farms Biogas CDM PDD, own calculations for project of 10,000 pigs

4.5 Transaction Cost Estimations for Single Small-scale CDM Projects

Next, transaction costs for three single small-scale biogas CDM projects of 50,000 pigs, 10,000 pigs and 5,000 pigs are estimated and quantified (table 15). The projects fit in small-scale CDM activity categories III.D and I.D as was presented above. The transaction costs are estimated lower for the smaller projects only in the case of stakeholder consultation and initial environmental evaluation, assuming smaller size lowers the cost slightly. Baseline determination and monitoring plan determination costs are based on consultant services and depend on the complexity of the project; therefore, the size of the project does not really make a difference if the activities are the same. The rest of the costs are fixed on the amount of CERs generated. The purpose of the table 15 is to show how the transaction cost estimation and quantification for Ratchaburi Farms Biogas CDM Project can be applied to other projects which have the same CDM activity categories. It shows that even if the size of a single small-scale CDM project changes it is mainly the transaction costs that are fixed on the amount of CERs that change.

The quantification based on conservative estimations show that the total transaction costs for a project of 50,000 pigs are $US 0,80 per every CER, whereas, for a project with 10,000 pigs, the total transaction costs are $US 3,08 per every CER, and for a project with 5000 pigs the total transaction costs are $US 5,97 per every CER. (table 15) The conservative estimations confirm the least viable kinds of projects of these three. The smaller project with 5000 pigs would never be implemented as a single CDM project, because the price of CER is less than the transaction cost per CER, unless the price of CER would increase remarkably. Here a CER price of $US 4.25 is assumed. The single project with 10,000 pigs would not be implemented either as such, however with some additional transaction cost reductions it could become viable. This will be explored in more detail in the next chapter. The biggest project of 50,000 pigs could possibly be implemented just as a single project, even without any additional attempts to reduce the transaction costs further.

Table 15 Transaction Cost Quantification for Single Small-scale CDM Projects

Transaction	Transaction Costs for 50 000 pigs (approx. 21364 CERs/yr)	Transaction Costs for 10 000 pigs (approx. 4273,15 CERs/yr)	Transaction Costs for 5 000 pigs (approx. 2136,4 CERs/yr)
10 years	213640 CERs	42728 CERs	21364 CERs
Project Design Document: -Baseline Calculation -Monitoring Plan - Stakeholder Consultation & IEE Total	 $ 20000 $ 20000 $ 7000 $ 47000	 $ 20000 $ 20000 $ 6000 $ 46000	 $ 20000 $ 20000 $ 6000 $ 46000
Host-country Approval Fee	$ 375	$ 375	$ 375
Validation	$ 12620	$ 12620	$ 12620
Registration	$ 2773	$ 0	$ 0
Monitoring	$ 12000	$ 12000	$ 12000
Verification & Certification - 1st turn - 2nd turn - 3rd turn - i.e. per following turns Total 2nd – 10th turn Total 10 turns	 $ 6620 $ 5120 $ 5120 $ 5120 $ 46080 $ 52700	 $ 6620 $ 5120 $ 5120 $ 5120 $ 46080 $ 52700	 $ 6620 $ 5120 $ 5120 $ 5120 $ 46080 $ 52700
Adaptation Fee, 2% of CERs, (w/ $4.25 per CER) - annually - total	 ($ 1816) $ 18 160	 ($ 363,2) $ 3632	 ($181,6) $ 1 816
Administration cost - annually - total	 ($ 2773) $ 24957 (9 times annual)	 (427,32) $ 4273 (10 times annual)	 ($213,6) $2136 (10 times annual)
Sub-total (after 1st Ver.& Cer., before the transfer of CERs) TC/CER	$ 81388 $ 0,38/CER	$ 77615	$ 77615 $ 3,63/CER
Total TC/CER	$ 170585 $ 0,80/CER	$ 131600 $ 3,08/CER	$ 127647 $ 5,97/CER

4.6 Transaction Cost Estimation and Quantification for Bundled Projects

To estimate and quantify transaction costs for bundled projects certain assumptions (table 16) have to be made concerning location, type, category and technology/measure, bundled validation timing and bundled verification and certification timing.

Table 16 Assumptions for Bundled Projects in this Research Study

- Projects are bundled in all stages.
- Stakeholder meetings are arranged at every farm.
- A very simple IEE is conducted.
- Bundled projects are located in the same province.
- Same type, category and technology/measure.
- Site-visits are done to all farms by DOE, no accreditation is based on sampling.
- All validation site-visits are done within the same trip.
- All verification site-visits are done within the same trip.

For a bundled project the baseline determination costs and monitoring plan determination costs are also based on consultant services and depend on the complexity of the projects. Therefore, if all the projects are of same type, category and technology/measure, those costs are the same as for one single project. The PDD costs rise in terms of the number of stakeholder consultations and the IEE in terms of the complexity of areas surrounding the farms. Stakeholder consultations take each 0,5 working days. Possible clustering of stakeholder consultations of neighboring farms could lower the cost, but is not assumed here. Validation and verification costs rise depending on the number of the farms. The international travel costs related to the accreditation are low per project if all the projects are bundled for the site-visits, i.e. if the site-visits are done during one trip.

Table 17 Transaction cost quantification for bundled projects, each 10,000 pigs, verification every year, no learning assumed, only the effect of bundling per se assumed

Number of Farms in Bundle	1	2	3	4	5	6
CERs per year	4 231	8 462	12 693	16 924	21 155	25 386
Total CERs	**42 310**	**84 620**	**126 930**	**169 240**	**211 550**	**253 860**
CERs Revenues w $4.25	181560	359635	539452,5	719270	899087,5	1078905
CERs Revenues w $12	512640	1015440	1523160	2030880	2538600	3046320
Transaction Costs / CER	**3,108603**	**2,475951**	**2,272946**	**2,176938**	**2,125479**	**2,0855**
CDM transaction costs:						
PDD Costs:						
Baseline determination	20 000	20 000	20 000	20 000	20 000	20 000
Monitoring plan determination	20 000	20 000	20 000	20 000	20 000	20 000
Stakeholder consultation & IEE	6000	8 000	10 000	12 000	14 000	16 000
Validation	12 000	21 000	31 000	40 000	48 000	55 000
Travel Validation	620	680	740	800	860	920
Host-country Approval (LoA)	375	375	375	375	375	375
Monitoring cost	12 000	24 000	36 000	48 000	60 000	72000
Verification and Certification	6 620	12 680	18 740	24 800	30 860	36920
2nd turn	5 120	9 680	14240	18 800	23 360	27 920
3rd turn	5 120	9 680	14240	18 800	23 360	27 920
4th turn	5 120	9 680	14240	18 800	23 360	27 920
5th turn	5 120	9 680	14240	18 800	23 360	27 920
6th turn	5 120	9 680	14240	18 800	23 360	27 920
7th turn	5 120	9 680	14240	18 800	23 360	27 920
8th turn	5 120	9 680	14240	18 800	23 360	27 920
9th turn	5 120	9 680	14240	18 800	23 360	27 920
10th turn	5 120	9 680	14240	18 800	23 360	27 920
Registration cost (inc. in admin.)	0	0	0	0	0	0
Adaptation cost 2% of CERs	3 600	7 200	10800	14 400	18000	21160
Administration cost	4 230	8 460	12690	18 850	27310	35770
Total	**131525**	**209515**	**288505**	**368425**	**449645**	**529425**

The transaction cost estimation and quantification for bundled projects is done for projects of 10,000 pigs and 5000 pigs. In the case of the project of 10,000 pigs, the bundles consist of 2-6 projects in order to remain under the small-scale CDM limits. Table 17 presents the quantified transaction costs for the project of 10,000 pigs, the Kanchana farm. The results show that bundling per se can reduce the transaction costs about $US 1 per CER at most, i.e. the transaction costs are reduced from $US 3.10 per CER (single project) to $US 2.09 per CER (6 projects in a bundle). However, the same transaction cost quantification is done for the project of 5,000 pigs in order to see the viability of smaller projects in bundles. (See table 30 for details in Appendix A.) In the case of the project of 5,000 pigs, the bundles consist of 2-12 projects in order to remain under the small-scale CDM limits. The results show that bundling per se can reduce the transaction costs about $US 2.34 per CER at most, i.e. the transaction costs are reduced from $US 6.03 per CER (single project) to $US 3.69 per CER (12 projects in a bundle). With 3, 6 and 9 projects of 5,000 pigs in a bundle the transaction costs are reduced to $US 4.36, $US 3.90 and $US 3.74 per CER, respectively.

4.7 Conclusion

This chapter presented the case studies in detail. The Ratchaburi Farms Biogas CDM Project provided a platform on which to base the underlining reasoning how to estimate and quantify transaction costs for similar but smaller projects. The estimations were done as thoroughly and as precisely as possible. They are extensively based on expert estimations, and the fixed transaction costs are calculated based on the emission reduction estimations, which use the methodology provided for the small-scale projects by EB and adopted from the Ratchaburi Farms Biogas CDM Project. The guiding UNFCCC simplified modalities and procedures for small-scale CDM projects, communication with several relevant stakeholders and consulting literature at several stages were done to ensure that the estimations and quantifications are in a reliable range. The estimations are rather conservative than too optimistic through the whole study. This chapter especially aimed at showing transparently the used estimations, who is the original estimation from or what is it based on and how is it used in the analysis. The results of this chapter are extensively used in the analysis of the chapter 5.

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CHAPTER V

TRANSACTION COST REDUCTION THROUGH POLICY OPTIONS

5.1 Framework for Analysis

The analysis builds up from two components, namely, from private sector investment appraisal for pig farm projects, in order to determine the financial viability of a single project, without and with CDM, and from social cost-benefit analysis for pig farm projects which considers those cases, which are not likely to be viable options from the private sector's perspective.

The private sector investment appraisal points out the project cases, which are not likely to be implemented without any additional effort. Therefore, the ´social planner´ needs to include environmental and social externalities of those projects to the analysis in order to determine what are the total benefits and costs to the whole society. This is shown through a social cost-benefit analysis (table 18). If the environmental and social benefits are considered high, additional ways to implement the projects can be sought further. Bundling is one such policy option: bundling of projects may be considered if these projects are too small to be realized as CDM projects individually. However, bundling itself does not come without transaction costs. Therefore, the ´social planner´ may eventually compare the bundling option to other policy options, which aim at encouraging the implementation of manure management projects. These include additional policy options within the CDM framework and also other policy instrument options besides the CDM, such as government abatement technology subsidies and pollution taxes. These other policy instruments are discussed, however, only in general. First the focus is on CDM policy options, and determining the effects of different options on three scenarios: 1) a single project without CDM; 2) a single CDM project; and 3) bundled CDM projects.

5.1.1 The Scenario 1: A Single Project ´Without CDM´

The analysis starts from considering a project from a business as usual (BAU) point of view. (See IRR in table 19 for project ´without CDM´.) This presents a case which is not likely to be implemented in the BAU scenario. As explained earlier the positive IRR ´without CDM´ does not necessarily mean non-additionality. For especially small-scale biogas projects the additionality testing by describing the existing barriers seems to give strong argument in favor of CDM. However, just by looking at the financial indicators of biogas plants one could assume different. The IRR can easily be positive and even above 15 % for biogas projects. In the case of biogas projects the IRR tends to be positive, because the estimated electricity generation pays off the investment. However, the risks are still considered too high, and the revenues from the avoided fuel costs are not perceived sufficiently high. One indicator of additionality is the government subsidies for biogas projects. They have been supported and subsidized in Thailand by the government since the mid-1990´s, and yet the amount of biogas digesters increases only slowly. Even the very-large scale pig farmers refer to high upfront costs, therefore, the barriers to implement projects are still there. The access to finance for the smaller farmers is even more prohibitive. The farmers rather invest in additional pig stocks, because the payback period is shorter (ERM, 2005). Therefore, the reality seems to be that wastewater treatment and biogas projects are not implemented without any additional incentives to the ´normal investment case´, even if the financial appraisal of the project predicts good returns on investment. The IRR for a single project without CDM is 19%. This is the benchmark level for CDM projects.

5.1.2 The Scenario 2: A Single CDM Project

Therefore, a CDM project to be additional and viable, it has to deliver higher returns than ´a normal investment project´. Hence, because the IRR for the case 1 is 19%, the IRR for viable CDM projects should be higher than that. A single farm CDM project represents a case in which a single farm absorbs all the transaction costs that incur from the project. This represents the normal CDM case, which will happen if the IRR is considered high enough. The scenario 2 will help show and estimate whether the CDM biogas projects will be implemented without additional effort. In scenario 2, the transaction costs may be too high to be absorbed by a single project or the price of CER too low. This can be seen from table 18, which presents the base cases in the analysis. It shows that the both single projects of 5,000 and 10,000 pigs are less viable than the project without CDM at the CER price of $US 4.25. However, the project of 10,000 pigs is not far from becoming more viable than the project without CDM, with already at the low price, therefore, additional ways how to reduce transaction costs should be tried to find.

Table 18 Cost-benefit Analysis of Single CDM Projects of 5,000 pigs and 10,000 pigs

A Single CDM Biogas Project	5000 pigs	10000 pigs
Costs	$US 99 000	$US 198 000
Revenues	$US 217 350	$US 434 700
Net Revenues (Revenues-Costs)	$US 118 350	$US 236 700
CDM Revenues ($US 4.25/CER)	$US 89 930	$US 179 860
Transaction Costs	$US 126 615	$US 131 525
Local Benefits	- Wastewater Reduction - Renewable Energy - Nutrient Recycling - Odor Reduction	- Wastewater Reduction - Renewable Energy -Nutrient Recycling - Odor Reduction
Global Benefits	Reduction of 21 156 tCO2e	Reduction of 42 310 tCO2e
IRR	8%	17%
NPV	$US 288,08 (w/ 8%)	$US 107 813 (w/ 8%)

5.1.3 The Scenario 3: A Bundled CDM Project

A bundled CDM project represents a scenario in which a number of farms share part of the CDM transaction costs, which are not fixed on the amount of CERs or CERs revenues. The analysis looks initially at how different sized bundles affect the attractiveness and viability of the project. Therefore, the first part of the analysis compares these three cases, and determines whether bundling per se can reduce transaction costs, and if so, how much it affects the viability of the project. The effect of bundling per se is compared to the single CDM project, however, the viability of bundled projects are compared to the project without CDM.

5.2 Bundling per se

Bundling per se can reduce transaction costs further from those which are achieved by using the simplified modalities and procedures for the single small-scale CDM project. For the project of 10,000 pigs, bundling per se increases the IRR for the bundles of 2 to 6 projects by 3%, 4%, 5% and 5%, respectively, compared to the single CDM project. For the project of 10,000 pigs, bundling per se increases the IRR to maximum of 22%. Moreover, for the project of 10,000 pigs, all the bundles of 2 to 6 projects result in higher viability than the single project without CDM. However, for the project of 5,000 pigs, none of the bundles of 2 to 12 individual projects result in higher viability than the single project without CDM at the CER price of $US 4.25. Therefore, bundling per se is not a sufficient policy option for the project of 5,000 pigs, even though the IRR for bundles of 3, 6, 9 and 12 projects rises to 14%, 15%, 16% and 16%, respectively. (See table 19 for details.)

If same cases are considered with a little bit higher price for CER, i.e. $US 6, the analysis shows that the viability of all the CDM projects naturally increases and the effect of bundling per se is the same. However, with the price of $US 6 per CER, a single CDM project of 5,000 pigs still remains under the IRR threshold of 19%, however, the two biggest bundled CDM projects become competitive compared to the single project without CDM. The single project of 10,000 pigs without CDM has a slightly higher IRR when it is brought under CDM with the price of $US 6 per CER and the bundle of 6 projects has an IRR of 26%. (See table 33 for details in Appendix B.)

Table 19 Bundling per se with CER Price of $US 4.25

	5,000 pigs	CER $US 4.25	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	49 804,55
2	Single Farm Project	8 %	288,08
3a	3 Farms Project	14 %	104 339,20
3b	6 Farms Project	15 %	262 412,54
3c	9 Farms Project	16 %	428 491,79
3d	12 Farms Project	16 %	583 600,84
	10,000 pigs	CER $US 4.25	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	99 609,09
2	Single Farm Project	17 %	107 812,75
3a	2 Farms Project	20 %	267 359,62
3b	3 Farms Project	21 %	425 906,49
3c	4 Farms Project	21 %	584 158,32
3d	5 Farms Project	22 %	741 866,83
3e	6 Farms Project	22 %	900 575,34

These first scenarios were considered with conservative transaction cost estimates and with no learning effect in order to compare and determine the effect of bundling per se for the bundled projects. This analysis is equivalent to the one presented in chapter 4 with only analyzing the effect of bundling per se on transaction costs. However, in this chapter, the project without CDM is used as a benchmark, because in reality it matters how high the transaction costs reductions are. Next, the ways to reduce the CDM transaction costs further with additional policy options to bundling per se are assessed, i.e. all following ways to reduce the transaction costs are added to the previous policy option. The effect of learning-by-doing and information availability and fewer verifications and certifications are therefore quantified, in addition to bundling per se.

5.3 Learning-by-doing and Information Availability

The scenarios are considered with transaction cost estimates, which take learning-by-doing and information availability into consideration. Due to learning-by-doing and information availability all proponents act with less transaction costs over time, in cases where the transaction costs are not fixed. In this analysis, it is assumed that the consultants can do her/his work faster with fewer costs. In fact, it is assumed that the local consultant can do the work by her/himself, therefore, the baseline determination costs and monitoring plan determination costs are reduced to half from the original high (for small-scale CDM methodologies) cost. [41] Additionally it is assumed that the cost of the monitoring system [42] can be estimated to be approximately 15 % lower in the future. Including these assumptions to the analysis, it is clear that the CDM option becomes more viable, however, with the lowest CER price of US$ 4.25, the project without the CDM is still more viable than the single and bundled CDM projects of 5,000 pigs and approximately equal with the single CDM project of 10,000 pigs. Bundling with additional transaction cost reductions due to learning-by-doing and information availability cannot therefore bring the bundled projects of 5,000 pigs above IRR of 19%. However, with the price of $US 6 all but the single CDM project of 5,000 pigs have at least an IRR of 19%. (For detailed results see tables 34 and 35 in Appendix B)

[41] The conservative baseline determination cost was estimated to be $US 20,000 and the monitoring determination plan was estimated to be $US 20,000.
[42] Monitoring systems for the first similar CDM projects at large-scale farms were estimated to be $US 12,000 each.

5.4 Fewer Verifications and Certifications per Project

Next, the scenarios are considered with fewer verifications and certifications per project, namely, every two years and every five years. Verification and certification every two years increases further the IRR of the single CDM project of 5,000 pigs with 2 %, however, it still remains low. Furthermore, these transaction cost reductions cannot still make all the bundled projects of 5,000 pigs with CER price of $US 4.25 more viable than the project without CDM. To have verification and certification every 2 years can be considered as a realistic option, and therefore, the viability of this option should be screened carefully for the projects of 10,000 pigs. (See table 20.) The bundle of six projects has reached an IRR of 24%, therefore, the increase compared to the single project without CDM is 5%. Also if the scenarios are considered with CER price of $US 6 (table 21), some biggest bundles of 5,000 pigs reach an IRR of 23% and bundles of 10,000 pigs reach an IRR of 28%.

Table 20 Verification and Certification every 2 years, Price of CER $US 4.25

Every 2 years	5000 pigs	CER $4.25	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	49 804,55
2	Single Farm Project	13 %	35 385,83
3a	3 Farms Project	17 %	166 767,33
3b	6 Farms Project	18 %	365 836,22
3c	9 Farms Project	19 %	572 911,03
3d	12 Farms Project	19 %	769 015,64
Every 2 years	10000 pigs	CER $4.25	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	99 609,09
2	Single Farm Project	20 %	142 910,50
3a	2 Farms Project	22 %	316 122,56
3b	3 Farms Project	23 %	488 334,62
3c	4 Farms Project	23 %	660 251,63
3d	5 Farms Project	23 %	831 625,33
3e	6 Farms Project	24 %	1 003 999,02

Table 21 Verification and Certification every 2 years, Price of CER $US 6

Every 2 years	5000 pigs	CER $US 6	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	49 804,55
2	Single Farm Project	17 %	59 736,72
3a	3 Farms Project	21 %	239 819,98
3b	6 Farms Project	22 %	511 941,53
3c	9 Farms Project	23 %	792 068,99
3d	12 Farms Project	23 %	1 061 226,27
Every 2 years	10000 pigs	CER $US 6	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	99 609,09
2	Single Farm Project	24 %	191 585,43
3a	2 Farms Project	26 %	413 465,71
3b	3 Farms Project	27 %	634 359,41
3c	4 Farms Project	27 %	854 951,35
3d	5 Farms Project	27 %	1 074 999,98
3e	6 Farms Project	28 %	1 296 395,65

However, finally, if the verifications and certifications are done only every 5 years, all the bundled projects of 5,000 pigs will become at least as viable or more viable as the project without CDM also with the lowest price of CERs. The feasibility and possibility of this option depends totally on how often the generated CERs revenues need to be transferred to the pig farms. The cost for receiving the revenues later than sooner determines whether this is feasible or possible. In any case, it does present the most attractive cases, because all the discussed transaction cost reduction options, which can be realistically quantified, are now included in the analysis, without assuming high prices for CERs. (See tables 36 and 37 in Appendix B.)

5.5 Transaction Costs per CER and Project Attractiveness

Transaction costs per CER are another indicator of the attractiveness of a CDM project. Table 22 shows step by step how each of the above policy option add to bundling per se, and reduce the transaction cost per CER as was done in chapter 4, however, now in more concise manner. The bundles of 6 projects with 10,000 pigs are assessed further, because it is suggested (ref. Maryappan et al., 2005) that an acceptable level for transaction cost of CERs revenues is 10%. The table 22 presents transaction costs per CER, which are for bundles of 6 project in different stages the following: $US 2.09/CER, $US 1.96/CER, $US 1.52/CER and $US 1.19/CER. Therefore for these cases, if the price of CER is $4.25, the following percentages of CERs revenues will be needed to cover the transaction costs: 49.1%, 46.1%, 35.8% and 28%, respectively. None of the results are very close to 10 %. Therefore, if 10% were a decision rule, these projects would become attractive with approximate CER prices of $US 20, $US 20, $US 15, and $US 12, respectively. (The same analysis can be done to the bundles of 12 projects with 5,000 pigs. See table 38 in Appendix B.)

Table 22 The Effect of Bundling per se and Additional Policy Options on Transaction Costs per CER for Projects of 10,000 pigs

Project/Projects in Bundle	1	2	3	4	5	6
CERs per Project/Bundle	42310	84620	126930	169240	211550	253860
1) Bundling per se	3,108603	2,475951	2,272946	2,176938	2,125479	**2,087233**
2) Learning & Information	2,588632	2,188029	2,068108	2,011493	1,983668	**1,961179**
3a)Verification every 2 years	2,104585	1,734755	1,619357	1,567153	1,541976	**1,521252**
3b)Verification every 5 years	1,74155	1,391574	1,282794	1,233899	1,210707	**1,191306**

5.6 Capacity Development and DNA Support

Overall capacity development increases the number of potential CDM project proponents, which increases the number of potential projects. This is also likely to increase the interest to finance and invest in CDM projects, if the risks are perceived lower. Capacity development lowers also the information barrier, enhances learning further, and project developers or proponents are able to use less outside help and change the ´buyer’s market´ situation toward having more options and bargaining space. Some local capacity building is needed for any types of CDM projects; however, in unilateral CDM projects the need is likely to be the highest. It is likely that some of the transaction costs, especially the PDD costs that are not fixed can be further reduced if the project developers do not have to buy consultant services. However, these are difficult to quantify within much certainty; therefore, it is just acknowledged in this analysis. However, to estimate and quantify the effect of unilateral CDM on the financial analysis to some extent, the same cases as earlier are still considered with a CER price of US$ 12, starting with bundling per se (table 23). (See additional tables 39-41 in Appendix B for detailed results.) The highest IRR of 41% is received for bundle of 6 projects either with verification and certification every 2 years or every 5 years. A CER price of US$ 12 is a conservative estimate for price of CER for unilateral CDM projects. In the unilateral CDM model the projects are developed without Annex I proponents and the ERPAs are signed in much later stage than in bilateral model. The price of CER is likely to be higher, because the risks are perceived lower after the project is already registered with the EB. This implies higher returns for all CDM projects, and the returns for bundled projects are in the range that makes them attractive even with bundling per se.

Table 23 Bundling per se, with CER Price of $US 12

	5000 pigs	CER $US 12	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	49 804,55
2	Single Farm Project	21 %	108 132,51
3a	3 Farms Project	28 %	426 604,28
3b	6 Farms Project	31 %	906 942,69
3c	9 Farms Project	32 %	1 399 239,26
3d	12 Farms Project	32 %	1 877 733,98
	10000 pigs	CER $US 12	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	99 609,09
2	Single Farm Project	32 %	323 427,79
3a	2 Farms Project	36 %	698 589,71
3b	3 Farms Project	37 %	1 072 751,63
3c	4 Farms Project	38 %	1 446 618,50
3d	5 Farms Project	38 %	1 819 942,06
3e	6 Farms Project	39 %	2 194 265,61

Therefore, the high prices for CERs have so far been attained internationally due to the delivery risk reduction. However, the possibility to trade unilaterally generated CERs at the European Emission Reduction Scheme in the future may change the situation even further toward higher CERs prices. The international transaction log which is suggested to enable this is supposed to be in place in 2007. After the system is in place the price of CER may still rise quite significantly. Even a price of $US 20 per CER is not an unusual estimate.[43]

In Thailand, acquiring the DNA support at the project approval level and other levels is crucial. This can affect the speed how fast projects are registered with the EB. If the project is delayed, because of DNA approval, the changes in rules or updated methodologies may require new methodologies study and PDD report, and furthermore, new validation report. These additional transaction costs can be estimated and quantified. For example, for the Ratchaburi Farms Biogas CDM project, which is now under a methodology revision[44], the application of the new large-scale methodology will cost in minimum approximately $US 40,000 and the validation approximately $US 30,000. Also the amount of CERs generated is affected by the methodology change; therefore, all the fixed transaction costs will change slightly for this project. Additionally, the DNA support affects many issues in general, which further affect the overall attitudes and efforts to enhance CDM development in Thailand. The national strategic planning that involves CDM cannot really start without DNA support and some initial experience in developing projects to the stage where the carbon credits and revenues can be transferred.

Additional transaction costs can naturally also relate to long delays or extra costs due to other barriers at different stages of the project, such as the development, construction, start-up and operation phases.

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[43] Gazelle (2006)
[44] Personal Communication with the Danish Royal Embassy (Danida-section) on Sept 21, 2006.

5.7 Government Subsidies and Technology Risk

From the host-country's point of view CDM projects or bundled projects represent just another policy option, whose benefits and costs need to be considered. If bundling is considered as a feasible way to encourage and increase the number of the wastewater and biogas systems at Thai pig farms, the Thai government may want to support it. Therefore, besides comparing the single projects without or with CDM, bundling as a policy option needs to be compared with other policy options, such as the current government subsidies or taxes. Here only the effect of a current government subsidy is compared in detail by including the subsidy in the cost-benefit analysis in the scenario 1, which is the project ´without CDM´.

The financial support to medium- and large-sized pig farms (over 5000 pigs) from ENCON fund has been in the first phase (1995-1998) as high as 47%, then during the second phase (1997-2003) still as high as 33% of the technology investment costs. The government support program is currently in its third phase and the financial support is reduced to 18% for the technology investment. The case-study projects ´without CDM´ with this subsidy would have an IRR of 25%. The third phase support program ends in 2008. (EPPO, 2006; Bhumiratana, 2006) Therefore, at the same time that the support program reveals that the government technology investment subsidy has been quite extensive and is therefore not an insignificant cost to the government, replacing it by CDM revenues poses some additional questions. How easily can an IRR of 25% or more be reached for the pig farm CDM projects in reality? And can an IRR be lower than 25% and yet encourage the investment? Therefore, at the moment the government subsidy can be considered as a barrier to CDM, because for CDM to be an attractive option a CDM project or a bundle should have an IRR higher than 25%.

Additionally, another major risk besides above mentioned delay risk should be considered, namely technology risk. It has been mentioned already earlier that the biogas technologies and biogas production in use involve a technology risk, which however can be mitigated by good and skillful maintenance. Yet, the possible risk and its implications on generated CERs should be given a consideration in the financial appraisal, therefore, a decrease in biogas production is considered. Moreover, a reduction of 5% and 15% in biogas production is included into the financial appraisal of the most realistic transaction cost reduction scheme presented above, which refers to the option of learning and information availability, verification and certification every 2 years, with the CER price of $US 6. Therefore, next the cases with government subsidy and technology risk are considered. For the scenario 1, with 18% technology investment subsidy and with the reduction of biogas production with 5% and 15 %, the IRR is reduced to 24% and 20%, respectively (table 24).

Table 24 Government Subsidy and Technology Risk (5% reduction)

Technology Risk 5%	5000 pigs	CER $US 6	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	24 %	58 710,69
2	Single Farm Project	15 %	48 343,00
3a	3 Farms Project	19 %	205 638,83
3b	6 Farms Project	20 %	443 579,22
3c	9 Farms Project	21 %	689 304,10
3d	12 Farms Project	21 %	924 823,73
Technology Risk 5%	10000 pigs	CER $US 6	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	24 %	117 428,09
2	Single Farm Project	22 %	168 797,99
3a	2 Farms Project	24 %	367 897,55
3b	3 Farms Project	25 %	565 990,39
3c	4 Farms Project	25 %	763 855,29
3d	5 Farms Project	26 %	961 264,10
3e	6 Farms Project	26 %	1 159 659,49

Table 25 Government Subsidy and Technology Risk (15% reduction)

Technology Risk 15%	5000 pigs	CER $US 6	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	20 %	44 129,68
2	Single Farm Project	12 %	25 555,56
3a	3 Farms Project	16 %	137 410,72
3b	6 Farms Project	17 %	307 123,01
3c	9 Farms Project	17 %	483 787,72
3d	12 Farms Project	17 %	646 282,63
Technology Risk 15%	10000 pigs	CER $US 6	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	20 %	88 259,36
2	Single Farm Project	19 %	123 216,41
3a	2 Farms Project	21 %	283 451,17
3b	3 Farms Project	21 %	429 252,35
3c	4 Farms Project	21 %	581 669,87
3d	5 Farms Project	22 %	733 778,92
3e	6 Farms Project	22 %	886 881,26

5.8 Costs and Benefits from Bundling

Considering the additional costs and benefits from bundling is important, because it finally may give a strong argument in favor or against the feasibility of bundling. The risks discussed above are generally found in any normal CDM project, however, it is also important to realize that the nature of bundling itself results in additional risks, mainly due to the increased number of parties, locations and some uncertainties that are increased with a project bundle compared to a single CDM project.

The least cost option to bundle small-scale CDM projects could be realized through a bundling unit or a bundling manager within an existing business unit, for example in a bank or an equity fund, which are specialized also in CDM project consulting, providing loans and/or equity for CDM projects. The costs would mainly accrue from developing a bundling registry and additional specific capacities for bundling. Therefore, these bundled projects would have to absorb an additional transaction cost relating to the activities performed by the bundling manager.

Moreover, this could be charged from the individual projects through a bundling fee. Therefore, lastly, an incremental bundling fee should be included in the financial analysis for every individual project in the bundle, making the transaction costs slightly higher for each of those than for a single small-scale CDM project. Normally, the bundling fee could include the incremental cost of the PDD development costs, however, those have been already considered above. Therefore, only the additional bundling administration cost is considered. The upfront administration cost is estimated to be $US 2000 per individual project and a yearly administration cost of $US 0.05 per CER, i.e. similar fee as the EB charges for their administration procedures, but in local rate. These are included in the financial analysis of project of 10,000 pigs as was presented in table 24, which took into consideration also the technology risk with 5% reduction in biogas production. Table 26 presents results from a comparison of bundled projects with bundling fee and the same amount of individual projects added up in order to be able to compare how the cost of bundling affect the viability of a bundle. It can be seen that the cost of bundling has only a minor effect and the viability of the bundled projects remain much higher. The final attractiveness of bundling would be determined by how much monetary benefits a bundling manager can derive from bundling.

Table 26 A Comparison of Individual Small-scale CDM Projects to Bundled Projects with Bundling Fees

10000 pigs	IRR	NVP (w 8%)	10000 pigs	IRR	NVP (w 8%)
Individual Farm	22 %	168798	Single Farm Project	22 %	168798
2 Farms	22 %	337596	2 Farms Bundled Project	24 %	361200
3 Farms	22 %	506394	3 Farms Bundled Project	25 %	555944
4 Farms	22 %	675192	4 Farms Bundled Project	25 %	749850
5 Farms	22 %	843990	5 Farms Bundled Project	25 %	942561
6 Farms	22 %	1012788	6 Farms Bundled Project	25 %	1136259

Note: CER price of $US 6 and other conditions as above in table 24.

The benefits from bundling could accrue for example from developing a general procedure for proceeding with the legal requirements, loan agreements, technology supply agreements, construction agreements, operation and maintenance contracts and power purchase agreements. The transaction costs could be reduced by developing standard procedures for selling the carbon credits. Bundling unit could exploit the economies of scale is the long term. Additionally, in reality, because the capacities to develop CDM projects and bundled projects are still scarce, sharing the limited expertise with number of projects would enhance the CDM development in general.

5.9 Conclusion

This chapter answered the guiding research questions: how transaction costs can be reduced through bundling of small-scale biogas CDM projects in Thailand; and how other policy options could enhance further the reduction of transaction costs particularly for small-scale CDM projects in Thailand. In order to give recommendations to different stakeholders, a framework for analysis was presented and also details from real practices and polices was presented to complement the framework in order to consider the viability of the small-scale CDM projects in reality. Yet, the results have to be discussed also in a wider context. By going back to the bundling literature review, it can be seen that some figures are quite different between this study and the Indian cases, in which the estimated transaction costs are much lower at all levels, which is likely to be partly a result of learning and lower costs for consultation and accreditation services. Especially the reductions of transaction costs by using the UNFCCC simplified methodologies and procedures are estimated to be very significant i.e. in average 71% lower than for normal large-scale projects in the Indian case.[45] This however, results that benefits from bundling stay in a relatively lower range. [46] By recognizing these differences, it is easier also to conclude that perhaps reaching the suggested acceptable level of 10% for transaction costs of CERs revenues is not so relevant, if the project under CDM is more viable and viable enough compared to the project without CDM especially in the case of these biogas projects. The non-monetary benefits of these projects are extraordinary high. Therefore, just getting these wastewater and biogas projects under a system that

[45] Refer to Bhardvaj et al. (2004)
[46] Refer to Mariyappan et al. (2005)

finances and compels their development can be enough. Additionally, the Indian figures show that the transaction costs can be reduced still significantly, and one purpose of this research study was to explore bundling with rather conservative transaction cost reductions estimations, in order to see whether small-scale projects could be realistically developed under the CDM.

The results from this research can give good guidance for future small-scale CDM project development in terms of how transaction costs can be reduced through bundling per se and other policy options, and can therefore be generalized to some extent for similar wastewater and biogas projects at Thai pig farms. The viability of wastewater and biogas projects is however more case specific and should be determined in more detail case-by-case if possible, yet it became clear that the viability of a bundled project is higher the closer it is to the upper limits of small-scale CDM projects.

CHAPTER VI

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This research study examined the small-scale CDM potential in Thailand, first through the general technical and institutional potentials, and then through specific case-studies of wastewater and biogas systems. The effect of UNFCCC simplified procedures and modalities, bundling per se and additional policy options on transaction costs and viability of small-scale CDM projects were investigated through the case-studies. Also the effect of major risks was assessed.

The potential to reduce emissions and exploit abundant renewable energies is high in Thailand, therefore, the technical small-scale CDM potential can be perceived high in Thailand along the large-scale CDM potential. Economic, social and environmental reasons support the greater use of domestic renewable energy sources. It becomes however clear that the transaction costs per CER, cost of abatement and price of CER are decisive in regard to the feasibility of bringing renewable energy projects under the CDM. The best small-scale CDM potential currently is perceived to be in biomass and biogas projects, because their installation sizes fit also under the small-scale CDM project limits for renewable energy and methane recovery activities (<15MW and <25 ktCO_{2e}) as larger single projects or bundles of projects up to approximately 12-15. Solar energy and micro-hydro are abundant in Thailand, however, sharing the high transaction costs requires bundling of very high amount of projects, which may not be practical in reality. At the same time, the Thai CDM project development, and therefore the CDM experience attained, is lagging much behind other ASEAN countries. A positive development in the DNA approval process could speed up making use of the otherwise sufficiently well developed institutional potential that enhances the realization of small-scale CDM projects in Thailand. Increasingly improving capacities for project development in Thailand and favorable policies for allowing very small renewable power producers to connect to grid are important factors for supporting the most attractive types of small-scale CDM projects.

Small-scale wastewater and biogas CDM projects at pig farms in Thailand presented an attractive option for further investigation, because even the larger single-farm biogas projects meet the eligibility criteria for small-scale CDM projects, the farms already exist in high numbers with growth in industrial operations, and therefore, the need for further enhancing manure management projects is high. Evidence from case-studies and their IEE and EIA reports confirm that wastewater and biogas projects at Thai pig farms can benefit highly the local environment, and they already receive high support from the provincial and central authorities. Implementation of wastewater and biogas systems is attractive, because the benefits received are perceived high. The benefits include local environmental and social benefits derived from the manure management and production of renewable energy locally, and global benefits derived from reduction of GHG emissions. Successful implementation of the projects will result in reduction of surface and groundwater pollution through reducing pollutants, increasing nutrients recycling and decreasing the need for inorganic fertilizer. The human and ecosystem health will improve due to the projects. The annoying odor that originates in pig manure will be reduced to great extent, which will reduce the conflicts with the households in nearby areas.

The high upfront technology investment cost is a barrier for implementation of wastewater and biogas projects in Thailand. Besides renewable energy projects are perceived still as risky investments. The CDM revenues can be however quite attractive for larger biogas projects, but especially the smaller projects suffer from high transaction costs. In fact, one of the main conclusions of this research study is that the UNFCCC simplified modalities and procedures do not decrease the transaction costs sufficiently for the single project of 10,000 pigs, which generates in average 4231 tCO_{2e} of emissions reductions per year, and for the single project of 5,000 pigs, which generates in average 2116 tCO_{2e} of emissions reductions per year in order to make them attractive for private investors.

The poor viability of these single CDM projects and the need for bundling was determined by comparing the project without CDM to a single CDM project. It was discovered that with low CERs prices it is not feasible to bring the projects of 10,000 pigs and 5,000 pigs as single projects under the CDM, because the IRR for them remains lower than for the project without CDM. The IRR for project without CDM is 19%, and for single CDM projects of 10,000 pigs and 5,000 pigs, the IRR is 17% and 8%, respectively. Therefore, investigating the effect of bundling was justified. Moreover, the effect of bundling per se was included in the financial analysis in order to find out the feasibility of bundling itself.

Bundling per se can reduce transaction costs further and, for the project of 10,000 pigs, all the bundles of 2 to 6 individual projects result in higher viability than the single project without CDM. However, for the project of 5000 pigs, none of the bundles of 2 to 12 individual projects result in higher viability than the single project without CDM at the CER price of $US 4.25. However, even for the project of 10,000 pigs the transaction costs per CER in all bundles are considered high. For the bundle of 6 projects, which is the most viable with an IRR of 22%, the transaction costs per CER are $US 2.09, i.e., about 49.2% of the CERs revenues are needed to cover the transaction costs. To be at the ´acceptable´ level of 10% the price of CER should therefore be approximately $US 20. The second main conclusion is therefore that bundling per se does not sufficiently reduce the transaction costs, even if the ´acceptable´ level is rather subjective.

Therefore, additional ways such as learning-by-doing, information availability, fewer verifications and certifications every two years or every five years, were further considered in order to reduce the transaction costs. The effect of learning and information availability improved the viability to some extent. Fewer verifications and certifications every two years or every five years, especially the latter, do have a significant effect on the viability. These additional option result together in increasing the viability in terms of IRR, e.g. for the bundle of 6 projects, up to 24% in case of the project of 10,000 pigs, i.e. 5% higher than for the single project without CDM. For the project of 5000 pigs, with the maximum 12 projects in the bundle, these additional options increase the viability in terms of IRR to 19%, with verifications and certifications every 2 years, and to 21%, with verifications and certifications every 5 years. In another way to look at it, these additional options result in reducing the transaction costs, e.g. for the bundle of 6 projects with 10,000 pigs, down to $US 1,52 per CER, if verifications and certifications are done every 2 years, and down to $US 1.19 per CER if verifications and certifications are done every 5 years, which means that 35,7% and 28%, respectively, of the CERs revenues are needed to cover the transaction costs at the CER price of $US 4.25. For the bundle of 12 projects with 5,000 pigs, similar options reduce transaction costs down to $US 2.64 per CER and $US 1.98 per CER. Therefore, the third main conclusion is that the transaction costs can be reduced to a viable level at least for some project bundles with these transaction cost reduction options. Yet, when the current government biogas technology subsidies, technology risk and cost of bundling are considered, it becomes clear that only the project of 10,000 pigs in bundles is likely to be viable enough in reality.

Therefore, the last main conclusion is that transaction cost reduction is central to the realization of these small-scale CDM projects. The project of 10,000 pigs and 5,000 pigs would never be realized as a small-scale CDM projects unless the transaction costs we reduced. And yet, some of these projects are not so unviable that they could not be developed under the small-scale CDM with some additional effort. Furthermore, these small-scale CDM projects could bring about local benefits, or in fact solve local problems, while addressing global concerns, if sufficient effort is put in developing capacities that enhance the realization of these transaction cost reductions.

6.2 Recommendations

6.2.1 Recommendations for Project Developers

Because the UNFCCC simplified modalities and procedures place restrictions on how bundling can be done, and because the EB may change or update the rules, also the small-scale CDM project developers have to keep themselves updated with the UNFCCC simplified modalities and procedures. When several pig farms are planning a bundled project it is outmost necessary to first find out the specific limiting factors concerning those types of activities that are aimed to be bundled. In these cases only renewable electricity generation for a grid (AMS-I.D) and methane recovery (AMS-III.D) were considered. For AMS-I.D the limit is output capacity of 15 MW and AMS-III.D the limit is maximum emissions reductions of 25 ktCO_2 annually. The estimated emissions reductions for methane recovery are calculated from the amount of pigs at the farms. Therefore, according to the calculations using the AMS-III.D methodology presented earlier, this equals to approximately 64 564 pigs. And because a bundle of projects is the more viable the closer it is to this limit, it is important to take into consideration in the planning stage. Therefore, in this research study the maximum bundles considered were 6 projects of 10,000 pigs and 12 projects of 5,000 pigs. The projects of 10,000 pigs are however much more viable when they are bundled, therefore, it can be assumed that at least projects of 10,000 pigs and larger are ready to be developed into bundled CDM projects in Thailand, especially if the other measures to reduce transaction cost than bundling per se are attempted.

Bundling can be done at different stages, however, the biggest transaction costs reductions can be achieved if the projects are bundled already for the PDD, i.e. the baseline calculation determination and monitoring plan determination for all projects are done jointly. Stakeholder consultations can possibly be organized also jointly if farms are located closely, otherwise they should be organized for each farm separately. The PDD and the initial environmental evaluation should explain the special characteristics of each CDM activity; however, common information such as main effects of the projects can represent all the projects. Validation of projects should be bundled and the site-visit should be scheduled to be done during one trip. This saves a lot in DOE´s travel costs. The same DOE should be hired to do the verification and certification and the site-visits should again be scheduled to be done during one trip. To reduce the verification and certification costs, they should be done less frequently than every year. Verification and certification every two years is a realistic option that has been utilized widely in unilateral CDM projects (ref. Krey, 2004). However, if there is a possibility to do the verification and certification only every five years, it would result in significant transaction cost reductions per project. There is several ways to reduce the high transaction costs further if the project developer or manager can avoid hiring consultant to write the PDD and determine the baseline calculation and monitoring plan according to the standardized methodologies. The baseline calculation methodology was presented in table 14 and replicating it is simple. Also the requirements for the standardized monitoring methodology are relatively simple as well. However, it is very important to keep updated with the new versions of each methodology used and see what the changes are, and whether they are applicable to the planned projects. Some standardized values are for example updated periodically. If there are uncertainties in the use of methodology, it can be reviewed by a consultant or another expert in the field. The small-scale methodologies are made to be easily replicable. Many of the pig farm managers already know the wastewater and biogas systems quite well so the knowledge can be disseminated easily to project documents and other developers. Naturally, the language used due to the international nature of CDM process in PDD is English, and can therefore, be a barrier to CDM development. If all the information is available, completing most of the information for the PDD should not be impossible task, if some time and effort is put into it. Applying the AMS-I.D is slightly more difficult, because the average weighted carbon emissions factors for the Thai electricity grid have to be calculated for every year of the crediting period (as in table 29 in Appendix A). Therefore, some of the information has to be received from EGAT. However, it has been recommended that this information should be kept updated and available for example at ONEP´s internet page, because one very practical issue to all project developers is access to data and information. Enhancing this makes it possible for the private sector to develop projects efficiently. Therefore, the main considerations for small-scale DM project developers at Thai pig farms are the size of the individual projects to be bundled together; the starting date for the crediting period; which policy options to reduce the transaction costs can be realistically utilized; which risks have to be taken into consideration, the costs and benefits from using a bundling manager's services. In fact, it seems that if the PDD development needs to be outsourced in any case, using a special bundling manager could be the most financially viable approach. And, finally, project developers should consider whether the benefits from bringing the project under CDM are high enough compared to developing the project without CDM.

6.2.2 Recommendations for Policy Makers

Clear policy on CDM at national level is important. In Thailand, this would be outmost important, because of the current situation. At the moment the developers of many of current CDM projects are in difficult situations, because of the delay of the Thai DNA approval. However, it is natural that the emphasis on CDM at the national policy level depends on how the local benefits that can be realized through CDM are perceived. The policy makers are first of all concerned about what needs to be done in order to improve the local environment, and second, how to get that done. As said, to national policy makers CDM is at best one choice among other options. Therefore, one option is to include CDM into the wider national plans and strategies or at least recognize linkages between decentralized energy and waste policies, which could be enhanced with CDM.

For example, in the case of biogas projects it should be considered how current policies for feed-in electricity tariffs, other subsidies and CDM go together or whether there should be changes in the practices or plans. It should be also considered seriously whether CDM could fit into the national plan as a ´substitute/supplementary subsidy´ to biogas projects at pig farms. From the results of this research study it becomes clear that individual CDM projects at medium-large sized pig farms may not be developed by the private sector in the current situation, however, bundling and other CDM policy options can bring the bundled projects to the same IRR range as the currently subsidized projects or even higher. It can be recognized that there is still need for technology investment support, of which the current Livestock Waste Management in East Asia Project is a good example. The replication projects in the future are likely to be in need of additional support especially in the early stage. It should be therefore seriously considered and explored if CDM can provide a part of a solution. Yet it has to be recognized that the current government subsidy can be a barrier to biogas CDM project development, at least in the case of small-scale projects.

Additionally, it should be considered whether subsidies are the right policy option for increasing wastewater and biogas production at Thai pig farms. The problem with subsidies is in measuring the marginal external benefit. Assigning monetary values on the marginal external benefits of these projects is difficult as mentioned earlier. However, to achieve an efficient outcome, the subsidy should equal the marginal external benefit of wastewater and biogas technology consumption measured at the efficient output level. Therefore, it is not likely that a subsidy on abatement equipment will in reality achieve allocative efficiency. However, it can still have the effect to encourage greater consumption of these technologies, because the price is artificially lower. For the polluter, subsidies are the most preferred option.

Subsidies also affect relative prices. They make other alternatives less attractive from a financial perspective. Biogas production does not necessarily result in most attractive environmental outcome unless other wastewater and nutrient recycling options are also implemented. It may also be that the biogas option is not feasible for all farmers; therefore, other options could be better. However, it is the biogas technology that is subsidized in these projects. Furthermore, subsidies may in the long term prevent new innovations from happening, because they are much less attractive than the “old” subsidized technologies, therefore, the normal subsidy phase out can be important. This seems to be happening with the Thai government biogas technology subsidies. The ´CDM subsidy´ is therefore less disruptive, because it is more independent of specific technology. It can be used for older and newer technology at the same time, because it is project-based. Additionally, for longer term, government subsidies may not be acceptable, because they conflict with the polluter-pays principle. Yet, again, if the subsidy is received through CDM, the case is a little bit different, because it does not burden the government's limited budget and it is a payment for the global benefit.

If the biogas technology investment support program will end, for example as mentioned in 2008, the Thai government is probably considering a new scheme for encouraging improved wastewater treatment systems at pig farms. A pollution tax is one possible solution, whose costs and benefits should be also considered. Tax only – option is not preferred by the polluters, because then they are made worse off by the system, and therefore, new taxes usually face a lot of resistance from polluters. Therefore, a tax-subsidy option could be a better solution, because one way of financing a subsidy on implementation of pollution abatement technology is to levy a tax on pig farms and to recycle the revenue back to the pig farmers in the form of grants for the pollution abatement technology, which would basically aim at making such a scheme to disappear in the end if it is successful. However, the concern remains whether the subsidies that can be paid out of the tax revenue will raise the rate of return enough to eliminate the need for the tax. If it can, then from the society's perspective, it can be the best option, because it may encourage the adoption of wastewater and biogas systems possibly better than taxes or subsidies by themselves. Yet, keeping the ´CDM subsidy´ along could possibly ensure that the revenues are increased enough. The additionality is likely to be proved, if the barriers exist and, because the legal compliance remains for wastewater standards, not for implementing anaerobic ponds and electricity generators.

Therefore, the policy options are considered from the local point of view. The difference between the policy options is about who gets the benefits and who pays for the pollution and emissions reductions. To the society it does not make a difference, which option is used in terms of the result, as long as the efficient level of pollution or emissions are achieved. However, it should be considered also what the implications from producing jointly both local and global benefits are. As outlined in this research, currently there are three different possible sources to pay for the pollution and emissions reductions, both local and global. Those are the government, the polluters and the international CDM investors. Each can do the job under certain circumstances. Yet, the international CDM finance in its current form does not do the job sufficiently. A lot of the global benefits are not paid or paid sufficiently by the international proponents, who are more responsible for causing climate change. The CDM shows this aspect quite clearly, because it excludes many of the smaller projects.

6.2.3 Recommendations for Further Study

To further this study, it is clear that there is need to determine the necessary institutional capacities, how they can be developed cost-efficiently and who the relevant stakeholders to work with are in order to enable the realization of small-scale biogas CDM projects in Thailand. Implementing a pilot bundled project, which exploits the synenergies with the LWMEA Project could be a feasible next step.

However, from a broader perspective, it could be beneficial to conduct research relating to issues of local benefits and technology transfer in Thailand, because it seems likely that CDM or something similar will continue being a part of the international climate change scheme. The importance of technology transfer and local benefits from it in the long term should be a key issue to be brought back to the discussions more strongly; however, it should be based on current developments in the area. The point of departure could however be what were the initial agreements stated in the UNFCCC and what the CDM was hoped to achieve. Lessons learned from the CDM so far should be used to assess what the CDM in its current form can achieve and what it cannot. The issues are very much the same as in the case of wastewater treatment and biogas CDM projects. The analysis should be based on what needs to be done in order to achieve local benefits, how those benefits can be achieved and who is responsible for paying the benefits.

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APPENDICES

APPENDIX A

CASE-STUDY A AND CASE-STUDY B DATA AND RESULTS

Table 27 Estimation of emission reductions in tonnes of CO_{2e} for Ratchaburi Farms Biogas CDM Project

Years	Annual estimation of emission reductions in tCO_{2e}
2006	101,149
2007	100,946
2008	100,804
2009	100,725
2010	100,473
2011	100,283
2012	100,059
2013	99,931
2014	99,782
2015	99,643
Total estimated reductions (tCO_{2e})	**1 003 797**
Total number of crediting years	10
Annual average (tCO_{2e})	100 380

Source: ERM, 2005

Table 28   Average Weighted Carbon Emission Factors

Type of Fuel	Conversion factor	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Hydroelectric		GWh	7,682	7,604	7,359	7,274	7,216	11,736	12,058	12,071	12,116	12,018	11,981
		MtCO2	0	0	0	0	0	0	0	0	0	0	0
		tCO2/MWh	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural Gas		GWh	90,668	96,369	116,596	125,960	137,914	145,410	157,377	171,019	185,047	199,690	215,252
		MMSCFD	2,012	2,154	2,602	2,767	2,993	3,145	3,333	3,510	3,739	3,954	4,186
	1.02TJ/mmscfd	TJ	749,166	802,033	968,725	1,030,005	1,114,145	1,171,032	1,240,879	1,306,767	1,392,124	1,472,093	1,558,511
	15.3tC/TJ	MtCO2	41,188	44,094	53,259	56,628	61,253	64,381	68,221	71,843	76,536	80,933	85,684
		tCO2/MWh	0.454	0.458	0.457	0.450	0.444	0.443	0.433	0.420	0.414	0.405	0.398
Heavy Oil		GWh	14,751	17,306	3,028	2,925	2,880	2,899	2,756	2,161	1,958	1,943	1,613
		MLitres	3,618	4,234	727	697	682	685	653	524	484	479	395
	39.77TJ/MLitre	TJ	143,881	168,380	28,916	27,723	27,127	27,246	25,973	20,843	19,252	19,054	15,713
	21.1tC/TJ	MtCO2	11,020	12,897	2,215	2,123	2,078	2,087	1,989	1,596	1,475	1,459	1,203
		tCO2/MWh	0.747	0.745	0.731	0.726	0.721	0.720	0.722	0.739	0.753	0.751	0.746
Diesel Oil		GWh	2,433	4,810	1,115	971	722	624	673	477	592	536	618
		MLitres	578	1,350	370	330	259	233	245	197	225	211	232
	36.42TJ/MLitre	TJ	21,051	49,167	13,475	12,019	9,433	8,486	8,923	7,175	8,195	7,685	8,449
	20.2tC/TJ	MtCO2	1,544	3,605	988	881	692	622	654	526	601	563	620
		tCO2/MWh	0.634	0.750	0.886	0.908	0.958	0.997	0.972	1.103	1.015	1.051	1.003
Lignite		GWh	16,399	16,622	16,798	16,973	17,063	17,176	17,315	17,370	17,282	17,320	17,251
		MTonnes	15	15	16	16	16	16	16	16	16	16	16
	10.47TJ/kt	TJ	157,783	159,877	166,473	166,892	166,473	166,473	166,473	166,473	166,473	166,473	166,473
	27.6tC/TJ	MtCO2	15,648	15,856	16,510	16,552	16,510	16,510	16,510	16,510	16,510	16,510	16,510
		tCO2/MWh	0.954	0.954	0.983	0.975	0.968	0.961	0.954	0.950	0.955	0.953	0.957
Imported		GWh	2,460	2,460	10,556	12,408	12,378	12,378	12,378	12,408	12,378	12,378	12,378
Coal		MTons	1	1	4	4	4	4	4	4	4	4	4
	26.38TJ/kt	TJ	23,751	23,751	98,667	108,611	115,470	115,470	115,470	115,734	115,470	115,470	115,470
	25.8tC/TJ	MtCO2	2,202	2,202	9,147	10,069	10,705	10,705	10,705	10,729	10,705	10,705	10,705
		tCO2/MWh	0.895	0.895	0.867	0.812	0.865	0.865	0.865	0.865	0.865	0.865	0.865
Renewable		GWh	1,179	1,179	1,242	1,251	1,251	1,788	2,600	3,229	3,781	4,440	5,176
Energy		MtCO2	0	0	0	0	0	0	0	0	0	0	0
		tCO2/MWh	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TNB		GWh	1,212	1,308	1,517	1,517	1,517	1,517	1,517	1,517	1,517	1,517	1,517
		MtCO2	0	0	0	0	0	0	0	0	0	0	0
		tCO2/MWh	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total		**GWh**	**136,784**	**147,658**	**158,211**	**169,279**	**180,941**	**193,528**	**206,674**	**220,252**	**234,671**	**249,842**	**265,786**
		MtCO2	**71,602**	**78,654**	**82,119**	**86,253**	**91,238**	**94,305**	**98,080**	**101,206**	**105,827**	**110,171**	**114,722**
CEF		**tCO2/MWh**	**0.523**	**0.533**	**0.519**	**0.510**	**0.504**	**0.487**	**0.475**	**0.459**	**0.451**	**0.441**	**0.432**

Source: ERM, 2005

Table 29 Emission Reduction Estimation for a Project of 5,000 pigs

$ER_{PROJECT} = BL_{PROJECT} - E_{PROJECT}$

$ER_{PROJECT}$ = Emissions reductions delivered by the project (tCO_2/yr)
$BL_{PROJECT}$ = Project baseline (tCO_2/yr)
$E_{PROJECT}$ = Project emissions (tCO_2/yr) – equals Zero

$BL_{PROJECT} = CO_{2e\ AVOIDED,CH4} + CO_{2\ AVOIDED,E}$

$CO_{2e\ AVOIDED,\ CH4} = CH_{4\ AVOIDED} * GWP_{CH4}$ (equation 1)

$CH_{4\ AVOIDED} = Q_{G,CH4} * D_{CH4} * t$ (equation 2)

$Q_{G,CH4}$ = Methane flow (m^3/d), estimated from
$Q_{G,CH4}$ = pig heads * VS_{PROD} * Bo * MCF_{LAGOON} * f_{LAGOON} * $E_{CAPTURE}$ (equation 3)

$Q_{G,CH4}$ = 5000 * 0,34 kg/d * 0,29 m^3/kg * 0,90 * 1,00 * 0,85 = 377,145 m^3/d (result eq.3)
$CH_{4\ AVOIDED}$ = 377,145 m^3/d * 0,67 kg/m^3 * 365 d/yr = 92,231tCH_4/yr (result eq.2)
$CO_{2e\ AVOIDED,\ CH4}$ = 92,231tCH_4/yr * 21 = 1936,85 tCO_{2e} (result eq.1)

GWP_{CH4} = Global warming potential of methane (= 21)
D_{CH4} = Density of methane (= 0.67 kg/m^3)
VS_{PROD} = Volatile solids production per head (= 0,34 kg/d)
Bo = Maximum methane production (= 0,29 m^3CH_4/kg VS)
MCF_{LAGOON} = Methane conversion factor – lagoon (= 0,90 (%))
f_{LAGOON} = Fraction of pig manure treated in lagoon system (= 1,00 (%))
$E_{CAPTURE}$ = Methane capture efficiency in biogas plant (= 0,85 (%))

$CO_{2\ AVOIDED,E} = KW_{E,GENERATED} * t * CEF_{THAI\ GRID}$ (equation 4)

$KW_{E,GENERATED}$ is estimated from,
$KW_{E,GENERATED} = Q_{G,CH4} * CV_{CH4} * t * E_{E,\ GENERATED}$ (equation 5)

$KW_{E,GENERATED}$ = 377,145 m^3/d * 35MJ * 0,28 = 1,0267 MWh/ d (result eq.5)

$CO_{2\ AVOIDED,E,2006}$ = 1,0267 MWh/d * 365 d/yr * 0,533 tCO_2/MWh = 199,74 tCO_2/yr (result eq.4)

$CEF_{THAI\ GRID}$ = Average weighted carbon emissions factor for the Thailand electricity grid ($kgCO_2$/kWh or tCO_2/MWh)
CV_{CH4} = Calorific value of CH4 (35 MJ/ m^3)
$E_{E,\ GENERATED}$ = Electrical conversion efficiency of biogas generation sets (= 0,28 (%))

Therefore, the project farm with 5000 pigs would result in reducing in year 2006:

$BL_{PROJECT}$ =
$CO_{2e\ AVOIDED,CH4} + CO_{2\ AVOIDED,E,2006}$ = 1936,85 tCO_{2e}/yr + 199,74 tCO_2/yr = 2136,59 tCO_{2e}/yr

Table 30 Estimation of emission reductions in tonnes of CO_{2e} for Biogas CDM Project of 10,000 pigs

Years	Annual estimation of emission reductions in tCO_{2e}
2006	4265,7
2007	4262,7
2008	4255,9
2009	4251,4
2010	4238,7
2011	4229,7
2012	4217,7
2013	4211,7
2014	4181,7
2015	4197,5
Total estimated reductions (tCO_{2e})	**42312,55**
Total number of crediting years	10
Annual average (tCO_{2e})	**4231,2**

Table 31 Estimation of Emission Reductions in tonnes of CO_{2e} for Biogas CDM Project of 5,000 Pigs

Years	Annual estimation of emission reductions in tCO_{2e}
2006	2136,6
2007	2131,3
2008	2128
2009	2125,7
2010	2119,4
2011	2114,9
2012	2108,8
2013	2105,9
2014	2090,9
2015	2098,7
Total estimated reductions (tCO_{2e})	**21156,41**
Total number of crediting years	10
Annual average (tCO_{2e})	**2115,6**

Table 32 Transaction cost estimation and quantification for bundled projects, each 5000 pigs, verification every year, no learning assumed, only the effect of bundling per se assumed

Number of Farms in Bundle	1	3	6	9	12
CERs per year	2 116	6 348	12 696	19 044	25 392
Total CERs	**21 160**	**63 480**	**126 960**	**190 440**	**253 920**
CERs Revenues w $4.25	89930	269790	539580	809370	1079160
CERs Revenues w $12	253920	761760	1523520	2285280	3047040
Transaction Costs / CER	**6,0309546**	**4,359877**	**3,906703**	**3,740049**	**3,693388**
CDM transaction costs:					
PDD Costs:					
Baseline determination	20 000	20 000	20 000	20 000	20 000
Monitoring plan determination	20 000	20 000	20 000	20 000	20 000
Stakeholder consultation & IEE	6000	10 000	16 000	22 000	28 000
Validation	12 000	31 000	55 000	72 000	96 000
Travel cost validation	620	740	920	1 100	1 280
Host-country Approval (LoA)	375	375	375	375	375
Monitoring cost	12 000	36 000	72 000	108 000	144 000
Verification and Certification	6 620	18 740	36 920	55 100	73 280
2nd turn	5 120	14 240	27 920	41 600	55 280
3rd turn	5 120	14 240	27 920	41 600	55 280
4th turn	5 120	14 240	27 920	41 600	55 280
5th turn	5 120	14 240	27 920	41 600	55 280
6th turn	5 120	14 240	27 920	41 600	55 280
7th turn	5 120	14 240	27 920	41 600	55 280
8th turn	5 120	14 240	27 920	41 600	55 280
9th turn	5 120	14 240	27 920	41 600	55 280
10th turn	5 120	14 240	27 920	41 600	55 280
Registration cost (inc. in admin.)	0	0	0	0	0
Adaptation cost 2% of CERs	1 800	5 400	10800	16200	21600
Administration cost	2 120	6 350	12700	23080	35770
Total	**127615**	**276765**	**495995**	**712255**	**937825**

APPENDIX B

COST-BENEFIT ANALYSIS TABLES

Table 33 Bundling per se, with CER Price of $US 6

	5000 pigs	CER $US 6	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	49 804,55
2	Single Farm Project	11 %	24 638,97
3a	3 Farms Project	17 %	177 391,86
3b	6 Farms Project	19 %	408 517,85
3c	9 Farms Project	20 %	647 649,75
3d	12 Farms Project	20 %	875 811,47
	10000 pigs	CER $US 6	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	99 609,09
2	Single Farm Project	20 %	156 487,68
3a	2 Farms Project	23 %	364 702,77
3b	3 Farms Project	25 %	571 931,28
3c	4 Farms Project	25 %	778 858,04
3d	5 Farms Project	26 %	985 241,48
3e	6 Farms Project	26 %	1 192 971,97

Table 34 Bundling per se with Learning-by-doing and Information Availability, with CER Price of $US 4.25

	5000 pigs	CER $US 4.25	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	49 804,55
2	Single Farm Project	11 %	22 288,08
3a	3 Farms Project	15 %	130 339,20
3b	6 Farms Project	17 %	294 412,54
3c	9 Farms Project	17 %	466 491,79
3d	12 Farms Project	17 %	627 600,84
	10000 pigs	CER $US 4.25	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	99 609,09
2	Single Farm Project	19 %	129 812,75
3a	2 Farms Project	21 %	291 359,62
3b	3 Farms Project	22 %	451 906,49
3c	4 Farms Project	22 %	612 158,32
3d	5 Farms Project	22 %	771 866,83
3e	6 Farms Project	23 %	932 575,34

Table 35 Bundling per se with Learning-by-doing and Information Availability, with CER Price of $US 6

	5000 pigs	CER $US 6	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	49 804,55
2	Single Farm Project	15 %	46 638,97
3a	3 Farms Project	19 %	203 391,86
3b	6 Farms Project	20 %	440 517,85
3c	9 Farms Project	21 %	685 649,75
3d	12 Farms Project	21 %	919 811,47
	10000 pigs	CER $US 6	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	99 609,09
2	Single Farm Project	23 %	178 487,68
3a	2 Farms Project	25 %	388 702,77
3b	3 Farms Project	26 %	597 931,28
3c	4 Farms Project	26 %	806 858,04
3d	5 Farms Project	27 %	1 015 241,48
3e	6 Farms Project	27 %	1 224 971,97

Table 36 Verification and Certification Every 5 Years, with CER Price of $US 4.25

Every 5 years	5000 pigs	CER $US 4.25	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	49 804,55
2	Single Farm Project	15 %	46 046,82
3a	3 Farms Project	19 %	196 418,20
3b	6 Farms Project	20 %	423 971,91
3c	9 Farms Project	20 %	659 531,54
3d	12 Farms Project	21 %	884 120,98
Every 5 years	10000 pigs	CER $US 4.25	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	99 609,09
2	Single Farm Project	21 %	153 571,49
3a	2 Farms Project	23 %	336 278,49
3b	3 Farms Project	24 %	517 985,49
3c	4 Farms Project	24 %	699 397,44
3d	5 Farms Project	24 %	880 266,08
3e	6 Farms Project	24 %	1 062 134,71

Table 37 Verification and Certification Every 5 Years, with CER Price of $US 6

Every 5 years	5000 pigs	CER $US 6	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	49 804,55
2	Single Farm Project	18 %	70 397,70
3a	3 Farms Project	22 %	269 470,85
3b	6 Farms Project	23 %	570 077,22
3c	9 Farms Project	24 %	878 689,51
3d	12 Farms Project	24 %	1 176 331,61
Every 5 years	10000 pigs	CER $US 6	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	99 609,09
2	Single Farm Project	25 %	202 246,42
3a	2 Farms Project	27 %	433 621,64
3b	3 Farms Project	28 %	664 010,28
3c	4 Farms Project	28 %	894 097,16
3d	5 Farms Project	28 %	1 123 640,73
3e	6 Farms Project	28 %	1 354 531,35

Table 38 The Effect of Bundling per se and Additional Policy Options on Transaction Costs per CER for Projects of 5,000 pigs

Projects in Bundle	1	3	6	9	12
CERs	21160	42320	84640	126960	253920
1) Bundling per se	6,030955	6,516186	5,860054	5,64158	**3,681573**
2) Learning & Information	4,991257	5,901819	5,481983	5,342273	**3,50829**
3a) Verification every 2 years	4,023393	4,555884	4,162512	4,031624	**2,637465**
3b) Verification every 5 years	3,297495	3,546432	3,172909	3,048637	**1,984345**

Table 39 Bundling per se, with Learning-by-doing and Information Availability, with CER Price of $US 12

	5000 pigs	CER $US 12	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	49 804,55
2	Single Farm Project	26 %	130 132,51
3a	3 Farms Project	31 %	452 604,28
3b	6 Farms Project	32 %	938 942,69
3c	9 Farms Project	33 %	1 437 239,26
3d	12 Farms Project	34 %	1 921 733,98
	10000 pigs	CER $US 12	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	99 609,09
2	Single Farm Project	35 %	345 427,79
3a	2 Farms Project	38 %	722 589,71
3b	3 Farms Project	39 %	1 098 751,63
3c	4 Farms Project	39 %	1 474 618,50
3d	5 Farms Project	40 %	1 849 942,06
3e	6 Farms Project	40 %	2 226 265,61

Table 40 Verification and Certification Every 2 Years, with CER Price of $US 12

Every 2 years	5000 pigs	CER $US 12	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	49 804,55
2	Single Farm Project	27 %	143 230,26
3a	3 Farms Project	32 %	489 032,41
3b	6 Farms Project	34 %	1 010 366,38
3c	9 Farms Project	35 %	1 543 658,50
3d	12 Farms Project	35 %	2 063 148,78
Every 2 years	10000 pigs	CER $US 12	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	99 609,09
2	Single Farm Project	36 %	358 525,54
3a	2 Farms Project	39 %	747 352,65
3b	3 Farms Project	40 %	1 135 179,75
3c	4 Farms Project	40 %	1 522 711,81
3d	5 Farms Project	40 %	1 909 700,55
3e	6 Farms Project	41 %	2 297 689,29

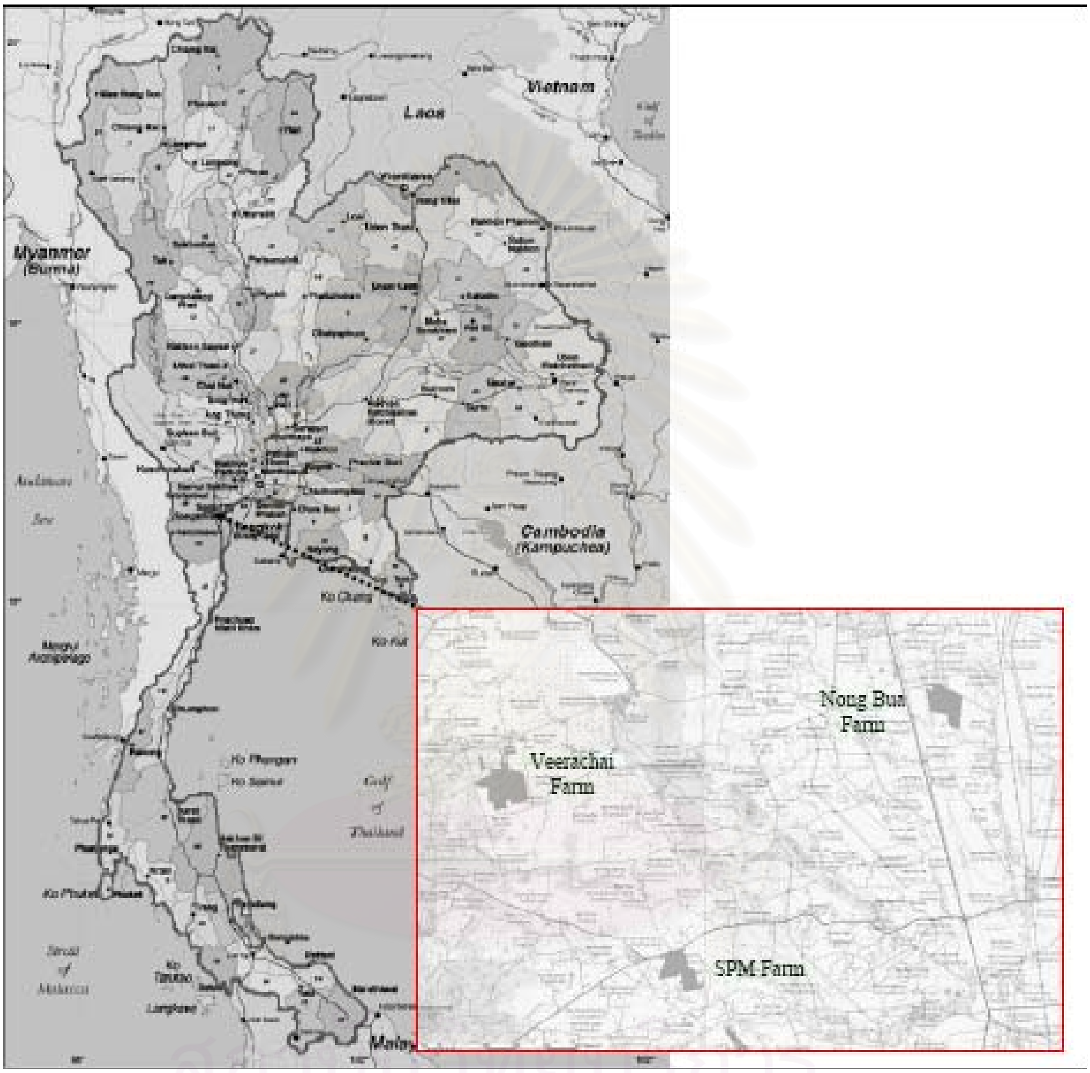
Table 41 Verification and Certification Every 5 Years, with CER Price of $US 12

Every 5 years	5000 pigs	CER $US 12	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	49 804,55
2	Single Farm Project	28 %	153 891,25
3a	3 Farms Project	34 %	518 683,28
3b	6 Farms Project	35 %	1 068 502,07
3c	9 Farms Project	36 %	1 630 279,02
3d	12 Farms Project	36 %	2 178 254,12
Every 5 years	10000 pigs	CER $US 12	
Cases	Number of Projects	IRR	NPV (w 8%)
1	Project w/o CDM	19 %	99 609,09
2	Single Farm Project	37 %	369 186,53
3a	2 Farms Project	39 %	767 508,58
3b	3 Farms Project	40 %	1 164 830,62
3c	4 Farms Project	41 %	1 561 857,62
3d	5 Farms Project	41 %	1 958 341,31
3e	6 Farms Project	41 %	2 355 824,99

APPENDIX C

MAP

Map 1 Location of the Ratchaburi Farms Biogas CDM Project



Source: ERM, 2005

BIOGRAPHY

Sanna Salmela received her M.Sc. degree in Environmental and Natural Resource Economics in July 2005 from Chulalongkorn University, in Bangkok, Thailand. She completed her BBA degree with specialization in Environmental and Risk Management in January 2004 after studying in the Helsinki School of Business, in Helsinki, Finland, and Pittsburg State University, in Kansas, USA. During the years 2001 – 2005 she complemented her studies with additional courses of Environmental Science and Politics, Development Studies and Sociology from the University of Helsinki. During her undergraduate studies, from January 2002 to October 2002, she worked as a Green Office Assistant at WWF Finland and coordinated the implementation of a Green Office Management System Project for reducing ecological footprint of the office and completed the management plan. She started her university studies after highschool in the University of Uppsala, in Sweden as a Swedish language and Chemistry student. Prior to her Master level studies she balanced between academics and sports career in Modern Pentathlon, in which she competed at international level.