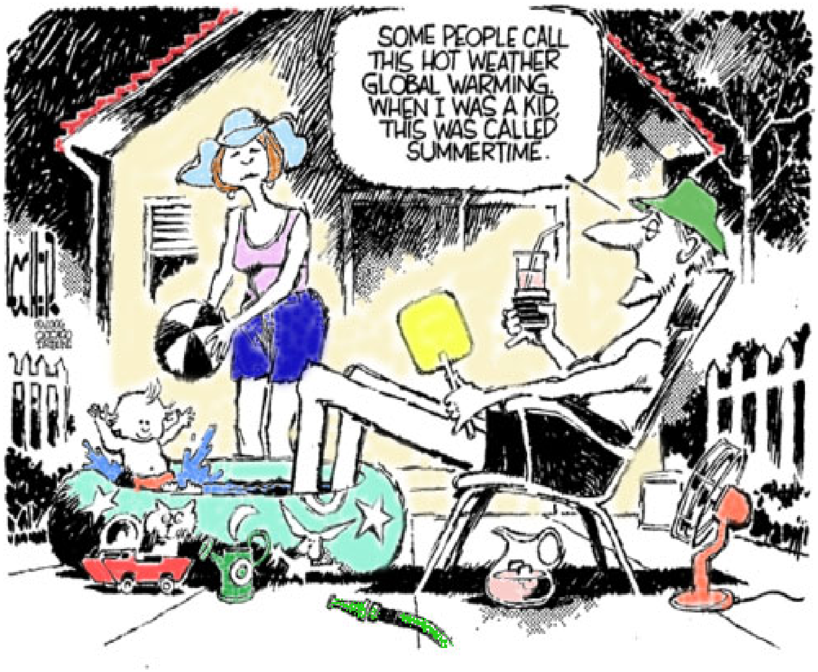
Master Thesis

The CDM and energy efficiency projects: how to approve a CHP-based district heating methodology?

Suggestions for changes based on a case study of approval attempts



Cássia Simons Januário
csjanuario@gmail.com

MSc. Environmental Policy and the Global Challenge: International, Regional and Local Perspectives, Roskilde University, Denmark.

Supervisors: Jan Andersen and Rikke Lybæk, Group n. 193

August 28, 2007

Abstract

This thesis analyses attempts to approve a CDM district heating methodology. This is approached using a case study method, in order to deeply understand the problem and suggest solutions. This empirical analysis is backed by the theory of sustainability, applied to district heating and cooling technology. Data is collected from primary and secondary sources and expert interviews.

The report includes chapters on district heating and cooling technology and CHP (combined heat and power) technology, including the benefits for reducing greenhouse gas emissions. A chapter on the Kyoto Protocol and associated problems is also included, both general and related to energy efficiency projects. Finally, a chapter on the case study is included, with an analysis of the reasons for lack of approval of a district heating methodology based on CHP, for CDM projects.

The proposals for the methodology have shown growing levels of experience in the drafting, increased complexity and thoroughness. The first proposal was rejected for being incomplete. The second proposal was also rejected, since even though it showed much more detail and complied better with the requirements of the Executive Board of the CDM, it was not considered conservative (it was considered that there was an overestimation of emissions reductions, thereby generating more revenue), and there was a lack of thoroughness and transparency. The third proposal again reflected many of the criticisms received and was more conservative. The basis for calculating emission reductions was changed several times throughout the process, to no avail.

Many of the problems did not refer to district heating technology itself, but to how to design a project that fits into the framework of the Kyoto Protocol and the CDM. And the problems reflected the disagreement between the project developers, the evaluators and the Meth Panel about what this design should be. It is difficult to establish a trend in the criticisms, they are almost never the same from one proposal to the nextSome of the problems are a fruit of the design of the Kyoto Protocol and the CDM.

Solutions to my research question, which is *How can the approval process of energy efficiency CDM methodologies, specifically targeting CHP and district heating, be improved?*, include: increased communication between the evaluators, the Executive Board and the project developers, more time and more funding to be devoted to the whole process, which may address the problems of lack of attention and thoroughness, clearer guidelines and more experience. General problems which affect the whole process can be solved by establishing a longer time frame for the second commitment period of the Kyoto Protocol, expanding the rules for forestry, encouraging the build up of experience with programmatic CDM with clear guidelines, using more full time paid staff. Ideas to be considered are also establishing a minimum standard definition for sustainability (this is currently defined by each country) to avoid a 'race to the bottom' and reconsidering the concept of additionality for projects with high sustainable development components.

Contents

Preface and Acknowledgements

This report is my Master thesis for MSc Environmental Policy at Roskilde University. As a foreign student in Denmark, I was glad for the opportunity to take advantage of Danish expertise in pursuing this degree. For my first year project, I wrote about offshore wind energy in Britain. Even though I was not focused on Denmark, being here gave me access to experts and information on the Danish experiences. For the thesis, I've written about district heating in connection with CDM (Clean Development Mechanism) projects. Even with little knowledge of Danish language, especially in the beginning, being here has made a difference in terms of the information I could procure in the course of my studies. Overall, that has been a positive aspect of studying in Denmark.

I would like to thank my supervirsors, Jan Andersen and Rikke Lybæk, my opponent Daragh Glynn and his supervirsor Peder Agger, and Marieke Head, for the valuable time and feedback I received from them. Many thanks to Desiree Della Monica Ferreira for proofreading and honest comments. Also, thanks to the department and the University for having made funds and resources available for my research. To the leaders of the Main Course II: thank you for the course and the demands which pushed me in the right direction!

I appreciate very much the time and information my interviewees were willing to give me, and I would like to thank Jens Brandt Sørensen for leading me to the case study I chose for this thesis.

To my friends and family, both here and abroad, and to my fiancé Sune Hørlück: I could not have done it without you! Your care and support mean the world to me.

Thanks!

Abbreviations and Definitions

I have tried to keep abbreviations to a minimum. In any case, this list should provide guidance to the abbreviations that have made their way into the text, and the following notes and points explain some key concepts related to the Kyoto Protocol. As a reference, my use of the word 'carbon' throughout the text follows the media's use of the word, and refers to all of the gases covered by the Kyoto Protocol.

Acronym	Meaning
AIJ	Activities Implemented Jointly[1]
Annex I countries	Parties to the Protocol with obligatory emission reductions
Danida	Danish International Development Assistance
CDM	Clean Development Mechanism[2]
CERs	Certified Emission Reductions, from the CDM
CHP	Combined heat and power generation
CO_2e	CO_2 equivalent[3]
COP/MOP or CMP	Conference and Meeting of the Parties[4]
COP	Conference of the Parties, establishes rules for UNFCCC
DNA	Designated National Authority of a Party to the Protocol[5]
DOE	Designated Operational Entity[6]
ex-ante	Before the event (a prediction)
ex-post	After the event (measured data)
GHGs	Greenhouse Gases
Grades: A, B, C	A: accepted, B: accepted pending revisions, C: rejected
GWP	Global warming potential
IEA	International Energy Agency
IPCC	Intergovernmental Panel of Climate Change
JI	Joint Implementation[7]
LULUCF	Land use, land use change and forestry
Meth Panel	Methodological Panel of the CDM[8]
NM	New (proposed) methodology for a CDM project
NM0058	Proposal 1 by Danida for a district heating methodology
NM0096	Proposal 2 by Danida for a district heating methodology
NM0181	Proposal 3 by Danida for a district heating methodology
Non-Annex I countries	Parties to the Protocol without obligatory reductions
PDD	Project Design Document for a CDM project
SSC	Small Scale CDM project[9]
UNFCCC	United Nations Framework Convention on Climate Change

1. AIJ were a sort of trial period for JI (and later CDM) projects, under which projects were carried out and emission reductions calculated.

2. CDM is one of the flexible mechanisms of the Kyoto Protocol, for projects in developing countries.

3. CO_2e is a unit of measurement of reduction of greenhouse gases covered by the Kyoto Protocol, chosen because CO_2 has the lowest global warming potential of

the 6 gases in question (carbon dioxide: CO_2, methane: CH_4, nitrous oxide: N_2O, hydrofluorocarbons: HFCs, perfluorocarbons: PFCs and hexafluoride: SF_6)

4. COP/MOP: Parties to the UNFCCC meet at a COP, Parties to the UNFCCC *and* to the Kyoto Protocol meet at a MOP.
5. DNA approves CDM projects, securing sustainable development in developing countries;
6. DOE independently validates, verifies or certifies projects
7. JI is one of the mechanisms of the Kyoto Protocol, for projects in (basically) transition economies.
8. Meth Panel evaluates new methodological submissions
9. SSC are for projects under 15GW, 60GWh or 60k ton CO_2e reduction. These methodologies are developed by the Executive Board.

Other concepts:

- Additionality: Emission reductions that happen in addition to what might occur in the absence of a CDM project;
- Baseline: a scenario showing what would have happened in the absence of the CDM, including baseline emissions;
- Methodology: A method for estimating a baseline and a monitoring methodology for determining the emission reductions from a CDM project;
- Rebound effect: Effect of changed patterns of consumption in response to a CDM project (if consumption increases, this increases the baseline emissions and reduces emission reductions). For example regarding district heating this could be less tolerance for cold rooms resulting in higher heat demand now that a district heating system is present;
- Gaming: Taking advantage of loopholes in the CDM that allow financial gain without reducing CO_2;
- Leakage: Net change in emissions outside the project boundary but caused by the CDM project (if the net change is positive, this diminishes overall emission reductions);
- Project Boundary: Boundaries beyond which emission reductions are not considered in a CDM project;
- Fugitive fuel emissions: By-products, loss or waste emissions from fuel production, handling or transport.

Chapter 1

The Problem

This chapter will present the research area, and upon this background the problem formulation is presented, with the basic research question and the need-to-know information to answer these questions. Further details are presented in Annex A.

1.1 Problem Area

Energy is one of the drivers of all natural and man-made processes. It is crucial to maintaining life on Earth and driving food production, industrial processes, and manufacturing everything which is a part of our lives. Our energy needs have been supplied by different sources over time, such as wood, peat, coal, oil, water, wind, among others. Some of these sources, namely fossil fuels such as coal, oil, and natural gas, release gases when burned and through their continued use, we have caused increased levels of pollution in the atmosphere. We have also induced anthropogenic climate change: global warming. The term is used here to refer to the average temperature increases on Earth, which are a product of man-made processes. They began in earnest at the time of the Industrial Revolution [Miller 2003, IPCC 2001].

These temperature increases are caused by the addition of certain greenhouse gases. These gases are so called because they trap heat in the atmosphere, keeping the heat emitted by the planet from escaping into space. This is very important for life on Earth, as it keeps the average temperature of the Earth a balmy 15^{o}C, rather than the sub-zero temperatures the Earth would have in the absence of greenhouse gases. These gases include carbon dioxide, methane, nitrous oxide, and many others. We are adding gases by burning fossil fuels, and the average temperature of the Earth is rising. We are also adding gases by cutting down forests which absorb them, and the use of certain farming methods (e.g. adding large quantities of nitrous oxide (N_2O) as fertilizer, some of which escapes to the atmosphere and water supplies) [Miller 2003, IPCC 2001, Flannery 2005].

This has the potential to bring many serious and even catastrophic consequences. They include changes in weather patterns, which in turn affect agriculture: where we plant, which crops we plant in those areas, the availability of water, sunlight and heat: in other words, this affects our patterns of food production. Desertification and salination are only some of the likely consequences of changed weather patterns on agriculture. Changed patterns and increased extreme weather events can make the incidence of floods, storms, wildfires and droughts rise. Extreme heat events can kill more people than extreme cold events. This will affect not only humans but other living organisms, causing changes in biodiversity, ecosystem equilibrium, and possibly mass extinctions [Miller 2003, Flannery 2005, New Scientist 2007].

Weather changes can also influence the transmission patterns of vector-borne diseases such as malaria, and of water-borne diseases such as diarrhea. Such large changes can eventually lead to migrations and so-called 'environmental refugees', which are expected to be much greater in number than current refugees from wars and political instabilities. Mass migrations will have untold consequences for local conflict, food availability, and the spread of disease. Certain coastal areas could become uninhabitable, and many of the world's cities are close to coastal areas or rivers. Climate scientists are unable to predict which negative and positive feedback loops will become active, but global warming can potentially fuel itself and make the changes all the more extreme [Miller 2003, Flannery 2005, Reuters 2007c].

The expected dire consequences of global warming require action now to try and avoid them. Besides the problems outlined above, fossil fuels are protagonists in political dramas as well.

> *"The recent spikes in petroleum prices, coupled with instability in the Middle East and the 'weaponisation' of energy supplies by the likes of Vladimir Putin and Hugo Chavez, have increased concern over energy security and the macroeconomic damage that can be done as a result of a dependence upon imported energy sources subject to the volatility of the international commodity markets"* [Sawyer 2007].

Relations with Russia and the Middle East, whom many countries depend on for natural gas and oil, can be problematic and affect prices and even availability of these commodities. War in Iraq and potential conflicts with Iran are two examples of this. Growing consumption and dwindling supplies are taking their toll: lack of investment in refineries is also taxing production and affecting oil prices. Global competition for resources by China, India and the US will likely cause price hikes [The Economist 2005b, The Economist 2006, Airtricity 2006]. And "the price of oil affects the cost of almost everything" [The Economist 2005a]. "In the absence of climate change policies, the most cost-effective, low-risk energy investment would almost certainly be coal an energy resource which like the US, Europe has in some abundance" [McCracken 2007]. However, coal is one of the dirtiest fuels in terms of greenhouse gas emissions [Flannery 2005].

For all the reasons outlined above, switching to non-fossil energy is advantageous and necessary. Climate change policy that requires reducing energy use and switching fuels can be an advantage for long term energy security [IEA 2007a]. Unfortunately fossil fuels, especially coal, are some of the cheapest sources available, making a switch a controversial issue from the point of view of countries' desire for economic growth. Energy is needed to power such growth, and money to pay for more expensive energy is not always available.

So called energy efficiency technologies include both energy saving and efficient use of use (e.g. both better insulation which reduces use of energy and CHP which uses energy more efficiently, are considered energy efficiency technologies). Energy conservation can accomplish significant greenhouse gas emission reductions, for example better building design can almost eliminate the need for heating and cooling. Energy saving should be the first measures taken to reduce emissions, followed then by energy efficiency [Andersen 2007, Bradley 2006, Hawken *et al* 1999].

1.1.1 The Kyoto Protocol

> *"It is hard to get the nations of the world to agree on anything, let alone a common approach to a difficulty which is complicated, whose consequences aren't entirely clear, and which will have its most severe effects decades and even centuries in the future."* [UNFCCC 2007]

The Kyoto Protocol is an amendement to the UNFCCC treaty. It contains more stringent targets and requires countries to reduce their greenhouse gas emissions, setting legally binding targets for developed nations and offering the so-called flexible mechanisms, which give countries options as to how they will reduce emissions. Countries can therefore choose the most cost effective option: reducing emissions, trading emissions, setting up projects in developing countries or post-Soviet economies [UNFCCC 2007].

The Protocol has the support of many nations of the world. It is very complex and must cater to a variety of interests [UNFCCC 2007]. Thus, it is inevitable that it also contains problems. To cite one example: the time frame of the agreement is currently too short: many projects that could potentially save a lot of CO_2 have not been invested in because the return on those investments will come after the end of the Protocol period (the first commitment period ends 2012). Holders of CERs (certified emissions reductions: tradeable certificates that testify to the carbon savings of the owner, generated by CDM projects) have been assured that the certificates and CO_2 savings they have invested in now will still be valid after 2012, but no one knows what the design of the post-Kyoto system will be like [Sørensen 2006]. "Preliminary findings from IETAs recent Market Sentiment Survey indicate that more than 90% of respondents believe that the greenhouse gas market market is an established instrument that will continue post 2012. In addition, more than 65% of those surveyed anticipated that a global market will be established in the next 10 years... However there is much ambiguity about the extent to which CDM and JI[1] will play a role in compliance" [The World Bank 2007].

One of the instruments of the Kyoto Protocol is the Clean Development Mechanism. This is the instrument through which developed countries can fund carbon emissions-reducing projects in developing countries, these projects then helping to offset carbon emissions in the developed countries. CDM projects are intended to be a means of technology transfer and a means of diminishing world emissions of CO_2, while helping countries that have emission reduction quotas meet their targets. In the context of climate change, "the main argument [for technology transfer] is that if developing countries industrialize by using obsolete, inefficient production techniques that were employed by richer countries to generate their wealth, then environmental deterioration will inevitably follow. Since most research and development occurs within the OECD regions, technology transfer and co-operation with developing countries and

[1] Joint implementation, another flexible mechanism of the Kyoto Protocol.

capacity building are likely to be necessary conditions for sustainable development" [Siddiqi and Lee 2001].

For each CDM project, the pursuing entity must have the project approved by the Executive Board of the UNFCCC. The system has developed in such a way that methodologies for each kind of project become approved and then can be followed by anyone who wants to have approved a similar project. Once there is a method for calculating current emissions and emission reductions, which is approved by the Executive Board, it is easier to get new projects of the same type started. Methodologies exist for many different kinds of projects, both general and specific. Currently there are 38 approved methodologies and 10 consolidated ones [CDM Pipeline Jan. 2007].

Methodology generation is a bottom up process. The parties interested in carrying out a project can choose from the existing methodologies, or create a new one and propose it to the Executive Board as a standard for the particular technology they want to employ. So for every new kind of proposal the Executive Board evaluates and sometimes changes its procedures to harmonize with a new idea or approach. As such, the procedures of the Executive Board and the methodologies are changed and revised *ad hoc*, and therefore are a system in evolution. This system is complex and introduces many uncertainties, possible disagreements, and also a lot of bureaucracy. Project developers never know if their methodologies will be approved, changed, revised. The operating and eligibility rules have been changed along the way (for example eligibility for small scale methodologies has been changed [WB-CFU 2006], and changes have been made to the forms for methodology submission, as evidenced in [Proposal 1: PDD 2004, Proposal 2: PDD 2005, Proposal 3: PDD 2006a]).

CDM should contribute to sustainable development. That is one of the objectives of the mechanism. To put it simply, there is no reason that developing countries should follow the same route as the developed world in resource and energy use to achieve the same standard of living, because then developing countries will end up in the same polluted state and add to the already stressed natural environment. Technology transfer is one key way in which sustainable development can be boosted [UNFCCC 2007]. The technology transfer aspect is important and should be linked to the generation of CERs. Unfortunately due to the difficulties encountered in the CDM, Danida (for example) has chosen to de-link technology transfer and CERs, focusing more on the purchase of CERs in the market [Andersen 2007].

> *Making development more sustainable ... can enhance both mitigative and adaptive capacity, ... and by changing development paths can make a major contribution to climate change mitigation, but implementation may require resources to overcome multiple barriers"* [IPCC 2007b].

When the CDM began, the first task was for interested parties to submit a project proposal and an accompanying methodology, which could then be used for other projects of the same nature. The first CDM methodologies to have gotten approval were, in Jørgen Fenhann's words, "low hanging fruit"[2]. These methodologies were simple and straightforward in the tracing of the carbon savings back to the project activity. The additionality criteria was easy to test, which is not the case with certain categories of

[2] Fenhann works with CDM at the Unep Risø Centre. Statement source: [Fenhann 2007]

methodologies, such as energy efficiency [Fenhann 2007, Hayashi and Michaelowa 2007]. The (in some cases) stringent policy of the Executive Board in relation to the approval of methodologies is meant to secure the integrity of the Executive Board in light of its objectives. Unfortunately, this also means that energy efficiency methodologies (new windows, better insulation, more efficient heating, among others), to cite an example, have had a difficult time being approved. [Sørensen 2006] highlights that in some of the methodologies being approved have not involved real technology transfer, just stop-gap solutions which could have been accomplished by simple legislation that raised environmental standards, diminishing the real utility of the CDM [Sørensen 2006], namely end-of-pipe projects for reducing HFCs, PFCs and SF_6 emissions.

In light of the new IPCC reports from 2007, which put more stress on adaptation as well as mitigation [IPCC 2007a, IPCC 2007b], the roles of sustainable development and technology transfer become even larger. The more developed a country is, the better their chances of being able to adapt to the changes brought about by climate change. The more sustainable development is encouraged, the better the chances for all the world to adapt successfully to climate change [Pielke *et al* 2007, Science Daily 2007]. At this stage, after many methodologies already exist and all the 'low hanging fruit' have been picked, the tendency is that the new methodologies that will be submitted for approval will be the more difficult ones. Many energy efficiency and renewable energy technologies reduce only CO_2 but encourage sustainable development. The approval of methodologies for these technologies has been more difficult due to their large scale and complexity, aside from the low CER returns (many previous methodologies concerned the other gases included in the Protocol, which have much greater warming potential than CO_2) [Fenhann 2007, Varming 2005].

1.1.2 Attempts towards a district heating CDM methodology

District heating is one of the energy efficiency technologies that can help reduce world emissions of greenhouse gases. A large district heating network is more efficient than several small ones, and a district heating network is more efficient than individual boilers and furnaces [Werner 2006, District Energy Library 2007, Overgaard *et al* 2005].

A district heating system coupled to a CHP (combined heat and power) plant can help avoid waste of energy at the power plant, and avoid use of extra fuel for central heating systems. A CHP plant run on renewable energy and coupled with district heating can significantly lower emissions [Nordvärme 1995, CHPA 2007, US CHPA 2007].

In the context of the Kyoto Protocol, district heating is a technology that brings few rewards: it generates few certificates as it only reduces CO_2, the gas with the lowest global warming potential of all the Kyoto-covered gases. It is, however, a technology that can bring sustainable development, even if it is complex and requires planning and administrative capacity. Therefore an attempt should be made to plan CDM projects using this technology [Werner 2006, IEA DHC/CHP 2002].

However difficult district heating and CHP technology can be in terms of planning and implementation as a CDM project, they are important for sustainable development and reducing greenhouse gas emissions. Due to this, the target of this thesis is to suggest ways to optimize conditions for approval of methodologies that contain these and other energy efficiency technologies.

The Danish Foreign Ministry has submitted three proposals for a CDM district heating methodology. The requests have been presented by Danida[3] with ABB Denmark as the contractor (responsible for implementation, but not part of the design of the proposal). They selected the consultancy COWI to write them, based on their expertise of district heating systems in China, the immediate target for the methodology to be used. The first proposal, called NM0058 and which I have called Proposal 1, was titled Energy Efficiency Improvements-Hou Ma District Heating, Shanxi Province, China, and was rejected (grade C) in 2004. The second proposal, NM0096, which I have called Proposal 2: Energy Efficiency Improvements - Hou Ma District Heating, Shanxi Province, P.R.C. (China), was rejected again (grade C) in 2005. When the second rejection came, the Ministry contacted two of the people involved in reviewing the proposals, Ralph Harthan and Lambert Schneider, who work for the Öko-Institut in Germany[4], to prepare a third proposal (as employees of the Öko-Institut rather than as consultants for the UNFCCC, with COWI giving support) [Jürgen 2007]. This third proposal, NM0181, which I have called Proposal 3: Introduction of a new primary district heating system - Houma District Heating project, Shanxi Province, P.R.C (China), has received a grade B[5] [UNFCCC 2007]. The Foreign Ministry is currently evaluating if a revision of the last proposal will be attempted [Jürgen 2007].

Briefly, Proposal 1 was weak and reflected a lack of experience on the part of the project developers. Therefore it was rejected. Proposal 2 was much better developed and written, but still it contained some problems, and was rejected. The problems included lack of thouroughness in estimating alternative options, non-conservative and sometimes non-transparent assumptions and calculations, among others. Proposal 3 was the best developed and most conservative one. The request for review of this proposal came as a suprise. The lack of approval of these methodologies reflects the difficulties of making a watertight methodology for energy efficiency projects, and also reflects some aspects with the CDM and the Kyoto Protocol such as the bottom up approach, and the requirements for additionality, to give some examples. These have unfortunate consequences for certain categories of methodologies. The desk reviewers are experts in district heating (in this case), but their opinions are not unanimous - they differ and it is unclear what criteria the Executive Board uses to choose who is correct and who should be listened to. Naturally, the failure also reflects problems related to the developers of the methodologies [Fenhann 2007].

1.1.3 Summary

Summing up key points in the problem area: our energy use is mostly of fossil origin and releases polluting and greenhouse gases into the atmosphere. Besides political considerations regarding price and availability of fuels, the threat of global warming can have catastrophic consequences for our way of life - affecting the weather, biodiversity, food production, disease patterns and health, and social structures.

[3]Danida stands for Danish International Development Assistance, which is part of the Ministry of Foreign Affairs of Denmark [UM 2007].

[4]The Öko-Intitut, in English the Institute for Applied Ecology, "is a leading European research and consultancy institution working for a sustainable future" [Öko-Institut 2007].

[5]The grades mean: A, approved; B, approved pending revision; C, rejected.

The Kyoto Protocol is an agreement signed by many countries, committing themselves to lowering their greenhouse gas emissions. CDM projects are a mechanism of the Kyoto Protocol, to bring sustainable development and transfer of technology to developing countries, by installing CO_2-reducing projects, which in turn help developed countries meet their targets. It's been more difficult to approve energy efficiency methodologies (there are different kinds of energy efficiency, but they have nearly all faced problems), due to their scale and complexity, compared to for instance end-of-pipe measures for the reduction of industrial gas emissions.

The Danish government has been attempting to approve a methodology for district heating, and has been denied three times. District heating is complex and can be difficult to handle in calculating additionality and leakeage.

1.1.4 Problem Formulation

The purpose of this report is to try and find a solution to the district heating methodology case. The main research question can be thus formulated:

How can the approval process of energy efficiency CDM methodologies, specifically targeting CHP and district heating, be improved?

The focus of the thesis will be on the question above, highlighting the aspect of sustainability. The district heating case will be handled as a case study. Technologies like district heating and cooling offer many benefits, not least that they increase efficiency of energy use, and help reduce global warming in doing so. This and other energy efficiency technologies should be more widely used to combat climate change, and therefore it is important to try to solve the problems in this case. Energy efficiency projects have the potential to aid sustainable development. An effort should be made to introduce these technologies in wider areas of the world. While district heating as a CDM methodology can be used in Eurasia, district cooling (a sister technology) has many applications in the warmer climates of many developing countries.

Supporting questions whose answers could illuminate the research question above are:

1. *Are CHP, district heating and cooling able to contribute to reduce greenhouse gases? What are the benefits of CHP, district heating and cooling technologies, and can they be used for CDM projects?*

2. *Can district heating and cooling impact sustainable development?*

3. *What are the main problems of the CDM, related to energy efficiency?*

4. *Why have the previous district heating methodologies not been approved? What solutions have been discussed in order to get these methodologies approved? Can anything new be contributed?*

The answers to these questions pose new, wider issues, such as the implications of the lack of approval of this methodology or other similar types of methodologies, for sustainable development and other goals of the Kyoto Protocol.

The target audience of this thesis includes the UNFCCC Executive Board and Meth Panel, Danida, COWI and the Öko-Institut, which are the parties involved in preparing and evaluating the failed district heating methodologies. They will have an interest in any possible fresh input or insights gained from the analysis of the case. In general, the wider UNFCCC staff, consultancies and other companies that are trying to develop new methodologies, begin projects and contribute to cutting global CO_2, will be interested in an improvement of procedures for energy efficiency CDM projects that bring sustainable development and reduce emissions. The interests of this audience are different: COWI and Danida would like to understand the denial of the previous proposals. Danida suggests that the evaluation of re-submitted proposals be made in comparison to the previously submitted proposals, as this would diminish contradictory criticisms. They also would prefer that discussion with evaluators be allowed. The process has left them frustrated and uncertain what the Executive Board really wants [Jürgen 2007][6].

The approval of a district heating methodology is wished for by the Foreign Ministry, by consultancies, companies and even non-governmental institutions that would/could be involved in such projects (e.g. the Unep Risø Centre). How to get this methodology just right would be very useful for Denmark and for countries on the receiving end of the projects (possibilities include for instance China, Russia and Eastern Europe for district heating, and many tropical countries for district cooling). District heating is one of the main technologies that Denmark can export, along with windpower, some kinds of biomass and waste management [Jürgen 2007, Sørensen 2006, Fenhann 2007]. This report is also relevant for politicians and civil servants, lobbyists and industry representatives. And finally, it is interesting for academics. The content of the thesis will be relevant in contributing to the discussions on ways to solve the climate change problem.

1.2 Structure of the Report

For every chapter or long section there is a summary to help remind the reader of relevant concepts and ideas, and bring home the main points I am trying to make. The report is organized as follows:

- Chapter 1. The problem. This chapter has introduced the problem area and the problem formulation, including the target audience. The idea is to situate the coming chapters by expanding on the importance of energy, global warming, and the Kyoto protocol.
- Chapter 2. Project design. This chapter explains the methodology, methods, data collection and analysis techniques adopted for this thesis.
- Chapter 3. Theoretical concepts. This chapter introduces the theory of sustainable development, which is the metric against which district heating, as a sustainable and carbon reducing technology, is measured. This basis is kept in mind throughout the analysis.

[6] This is the position of this source, which I have taken to represent the wishes of Danida in this case, even though it is not an ‘official’ published statement.

- Chapter 4. The Kyoto Protocol and the CDM: Issues. This chapter describes problems of the Kyoto Protocol and the CDM which affect the uptake of energy efficiency and district heating methodologies. This is analysed in connection with environmental sustainability. This helps answer sub-question 3: What are the main problems of the CDM, related to energy efficiency?

- Chapter 5. District heating and cooling. This chapter introduces basic technological aspects of district heating and cooling, setting in the context of the CDM and sustainability. This chapter answers sub-questions 1 and 2: Are CHP, district heating and cooling able to contribute to reduce greenhouse gases? What are the benefits of CHP, district heating and cooling technologies, and can they be used for CDM projects? and Can district heating and cooling impact sustainable development?

- Chapter 6. The district heating CDM methodologies. This is the case study. The introductions and discussions of the previous chapters set a backdrop for the events connected with approval attempts for a district heating methodology. This chapter contains the basic description of the case, a short introduction to China, and comments, discussion and summary of the case. This chapter answers sub-question 4: Why have the previous district heating methodologies not been approved? What solutions have been discussed in order to get these methodologies approved? Can anything new be contributed?

- Chapter 7. Discussion and Conclusion. This chapter includes a general discussion of my research questions and answers to them, in light of sustainable development as an objective of CDM projects. Each sub-question and the main research question (How can the approval process of energy efficiency CDM methodologies, specifically targeting CHP and district heating, be improved?) are answered and suggestions to solve the problem are made.

- Annex A. The Kyoto Protocol. Basic introduction to the Protocol, the CDM, and methodology approval steps.

- Annex B. Global Reporting Initiative core indicators of sustainability.

- Annex C. Interviewees.

Chapter 2

Project Design

This Chapter introduces how I plan to go about answering the research questions. I explain the approach and the underlying assumptions, and in the next Chapter (3) I explore the theoretical concepts which will be applied. I also discuss the merits and drawbacks of the theory and the general methodology and project design, and how I have applied the design.

The nature of this thesis is the description of the problems associated with approval of a district heating CDM methodology, upon the background of the Kyoto Protocol and the CDM. I use a case study of the failed attempts at approval of the methodology. I set this in the context of some of the ultimate objectives of the CDM and the Kyoto Protocol, namely sustainable development. It is an inductive and applied research piece directed at solving a specific problem - how to bring about the approval of a district heating CDM methodology.

The purpose of research is then best suited to the application of an interdisciplinary approach, where the important aspect is the solution to the problem, rather than 'disciplinary purity'. The field of research is therefore a mixture of political, economical and environmental issues, with a methodological approach based on qualitative data gathered from interviews and documents, and a case study, against the backdrop of a technological and logistics oriented assessment of district heating and emission reductions. The problem is complex, and the aim of the project is to offer a lot of different information, to be pieced together and which will hopefully add to a greater understanding of the issues involved.

The data collection is guided by the requirements of the research questions and sub-questions. The methodology is mixed, on account of the different strategies for gathering information and the different kinds of information gathered. It is also mainly exploratory and problem solving in nature, with some instances of description and explanation.

2.1 Methodology

The methodology being applied is a mixed one. The overarching approach is qualitative, because the thesis is used as a vehicle to deeply understand the complexity of the Kyoto Protocol and the solutions being discussed and carried out, in an attempt to know how to best guide any necessary changes. The approach is problem based and is the approach favoured by the department and Roskilde University, and it builds skills that allow one to tackle other problems in other fields [Olsen and Pedersen 2005], meaning it is flexible and open. The overall approach is then "problem and context oriented approach with a methodology generating aspect" [Lybæk 2003].

The approach was developed based on interviews, cooperation with supervisors and staff at the university, familiarization with research methods and analysis techniques, and delimited by the research questions. Data collection will take place in the form of interviews and primary and secondary source documents. Many of the documents are public and easily available, since Kyoto Protocol documentation can be found online.

A case study can be defined simply as in depth research of a few, or one, case. Cases can arise from naturally occurring phenomena, and their analysis can be directed at the uniqueness or alternately the generalisability of the case. The objective is to gather a large volume of (often unstructured) information [Hammersley 2004]. A case study can have several roles in an evaluation: explanatory, descriptive, illustrative, explorative and evaluative [Yin 1994]. For the purpose of this thesis, a case study is seen as a part of the research design, which can incorporate multiple methods for collecting data. The evaluation that is being carried out of the attempts to approve the district heating methodology, in the form of a case study, is descriptive, illustrative and explorative.

"What is my case a case of?" [Schrank 2006] The district heating case is approached as a unique case. My analysis will focus on the approval process failure, and I will not go into depth into other aspects of the case, for example China and their energy policy. It must be noted, of course, that there are some characteristics of this case that are common to other energy efficiency methodologies, and these are discussed (briefly, their decentralized nature, low CER generation, complex planning, potential for technology transfer and sustainable development). The idea of approaching the case as unique is to try and find solutions to the problems. The data collection methods used were the study of documents and some qualitative interviewing.

There are several instances when a case study is the most appropriate approach. Conditions for that include a research question of the type 'how' or 'why', a research question where the events cannot be controlled (as opposed to laboratory settings), and a contemporary focus. These conditions are all valid for my main research question. My chosen case study can offer insight into a phenomena that is fairly new and with few, if any, relevant comparatives. The process highlighted as lacking in the case is important for the future of the Kyoto Protocol and a reduction of greenhouse gases, therefore even without a direct comparison to a similar case, this one-shot case study can offer valuable insight [Schrank 2006, Yin 1994]. My one shot case study is supported by evidence found in documents and by observations of the outside world.

The chosen methodology is biased by a technocratic viewpoint, both on the part of the researcher and the stakeholders interviewed in the process[1]. Quantitative data is used as a base for discussing technological merits and economics of the previously

[1] Technocracy in this case means "management of society by technical experts" [Merriam Webster Dictionary 2007a]. A technocratic viewpoint is one that supports the idea of policy being made by "technocrats, or those with highly technical knowledge and expertise whose decisions are unconstrained by political processes" [UNRISD 2004].

approved methodologies, and the expert opinions collected carry the same kind of bias. The project does not include non-decision-maker stakeholders, the users of the CDM projects, and the beneficiaries of less atmospheric CO_2, and therefore is not democratic, but technocratic. The scope and value of this thesis rests on finding a way of having a district heating methodology, adding to the discussion about the value of current CDM projects as a solution to global warming, and potential for discussion of the issue currently exists, including media coverage. At the end, an attempt will be made at generalizing and suggesting further research.

Validity and Reliability: Validity is in essence the measurement of whether what was studied is an accurate representation of reality [Smith 2004]. Triangulation can be defined as the use of different data collection methods in order to strengthen the picture of reality being generated [Frechtling *et al* 1997]. The validity of the data collected for this thesis is reinforced by triangulation in several ways: by checking other sources such as books to confirm the interviewees statements or analysis, by asking some of the same questions to different interviewees. I have tried to include what the interviewees have stated rather than my opinion of it (authentic data), even if it is contradictory to my opinions (inclusiveness)[Yin 1994]. The validity of the thesis also rests on the strength of the explanations given - by the logic used in them.

Internal validity is the certainty with which one can affirm causal relationships in the phenomena being researched. This is confirmed by the absence of other plausible explanations for the same phenomena [Brewer 2004]. This is valid for explanatory and causal studies, not for descriptive or exploratory studies [Yin 1994]. Therefore, the concept of internal validity in my thesis, which is descriptive and exploratory in nature, is not applicable.

This discussion on external validity is based on concepts from [Yin 1994]: external validity is the extent to which the data can be generalised. The case study was chosen based on its unique characteristics, but it also has common characteristics with category of project that the district heating methodology falls into: energy efficiency. These characteristics are a potential for technology transfer and fostering sustainable development, low level of CERs generated and therefore a longer return on investment (compared to other CDM projects), and complex planning requirements. Since the case was not chosen based on its generalisability, it is not obligatory to apply the concept of external validity. However since the case can, to some extent, be generalised, I will show these common characteristics so as to justify the external validity of the case. These characteristics reflect a theory about what constitutes energy efficiency projects in the context of the CDM.

Reliability is indicated by having few random errors or inconsistencies in the data. In qualitative studies, reliability can be defined as the ability of a result to withstand investigation by different methods, and remain stable throughout and over time [Smith 2004]. The reliability of this thesis is increased by the investigation of the same phenomena (namely, issues related to the Kyoto Protocol) by two different methods: interviews with relevant stakeholders and analysis of documentary data.

The case for using a mixed-method approach, meaning mixing (in this case) qualitative methods or analysis at different stages of the project, comes from the fact that studies are carried out in a “complex social environment with features that affect the success of the project. To ignore the complexity of the background is to impoverish the evaluation. ... By using different sources and methods at various points in the evaluation process, the evaluation team can build on the strength of each type of data collection and minimize the weaknesses of any single approach. A multimethod approach to evaluation can increase both the validity and reliability of evaluation data. ... This approach - called triangulation - is most often mentioned as the main advantage of the mixed method approach. Combining the two methods pays off in improved instrumentation for all data collection approaches and in sharpening the evaluator's understanding of findings."[Frechtling *et al* 1997]. Qualitative methods are used when interviewing in depth and collecting information from written sources.

2.2 Data collection methods

Searching documentation is one of the data collection methods used in this thesis. The strengths of this method include that is is exact, stable, and can have a long coverage of events over time. The weaknesses include unknown bias on the part of the author, bias on the part of the researcher, and problems of access to data (e.g. documents can have special access restrictions). While bias cannot be filtered out from documentary evidence, the data can be compared to data from other sources in an attempt to reduce bias [Yin 1994]. Primary data on the Kyoto Protocol will be gathered from documents, websites and records. Secondary sources include journal articles and books. These sources provide most of the material and come from having access to libraries such as RUb[2] and bibliotek.dk. Kyoto Protocol documents are public, so access to data is a lesser problem. At the same time, the processes of the different institutions related to the Kyoto Protocol are still evolving and changing quickly. This puts a constraint on keeping abreast of all the new information. The documentary evidence for this thesis is usually from no later than Spring 2007, therefore I have attempted to check if these are still valid at the time of writing (Summer 2007).

Qualitative interviewing is a method designed to obtain in depth information about the perceptions of the interviewee on a certain topic [Warren 2004]. The advantages of an interview are that it can be targetted and insightful, while the weaknesses are bias of response and due to "poorly constructed questions", innacuracies and reflexivity ("interviewee gives what the interviewer want to hear") [Yin 1994]. The style of questionnaire used in this thesis was verbal questioning of the interviewees. These in depth interviews were conducted informally and without recording, in an attempt to keep the interviewees comfortable. This is very important so that they feel their contribution is important and are willing to freely share their information or opinions on the topics I am questioning them on. Note-taking was kept to a minimum to avoid losing fluency in the conversation. The interviews were semi-structured, to make sure that there is an agenda that is being covered, but open ended to allow the exploration of new topics that may arise. The agenda for each interview was different, reflecting changing needs for information. Such exchanges of information throughout the project attempted to keep it grounded, useful, and relevant.

[2] Roskilde University library

Interviews conducted during the project include initial scoping and familiarization with the topic, which helped choose and refine the idea for this thesis, and for collecting both specific information to be used to fill knowledge gaps, and the impressions of the interviewees of the problems and possible solutions of the specific case being studied. The interviewees included a representative each from government, industry, and an international organisation, and two individuals involved in the writing process of two of the proposals (one each). The interviews lasted between 30 minutes and a little over an hour. Some of them were conducted face to face and others by telephone. A summary of the interviews was written afterwards. The validity of the data was checked by having the different interviewees give their view of the district heating methodology story. In this way I was able to understand what actually happened and this, together with the documents made available publicly, allowed me to make my own analysis of the case. Annex C contains some interview details.

2.3 Data analysis

This step happens, to some extent, in line with the data collection phase. "Because data collection and analysis processes tend to be concurrent, with new analytic steps informing the process of additional data collection and new data informing the analytic processes, it is important to recognise that qualitative data analysis processes are not entirely distinguishable from the actual data."[Thorne 2000]. But a separate phase does happen at the point when all the data will have been assembled and will be evaluated upon the backdrop of the theoretical framework.

The analysis process of a case study can use phenomenological, grounded theory, ethnographic, narrative, or 'general' (in the sense of standard qualitative research) techniques. General qualitative research techniques can be divided into description, analysis and interpretation [Jones 2006]. My approach is an in depth analysis in order to understand a complex situation, with many stakeholders and many different documentary sources, and then to elucidate the reasons why the situation has occurred as it did, and how the problems encountered can be solved. I use a general qualitative analysis technique, including all the divisions cited above, to try to see the data, or the truth, as it is, or too see behind it. This approach is supported by my own view of data and reality as existing independently from the observer.

2.4 Use of theory and design for answering the research questions

This section explores how the methodology just described will be used to answer the research questions. Also, this section explores the use of theory and a note on alternative approaches which could have been used instead. The sub-questions and the main research question are each treated separately.

The unique case study approach and the fact that there is no wide-ranging experience with district heating and cooling, CHP or even energy efficiency CDM methodologies, lead to the almost necessary application of a qualitative in depth approach. The project design is therefore adapted to the requirements of the problem at hand.

The research questions are answered using the following:

1. *Are CHP, district heating and cooling able to contribute to reduce greenhouse gases? What are the benefits of CHP, district heating and cooling technologies, and can they be used for CDM projects?* Chapter 5 will be used to answer this question. This Chapter contains an introduction to district heating and cooling, CHP, and a discussion of the technologies, how they can contribute to sustainable development, and how they are represented in the CDM. This is based on collected documentary evidence and is presented in order to help the understanding of the importance of these technologies for reducing emissions and boosting sustainable development.

2. *Can district heating and cooling impact sustainable development?* Chapter 5 will also be used to answer this question. This analysis will be based on the evidence presented to answer the previous research sub-question, and on the presentation of the theory of sustainable development in Chapter 3. The theory will be applied through the use of indicators for sustainable development (see note below).

3. *What are the main problems of the CDM, related to energy efficiency?* Chapter 4 will answer this question. The Chapter contains a description of main problems of the Kyoto Protocol and the CDM, with a focus on energy efficiency. The more general focus on energy efficiency instead of CHP and district heating and cooling is due to the fact that there are few experiences and thus little material that deals directly with CHP and district heating and cooling in connection with CDM methodologies or projects. The specific technologies I target fall into the category of energy efficiency, and there is some data concerning this category in connection with the CDM already. The data here is based on documentary evidence.

4. *Why have the previous district heating methodologies not been approved? What solutions have been discussed in order to get these methodologies approved? Can anything new be contributed?* Chapter 6 will answer these questions. The Chapter contains a quick description of each of the methodology proposals and a table containing all the criticisms each of them received, plus a summary and discussion. The case study approach is used here, the case being defined as the failed methodology proposals and the project proposals that accompanied the methodologies. Analysis of one aspect of this case (the failed methodology proposals) is carried out. The reason only one aspect of the case was used is the illustrative value of this aspect in relation to the CDM and Kyoto Protocol and the problems with these systems. The objective of the thesis is to evaluate the proposals and suggest changes that can lead to approval of more energy efficiency methodologies, because these technologies are crucial to fighting climate change and encouraging sustainable development. Data collection for this case is based on documentary evidence and on interviews with key persons involved in the process. The interviews confirmed a lot of information and gave different perspectives on the problem, therefore having been crucial for the research process.

And finally, the answer to the MAIN RESEARCH QUESTION: *How can the approval process of energy efficiency CDM methodologies, specifically targeting CHP and district heating, be improved?* The answer to this question is a combination of solving the problems of the Kyoto Protocol and the CDM, and solving the problems encountered in the methodologies. These problems are discussed in Chapters 4 and 6 and solutions are discussed in Chapter 7, aside from the Chapters already mentioned in the sub-questions.

Use of theory: The theory I have chosen does not have a prescription for what type of information is needed to apply it. Therefore it is not necessarily closely linked to the data collection and analysis methods. The theory was chosen because it is a good metric against which to measure the benefits of district heating and cooling and CHP. This in turn strengthens the case for use of these technologies in a CDM setting. The basis of this thesis is therefore empirical, with the theory being used to set into context, inform, and guide evaluations and suggestions for action.

The theory of sustainable development, as will be shown in Chapter 3, is very holistic and can thus lend itself to many different kinds of interpretations. Also, depending on these interpretations and the objectives the theory is used for, it can lend itself to varied and sometimes vague ways of measuring whether sustainable development has in fact been achieved. I have chosen to use indicators developed by the GRI (global reporting initiative). I have selected, from their core indicators, those which would be applicable to the district heating project I am using as a case study. I have further selected some of the indicators I list in section 3.2, in order to be able to go into more depth in those issues. The rationale for my choices is explained in the same section.

A note on alternative approaches: other types of information could have been procured in the same case study framework, other approaches to the design could have yielded different angles of the problem.

Perhaps a deeper analysis of the actors and their motivations in this case would have given interesting results. Since every energy efficiency methodology seems to be unique, and reviewers sometimes directly contradict each other in their evaluations, a key-stakeholder analysis might uncover something. An evaluation of the monitoring methodologies might also have been interesting. Although I believe the reason for rejection of the methodologies did not rest with the monitoring methodologies, there might be something to be learned as well.

Contacting the World Bank to get hold of their draft documents for a district heating methodology might add interesting information. I am aware that they consulted with Danida in the preparation of the methodologies, so perhaps an analysis of their documents might have shed light on the decisions made by COWI and Danida.

A related issue are the AIJ (activities implemented jointly) district heating projects. The AIJ is a pilot phase for the Joint Implementation mechanism and several district heating projects were carried out. Short reports on these are available at the UNFCCC website, but not detailed descriptions of how emission reductions were calculated. Contacting the parties involved in such projects and getting hold of those documents might be a source of information and inspiration for an eventual new attempt at a district heating methodology. However, I can attest to the difficulty of obtaining this documentation - I was not able to establish contact with the project managers.

Further research, expanding on what I and others have analysed regarding energy efficiency methodologies, may be able to uncover new trends, especially as the number of these methodologies increases. Also, analysis of version 4 of Proposal 3, when the proposal becomes available, would strengthen this type of analysis.

2.5 Summary

Briefly speaking, the project design is the following: the report is centred on a case study of attempts to approve a district heating CDM methodology. The case will be described and discussed, and set in the context of sustainable development, the design of the Kyoto Protocol and of the CDM. The case is analysed as a unique case in order to find a solution to this problem, but parallels can be drawn to other energy efficiency CDM methodologies.

The approach to gaining knowledge and solving this problem is inductive, problem-based, and uses multiple research methods, as befits a case study research design. Validity will be tested and assured based on triangulation, that is, different data collection techniques. Triangulation allows one to see the data being collected from different points of view, helping discern a realistic picture of it. External validity is not relevant since generalisation is not the intent of the analysis, but it will be exemplified by brief discussions on common characteristics with other energy efficiency methodologies. Reliability will be increased by having multiple sources of information, from interviews and documentary evidence, weeding out inconsistencies in the data.

Data collection methods include searching for documentary evidence, both primary and secondary, and the use of qualitative, semi-structured interviewing with key persons connected to the district heating methodology. Data analysis will follow a general qualitative technique, with description, analysis and interpretation, and will be concurrent with the data collection, for the most part.

Chapter 3

Theoretical concepts

This section will introduce the theoretical concepts that I will use to base my analysis and discussion of district heating and cooling and CHP technologies on. This is necessary to understand the benefits of these technologies and why they should be used in the framework of the Kyoto Protocol and the CDM to achieve emission reductions and sustainable development.

3.1 Sustainability

The theory of sustainability/sustainable development has concepts that are useful in structuring this thesis. The principle of the CDM projects and the Protocol itself is to diminish the emission of greenhouse gases, and thus reduce climate change. The underlying concept is that of sustainability. The concepts of this theory therefore offer an adequate lens through which to measure if those principles, or objectives, are being reached.

The UNFCCC adopts the Brundtland Commission's definition of sustainable development: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [UNFCCC 2007]. The definition is overarching, but vague. Sustainable development is frequently articulated in the form of the following image (Figure 3.1). The image is less vague but still does not offer ways of measuring sustainable development.

Sphere: Social, or human capital, is the concept used to call for social sustainability, which can mean fair practices in labour, towards the community and the region a business is in. Concretely speaking this can mean paying fair wages, having a safe work environment, not using child labour, to cite just a few examples. It can also mean giving something back to the community in the form of education, for instance [GRI 2007]. Social criteria for sustainable development include "poverty alleviation, equity and improved quality of life" [Olsen, undated].

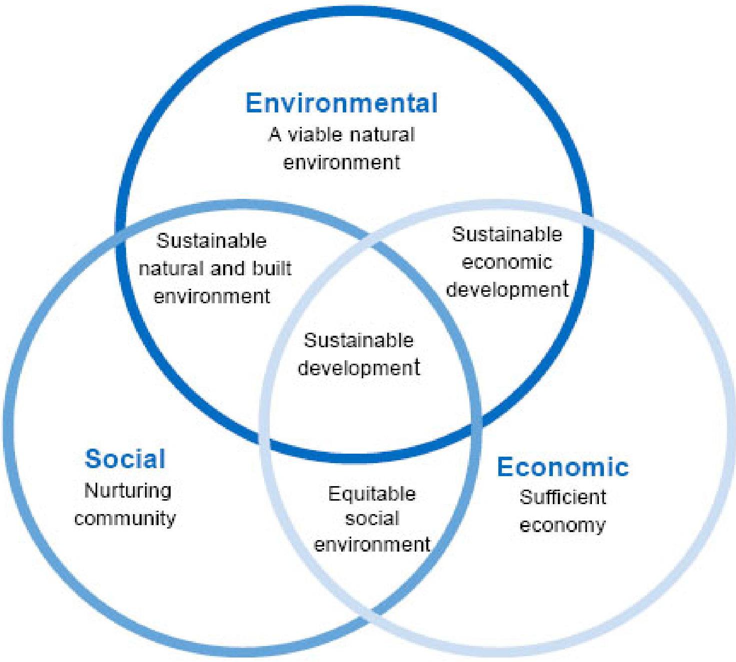


Figure 3.1: Definition of sustainable development encompassing the three spheres: social, economical and environmental. The image shows the interplay between these spheres and the results that can come from them. Source: [CIRIA 2007].

Sphere: Environment, or natural capital, is the concept related to environmental sustainability. A business would ideally try to reduce its ecological footprint[1], diminishing waste and energy consumption, for example [GRI 2007]. Environmental criteria for sustainable development includes (in the context of global warming) "reduction of greenhouse gases and the use of fossil fuels, conservation of local resources, improved health and reduced pressure on local environment" [Olsen, undated].

Sphere: Economic is the economic sphere's bottom line. Economic criteria for sustainable development include "financial returns to local entities, a positive balance of payments and technology transfer" [Olsen, undated]. So how can one assess the economic sustainability of a project or a technology?

One option is the use of cost benefit analysis, to "evaluate the potential risks, fixed costs, operational costs and benefits of the project" [New Venture Tools 2007], so it can be used to assess the best course of action for maximum profit and maximum economic sustainability. It is a tool that can help compare projects and choose the one that brings the most benefit. It should be used as a factor in decisions, but decisions should be made considering other evaluations aside from just cost benefit [Tietenberg 2006,

[1]Ecological footprint can be defined as "the total ecological impact (the amount of land, food, water, and other resources needed) to sustain a person or organization. This is usually measured in acres or hectares of productive land" [Sustainable Management Dictionary 2007].

Kopp *et al*, undated]. Economic tools should be used to estimate the least cost of achieving a set goal (rather than using economic tools to determine the best economic goal). Cost benefit analysis requires a common unit of measurement, a bottom line, which is usually money [Watkins 2007]. "Quantifying costs and benefits is generally the most difficult aspect of formal decision making." "The subjectivity of cost-benefit analysis is most glaring in the use of numerical quantities for values. These numbers always represent somebodys judgement of value" [Nolt 2007]. Valuing everything in a common unit of measurement, putting a price on everything, is not easy. There are many things which have no monetary value, such as the environment and human lives.

3.2 Indicators of sustainability

For the purpose of my evaluation, I will use the following indicators as a basis for discussion of the sustainability merits of district heating. This will answer one of my sub-questions. I use indicators because they aid the 'measurement' or assessment of sustainable development, which otherwise can become overly vague.

> *Indicators are pointers. Used effectively, they reveal conditions and trends that help in development planning and decision-making* [Tschirley 1996].

Indicators are used to monitor the state or evolution of a system, based on information gathered out of that system [Merriam Webster Dictionary 2007b]. Indicators are usually simpler in nature than the systems they measure, that being the advantage of using them to quickly gauge the state or progress of what is being examined. However, care must always be taken in reducing a complex environment to a single number that can, theoretically, be comparable (over time, for example). In practice a single number to represent the whole of a system can render that number meaningless. In finding indicators for a system it is always a balance between too many indicators, which cause confusion and complexity, and too few, which don't represent all of the reality [Bell & Morse 1999].

The complexity of sustainable development can make the task of choosing the right indicators to measure it a herculean one. The comparison or compilation or reduction of the chosen indicators to provide a final answer on whether development is sustainable or not can also be very difficult [Bell & Morse 1999]. Many different sets of indicators have been developed by different people for different purposes (see [IISD 2007] for a compendium). Sets of indicators should therefore be used for the purpose they are developed for [Young 1998, Lyytimäki & Rosenström 2007].

I have chosen to focus on indicators that could show changes brought about by a district heating or cooling or CHP project, in a CDM setting. These were derived from the Global Reporting Initiative's indicators and some of the ones given by [Olsen, undated] in her literature review. The GRI indicators have been developed in partnership with many professionals, companies and international organizations, and are meant as globally applicable indicators. More details about the Global Report Initiative and their indicators can be found in Annex B.

The discussion of the indicators I have chosen is carried out in Chapter 5, to answer my sub-question 2. In Table B, I give indicators that can be affected by a district heating or cooling CDM project. I have chosen only some of those indicators for my analysis, to allow me to go more deeply into them. Also, given the time, space, and type of information collected for other sections of this thesis, it was necessary to limit the number of indicators I developed an analysis of. My final choices are in Table 3.2, below:

Table 3.1: Selected social and Environmental sustainability indicators.

Sphere	**Indicator**
Social	Training and education: average hours of training per year per employee by employee category;
Social	Improved health and quality of life;
Environmental	Direct energy consumption by primary energy source;
Environmental	Indirect energy consumption by primary source;
Environmental	Total direct and indirect greenhouse gas emissions by weight;
Environmental	NOx, SOx, and other significant air emissions by type and weight;

I have excluded the economic indicators, since measuring revenues, operating costs, employee compensation, donations and other community investments, retained earnings, and payments to capital providers and governments, financial implications and risks related to climate change, procedures for local hiring, technology transfer, and all the other economic indicators mentioned in Table indic, would easily have been another thesis report. It would require specific information about the Hou Ma project, which while important is not the focus of my analysis.

I have excluded certain environmental indicators, such as water withdrawal and discharge and initiatives to mitigate environmental impacts of products as services, because it again requires specific information about Hou Ma that is not the focus here. I have also excluded materials used by weight and volume, since this concerns coal, which is also energy.

I have excluded the social indicator of employment, since it can unfold itself into a complex myriad of information specific to the project in Hou Ma. Also, total workforce employed by a project can be viewed as a superficial indicator, and due to a lack of space and focus on other aspects, the detail required to really go into different indicators of employment is out of place here.

I will comment briefly on the social, economic and environmental aspects and then go into more detail concerning the indicators above in Chapter 5.

3.3 Summary

Sustainable development is often divided into three spheres: the social, the environmental and the economic. The idea is to try and find a path that can secure sustainability in all the spheres: something that can ensure a viable natural environment, a nurturing community and sufficient economy, for now and for the future.

In more practical terms, this can be expressed by a series of social, environmental and economic indicators, developed by several people and organizations. The indicators that are relevant for a district heating CDM project include employment, training and education, life quality and health, energy and water consumption and discharge, materials used and emissions of different gases, economic value generated and distributed, financial implications of climate change, financial government assistance, spending on locally based organizations and on local personnel, development of infrastructure.

Some of these indicators will be discussed further on in Chapter 5 to show why district heating projects can increase sustainable development.

Chapter 4

The Kyoto Protocol and the CDM: Issues

> *"Energy efficiency can help address the challenge of increasing access to modern energy services, reduce the need for capital-intensive supply investments as well as mitigating climate change"* [Figueres and Bosi 2006].

This chapter will expose some of the problems of the Kyoto Protocol, specifically focusing on the CDM and energy efficiency projects. "Energy efficiency is one of the most promising sectors for making energy more affordable, improving energy security and reducing emissions in developing countries" [Figueres and Bosi 2006]. The chapter will show how the lack of definition of details prior to the Kyoto Protocol, the need for a perception of integrity, credibility and fairness, the uncertainty about the post 2012-scenario, and the bottom up approach to projects, add up to form some of the problems such as lack of guidelines and communication, and lack of funding.

This chapter will focus on energy efficiency projects and methodologies, exposing the barriers to their development, such as host-country problems, high cost for designing and often re-submitting new methodologies, high complexity. The chapter will also expose some problems of the CDM such as unequal representation of regions and technologies, lack of sustainable development benefits in the CDM. More details about the Kyoto Protocol and the CDM can be found in Annex A.

The reason there is a description of these problems is that they directly affect the uptake of energy efficiency technologies such as CHP, district heating and cooling.

4.1 The Kyoto Protocol

The Protocol is successful, even if only because international agreements of this sort are so difficult to agree on - and make legally binding. Many countries have other more pressing development and environmental problems and objectives, pushing climate change lower on the agenda [Munasinghe and Swart 2005]. Besides, the precise effects of global warming, the distribution of these effects and the consequences are uncertain and unequal for each country of the world. While the science cannot be denied, the choice to do something about the problem is a political one [Bothe *et al* 2005]. So while the Protocol only scratches the surface and only begins to try to solve the problem, it is a good first step.

> *"Notable achievements of the UNFCCC and its Kyoto protocol are the establishment of a global response to the climate problem, stimulation of an array of national policies, the creation of an international carbon market and the establishment of new institutional mechanisms that may provide the foundation for future mitigation efforts (high agreement, much evidence)"* [IPCC 2007b].

All the details of the Kyoto Protocol and its mechanisms were not defined at the time of signing in 1997. The Marrakesh Accords in 2001 ended years of negotiations on the functioning of the mechanisms. "To ensure environmental integrity of the reduction credits generated by CDM projects, an independent validation of project documentation and verification of emission credits was agreed and a CDM Executive Board set up." Positive developments have been falling times between submission and registration of projects, among others. Still, there are many details which have yet to be sorted. For example, the details of procedures for programmatic CDM projects are still being defined [UNFCCC 2007, Michaelowa 2005]. These uncertainties have meant that private companies have directed their investments at quick-return and low sustainable development projects, and countries have been slow to commit and set up the necessary institutional frameworks.

The perception of integrity is crucial for the UNFCCC and all the connected institutions, to make the climate regime work. As an example, there is a complex compliance system, based on a domestic court system but without the bipartisanship of a civil court and "the prosecution aspect of a criminal case". This system is mean to ensure fair and credible enforcement, with representation from different categories of countries and different areas of the world [Stokke *et al* 2005]. Likewise, the whole of the climate regime must be credible: everyone must believe that there will be no double counting or lack of counting of emission reductions, that the institutions can be trusted and are not corruptible.

However, this can - and has presented some practical problems. An example is given by the case study: no communication in person was possible with the members of the Meth panel and the Executive Board that evaluated the proposals, despite attempts to establish them [Jürgen 2007]. Therefore, the questions and recommendations made by the Meth Panel and the Executive Board were not well understood, and were not clarified by either further written communication or a meeting.

The first commitment period of the Kyoto Protocol is 2008 to 2012. There is much uncertainty over what shape the regime will have post 2012. It is known that something will exist, and that for instance the CERs generated in the first commitment period will still be valid, but otherwise not much is known [UNFCCC 2007, Sørensen 2006]. A central problem is that "industrialized countries need the lesser developed countries to take action, but for those developing countries to take action, they need incentives. Those incentives come through the carbon market. But the carbon market can only achieve reductions in emissions if industrialized countries take on targets" [Platts 2007]. Talks are in process and negotiations on this are set to start in Copenhagen in 2009 [Miljøministeriet 2007].

The uncertainty of the post 2012 regime presents some problems for investors and also influences the projects that are begun now. The lifetime of a new power plant, for instance, goes many years past the first compliance period, whereas an investment of filters for industrial gases has a much more immediate and certain return. In this way, certain kinds of energy efficiency and renewable energy projects have been marginalised.

4.2 The CDM

The sources of world greenhouse gas emissions covered by the Kyoto Protocol are shown in Figure 4.1. As can be seen from the figure, the major categories of emissions are energy use, land use change and agriculture (LULUCF). In the land use change category, most emissions come from deforestation, and yet avoided deforestation is not a valid project category under the Kyoto Protocol [UNFCCC 2001][1]. In energy use, many existing CDM projects fall under the industrial energy use, while few or none deal with non-industrial heat and transport [CDM Pipeline May 2007]. This highlights a gap in the CDM projects: some areas of emissions have not been targeted as much as others, and this represents a loss in terms of the CO_2 reducing potential of the CDM. There are several reasons for this.

The financial return on CDM projects can differ very much by the type and location of the projects. The CERs (certified emission reductions) generated by a project are measured in CO_2e (CO_2 equivalent). CO_2 is therefore the measuring stick for the other gasses included in the Kyoto Protocol, and has a CO_2e value of 1, while all the other gases have a higher CO_2e, as can be seen in Table 4.1. Therefore, projects that cut HFC-23, for example, generate many more CERs and are a much better investment than projects that cut only CO_2 - even though we have learned from Figure 4.1 that emissions of CO_2 are much greater than HFC-23.

Table 4.1: Global warming potential (GWP) of the gases covered by the Kyoto Protocol. Source: [EPA 2007]

Gas	CO_2	CH_4	N_2O	HFC-23	HFCs	FCs	SF_6
GWP	1	21	310	11700	140-11700	6500-9200	23900

Besides the better returns for an HFC-23-reducing project, the cost for generating these credits is very low - less than 1€ per tonne of CO_2. Almost regardless of the CER sale price, one can make a profit cutting industrial gases, while this is less certain for other types of projects [The Economist 2007]. There is wide variation in how much the CO_2 credits contribute to the financial aspect of the project. For energy efficiency, certificates can contribute to reduce 10 to 50% of the project cost. There is a lower limit

[1] See [Fearnside 2001] for an interesting argument on the varying reasons displayed by Europeans, North and South Americans for supporting, or not, avoided deforestation in the Kyoto Protocol.

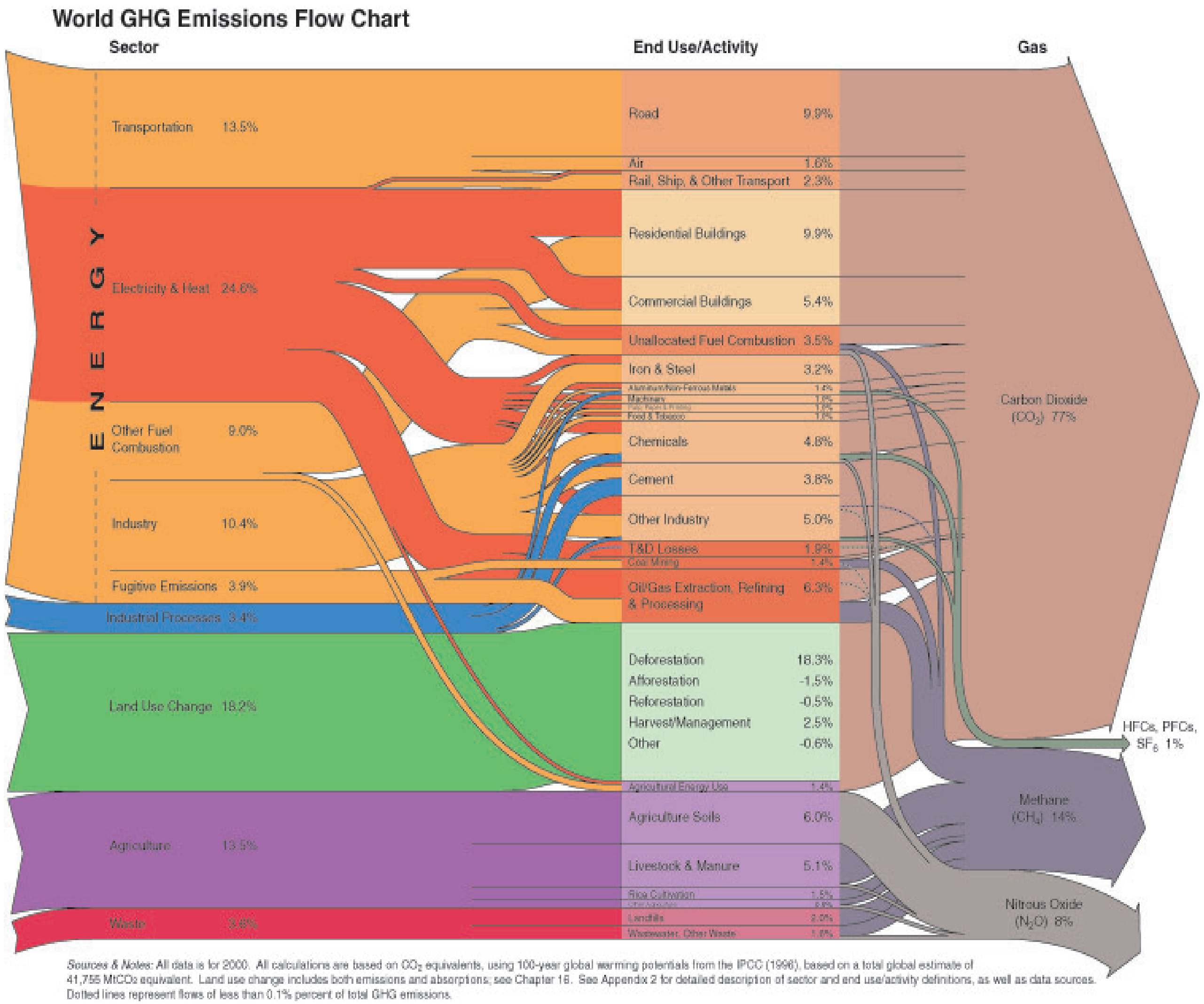


Figure 4.1: Flow chart of world emissions of the greenhouses gases covered by the Kyoto Protocol, showing sources and end uses, and relative percentages in function of the total volume. Image source [WRI 2000].

normally set by buyers and developers for CDM and JI projects (50 000 tCO_2/year), below which administration costs become "a disproportionate burden in relation to the contract value" [Iversen 2006a, Iversen 2006b]. Therefore for an expensive project, such as a capital intensive district heating network, with a low CER return (based only on CO_2, for example), the administrative costs can be high and that means that these types of projects are not invested in.

HFC-23 projects were lower in number in 2006 compared to 2005. Some observers think that may indicate that the HFC-23 projects are drying up, leaving the 'higher hanging fruit' to take up more space in the CDM project portfolio [The World Bank 2007]. A reason contributing to this drying up is the limiting of HFC-23 projects in new facilities (it was so profitable new HCFC-22[2] facilities were being built to gain credits for reducing the HFC-23 coming from these facilities) [Holmboe 2006, Fenhann 2007].

Figure 4.2 shows, by percentage, the CDM projects by sector, and the CERs generated by these projects, present and expected until 2012 [CDM Pipeline May 2007]. The relationship between the CERs generated and types of projects that generate them is made clear. Also clear is that fact that the CERs generated so far are mostly from industrial gas projects. This shows why there has been such a focus on, for instance, industrial gases, to the detriment of energy efficiency projects.

> *"Energy efficiency options for new and existing buildings could considerably reduce CO_2 emissions with net economic benefit. Many barriers exist against tapping this potential, but there are also large co-benefits (high agreement, much evidence)"* [IPCC 2007b]

The sectors covered by CDM projects do not match the sources of emissions as shown in Figure 4.1. For example, the transport sector and decentralized heat and power generation and use are much harder to implement measures for, being that they are so dispersed. The costs for monitoring go up, for instance, and since the greenhouse gas that is cut is often only CO_2 and not one of the more potent greenhouse gases, few CERs are generated [WIC 2006]. On the other hand, an end-of-pipe measure for a factory is methodologically simpler and cheaper and more straightforward to monitor - it is easy to assess additionality, leakage, and other issues that plague energy efficiency methodologies.

A "key element for attracting CDM investments is the host countrys application of quick and transparent procedures for screening, evaluating and approving projects. To achieve this goal, the National CDM Authority should implement a standardized system to screen, evaluate, and approve CDM projects. Host countries will need to establish guidelines for presenting projects." [Unep Risø, undated]. Countries have achieved this a at different speeds and with different levels of competence, and therefore some countries (such as China) have attracted much more investment than others [CDM Pipeline May 2007].

[2]HFC-23 is a by-product of this refrigerant.

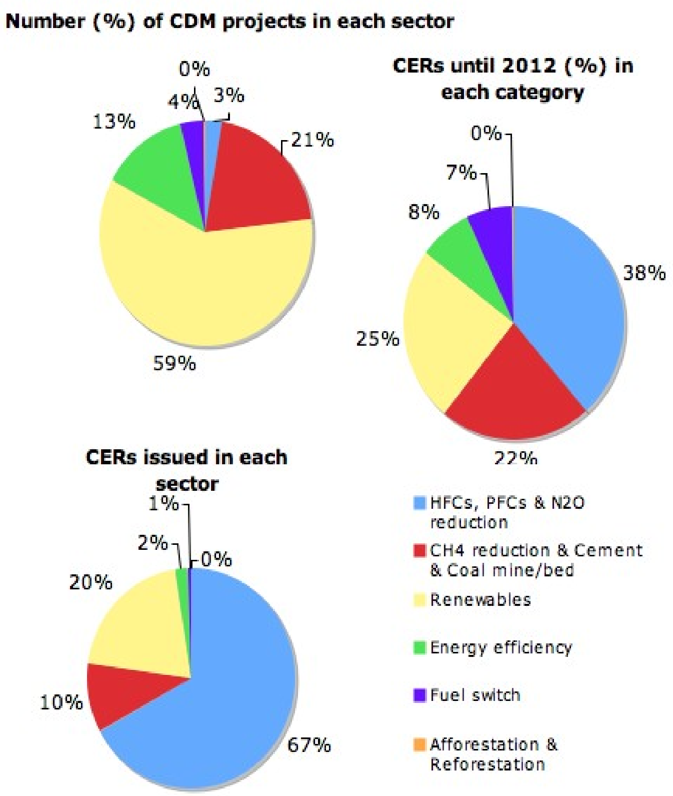


Figure 4.2: Graphs showing the number of CDM projects by category, the expected CERs generated by these projects up to 2012, and the CERs already generated. Note how the HFC, and other industrial gases generate many more CERs than other types of projects, and note also how they have been the first projects to be implemented and begin generating CERs. Adapted from [CDM Pipeline May 2007].

The costs for developing a CDM project are high. In 2005, the cost for developing a "standard PDD [project design document] for a straightforward project type with an approved methodology" could be 15 000 €, and the cost for developing a new methodology could be three times that. Validation varied between 7 000 and 15 000 €, a fee must be paid at the request for registration, and once the project starts generating CERs there is a small administrative fee (per CER) for the Executive Board. Verification is expected to vary between 5 000 and 10 000 €. "Costs for host country approval can be huge due to the delays involved." Under these conditions, the price of the CERs is crucial to the financial closure of projects [Michaelowa 2005], especially since the prices do not reflect the size of the projects, so smaller projects suffer [T@W 2007].

The costs for the failed district heating methodologies must have been among the highest values mentioned above, especially since the methodology was submitted three times and still included two additional version submissions. Danida has stood behind the effort for this methodology for several years now, whereas a private company would probably have given up long ago. The costs and possible complications are sure to reduce the number of private companies interested in developing new methodologies, leaving out a sector that could potentially contribute to reducing climate change.

4.2.1 Sustainability

The Clean Development Mechanism has the dual goal of promoting costs effective CO_2 reductions and sustainable development. But, it has turned out that sustainable development is being sacrificed for the cost effective reduction in emissions. Host countries can define what sustainable development means to them, and this puts pressure on them to lower the requirements in order to attract investment. Neither developing nor developed countries have an incentive to promote a high standard of sustainable development [Sutter and Parreño 2005]. To avoid a 'race to the bottom', an alternative would be to have an "increased Executive Board adaptation levy for end-of pipe non-CO_2 reduction projects" [Michaelowa 2005].

Sustainable development, as measured by employment, equitable distribution of ownership and local air quality, has been shown to *not* be promoted by CDM projects. Ownership of most projects is by local companies or host governments, so revenues flow towards the host population but not necessarily to the poorest in those populations. The projects which generate the highest volume of CERs, such as those that reduce HFC-23 emissions, hardly increase employment in the host country and do not influence the local air quality very much. By contrast, small scale biomass and other energy generation projects (which are few and far between) can add considerably to employment in the host country. Projects can contribute positively to local air quality in the case of fuel switches, depending on the fuels involved, for example. An analysis of the first 16 CDM projects in relation to sustainable development is exemplified by Figure 4.3. In the figure it can be seen that the projects that generate the most CERs have a low and sometimes negative contribution to sustainable development, whereas the projects high on the development scale are typically small and generate few CERs. While this is a study of only a few projects, and acknowledging that the 'low hanging fruit' are the projects which generate the most CERs, the pattern is still the same nowadays [Sutter and Parreño 2005].

The base idea for emissions trading is that emission reductions should be carried out in the most cost effective manner possible. This means that through the CDM, Annex I countries can carry out reductions in developing countries where it is cheaper [UNFCCC 2007]. This mechanism is working well at rewarding what it was meant to: the least costly reductions are those that have the lowest monitoring costs and that are easiest to develop a methodology for, and these reductions are happening in a lot of middle-income countries such as China, India and Brazil [CDM Pipeline May 2007], since these countries are still cheap but are not plagued by all the administrative problems that the least developed countries face [WIC 2006, Varming 2005].

However, the CDM trading mechanism is not set up to reward the other goals of the CDM, such as sustainable development. "Development benefits of CDM projects are often limited, especially of the large projects destroying industrial gases" [Michaelowa 2005]

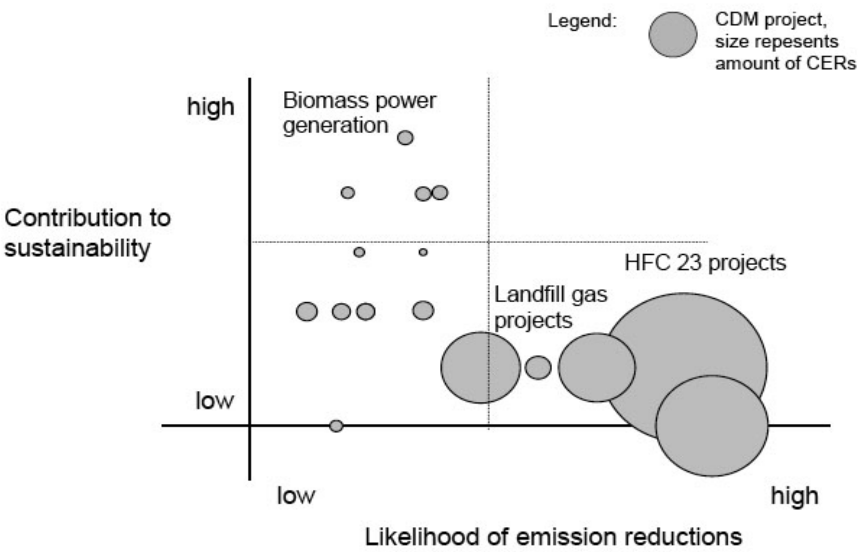


Figure 4.3: Graph showing the first 16 CDM projects in relation to reducing emissions and achieving sustainable development. The projects that generate the most CERs have a low contribution to sustainable development, the projects high on the development scale are typically small and generate few CERs. Image source [Sutter and Parreño 2005].

- and these are exactly the projects generating the most CERs and most widely implemented up to now (Figure 4.2). "Such projects do not create many jobs and also do not contribute directly to community development unless a part of the CER revenues is spent for this purpose" [Michaelowa 2005].

A CDM Gold Standard label is defined as a label that will be attached to the CERs generated by CDM projects which contain a high sustainable development component, usually projects in renewable energy and energy efficiency. Sustainability criteria is provided by the label rather than being government-defined, and must be tested by local consultants. The prices for these certificates are higher than for regular CERs. As long as this does not taint non-Gold Standard projects as dirty, the existence of such a standard should not be a problem for reaching the emission reduction targets [Michaelowa 2005].

4.2.2 The Executive Board

The lack of resources in the Executive Board is one of the biggest problems being faced. "All Executive Board functions are severely constrained by a lack of resources. . . . While many stakeholders, and even members of the Executive Board and Meth Panel, have noted the need for more resources to compensate panel members for their time and to have more support through the Secretariat (including possible full time expert support), the major shortfall in resources means that this is unlikely to happen in the near future"[Econ 2005]. The fact that experts are not employed full time by the CDM

Executive Board, but must instead have a 'day job' and work for the CDM in their spare time, may take its toll. For the district heating project I am using as a case study, the expert reviewers seemed to dedicate enough resources to understand the project and make criticisms, but they did not develop fully their suggestions for action.

"The severe financial restraint on the CDM is not likely to be overcome, at least in the short-term, without more financial assistance from the Parties. The Meth Panel has been affected by both resource and political constraints placed on it by the CDM Modalities and Procedures. The Meth Panel members are generally unpaid for much of their work" [Econ 2005]. The financial assistance of the parties must compete with all the other priorities the parties have. Frequently climate change is not the top priority, therefore the needed financial assistance may be difficult to come by.

The approach to methodology generation, with exception of small scale projects (SSC), is bottom up, which means that new proposals for changing the way things are done are evaluated as they appear. This "bottom-up approach, based on engineering analysis of each relevant component, allows for accurate calculation of emission reductions and has been preferred by the Meth Panel and Executive Board" [Hayashi and Michaelowa 2007]. This leaves room for innovation and improvement of the processes, but it can also generate considerable uncertainty on the part of project developers and investors. It can sometimes cause confusion and conflict, which is exemplified by the case study performed in this thesis: the developers of the district heating methodology addressed in Chapter 6 were uncertain over how the Executive Board wanted everything done [UNFCCC 2007, Jürgen 2007]. Also, "project participants do not always understand the reasoning behind the Meth Panel recommendations, which complicates revising and resubmitting their proposals" [Econ 2005].

"Drafting, submitting and registering a new methodology is a time and money intensive process. Hence in most cases it makes more sense to use an existing approved methodology" [Esdalle-Bouquet 2007].

The amount of work related to evaluating and approving a new methodology overwhelmed the Executive Board at first, making the establishment of a clear border of eligibility for projects a difficult task. Besides, "it can be difficult to get an overview of the entire pipeline and all the approved and not approved projects, thus it can be almost impossible to define a clear line of eligibility". The border of eligibility of projects is murky and this uncertainty can penalise new projects [Holmboe 2006].

"The current process of feedback to project participants and revisions in order to assist methodologies reach 'A' status (approved) can be time consuming. It delays project proposals and places further obligations on Meth Panel members who already face serious time constraints between reviewing new methodologies and considering the revised submissions from 'B' cases (approved pending revisions)" [Econ 2005]. The CDM rules (Modalities and Procedures) dictate that methodologies should be approved within four months. In the face of the amount of work and little time and compensation that members of the Meth Panel or expert reviewers receive, these four months are not always possible. Therefore the Executive Board has used the grade B, since a case that needs review and resubmittal only requires a Meth Panel review, "without having to go through the entire public comment and desk review process a second time." It seems the tactic has worked effectively [Econ 2005].

4.2.3 Energy efficiency in the CDM

Energy efficiency in heating and cooling, improved energy efficiency and combined heat and power generation are all key mitigation technologies (which are commercially available today) mentioned by the IPCC in its most recent reports [IPCC 2007b].

However, there are few energy efficiency projects in the CDM, compared to non-energy efficiency projects. "This under-representation of energy efficiency projects in the UNFCCC pipeline is not only a lost opportunity in terms of CER volumes but could potentially become a challenge for ensuring support for and continuity of the CDM itself. Given the uncertainty about the post-2012 regulatory framework, project activities that have a short pay-back period and require a short time to implement are likely to become increasingly important over the next couple of years" [WB-CFU 2006].

Energy efficiency projects can stimulate sustainable development by training and education of the general population and also energy-specific workers, by improved health and life quality in case of less use of polluting fuels, by fewer emissions of greenhouse gases, NOx, SOx, soot and mercury from fossil fuel power plants, which affect air quality, health and climate change, by reducing costs associated with generating heat and power, diminishing health costs associated with pollution, and possibly by encouraging technology transfer to achieve higher energy efficiency, which has a long term benefit for the area being considered.

The IPCC adds that investments in new energy infrastructure in developing countries "can, in many cases, create opportunities to achieve greenhouse gas emission reductions compared to baseline scenarios. Additional co-benefits are country specific but often include air pollution abatement, balance of trade improvement, provision of modern energy services to rural areas and employment". There is high agreement, and much evidence for this statement [IPCC 2007b].

There are other problems which plague energy efficiency projects, independently of the CDM . Both Annex I and non-Annex I countries face barriers for implementation of energy projects. Besides non-CDM barriers such as subsidies for fossil fuels, grid connection problems and power purchase agreements, there are problems with lack of clear government policy on sustainability criteria for each country, long and complicated approval processes, barriers related to financing, poverty, lack of expertise, equipment and technology, higher costs for obtaining reliable information, lack of long term planning, institutional culture, limitations coming from building design and lack of appropriate policies and programmes. And these are worse in developing than in developed countries. "Often even those energy efficiency measures that financially outperform alternative investments in the same markets are not undertaken due to a host of barriers not related to the CDM. The bad performance of energy efficiency projects under the CDM is therefore not exclusively related to shortcoming in CDM methodologies." [WB-CFU 2006, Proposal 2: PDD 2005, IPCC 2007b]. Fewer projects in these areas are carried out. Therefore, the CDM is not having an impact on a key sector of the problem, both based on the problems with the mechanism and the lack of removal of other kinds of barriers.

Energy efficiency or decentralised energy projects are more complex because they often must incorporate some kind of long term energy planning, while industrial gas projects can target a single factory or even a few, but not the 'spread out-ness' of district heating or lighting. The planning often involves regulatory issues concerning pricing and subsidies, use of specific fuels, energy efficiency measures, load management between heat and power production, municipal planning for energy, disruption due to laying of pipes [Bernsen and Foged 2000]. These are just a few examples of the possible complexity of a district heating project, and each case is individual in the requirements and municipal planning procedures.

A CDM project must be additional, which means that it must be new, above and beyond planned developments, it cannot be something that was going to happen regardless of the CDM. But if you have energy planning, such as what you would need for a district heating system, then what is a part of such planning can often not be considered additional, and therefore it cannot be a CDM project. This diminishes a great potential of cutting greenhouse gases. This is where a programmatic CDM approach can contribute (more below) [WIC 2006, Varming 2005, Andersen 2007].

Additionality conditions have been reviewed in the past [Andersen 2007] and perhaps they should be reviewed again. The problems that have kept energy efficiency methodologies from being approved often have to do with additionality, since they are the most economical choice, even if they have not been implemented due to other barriers. Additionality conditions should be different for projects that contribute to sustainable development.

"Energy efficiency CDM projects have faced several major challenges, notably regarding baseline and monitoring methodology development and additionality assessment" [Hayashi and Michaelowa 2007]. The baseline often needs to be dynamic, meaning it needs to take into account fluctuations in production, demand, supply and efficiency changes. A strategy for monitoring sometimes needs to be different and include sampling, for example [James 2005]. Energy efficiency projects have had the highest rate of rejection in all of the CDM, and this rejection rate has not changed in any significant way over time. Figure 4.4 shows a picture of the methodologies submitted at the end of 2006 [Hayashi and Michaelowa 2007].

The barriers vary according to the end users (meaning, industrial energy efficiency projects have different barriers than transport or consumer energy efficiency projects). A district heating project methodology, as will be discussed in Chapter **??**, can be difficult to design in terms of ownership of the CERs, double counting of reductions (depending on how the monitoring is done) and monitoring strategy, for example. The balance between the cost of monitoring and the loss of CERs in case of equipment malfunction (for instance) can be difficult to find [James 2005].

One of the problems of projects that do not generate a large number of CERs, especially in light of the needed investment, is that additionality may be harder to show, since it is a smaller percentage of the expected revenue. Energy efficiency projects can be economically viable on their own, but as mentioned above they can still face other barriers that keep them from being implemented. While the analysis of these barriers is more subjective, the combined financial and barriers analysis can sometimes solve the problem. Also, investment decisions are not always made based on least cost but on least risk and highest return. And the developing country risk needs to be taken into consideration in the financial analysis [Hayashi and Michaelowa 2007, WB-CFU 2006].

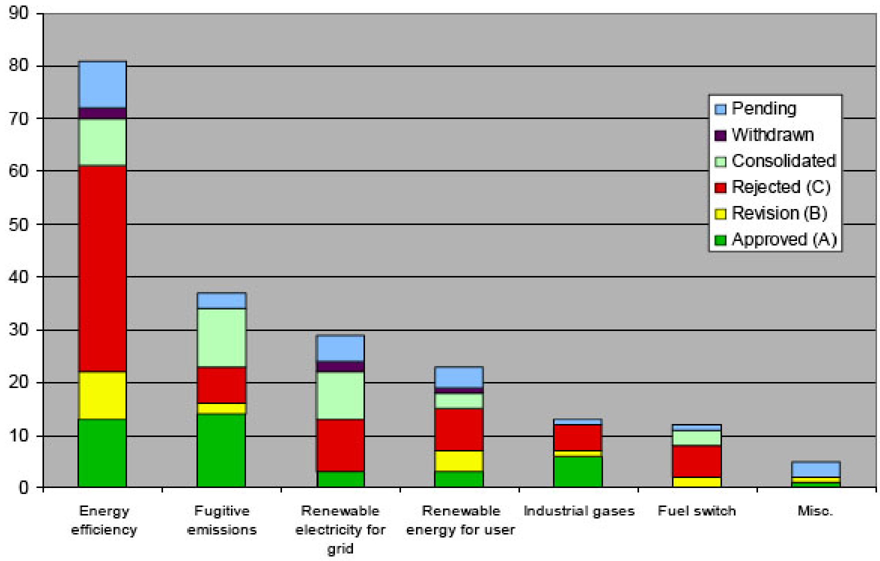


Figure 4.4: Graph showing the categories of methodology submission for CDM projects to the Executive Board, and their status: approval, revision, rejection, consolidation. Note the high number of submissions, and the high rate of rejection, of energy efficiency projects. Image source [Hayashi and Michaelowa 2007].

[Michaelowa 2005] contains some suggestions for streamlining the additionality assessment.

There is an "unfortunate and unnecessary recent tendency to account for so-called 'rebound effects' as leakage in CDM methodologies for large-scale energy efficiency project activities" [WB-CFU 2006]. The rebound effect is a change in patterns of consumption as a result of a CDM project, often in situations of suppressed consumption in developing countries. In this case, if the project stimulated the population of Hou Ma to expect a higher level of comfort in their homes, increasing their use of heat as a consequence of the project. This effect has been considered leakage by the Meth Panel, meaning they believe that the change in the baseline emissions needs to be accounted for in some way, but the methodology developers disagree and think this effect is small.

The 'rebound effect' is not even a part of the approved CDM glossary, but the Executive Board has recommended that this effect should be considered for some projects, even rejecting projects that did not consider it such as NM0096 (Proposal 2). Rebound effects are not considered leakage in some kinds of projects, like electricity generation, SSC energy efficiency methodologies, and projects that have clear rebound effects have been approved notwithstanding. "A few large-scale energy efficiency approved methodologies also lack appropriate treatment of this issue". "Clear and consistent methodological guidance is lacking and decisions by the Meth Panel/ Executive Board have been extremely inconsistent" in this matter [UNFCCC 2007, Hayashi and Michaelowa 2007].

The World Bank considers that considering the rebound effect "is outside of the scope of the CDM Modalities and Procedures, as defined in the Marrakesh Accords, because it imposes restrictions on the use of the CDM for development purposes", in effect undermining the sustainable development goal of the CDM. Also, considering these effects contradicts “paragraph 46 of the Modalities and Procedures for the CDM, which states that ‘the baseline may include a scenario where future anthropogenic emissions by sources are projected to rise above current levels, due to the specific circumstances of the host Party’. It would be of particular importance for energy efficiency projects to allow for a baseline that assumes the same output or service level that is achieved through the project activity. In the context of energy supply constraints and suppressed energy demand, which are prevalent in the economies of many developing countries, energy efficiency activities are often of the type ‘more output with given input’ and not of the type ‘same output with less input’. Not to allow for this development effect of energy efficiency projects would penalise many developing countries, contradict the objectives of the CDM and severely limit the use of the CDM to support energy efficiency projects” [WB-CFU 2006].

4.2.4 Programmatic CDM

A possible solution to the lack of energy efficiency projects is the use of programmatic CDM. Briefly, programmatic CDM is a programme of activities, these activities being for example several small projects, bundled together into one methodological and administrative unit. Reasons that allow for the possibility of solving some of the problems energy efficiency technologies face include that a programme of activities has lower transaction costs per unit of emissions, allowing energy efficiency projects, with their complex and costly monitoring and low CER-return, to reach high enough CER returns to stimulate their development.

The idea of a sectoral approach to CDM has been defined in different ways. It has been called policy based and government driven, or a bundling of projects, or programmatic project activities, or sectoral crediting. The Executive Board has decided that you can have bundles of projects, and you can have a programme of activities, but you cannot have a policy or a standard as a CDM project. But, there has not been clear guidance provided in terms of operational details yet. It is unclear whether this guidance will come in the implicit form (from experience based on the Executive Board’s analysis of each case) or be defined explicitly [WIC 2006, Varming 2005, UNFCCC 2005, Holmboe 2006].

While a policy (being an expression of intent) is not allowed as a programmatic CDM project, a “programme of activities addressing mandatory local/ regional/ national policies and regulations are permissible provided it is demonstrated that these policies and regulations are not enforced as envisaged. If they are enforced, the effect of the PoA is to increase the enforcement beyond the mandatory level required” [Executive Board 2006c]. In other words, enforcement of policies and laws is allowed as a project. This puts into the perspective the Chinese situation (the compliance gap existing related to many policies in China), mentioned in Section 6.1.

The discussions surrounding programmatic CDM relate to larger discussions of the Kyoto Protocol, namely that the Protocol can be a perverse incentive for countries not to enforce climate-change regulations, using the Protocol as an excuse for not promoting the good of the country and the planet. The definition of additionality, as I understand it, is that the Protocol represents action above and beyond what countries would normally do, and it should not replace policy-making that a country would normally undertake. In the same way, programmatic CDM should represent action above and beyond what the laws of a country require, and not substitute law-making - and this is especially relevant in the case of a programme which includes several smaller projects[3].

Issues that need to be resolved/tested in connection with programmatic CDM are: how to determine the baseline, additionality, crediting period, project boundaries, cost-benefit distribution, and how to avoid double counting [WIC 2006, Varming 2005]. The calculation of emissions reductions will be rather complex and may require experimentation with different methods[4]. The staff requirements for coordination of a programmatic CDM will be high [Hayashi and Michaelowa 2007]. Early on the Meth Panel also raised several questions for the Executive Board to consider in its decision-making process [Meth Panel 2006a].

The Executive Board has said that additionality as a whole will involve showing why, without the CDM, the "proposed voluntary measure/ standard would not be implemented, or the mandatory policy/ regulation/ standard would not be enforced, or that the programme of activities will lead to a greater level of enforcement of the existing mandatory policy/ regulation/ standard" [Executive Board 2007a]. This is the same principle of additionality for non-programmatic CDM. Here too should the idea of additionality conditions being different for projects that increase sustainable development be implemented. "Additionality assessment (to exclude free-rider effects) needs careful consideration. It is not very clear yet on which level additionality assessment must be conducted: on the programme level, on the individual participant level, or both?" [Hayashi and Michaelowa 2007].

The UNFCCC COP/MOP 1 and 2 decisions ([UNFCCC 2005, UNFCCC 2006]) have increased the momentum of programmatic CDM projects, and "the Meth Panel/Executive Board have worked on guidance related to the registration of project activities under a programme of activities as a single CDM project activity and recently finalized its work." [Hayashi and Michaelowa 2007] . The Executive Board announced after its 32nd meeting that the way has been further "cleared for Kyoto mechanism to boost green investment in developing countries. [The CDM] is set to scale up, in reach, scope and effectiveness, as a result of new procedures and guidance for programmatic CDM" [Executive Board 2007d]. (See [Executive Board 2007c] for further details.)

"The possibility of clustering several small activities into one single CDM project activity, using a single PDD, is of particular importance for energy efficiency activities because individual activities are often too small for stand-alone CDM project activities even under simplified SSC-methodologies" [WB-CFU 2006]. The potential impact of

[3]A programme could conceivably be energy efficiency projects in factories of a specific sector, or perhaps it can also include action from many individuals, for example exchange of incandescent for efficient lightbulbs. These examples show the different issues relating to programmatic CDM: definition of what is a policy or a programme or a standard, and whether these are voluntary or obligatory, and whether effects are directly traceable or not.

[4][Hayashi and Michaelowa 2007] have identified a random experimentation approach and a technology penetration approach to calculating emission reductions, and which has been used by the Executive Board in different instances. The random experimentation consists of sampling a number of units and comparing that to a number of units outside the project, while the technology penetration approach consists of comparing technology penetration rates with and without the project, by means of a survey. The latter approach is complicated and has not been favoured.

programmatic CDM is that it can contribute to sector-wide transformations and lower costs, which are both good for more renewable energy and energy efficiency projects. The sustainable development brought by the projects will still not be reflected in the CER prices, and it may affect the CER prices in a negative way (lowering their value because more projects will come online). It may also make worse the geographical imbalance in CDM projects, leaving behind the poorest countries because they dont have the administrative capacity to handle CDM projects or programmes [WIC 2006, Varming 2005].

Programmatic CDM has the potential to bring on sector wide changes as it can, for example, be applied to a sector or manufacturers of a specific material or product. This has a much larger potential for decarbonising economies than a single project in a single factory. Programmatic can, in this way, make climate change part of the growth of the sectors targeted. Also, civil society, politicians and policy-makers would be involved and this may affect the decisions that impact on the environment and on climate change. The development of the economy may also be stimulated as suppliers come in to cater to the new standards [Holmboe 2006].

4.3 Summary

The Kyoto Protocol is a first step in a worldwide attempt to address global warming. It represents a feat in international environmental policy, in that so many nations with differing interests and priorities were able to agree on a way of working together to solve this problem. The Clean Development Mechanism, the CDM, is one of the flexible mechanisms of the Protocol, allowing developed countries to set up projects in developing countries, these projects reducing emissions and counting towards the obligations of the developed countries.

The Protocol and the CDM have, however, many problems. Many details of the functioning of the mechanisms were not worked out until years after the Protocol was agreed upon, and some details are still being hammered out. The integrity, credibility and fairness of the institutions has much value, for what is the worth of an international climate regime that no one can trust? And yet, this carries with it some practical problems of access and communication.

The time frame of the agreement is short in light of the lifetime of some of the possible investments that could help solve the global warming problem and bring sustainable development to many countries. The bottom up approach for CDM project types leaves room for innovation but also much uncertainty for investors. Host country administrative procedures for projects can cause delays and confusion due to unclear guidelines. Developing countries have barriers related to financing, poverty, lack of expertise, equipment and technology, higher costs for obtaining reliable information, lack of long term planning, institutional culture, limitations coming from building design and lack of appropriate policies and programmes. The cost for setting up a CDM project, especially with a new methodology, are high. So even when an energy efficiency project is financially more attractive these barriers can keep it from happening.

The existing and proposed CDM projects tend to fall into only a few categories of world emissions. There is much potential for reducing emissions in transport, for example, and some energy efficiency measures, but these kinds of projects do not carry the same financial returns as other projects. There is no doubt that many of the approved industrial gas projects reduce CO_2e, but they often do not contribute to sustainable development. This fact could potentially undermine future support for the Kyoto Protocol, reducing our chances of handling climate change.

Many projects that can contribute to sustainable development, aside from often not bringing many financial rewards, are also more methodologically complex. To cite an example, energy efficiency projects have faced many problems due to this complexity. The working out of an acceptable method for calculating emission reductions, and measuring additionality, is difficult. Assessing leakage and the rebound effect have also played a part in the difficulty. All this, plus the cost of generating CERs compared to the expected value and volume of the return, have combined to reduce the number of projects that promote sustainable development in the CDM. Perhaps some changes may be called for in order to boost the development component of the Clean Development Mechanism.

The Executive Board of the CDM is constrained by a lack of resources, and this affects the time taken to review proposals and the grade a project can receive. Work by experts must be done in addition to their ‘day jobs’, limiting the time they have to dedicate. Parties to the Protocol, however, have other priorities aside from climate change, and may not be prepared to fund the administrative bodies of the UNFCCC in an adequate way.

Programmatic CDM may be one way of reducing costs and increasing CER output, creating more energy efficiency projects. The practical procedures for programmatic CDM, however, need to be defined and tested and are bound to be more complex than the CDM rules already are, making it difficult to handle.

Chapter 5

District Heating and Cooling

> *"Can you imagine an urban area with individual supply of electricity and water, and with each house having its own sewage and garbage disposal system? These services are almost always supplied by public or private companies - so why should each house have its own furnace, which takes up space, pollutes and requires the house owner's attention for operation and maintenance?"*
> [Randløv 2001]

This chapter will introduce district heating and cooling and CHP, and discuss the advantages of these technologies for reducing greenhouse gas emissions and boosting sustainable development. Here is where the indicators for social and environmental sustainability presented in Chapter 3 will be used. The reason this information is presented is to show why this is a relevant technology for CDM projects and why, therefore, more effort should be made to increase these and other energy efficiency methodologies in the CDM.

5.1 District Heating

Space heating is a necessity in many parts of the world in winter and can be accomplished through a few different systems.

Central heating is often used, where in a building or house, a furnace, stove or boiler will produce heat and this will be distributed through the space by pressurized air pipes, hot water pipes or steam pipes. The most common kinds of fuels used are natural gas, oil and coal. Solar power is slowly gaining ground, and wood, electricity, nuclear power and other forms of energy are also used [ACH 2007]. Some of these fuels can cause indoor and outdoor pollution, depending on the fuel and how it is handled [McCally 2002]. For instance, in the town of Hou Ma in the case study used in this thesis, the use of coal in individual furnaces and stoves in homes, together with the lack of flue gas filters and low chimneys, mean that there is a lot of air pollution coming from the combustion of coal, and from the storage and transport of it - it is kept in open air storage areas and transported in trucks, which means that coal dust rises every time it is handled or moved [Proposal 1: PDD 2004].

Boilers and furnaces can be condensing or non-condensing. Condensing means that efficiency is 89% or higher, and so much heat is extracted that vapor in the exhaust area condenses [EERE 2005b]. If a boiler uses hot water, it has the advantage that it can provide hot water for washing machines or showers, using a heat exchanger[1] [ACH 2007]. Modern stoves can use pellets made of corn, sawdust, or other biofuels, and are much more heat efficient than older ones [Pellet Stoves 2007].

An alternative to central heating is district heating, which is a system to distribute heat over an area, commonly a city, from a central heat generation unit. A centralized system can be more efficient and reduce local air pollution compared to the use of individual boilers, stoves and furnaces [District Energy Library 2007, IEA 1983].

District heating can be based on heat-only boiler systems, on CHP[2] plants, known also as cogeneration, on waste incineration, waste heat from industrial processes, and even waste heat from nuclear power plants [District Energy Library 2007, IEA 1983]. The regions of the world where district heating is used include Northern Europe, Central and Eastern Europe, North America, China, Russia and other North Asian countries [Sweheat 2007].

District heating has many advantages over individual heating systems. They can increase effective building space and reduce building construction and operating costs. Air quality can be improved and the encouragement of switching to cogeneration can lead to more energy efficiency. The fuels used can be many, adding flexibility and security of supply and allowing for less cost [NRC 1985]. The fuels used can be indigenous, reducing oil imports, for example. One large central boiler plant is more energy efficient than many small individual boilers. The possibility of using waste energy also reduces costs in purchasing fuel for heating. The use of heat from waste incineration solves two problems at once: what to do with waste and how to heat homes and buildings efficienctly. The use of biofuels can diminish emissions of CO_2. All of these factors apply as well to district cooling [Sweheat 2007, IEA 1983].

The different fluids used in district heating systems require different set-ups to work properly. Steam-based heating requires steel pipes, which can corrode and lose 15-45% of the heat during distribution. Steam is also less efficient than hot water in terms of the energy required to heat any given space [NRC 1985].

Hot water based heating can be transported longer distances (up to 25 km, compared to no more than 5 km for steam-based heat), is more efficient compared to the energy used to heat the water, is a closed loop, so little or no water is wasted, has a lower loss during transmission (5-15%), but on the other hand two pipes are required and water pressure should be kept constant [NRC 1985]. The limiting factor in the distance the heat can be transported are the pressure fluctuations [Avedøre 2007]. Also relevant are the flow rate of the water and its temperature, and the size and density of the area to be heated, which could make longer distances feasible [IEA 1983].

The temperature of the water can vary between 40-50^{o}C for a solar energy based system [DLSC 2007] up to about 100^{o}C for low temperature systems, and go up to 120^{o}C for standard and more than 150^{o}C for geothermal based high temperature systems [Euroheat and Power, undated (a), Nordvärme 1995, Oslo Airport 2007]. The heat is transferred in the power plant to the pipes by means of a heat exchanger. A heat

[1] Basically, the medium passing on the heat and one receiving it are separated by metal tubes, plates, or similar, and heat is transferred by contact [Avedøre 2007].

[2] Combined heat and power

exchanger is always necessary for temperatures above 150^{o}C, and may be necessary below this temperature between the primary line and the homes. Below 120^{o}C (which was standard in Denmark already in the 1980s) homes can be heated directly from the main lines [IEA 1983]. Double pipe systems consist of one pipe entering the building with hot water and then another taking the cooler water out of the building after use (the second pipe) [Andersen 2007]. Operating a system at lower temperature can reduce costs associated with the thickness and insulation of pipes, and also reduce heat losses along the distribution system [IEA 1983].

> *"In our time, with words such as Kyoto Protocol, global warming, climate change and sustainable development very much in the air, district heating offers one of many potential paths to a more carbon-lean energy sector."* [Werner 2006]

District heating based on renewable sources of energy has several advantages when it comes to reduced pollution and emissions. The examples cited below mean that fossil fuels are not needed to supply heat, and their emissions are therefore avoided:

- Straw, widely available in agricultural areas, is burned in Denmark for the production of heat and sometimes power. Straw has fewer sulfur and nitrogen emissions than fossil fuels and is CO_2 neutral since the CO_2 released in burning was absorbed during growth. Cogeneration of heat and power based on straw has reduced emissions of CO_2, SO_2 and NOx compared to power generation based on fossil fuels [Euroheat and Power, undated (a)].
- Geothermal heat can be channelled through a city and offer heat and hot water. This is done in places such as Iceland and Italy [Euroheat and Power, undated (a)].
- Solar panels have been used even in places such as Denmark, Germany and Holland, besides sunnier countries, for district heating, both Summer and Winter [Euroheat and Power, undated (a)].
- Deep lake or sea cold water can be used in district cooling networks such as in the city of Stockholm in Sweden. Air conditioning is usually powered by electricity (generated often by fossil fuels) and at the time the Stockholm project was begun, air conditioning also released CFCs and HCFCs into the atmosphere [Euroheat and Power, undated (a)].
- Municipal waste can be incinerated to generate heat and power, offering a solution for an area's heat and power needs as much as for the problem of what to do with municipal waste [Euroheat and Power, undated (a)]. "Increasing political demands for environmentally acceptable disposal of waste products such as garbage, chemicals, straw, etc, now give district heating a new dimension, as energy from almost any combustible material can be exploited" [Nordvärme 1995].
- Industrial surplus heat can also be channeled into a district heating system. For instance this, together with municipal incineration, helps supply the city of Vienna with heat. It qualifies as avoided carbon emissions, and uses industrial heat that would otherwise be cooled and wasted. Vienna is also heated by CHP plants,

and the whole system is believed to save 68% of energy compared to the individual oil-based boilers that would be otherwise required. The CO_2 emissions are about half (per MWh used) than if the city used average gas boilers. Similar examples can be found in Switzerland and Sweden. The graphs below (5.1) show the saving of energy and emissions from a scheme operated by the town of Lindesberg in Sweden in cooperation with Assi Doman, a cardboard manufacturer [Euroheat and Power, undated (a)].

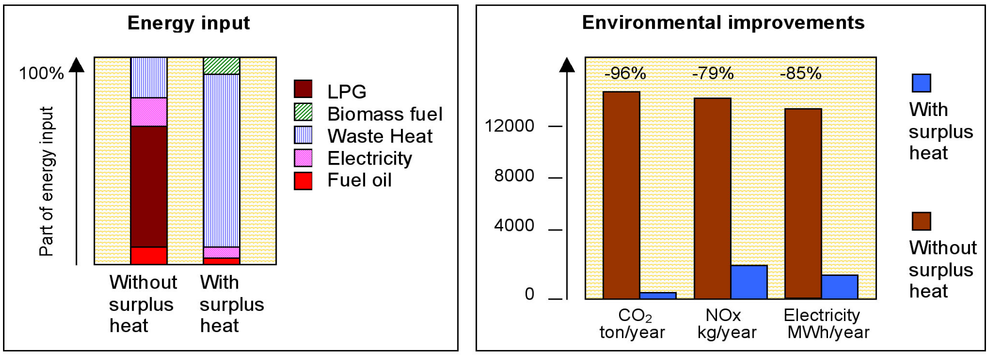


Figure 5.1: Graphs showing the much smaller energy use and fewer emissions as a result of the use of waste industrial heat rather than fossil fuels to generate heat for the city of Lindesberg, Sweden. Adapted from [Euroheat and Power, undated (a)].

5.2 CHP and conventional power generation

A traditional power generation system works on the basis of a fuel being burned to produce steam. This steam at high pressure then spins turbines connected to a generator, producing electricity [Herbert 2004]. In a CHP plant, the exhaust heat from the turbines is put through a heat exchanger and is then transmitted through pipes to the end users of this heat. The relationship between CHP and conventional power generation can be very simply understood by the following example: "for each *eight* 'barrels of energy' consumed in a combustion plant: *one* 'barrel of energy' is lost through the chimney or in the plant; *three* 'barrels of energy' are converted to useful electricity; *four* 'barrels of energy' are wasted in cooling systems or *four* 'barrels of energy' are converted to useful district heating" [Nordvärme 1995].

> *"To be fully efficient, CHP must have a demand for heat, either industrial or district heating"* [IEA 2007b].

Electricity production creates excess heat that needs to be cooled and discarded, often by way of cooling towers or cooling in the sea, unless the heat is put to some use. Using fuel to create heat wastes some of the high potential of this fuel to create electricity or work. The joining of these two systems in a CHP plant uses the available fuel to the largest efficiency, getting the most energy out of it. It means that less fuel can be used to generate heat and power [CHPA 2007, US CHPA 2007]. The IEA[3] estimates that "the electricity sector alone will need to spend almost $10 trillion [US dollars] to meet a projected doubling of world electricity demand, accounting for 60% of total energy investment" up to 2030 [IEA 2005]. This is another argument for why CHP should be used in connection with district heating, which could help put such large investments to even better use.

The most common types of CHP plants are Gas Turbine, which use heat from the flue gas or turbines, Combined Cycle[4] which is a power plant adapted to CHP, Steam Turbine, which uses heat from steam, and Molten-Carbonate Fuel Cells[5]. There are also small-scale CHP plants and MicroCHP, at the level of a small business or home [WADE 2007, COGEN 1999].

Fuels used in CHP plants include natural gas, oil, coal, biogas and others. Biogas can originate in the burning of municipal waste, farm waste such as straw, or sewage treatment sludge, among other things. The waste is 'consumed' in an anaerobic[6] process, generating gases such as methane [Gulf Coast CHP]. The fuels most used are coal, followed by natural gas and oil [Euroheat and Power, undated (b)]. This fact coupled with the fact that these systems that are in use or being refurbished will probably be in operation for many years to come means that the focus should be as much on switching fuel as on efficient use of these fossil fuels.

In practice, some of the energy that would go to electricity production is diverted towards heating in a (retro-fitted) CHP plant, requiring the power plant to manage the allocation of different percentages of power and heat generation in order to maintain high efficiency and adequate production [Olsen 2006]. In a condensing power plant, such as the one in the town of Hou Ma, the ratio between the heat and power provided can be changed, which allows the power plant to adapt in case of a reduction of energy consumption. In a back-pressure power plant, the ratio is fixed, presenting problems if for example, a campaign for saving energy is started up in the region [Andersen 2007].

A simple diagram such as Figure 5.2 makes the relationship between heat and power production explicit. To cite an example of this management, the Danish power plant Avedøre 2 (Figure 5.2) produces 580MW of electricity when it is at full electricity production and no heat production. When heat production is at a maximum, the plant produces 510MW of electricity plus 560 MJ/sec of heat, wasting less than 10% of the energy in the fuel. Only 48% of energy is used in full electricity production mode, and without district heating, the rest is wasted [Avedøre 2007].

To maintain current levels of power production when a power plant is retro-fitted for CHP generation, more fuel will need to be used for the heating part, which is

[3] International Energy Agency.

[4] Combined cycle means the process uses more than one thermodynamic cycle. A CHP plant uses heat at high temperature for input for making electricity, and heat at lower temperature for input into the heating system. These constitute two different thermodynamic cycles [NPPC 2002].

[5] A fuel cell creates electricity by electrochemical processes based on hydrogen (or hydrogen-rich fuels). The hydrogen's positive and negative ions are separated and positive ions connect with oxygen or another medium, causing the electrons for flow and form current before re-conecting to the positive ions + medium. This 're-conection' generates the by-products. These are often heat and water. Molten carbonate cells are cheaper than other fuel cells and are being developed for natural gas and coal-based gas power plants (the gas is the fuel put into the fuel cell). In a CHP setting, efficiency can be 85% [EERE 2006].

[6] Oxygen is not consumed by the degrading bacteria.

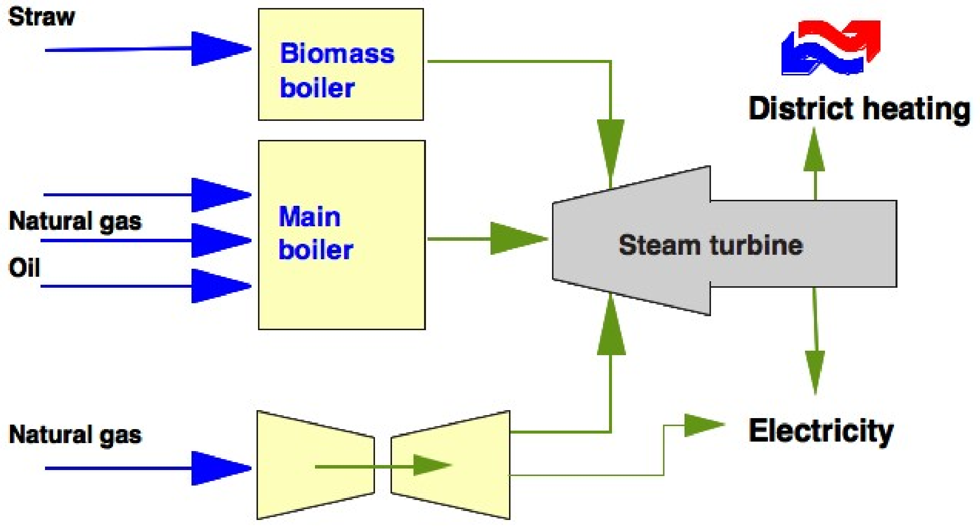


Figure 5.2: Avedøre CHP Plant diagram (situated South of Copenhagen), showing how the output from the steam turbine is divided between what goes to the electricity generator and what goes to the district heating network. Source: [Avedøre 2007].

exactly what was proposed for Hou Ma city in China in Danida's district heating CDM methodology [Proposal 1: PDD 2004], but the overall consumption for both systems will be less. The scale of the change can be observed in Figure 5.3.

The heat generated from a CHP plant can be used close to the plant or distributed to a nearby district heating system. Unlike electricity, which can be transported over longer distances, heat is lost much more easily through the pipes that transport it, insulated or not, and the process of installing this system and moving the heated water makes long-distance transport less viable. Most often a CHP plant produces electricity first and heat as a byproduct. Only in heat intensive industries, such as metallurgy, is heat produced first and electricity as a by-product [Sequoien 2007].

The presence of a district heating network means that the heat from a CHP plant can be supplied to not only industrial facilities but also homes and commercial buildings. There are differences in the temperatures required by homes, for example, which are lower than the heat supplied for many industrial applications, and this lower temperature allows the power plant to have a higher efficiency[7] "In addition, as industry becomes more electrically intensive, large industrial heat sinks for low-grade energy are increasingly hard to find. Urban buildings, accessed through district heating and cooling, are a more stable long-term partner for CHP plants" [IEA DHC/CHP 2002].

The cost of starting up a district heating network in connection with CHP includes the additional cost of heat production, laying the network and the consumer connec-

[7]The explanation for this is that, for instance at Avedøre power plant in Denmark, steam is extracted from the boiler by three different turbines. The first one is at high pressure and high temperature, the second is at lower pressure and temperature, and the last one is at the lowest pressure and the steam that goes through that can be used for either electricity or heat. If it is being used for home-heating the temperature is lower than for some industrial uses, therefore the heat can be extracted at the last phase, allowing full use of the steam's 'capabilities' for both electricity and heat [Avedøre 2007].

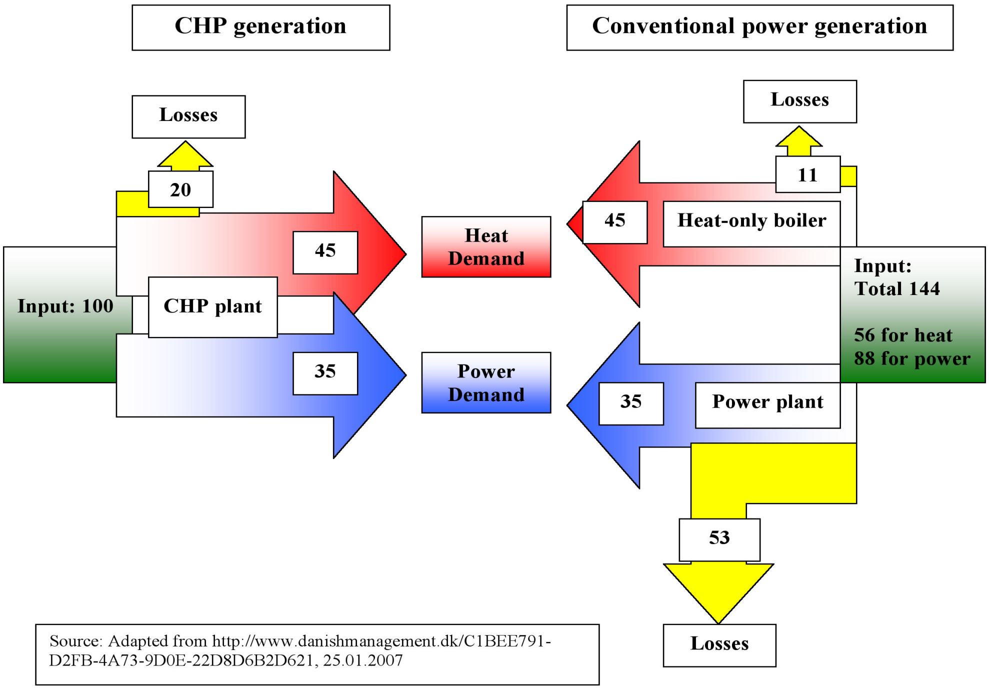


Figure 5.3: Comparison diagram between a CHP and two conventional plants, one for heating and the other for power production. Notice the energy losses for the conventional plants, compared to the CHP-type plant. Adapted from [DEM 2007]

tions. With high energy prices and high building density, this can be competitive with alternative heating options [IEA 1983].

The best use for the waste heat of a CHP power plant would be to distribute it to a district heating network. In the Summer, when this cannot be done, a district cooling system is the next best alternative for what to do with this surplus heat. In places that do not require heating in Winter, district cooling based on cold water from a deep lake or the sea is the best alternative. This works by pumping cold water through a district cooling network (similar to a district heating pipe network).

5.3 District cooling

> *As "regional energy demands grow exponentially, the emphasis will be on energy-efficient and environmentally friendly technology. District cooling satisfies both these requirements"* [Gulf News 2006]

This section describes the characteristics and advantages of district cooling. This information is presented because a district heating CDM methodology can be changed to adapt to district cooling, and this technology is relevant in many countries where a CDM project could be envisaged.

District cooling is a system which uses the same kind of pipe structure as district heating but provides cooling. This is relevant in many parts of the world, such as all tropical areas, and even as far North as the cities of Helsinki, Stockholm and Copenhagen. The cooling is often done by circulating cold water, or by using the district heating system to distribute heat to heat-driven chillers. This heat could be waste heat from industry, waste incineration, or any other of the several processes cited above [IEA DHC/CHP 2002]. For instance, in Copenhagen district heating is supplied by many CHP and waste incineration plants, and during the Summer months when heating is not needed the surplus heat goes towards district cooling for large buildings, where the absorption chillers are installed in substations [Foged and Skov 1999].

District cooling is more cost effective and environmentally friendly than building specific cooling alternatives such as air conditioning [Helsinki: DC 2007]. District cooling can reduce a building's use of electricity by 60%, reducing costs. Costs are also reduced by the less need for maintenance, "enhanced efficiency and reliability, and space savings". Buildings users also benefit from less noise [Gulf News 2006].

The Cogen 3 project in ASEAN countries[8] stimulated many pilot projects to demonstrate cogeneration, and district cooling was installed in many places. For example, a district cooling system with cogeneration operates in Kuala Lumpur city centre, at the Kuala Lumpur international airport, at the Putrajaya government administration centre, and district cooling systems with thermal storage operate in several other parts of Malaysia [COGEN III 2007, Beck-Larsen 2004]. These demonstration projects and wide use of district cooling in countries such as the United Arab Emirates, show the benefits of district cooling in both warm and cold countries [Gulf News 2006].

The ban on CFCs kick-started the development of district cooling systems in several areas. Systems operate with water at an average temperature of 10^oC [Euroheat and Power, undated (a)]. The city of Stockholm, for example, has a district cooling system based on sea water from the Baltic Sea. The water is taken in from the bottom of the sea and cooled further in heat pumps. There, the water temperature is 6^oC at delivery to buildings and up to 16^oC upon return [Fermbäck 1995].

Heat pumps transfer cold or heat from one area to another, by extracting the heat out of the medium (e.g. water, air). This is the mechanism at work in the case of, for instance, an air conditioner, a refrigerator, or a cold water drinking fountain. Heat can be transferred from the air (the heat present in cold air outside a house can be brought in to heat the house), the ground, underground water or even hot rock [EnerGuide 2004]. Heat pumps do not generate heat, therefore they are more energy efficient than furnaces and air conditioners for non-extreme heating and cooling needs. They can use electricity or even part of the heat being transferred (absorption heat pump), and heat or cool water (reverse cycle chiller) [EERE 2005a]. A heat pump has 30-50% less fuel use and therefore less emissions than a boiler being used to heat the same space. A heat pump coupled to a CHP system uses 50% less energy [IEA Heat Pump Centre 2004].

5.4 Discussion

> *"The fundamental idea of district heating and cooling is simple but powerful: connect multiple thermal energy users through a piping network to environmentally optimum energy sources, such as combined heat and power (CHP),*

[8] Association of South East Asian Nations

> *industrial waste heat and renewable energy sources such as biomass, geothermal and natural sources of heating and cooling. The ability to assemble and connect thermal loads enables these environmentally optimum sources to be used in a cost-effective way"* [IEA DHC/CHP 2002].

The advantages of shifting to district heating is that such systems can be operated competitively (they can compete, price-wise, with other heating systems). They can reduce costs for consumers due to less fuel use (assuming they pay for the full value of the fuel they use[9]). They can also increase building space, adding to the market value of the building, and reduces operation and maintenance costs of a furnace or boiler.

Further, air pollution caused by certain kinds of fuels is removed to a different site, possibly with better dispersion measures, improving air quality. Installing a district heating system is an investment in urban development[10], and if it uses waste or sewage treatment sludge as fuel, it can help solve another problem that cities often have - how to dispose of waste. District heating and cooling therefore lend themselves well to rapidly growing cities in many developing countries [NRC 1985, IEA DHC/CHP 2002].

One issue that needs to be considered, though, is the large capital cost of mounting the distribution network. This can be 70% of the cost of the project and explains why district heating is considered suitable for densely populated urban areas, but not necessarily suburbs or other more sparsely populated regions. It is expected that these costs will fall over time, as newer solutions for pipes and other advances in technology become available [NRC 1985].

Another issue is the liberalisation of energy markets, a topic widely discussed currently. Liberalisation reduces long-term investment in infrastructure development such as a (capital intensive) district heating system. This means that while governments can pass on to private companies the responsibility of providing electricity, these companies compete on price, and therefore may not make very capital intensive or long term investments. Governments must be ready to make these investments in energy infrastructure to ensure the long term supply of heat and power. On the other hand, emphasis on distributed power generation is an incentive for the installation of district heating systems, because then local players will be responsible for both heat and power generation, easing the planning processes [IEA DHC/CHP 2002].

It is important for energy planners and all levels of governments to recognise their own importance in planning and installing district heating systems. The long term benefits are too far away from the scope of short term trading in a liberalised energy market to make sure that CO_2 cutting, energy efficiency and overall strategic planning are handled suitably [IEA DHC/CHP 2002]. Besides the high capital cost of district heating systems, all the planning procedures are complex and companies may not want to deal with all the potential conflicts.

There are myths that surround district heating, "based, in part, on poorly maintained systems in the Central and Eastern European countries. These misconceptions

[9]Subsidies and taxes change the retail price for electricity and gas. In China, energy is subsidized therefore consumers will not feel the drop in costs as much [Liang 2007].

[10]The presence of a district heating system can stimulate the development of an urban area by offering 'ready to use' heating infrastructure, potentially revitalising and allowing for the redevelopment of old city centres, attracting residents and businesses [NRC 1985, IEA 1983].

cloud the real fact that, where based on waste heat utilisation these systems are more efficient than the direct use of natural gas, and provide many opportunities to increase use of renewable energy sources" [IEA DHC/CHP 2002]. District heating systems are still subject to high heat losses (12-15%), but they are slowly being refurbished or exchanged for individual heating based on natural gas [Euroheat and Power, undated (b)].

One myth is that district heating, being local in nature, is not compatible with large-scale power generation systems. District heating operators often "have limited ability to raise capital and to absorb early losses" [IEA DHC/CHP 2002]. This is contrasted with national utilities, which often do not suffer from these problems, and can therefore appear more competitive. The local nature of district heating and inability to raise sufficient capital is one of the barriers mentioned in the Hou Ma project, to explain why the project would not have been carried out without the CDM. But the different scale of heat and power technologies need not hinder their combined use, and the cost of district heating systems is not hurt, in the long term, by the lack of economies of scale, since district heating systems take into account environmental costs [IEA DHC/CHP 2002].

Flexible fuel solutions such as that adopted by the Avedøre CHP plant in Denmark mean that users and companies are insulated from price fluctuations deriving from the market. This is also an energy security consideration. Other ways in which district heating can contribute to energy security include shifting peak power loads by storing heat or ice in a district cooling system, since air conditioning demands a lot of energy, and generating power close to where it will be used [IEA DHC/CHP 2002].

Pointing to Eastern and Central European bad experiences with district heating are a fallacy, because fixed flow systems without insulated pipes or metering, with poor upkeep and without the possibility of a technological upgrade, are not the norm for modern systems. These older systems are ineficient because they are the result of central planning without competition or technological evolution. Technological advances made in the West could not be adopted in these countries. But these systems can now be rehabilitated and made much more efficient. The ever increasing use of energy makes ever increasing quantities of heat available, making district heating based on CHP an ideal outlet for low grade heat [IEA DHC/CHP 2002]. "The potential market for [renewable energy] and DH/CHP solutions in Eastern Europe, the former Soviet Union and Asia is huge" [Grue and Meyer 2005].

Factors that facilitate the development of district heating systems include government support, high energy prices, a long heating season (which means a shorter return on investment), access to a close and secure heat supply, access to low-cost capital, presence of a single responsible organisation for planning, financing, construction and operation [IEA 1983].

Factors that limit the development of district heating systems include high costs for consumer connection and retro-fitting, better insulation (which reduces the need for heating), difficulties and long time in planning and siting (lack of a close heat supply), planning and price agreements made with power utilities (many power utilities would rather not produce heat since it entails more complex load management, for example, so they will not sell the waste heat at a favourable price for consumers), negative regulatory regimes, uncertainty over energy prices, and high cost of capital [IEA 1983].

5.5 District heating and cooling and the CDM

> *"Avoided carbon dioxide emissions from the use of district heating and combined heat and power (CHP) is significant and is about half of the magnitude of carbon dioxide reduction presumed in the Kyoto protocol"* [IEA DHC/CHP 2002]

"District heating offers effective potential to reduce carbon dioxide emissions. The five fundamental ways of reducing carbon dioxide are substitution of fossil fuels, deposition of carbon dioxide, lower demand, higher efficiency in energy conversion and retrieval of conversion losses in energy conversion processes. District heating makes it easier to utilise the first and fifth ways" [Werner 2006]. The IEA has a programme of RD& D[11] on district heating and cooling[12]. They stress in [IEA DHC/CHP 2002] that "the important role DHC can play in meeting Kyoto targets and other environmental and energy policy goals" is being ignored by the IEA, the EU and national governments.

"It is more feasible to control emissions from a few large plants than from thousands of household boilers spread over a city" [Nordvärme 1995]. Currently district heating CHP systems avoid about 3-4% of emissions from worldwide combustion of fossil fuels. This number can increase through the increased spread of both types of systems in the world. Switching fuels (38% of the fuel used in district heating/CHP plants currently is coal) will further reduce emissions and district heating and CHP systems are adaptable to such changes. Indeed, many CHP systems already run on municipal waste and straw, among others [IEA DHC/CHP 2002].

> *"Emissions trading could facilitate significant additional greenhouse gases reductions through DHC and CHP"* [IEA DHC/CHP 2002]

The district heating and cooling technologies such as the ones mentioned below could in principle be developed as CDM projects:

- use of CHP rather than heat only boilers;
- substitution of individual boilers or small scale district heating for large scale district heating;
- use of straw and other biomass rather than fossil fuels;
- use of solar or geothermal heating rather than fossil fuels;
- waste incineration and use of industrial waste heat, rather than wasting and even having to cool that energy;
- use of deep water cooling rather than air conditioners;
- substitution of air conditioners, furnaces or boilers for heat pumps.

[11] Research, development and demonstration
[12] www.iea-dhc.org

Projects that involve a larger scale energy planning are more complex and require a better administrative capacity than many countries possess. This kind of gap is already seen in the percentage of CDM projects that have been set up in middle income countries versus the least developed countries [CDM Pipeline Jan. 2007]. District heating is a type of technology that requires longer term planning. The problems that this brings in the framework of the CDM (such as additionality) and possible solutions have been discussed in Chapter 4.

Another problem for district heating and cooling projects in the framework of the CDM is that the emission reductions that can be achieved are smaller than the end-of-pipe solutions for industry, that are based on the other gases covered by the Kyoto Protocol. The sale of certificates is based on CO_2 equivalency, and all other gases covered by the Kyoto Protocol have much larger global warming potential (and therefore generate many more certificates than CO_2 alone) [EPA 2007]. The result is that current CDM projects reduce greenhouse gases but don't implement wide-ranging changes. The types of projects that would increase sustainable development, such as DHC/CHP, often require more administrative capacity, a certain level of infrastructure, and involve sector-scale changes. Developing countries may not be able to provide such a base. There is no financial reward for sustainable development, only for cutting CO_2 [WIC 2006, Varming 2005, CDM Pipeline Jan. 2007].

5.6 District heating and cooling - contribution to sustainable development

The indicators given as base for discussion in Chapter 3 will be used here. To reiterate, the indicators were derived from the Global Reporting Initiative's indicators and some of the ones given by [Olsen, undated] in her literature review. More details about the Global Report Initiative and their indicators can be found in Annex B. Indicators which can be affected by a district heating or cooling CDM project include:

Social indicators

- *Training and education: average hours of training per year per employee by employee category.* Training of personnel for installation, operation and maintenance will be necessary for a district heating project, and is included in the Hou Ma project. The foreign professionals that will be present are scheduled to leave China after the projects has been started up. This training can then be passed on to the next 'generation' of workers, in order to keep the system up and running. Therefore a district heating project will have a positive effect concerning training and education of the workers involved. It can also have a positive effect if an information campaign is carried out to teach the population about energy conservation and efficiency and heating systems.

- *Improved health and quality of life.* A district heating or cooling network that substitutes coal fired individual boilers and furnaces, such as the project in my case study, will contribute to improved health and by proxy quality of life, by decreasing air pollution, thereby improving health, and by the ease of use of district heating rather than individual appliances, meaning the population spends less time taking care of the operation and maintenance of this equipment, aside from the space gain in their homes.

Environmental indicators

- *Direct energy consumption by primary energy source.* This refers to the consumption of coal, natural gas, or other fuels [GRI 2007]. Energy consumption will be reduced due to the lower consumption of coal for a district heating system. Less primary fuels are used by a more efficient large district heating network, compared to a less efficient small network or individual-home solutions. Besides the higher efficiency of a large vs. small system, less coal is used for heat generation, since surplus heat from power generation is used in the district heating system.

- *Indirect energy consumption by primary source.* This refers to "the energy required to produce and deliver purchased electricity and any other intermediate energy products (such as district heat) that involve significant energy consumption upstream from the organizations reporting boundary", and includes electricity, heating and cooling, steam, and other products [GRI 2007]. The indirect energy use of the power plant delivering the district heat will rise some, due to the distribution of the steam by use of heat exchangers and pumps, but this may be offset by the lower use of indirect energy in individual homes and small heating networks (if they're run on electricity, for instance). In the case study I have chosen, the small existing district heating network and the individual homes are heated using coal as a direct fuel, therefore the indirect energy consumption by a large district heating network will he higher than that which it is replacing.

- *The overall energy balance,* taking both indirect and direct energy consumption, will be lower, since the rise in the use of indirect energy more than offsets the direct energy consumption associated with the previous system.

- *Total direct and indirect greenhouse gas emissions by weight.* This will clearly benefit from the introduction of a large district heating network, which uses less energy overall, especially when coupled to a CHP plant. The emission reductions will be by at least half, if emissions reductions are only counted from the substitution of a small for a large and more efficient district heating network. Even though the emissions of the substitution of individual boilers is not counted in the latest version of the proposal, there will also be a reduction of emissions from this source (see Chapter 6 for more details).

- *NOx, SOx, and other significant air emissions by type and weight.* Coal plants, such as the one in the case study, emit appreciable amounts of NOx, SOx, smog, ozone, soot and mercury [Sierra Club 2007]. These emissions will be reduced with reduced use of coal for a large district heating system, therefore such a project can have a positive impact.

We cannot directly compare all the different indicators as they are different in nature. But we can see that a district heating project would offer training and education and have a positive effect on quality of life and health. While we cannot conclude on employment, this social balance still is, in my view, positive.

The use of energy would diminish but the use of water would most probably increase a little. The emissions of other polluting (non greenhouse) gases would lessen, improving air quality. The environmental balance is more difficult to judge, however the possibility of catastrophic effects due to global warming looms larger than the effects of a small increase in water use. I consider this balance to be positive as well.

Possibilities for more revenue on the part of the power company, and more compensation for workers, exists in connection with a district heating project. District heating is the most economically viable option, as shown by the case study. Negative economic points connected to CDM projects in general is the possibility of less infrastructure investments by governments. Despite the high capital investment, the slowly spreading use of district heating and cooling points to a positive economic balance.

5.7 Summary

> *"The flexible mechanisms open up new revenue possibilities for [renewable energy] and DH/CHP projects, improving the return on investment of the projects"* [Grue and Meyer 2005].

District heating is a system that distributes heat to an area from a central generating unit. A district heating system can substitute individual heating and uses less fuel overall (by comparison). District heating can use even less fuel if it based on waste heat, for instance from industrial processes, by burning agricultural waste such as straw, by using waste heat from power generation, by using solar heaters or geothermal heat. These sources can reduce pollution and greenhouse gas emissions from burning fossil fuels for heating. District heating systems can be based on steam or hot water transported in pipes, which heat by means of a metal surface that emanates the warmth.

District cooling distributes cool water in the same way as district heating, and can be based on cold water from a sea or lake, or on using waste heat, which is made cold by a heat pump. The presence of a district cooling system avoids the emissions of fossil fuels from electricity generation and also from CFCs.

Combined heat and power generation, CHP, is a very good way of using all the energy available in a fuel, since power production alone often uses less than half of the energy contained in fuel. Fuels used in CHP plants include natural gas, oil, coal, biogas (from burning waste) and others. Using the rest of the fuel for district heating or cooling rather than having to cool it ensures the most efficient use of the fuel.

District heating and cooling systems are appropriate for cities and areas with dense housing, since the heat cannot be transported such long distances as, for example, electricity can. They can help solve the waste disposal problem of large cities, and can be operated in a cost competitive manner. There are high capital costs associated with installation of such a system, which is one reason they are only competitive in more densely populated areas. The large investment means that governments should plan for these kinds of systems as their cost cannot be recuperated in the short term (market actors will not normally choose such a path).

Modern district heating and cooling can be integrated into power production and take environmental costs into account by using energy efficiently, thereby making it sustainable. Flexible fuel solutions for CHP plants and district heating and cooling systems can shield users from price fluctuations and ensure energy security. Current systems are based on variable flow with insulated pipes, reducing heat loss and allowing supply to be coordinated with demand, reducing the waste of heat.

District heating and cooling systems should be used in the framework of the CDM, in light of the energy efficiency benefits they offer. Emissions from a single large system are easier to monitor and control than dispersed emissions from individual heating and cooling solutions. These technologies require long term planning and high investment, and are complex to begin and administer, but they offer sustainable development benefits and reduce greenhouse gas emissions.

The sustainable development benefits in the social sphere can be, for instance, training and education, health benefits and improved quality of life associated with less pollution and ease of use. In the environmental sphere, less energy use and fewer emissions of greenhouse gas and pollutants are all benefits. Economic benefits include less cost of energy for the population, opportunity for technology transfer and demonstration, possible development of a local market and injection of capital into a local economy.

Chapter 6

The district heating CDM methodologies

> *"Project-based trading mechanisms provide an opportunity to credit the total emissions benefits of a district heating and cooling/CHP project"* [IEA DHC/CHP 2002][1]

Chapters 4 and 5 were presented to ease the understanding of the benefits of district heating and cooling and CHP technologies, and to explain the main issues with the CDM and the Kyoto Protocol related to energy efficiency technologies.

This Chapter is a product of the analysis of the failed district heating methodology proposals. This chapter describes three CDM project proposals that have been submitted by Danida to the Executive Board of the CDM. I begin with a short introduction to China, since this the focus of these district heating methodologies. Following are a discussion of each of the proposals, and a table that summarises all the criticisms received.

This table (6.2.4) shows that the failure of approval of these methodologies has much to do with how to design a district heating CDM project, and not so much to do with district heating or CHP technology on its own. The table also shows that the criticisms have been for the most part addressed at each step, and have been mostly different from one proposal to the next. Also, the evaluators for the different proposals were in disagreement not only with the project developers, but amongst themselves, regarding what a district heating and CHP CDM project should look like.

A summary and discussion of the case follows. This chapter shows that by trying to safeguard the credibility of the Kyoto system by applying stringent rules for CDM projects, the Executive Board may be undermining the will to propose projects that are complex, and/or that encourage sustainable development. This would be a sore loss for the CDM and could undermine the credibility of the Kyoto system in another way: threatening countries' commitment to a system that is not doing what it promised to do.

[1]The total emissions benefits refer to the environmental and energy security benefits of district heating and cooling/CHP systems in general, and the specific benefits which extend both to the power sector (electricity) and the building sector (heat).

6.1 China

China is one of the largest countries in the world, and one of the most populated - more than 1 billion people. The economic growth rate, as measured by GDP, is very high - averaging more than 8%/year in the last 25 years. The consumption level is growing rapidly, including use of energy and other resources [China.org 2007].

China's push for modernization has led to many negative environmental consequences, such as a massive pollution problem, to cite but one. China is now the world's biggest emitter of carbon dioxide, having passed the US in 2006 - Chinese emissions were 6200 million tonnes of CO_2, compared to 5800 million tonnes for the US and 600 million tonnes for the UK [The Guardian 2007].

The driver for the emissions is a surge in the use of coal and also increased cement manufacturing. China's extraction of coal has surged more than any other country's in the past few decades and they currently build the equivalent of 2 coal power plants per week [IEA 2006, BBC 2007b]. China is building intensively, including new homes and buildings, and "because of backward technologies and the fact that coal is used for the greater portion of its energy supply, the growth of Chinas GDP is very dependent upon fossil fuel consumption. ... Its energy comes from 67,1% coal, [and] in comparison with the world average where coal use stands at only about 22%, the Chinese economy is much more highly greenhousegas-intensive than the world average" [CDM Guide: China 2005].

Chinese emissions per capita are still a quarter to a sixth of US emissions per capita, and are driven to some extent by global demand for Chinese-manufactured products and outsourced industries (export growth was an average of 17% in the 1990s) [The Guardian 2007, Weiss 2005]. China has made clear that it prioritizes growth over satisfying "international demands to help combat global warming", pointedly referring blame to the developed countries [Reuters 2007b].

Despite the priority of growth over environmental concerns, China needs to begin dealing with some of its environmental problems. For instance in the Olympics to be held in Beijing in 2008, "the world is meant to marvel at the host country's advancement and exemplary organisation" [Nordqvist 2005], and yet pollution abatement has not been effective [The Guardian 2007]. China is lagging behind its own energy efficiency standards for buildings and wasting millions of tonnes of coal. This is hurting economic growth and is made worse by the fact that China accounts for the highest level of construction in the world. Therefore new energy efficiency standards were announced recently: "the newly tightened standards slice allowable energy consumption of heating, lighting, and air conditioning by up to 65% in some areas" [Reuters 2007a, The Grist 2007a].

China's high energy use and lack of energy efficiency, and the magnitude of the problem, make clear the advantage of, for example, a district heating system connected to a CHP plant, which substitutes separate heat and power generation and reduces the use of coal. The China CDM country guide states that "CHP and district heating are the priorities of energy conservation technologies in the building sector" in China [CDM Guide: China 2005]. The national government supports district heating in principle, but without specifying which system is best. Municipal governments, responsible for heat, often choose heat-only systems due to cost considerations (they're cheaper)

[Proposal 1: PDD 2004, Proposal 2: PDD 2005, Proposal 3: PDD 2006a].

There is a wide gap between regulation and implementation in China. Energy efficiency regulations are not always complied with at the local level and climate change is something left for the high policy spheres. Energy efficiency and climate change are not linked at the local level. The 'harmony imperative'[2] encourages feigned compliance while preventing frank dialogue directed at solving problems [Nordqvist 2005]. While this is no excuse to allow CDM projects in lieu of regulation, the regulation-compliance gap is in fact a barrier and must be dealt with. It matters to address this through the CDM since China is such a big polluter - otherwise there may not be hope of preventing catastrophic consequences of global warming.

General problems connected to tackling climate change in China include: their wish to not have emissions monitoring (as possible proof of bad performance), the lack of appreciation of the value of corporate social responsibility, conservatism related to new approaches or new processes for running businesses, and protectionism of local industry. Also, it must be understood that in China technology transfer is made from one government to another, not between businesses [Nordqvist 2005]. These barriers are all addressed by the district heating proposals, which cite conservatism as a main argument for why such a solution has not been implemented in Hou Ma. The fact that district heating technology is being transferred by the government of Denmark (meaning the CDM project is from Danida) counts as a plus in the normally skeptical Chinese attitude towards the CDM and its objectives. This opportunity should not be lost.

A large proportion of CDM projects happen in China, and about 60% of all CERs contracted as of 2002 were generated there. China has a large potential because it can bring economies of scale to projects, lowering costs, and because it has a favourable climate for investment, with "strong support from institutions and experienced project developers" [CDM Pipeline May 2007, The World Bank 2007].

Even though costs for CDM projects may be potentially lower than in other countries, district heating is a type of project which is capital intensive. This represents and opportunity for the CDM to make a contribution to sustainable development and reducing CO_2 emissions, and it should, therefore, contribute to reducing these costs if possible. See [Kaneko *et al* 2006] for cost rankings of different sorts of projects in China.

A note on the sustainability of coal: Coal is one of the most polluting fossil fuels. It contributes to environmental damage and social problems by its effects on health and employment, to cite but two. It is not a renewable form of energy. As such, it is not sustainable [Greenpeace 2005].

However is it also cheap and abundant in China. And as mentioned above, China is making a point of prioritising development over climate change. This means, in effect, that China makes abundant use of coal and will continue to do so for some time. China needs to reduce as much of its energy consumption as possible - including coal based energy use. The coal power plants China is building today will be in operation for decades to come. Therefore, an effort should be made towards, at the very least, using the existing coal power plants in the most efficient way possible.

[2]The outward show of harmony as a main principle mediating Chinese relationships.

Pursuing district heating systems as a more sustainable alternative to individual and small innefficient heating networks makes sense even when the power and heat are being supplied by fossil fuels. Doubtless a CHP system with district heating and run on renewable energy is more sustainable, but fossil fuel-run CHP with district heating is still better than no use of the waste heat at all, especially since these power plants will be polluting for so many decades to come.

Some have suggested that the Executive Board should limit projects that endorse the continued use of coal such as the Hou Ma project, in spite of the benefits of this project for sustainable development and reducing emissions [Andersen 2007]. However this would limit the benefits of the CDM, in effect leaving many Chinese projects out of the CDM, since coal is such a cheap, abundant and widely used source in the country. Perhaps projects that endorse the continued use of fossil fuels could be financially penalised, but excluding them from the CDM would ensure a lost opportunity for targeting the country with the highest emissions in the world.

6.2 The methodology and the Hou Ma project

This section is an introduction to the situation of the town of Hou Ma in Shanxi province in China. Each proposal gives an introduction such as this one to the project, and then explains the methodology and the monitoring methodology. I only give one introduction for all three proposals, and then expand on the methodologies, as there are no significant changes to the introductions of each proposal. I will not evaluate the monitoring methodologies. The criticisms received in connection with them mostly refer to discrepancies between the methods for establishing the baseline emissions and the monitoring of project activities, and closer attention to detail can avoid or fix most such problems.

The proposals contained a new methodology for switching from individual and small scale district heating to large scale district heating, based on conversion of a fossil fuel power plant to a CHP plant. The new methodology includes a method for determining the baseline, the project activities, and the monitoring strategy. Also, a specific project proposal was submitted, to use the new methodology to install a large district heating system in the town of Hou Ma in Northern China. This new methodology has been designed and submitted for approval because no methodology for district heating yet exists. If approved, it can be used by other proponents of similar projects [Proposal 1: PDD 2004, Proposal 2: PDD 2005, Proposal 3: PDD 2006a].

"Compared with district heating systems in other Nordic and many European countries the Danish systems are characterized by: low pressures and low temperatures in the network, many direct connections to the buildings and a low heat density due to many single family houses and other buildings with low heat demand connected to the district heating network" [Bøhm 1999]. Denmark is in a prime position to export this technology and spread the benefits of district heating to developing countries.

Danida has commissioned the proposals. The first two have been designed by COWI (a consultancy) and the last one by the Öko-Institut in Germany, in cooperation with COWI. The design of a district heating system as a CDM project is complex and this is partially responsible for the failure of approval. However, the lack of approval of the three proposals have left those involved in the preparation processes very frustrated and uncertain what is actually required for this methodology to be approved [Jürgen 2007].

> *"The projects introduce a fundamental modernisation by appliance of efficient district heating technology in a country with an extensive, old-fashioned and inefficient district heating sector"* [The Danish 92 Group 2005]

Substitution of individual heating for a large district heating system saves energy, reducing greenhouse gas emissions, and reducing pollution. The project area (Hou Ma) has both a small district heating network based on small heat only boilers, plus individual heating in homes, based on stoves and furnaces. Coal is used in these systems. The coal is transported in open trucks, which adds to particulate matter (air pollution) and often chimneys are low, adding to air pollution as well as emitting CO_2. A large district heating system would use less coal overall [Proposal 1: PDD 2004, Proposal 2: PDD 2005, Proposal 3: PDD 2006a].

The cost of installing this capital-intensive system will be shared and the sale of CERs is what provides financial closure[3], which would not be possible otherwise. Without this CDM project, the chances that a large district heating system would be set up in a small town like Hou Ma are small [Proposal 1: PDD 2004, Proposal 2: PDD 2005, Proposal 3: PDD 2006a].

Box 6.1: The Hou Ma project

- Hou Ma population: 188 000 (small by Chinese standard);
- Hou Ma heating days per year: 120;
- Heated building area: 2 389 600 m^2;
- Power supplied by: provincial authority; heat by: municipal authority;
- Primary network: 16 km of pipes from the power plant to the substations;
- Substations: 23-25, linked to the homes by an already existing network (covering 500 000 m^2 with 88 boilers);
- Heat capacity needed: about 145MW; heat demand: about 1050 TJ/year;
- Emissions reductions: From 1 525 789 tonnes of CO_2e to 508 573 tonnes of CO_2e in the first proposals, from 1 008 735 tonnes of CO_2e to 364 399 tonnes of CO_2e in the last proposal, the latter baseline including only the existing district heating network;
- [Proposal 1: PDD 2004, Proposal 2: PDD 2005, Proposal 3: PDD 2006a].

The project proposes to make the provincial power station a co-generation plant, and installs equipment and pipes. The existing pipes will be used as a secondary pipe network. The power station can be turned into a cogeneration plant because two extra

[3] Lack of financial closure means that the funding that is available would not be enough to complete the project. The sale of CERs injects needed funding, making the project possible and thereby providing financial closure.

production lines were introduced in 2002, which allow for the extraction of steam. Equipment to be installed includes a steam extraction unit and a main heat exchanger at the power plant [Proposal 1: PDD 2004, Proposal 2: PDD 2005, Proposal 3: PDD 2006a].

A control apparatus for the whole district heating system will be installed in the office of the public utility company which coordinates the current system, allowing the control of the flow to be adapted to the consumption [Proposal 1: PDD 2004, Proposal 2: PDD 2005, Proposal 3: PDD 2006a]. This ability to adapt the flow to consumption is one of the advantages of modern Western district heating systems compared to what exists in China.

New buildings are going up in China every year and they are overwhelmingly high-energy consumption buildings. "With increased standards of living, more energy is used for heating, air conditioning, lighting, and electrical appliances" [CDM Guide: China 2005]. Therefore, the introduction of district heating can help reduce China's quickly growing energy consumption.

District heating in China is based in fixed-flow systems operated at high temperatures, resulting in low efficiency, compared to Western European systems based on variable flow, which can be adapted to demand, and which are run at low temperatures (this means that you get all the power you can out of the fuel before sending it on to the district heating network, achieving maximum efficiency) [Proposal 1: PDD 2004, Proposal 2: PDD 2005, Proposal 3: PDD 2006a]. In China "the energy used for heating per unit of floor space is three times that of developed countries." Also, "the portion of energy used by residential buildings as a percentage of the total energy consumed nationwide has risen steadily since 1996" [CDM Guide: China 2005].

The savings of CO_2 from the project come from less use of coal for boilers at home and from the existing district heating, which has the added benefit of improving air quality by diminishing the coal dust in the air. Also, the use of surplus heat from the power plant makes it much more efficient, reducing the need for cooling the steam from power production. There is an added amount of coal that will be used at the power station to produce the heat, but this will be much less than what is currently used to supply the small boilers, stoves and furnaces [Proposal 1: PDD 2004, Proposal 2: PDD 2005, Proposal 3: PDD 2006a].

"The principle in the methodology is to calculate how much fuel is needed for heating ... in the base line and the project scenarios, and subsequently calculate emission reductions" [Hofman 2005]. Basically the proposals all calculate emission reductions based on heat supplied at the power plant. In Proposal 1, this is taking into consideration heat production and marginal efficiency of heat production (related to the decline of electricity production for each heat unit supplied) [Proposal 1: PDD 2004]. In Proposals 2 and 3, this is done taking into consideration fuel demand, calculated based on heated floor area, boiler capacity, number of heating hours and boiler efficiency[4] [Proposal 2: PDD 2005, Proposal 3: PDD 2006a]. Subsequent versions of Proposal 3 (versions 2 and 3) change the measuring point of heat supplied in the baseline to the secondary heating network [Proposal 3: Methodology 2006b].

The project would have demonstrative value (variable flow district heating systems, based on co-generation of power and heat, and using pre-insulated pipes), and ca-

[4] Heat demand is considered equivalent to heat supplied in the formulae provided.

pacity building in the form of training for planning and operation (as there is no expertise in these kinds of variable flow systems in China) [Proposal 1: PDD 2004, Proposal 2: PDD 2005, Proposal 3: PDD 2006a].

Table 6.2.4 shows an exhaustive list of all the criticisms received. I will comment the proposals and give a short summary of the criticisms here, but a longer list will be presented in the table, including who made the criticism and comments as to how it was dealt with. I present this table because the devil is in the detail - the idea for a district heating methodology is not being disputed, only the way it has been developed in relation to accounting for emission reductions.

6.2.1 Proposal 1: NM0058

The proposal was evaluated by Randall Spalding-Fecher and Naoki Matsuo, and commented on (in the public consultation period) by Ralph Harthan. The reviewers agree that the proposal is not what it should be: "the description [of the methodology] is not adequate, because it makes an argument for a baseline scenario in qualitative terms rather than laying out a process for deciding on a baseline scenario - which is what methodologies are supposed to do" [Spalding-Fecher, undated, Matsuo, undated, Harthan, undated, Proposal 1: PDD 2004].

This methodology was not considered widely applicable - it was designed for this project in China and did not contain any wider applicability criteria (other countries or similar systems). The choice of baseline was not made based on calculations, and the explanation for the final choice was incomplete. Additionality and leakage were not justified or tested. Ways of obtaining and dealing with boiler efficiency, value of cogeneration and emission factor were not provided. The time frame of the change from one system to the other was not addressed. Uncertainties in the method were not addressed. The boundary was unclear. These points are related to lack of transparency and conservativeness. Table 6.2.4 shows and comments on each criticism in more detail.

The recommendation of the Methodology Panel for non approval incorporates the critique of the two desk reviewers [Meth Panel 2004]. The Executive Board therefore rejected the proposal [Executive Board 2004].

6.2.2 Proposal 2: NM0096

COWI prepared Proposal 2[5] after the grade C (rejection) of Proposal 1. At the time, "a contract for supply of part of the equipment [had already] been signed, and the manufacturing/installation of equipment [was] in progress" [Proposal 2: PDD 2005]. The installation was completed in May 2006 [Proposal 3: PDD 2007]. Despite this, the actual project was cancelled late in 2005 [UM 2005].

The additionality was identical as that of Proposal 1 (the project was considered additional), but included not only the previous arguments for this, but also a criteria for defining the additionality. This criteria comes from the UNFCCC. Figure A.4 illustrates

[5]When this was submitted, the actual forms used (pre-determined by the Executive Board) were already different from the previous submission (for example the methodology submission form is now separate from the project design document), reflecting the quick changes taking place and the lack of established rules and procedures from the start of the Protocol.

the steps in development of the baseline and testing of additionality for this kind of project [Executive Board 2005a, Proposal 2: PDD 2005].

Not performing the investment analysis, which is part of the demonstration of additionality, has been used by energy efficiency project developers in an attempt to avoid showing how small the CER revenues are compared to the whole budget of the project, as this can invalidate the additionality. "Although it is not mandated by the additionality tool, application of both the barrier and investment analysis has been the first priority recommendation by the Meth Panel/ Executive Board" [Hayashi and Michaelowa 2007] - and so it should be since the additionality criteria is not only financial but also encompasses other kinds of barriers. The application of both tools can therefore sometimes prevent the financial analysis from invalidating additionality.

The method for determining the baseline scenario was designed as follows: an evaluation of current regulations in the field, historical assessment of how (in this case) heat has been supplied in Hou Ma, and current state-of-the-art in the field. The baseline was therefore determined for the project, and was identical to the baseline for Proposal 1. The emissions in the baseline were 1 495 000 ton/CO_2 and in the project scenario 565 000 ton/CO_2 [Proposal 2: PDD 2005, Proposal 2: Calculations 2005].

Compared to the criticisms received in Proposal 1 (see Table 6.2.4), the following issues were addressed: guidelines for measuring additionality were provided. The baseline was calculated, based on guidelines for determining a baseline in such types of projects, and was different from the methodology. Ways of obtaining and dealing with boiler efficiency, value of cogeneration and emission factor were provided. The time frame for the shift from individual/small boiler systems to a larger district heating system was made explicit. The boundary was more clearly stated. Thru these steps, the methodology sounds more widely applicable and more transparent. Leakage and uncertainties were not addressed [Proposal 2: PDD 2005].

A technical query was requested by the Executive Board, which was responded to by COWI/Danida. The query requested preliminary clarifications before the evaluation and grading of the proposal.

Unfortunately the query was unclear on several points and also contradictory. The applicability was considered both too broad and too limited, and COWI's answer stated the difficulties of making a widely applicable methodology of this complexity level, which would make it too complicated to use. Some formulas were stated as missing when they were in fact included (I checked this myself and the formulas were there - I also did not understand what the Executive Board thought was missing), and some things were considered unclear, without explanation as to what was not understood. COWI requested an oral consultation, and had questions regarding what the Board was asking, but they never got a reponse [Proposal 2: Tech Query Response 2005, Jürgen 2007, Lorenzen 2007]. See Table 6.2.4 for the detailed criticisms and comment.

This highlights problems of lack of communication, lack of clear guidance, and apparently lack of attention, aside from the problems brought by the bottom up methodology generation process, which makes methodologies specific to the need of the developer and not more general as the Executive Board would like them to be (see below).

Critique of this proposal was prepared by Lambert Schneider and Yvonne Hofman. These second evaluations focussed more on specific errors rather than on general statements, in keeping with the second proposal's length and level of detail and appropriateness [Schneider 2005, Hofman 2005].

Yvonne Hofman highlights some of the same points as Lambert Schneider, but disagrees on others. She considers the methodology applicable to different kinds of projects, which is not the trend so far expressed by the other reviewers. She also considers the basis for determining and assessing the baseline appropriate and adequate [Hofman 2005].

The fact that there are differences in the evaluation of different experts indicates the existence of personal differences of opinion as to what is appropriate as a CDM project. Some of the evaluators' criticisms directly contradict each other, such as the assessment of applicability, choosing the baseline scenario and the boundary. This is an example of the uncertainty regarding the practical application of the rules of CDM, which is a consequence of the bottom up approach to methodology generation and the lack of funding (i.e. time to spend making the Executive Board's work consistent and thorough).

Common criticisms from both reviewers argued that the baseline was not conservative as it was based on estimations rather than measurements (*ex-ante* rather than *ex-post*), that there were some glitches in the formulas presented, uncertainties were not estimated, and there were inconsistencies in and between the methodology and monitoring proposals. The reviewers disagreed on the applicability of the methodology, the adequacy of the baseline assessment and project boundary, and the presence of leakage (rebound effect).

Some of the questions raised by the Executive Board in the technical query were similar to Lambert Schneider's points (weak baseline criteria, limited applicability, unclear or missing formulas and calculations). The response given by COWI in the tech query was apparently not considered appropriate by the reviewers, and no response was forthcoming from the Executive Board. Table 6.2.4 shows and comments on each criticism in more detail.

The Meth Panel makes an evaluation based on the expert reviews. In this case, they seem to have taken most of the problems highlighted, even if the reviewers disagreed on whether this was a problem or not, and used them as justification for their recommendation to the Executive Board. The Meth Panel therefore incorporated the text from both the reviewers' critique in their evaluation, and denied approval, stating that although relevant issues had been addressed in Proposal 2, it had not been done adequately [Meth Panel 2005]. This shows the lack of time and resources available to the Meth Panel, which used the expert evaluators' opinions even if they were contradictory, and suggested grade C based on problems that were not considered an issue in other methodologies (for example the rebound issue. See more below).

The reasons for rejection were: the baseline scenario was not conservative and "key parameters should be monitored *ex-post* in order to avoid gaming". Design thermal ratings (what I refer to as boiler capacity) should not be used for stoves and furnaces due to the level of uncertainty over the project period. The criteria for identifying the baseline is not adequate and the alternative scenarios proposed are limited. There are inconsistencies between the baseline and monitoring methodology, lack of certain information exists in the alternatives not chosen as the baseline or project activity, and some of the assumed values are questioned, and not considered conservative. "Rebound effects are not taken into account". The applicability is unclear, the project boundary is also unclear. Uncertainties are ignored and data needs to be better documented. The monitoring methodology was also denied approval because many changes would have to be made to both the baseline methodology and the monitoring methodology to make them work [Meth Panel 2005]. Accordingly, Proposal 2 received a grade C (rejected) [Executive Board 2005b].

The fact that design thermal ratings for stoves and furnaces should not be used in the baseline, and no other acceptable way to include these individual heating systems in the baseline was found, means that in Proposal 3 these have been excluded from the baseline. In Box 6.1 we can see that the area covered by these is larger than the building area covered by the existing district heating network, which in effect excludes a portion of the city from the baseline. This is a problem because it excludes the participation of private companies in expanding the district heating network, since no emissions reductions are counted and therefore no profit can be made from that. This limits the task to not-for-profit organisations. The idea that since the uncertainty is too large, we simply do not consider this part of the problem, seems unfair and is discouraging. Whatever smaller benefit could have come, even if fewer CERs were generated due to the uncertainties, is null. This could potentially undermine trust in the fairness and accessibility of the Kyoto Protocol.

6.2.3 Proposal 3: NM0181

The responsibility for this methodology was assigned to the Öko-Institut in Germany, with COWI providing support [Lorenzen 2007]. Lambert Schneider and Ralph Harthan are both with the Öko-Institut and were involved in the preparation of this proposal (Lambert more than Ralph). The idea here would be that the reviewers, being familiar with the requirements and procedures of the Executive Board, would be better placed to design a methodology that could get approved [Fenhann 2007, Schneider 2007]. Three versions of the this proposal were submitted: version 2 in response to preliminary feedback and version 3 in response to the grade B the proposal received (revision needed). The revisions were done by COWI.

The Meth Panel again asked for preliminary feedback, with the expected result of a version 4 for this Proposal. This version was not available at the hand in date for this thesis. An analysis of this version would have been interesting but not fundamental to my conclusions.

The new methodology for this proposal was named "Introduction of a new primary district heating system". Main changes include that emissions only from the existing secondary network are counted, and not emissions from individual boilers and furnaces in the baseline. Also, the baseline emissions are measured as heat supplied to the existing secondary network and project emissions are measured as heat supplied to the primary network. It is considered that losses in the secondary network will be the same in both scenarios, allowing for the determination of losses in the primary district heating network. Accordingly, the emission measurement formulae were changed, and expanded to accommodate different building types, more options for choosing the appropriate boiler/furnace efficiency, and an adjustment factor for efficiency changes to the secondary network[Proposal 3: PDD 2006a].

Throughout the text of the new methodology, the possibility of revision to broaden to applicability of the method is indicated as possible by those interested in using the methodology for a slightly different application of the same type (i.e. inclusion of emissions from hot tap water). Reference is made several times to methods used in approved methodologies, sometimes even methods that have caused the failure of approval of previous Proposal submissions (i.e. justification for lack of treatment of rebound effect, to cite one) [Proposal 3: PDD 2006a].

The steps for the determination of the baseline and alternative scenarios follow about the same procedure as for determining the baseline for Proposal 2, but including more options and more explicit justification of choices. The conclusions, though, were the same: that without the project business as usual would be replacement of old coal fired boilers for new ones, and that without the project as a CDM project the financial, technological, institutional and prevailing practice barriers could not be overcome [Proposal 3: PDD 2006a, Proposal 3: Methodology 2006a].

The method for determining the emissions in Proposal 3 yielded 1 026 000 ton/CO_2 for the baseline and the "emissions associated with heat extraction from existing power plant(s)" were estimated at 375 000 ton/CO_2 for the project scenario [Proposal 3: PDD 2006a, Proposal 3: Methodology 2006a, Proposal 3: Calculations 2006].

The additionality was tested following the steps outlined in Proposal 2, and according to the additionality flow chart (Figure A.4) the project is additional. The determination of emissions followed the same steps as for Proposal 2, but using *ex-ante* data only as a guideline, to be confirmed *ex-post*.

In relation to the previous proposals, many of the issues have been addressed, both the very small up to the main criticisms. The steps in Proposal 2 are more clearly stated than in Proposal 3, and the substantial differences in the method for determining the baseline and the additionality are the more conservative values used in Proposal 3, which show higher efficiency for the existing boilers, a smaller heat demand (since only the existing district heating network was included), and smaller CO_2 reductions.

Lambert Schneider, who was a desk reviewer for Proposal 2 and helped prepare Proposal 3, seemed to have reviewed some of his critiques, when preparing the latest proposal. For example, he criticized the ruling out of natural gas due to a distance of more than 50km from the nearest pipeline, and this was the justification given for ruling it out in this proposal. He criticized the non-addressing of the rebound effect as a source of leakage and yet leakage was not addressed in Proposal 3. He himself told me that he believes that including the rebound effect or not is more a matter of policy - it is a decision whether such effects will be considered or not [Schneider 2007]. The rebound effect happens when the installation of the project causes, for example, consumption patterns to change (as would be possible in this case).

Critique of this proposal was made by Deborah Cornland and Georgiy Geletukha. The first reviewer seemed to have an overall good impression of the proposal, except for the method for barriers analysis. Georgiy Geletukha thought several major changes should be made, and considered that "some of expert and Executive Board comments and recommendations on previously submitted methodology Proposal 2 have been reacted in the NM0181 but not all and not always adequately" [Cornland 2006, Geletukha 2006].

A preliminary review was requested by the Meth Panel and responded to. The points on which clarification is requested are not made public where the other documents relating to the proposal can be found, so we can only judge what they are by the responses given in the form of the preparation of version 2 of the proposal. The preliminary review mechanism was introduced to diminish the bureaucracy associated with review of different versions of proposals: the new version will not be evaluated by desk reviewers or public consultation, only the Meth Panel and the Executive Board.

The changes that were made are as follows: several passages were excluded, which dealt with provisions to avoid the rebound effect, and provisions that demand project participants must have the right to make the changes required in the methodology. A reasoning for why the rebound effect is not considered was provided instead (stating that fuel prices and other conditions have a bigger influence on choosing to increase consumption, that growth in consumption would happen in future anyway, that the methodological complexity of dealing with this would make the methodology un-usable, and that this effect was ignored in other approved methodologies). Leakage treatment was changed, with a suggestion to consult the treatment given in another methodology under certain conditions (i.e. fuel switch). Further barriers were included for the barrier analysis and the inclusion of new buildings in the methodology was clarified [Proposal 3: Methodology 2006b].

Changes to the project document include an explanation for the use of default values in order to demonstrate the applicability of the methodology, stating that these are not the values that will be used in the determination of the baseline and project scenario emissions. Changes to the formulae were reflected in this document as well [Proposal 3: PDD 2006b].

The Final recommendation of the Meth Panel, which is the evaluation of version 2 of Proposal 3, contains the following comments: the justification for the for lack of consideration of the rebound effect was not accepted, losses in distribution should be considered, heat distribution efficiency should not be constant through all crediting periods, they identified a conceptual problem regarding one of the formulas (I have not found evidence for this - see Table 6.2.4). This baseline should not apply to heat-only boilers in new buildings due to uncertainties (it currently applies to CHP or heat only boilers for new and existing buildings), and additional definitions for three parameters in formulas should be provided. Two alternative scenarios were suggested for the baseline estimation, and more specific guidance on two points of determining additionality should be given. Possible solutions to many of these problems are suggested in the Meth Panel's recommendation [Meth Panel 2006b]. The proposal got a grade B (revision needed) [Executive Board 2006b].

Compared to Proposal 2, there were small adjustments to the baseline alternative scenarios, and the applicability conditions, but overall it was satisfactory. The use of estimations rather than measurements seems to have been solved, along with the project boundary. Uncertainties and the rebound effect are still pending resolution. New issues were brought up as problems.

The Meth Panel believed that emission reductions should be counted up to a cap of historical fuel use, and they felt this would solve many of the problems they identified. It would solve the rebound effect problem, the estimation of heat loss from the primary network, and the problem of the emission factor. The project developers disagreed and thought this would be unrealistic (see below).

When a proposal gets grade B, the project developers have some time to prepare a resubmission. This will not have to go through another expert review or public consultation session, being reviewed solely by the Meth Panel and the Executive Board.

A revision was prepared and resubmitted. Changes to the methodology include the exclusion of heat only boilers for new buildings, added applicability conditions include presence of a clear project boundary, this boundary being reverted back to the cogenerational part of the power plant instead of only the heat-generating part of the plant (see Table 6.2.4). It was suggested that the new tool for defining additionality be applied, which it was, including the added applicability conditions suggested and leading to the same result. The method for calculating emissions was changed following changes in the project boundary and as a result of consultation with experts and use of previous approved methodologies [Proposal 3: Methodology 2007].

The position on the rebound effect was maintained in spite of the Meth Panel critique, with the following comment: "the introduction of capping factors or similar measures to take into account any changes in service level, would according to the project developers mean unequal handling of the energy markets of respectively electricity and heat and furthermore it would imply unrealistic measuring requirements and disproportionate transaction cost. It should be mentioned that this position is supported by a large number of interviewed Chinese, Danish and International experts" [Proposal 3: Methodology 2007].

The changes to the PDD include reapplication of the changed methodology, recalculations of emissions, new facts and pictures from a site visit conducted in April 2007 [Proposal 3: PDD 2007, Proposal 3: Calculations 2007].

The Meth Panel asked for further clarifications at its meeting from 9-13 July 2007. Respondents have four weeks to respond, and in case they do not the Panel's recommendation will become final and be referred to the Executive Board [Meth Panel 2007]. The recommendation had not been made public by the hand-in date for this thesis.

6.2.4 Criticisms table

Table 6.2.4 shows an exhaustive list of all the criticisms received. Along with this information is the number of the proposal and the evaluators. Version 2 is indicated as 3(2). Following are my own comments. The problems are mostly different for each proposal, even when they fall in the same category - disagreements turned up at every step. Ultimately in the effort to maintain credibility, the Executive Board has undermined the will of the project developers to participate and missed the opportunity to encourage sustainable development, which could potentially threaten countries' trust in the Kyoto Protocol.

Table 6.1: Summary of criticisms to the proposals.

Critique	Proposal	Evaluators	Comment
Issue: additionality. No additionality test	1	Ralph, Randall	This was fixed in Proposal 2
Issue: additionality. Incomplete explanation of baseline choices	1	Naomi, Randall	For example, in 1: there is no evidence provided that environmental legislation in China in the near future will not limit the use of the boilers and stoves to limit air pollution. Therefore the additionality criteria is not fully satisfied by simply providing figures showing small boilers to be the least cost solution. See below for a 'counter-analysis' of this issue. The additionality issue was solved in further proposals.
Issue: additionality. Additionality conditions should include clearer definitions	3(2)	Meth Panel	"Step 1: The methodology should require that the exclusion of the baseline scenario alternatives from the set of potential alternatives must be substantiated by evidence in the draft CDM-PDD that can be checked by the DOE, and in Step 3: More specific guidance for the application of the investment analysis in the context of heat generation technologies should be given, e.g. regarding calculation of financial indicators. An approach in analogy to step 4 in ACM009 (p.3) might be a solution to this[6]. Also, in the modified documents, the condition "The decision-making on which heat supply technologies are used in the project area is under the control of the project participants" has been removed. It is not clear why it was done. This requires the modification of the baseline selection part" [Meth Panel 2006b]. The latter two issues above were addressed in version 3.

[6] "The project proposers may consider the use of the Combined Baseline and "Tool for the demonstration and assessment of additionality", if applicable to the specific project situation (this tool was not available at the time of submission of the CDM-NM)

Table 6.1: Summary of criticisms to the proposals.

Critique	Proposal	Evaluators	Comment
Issue: applicability. Unclear, inconsistent and limited applicability	1, 2	Ralph, Naomi, Randall, Lambert	In 1: Applicable only to China, and applicability to similar projects missing. This was fixed in Proposal 2. In 2: Methodology is not applicable to improvement of energy efficiency (only introduction of district heating). It is not applicable to all kinds of supply side efficiency, and is limited to coal and natural gas supply. Only coal can be used in existing boilers, no new cogeneration plants, no backpressure plants. Only applicable to new systems (rather than the stated new and existing). The applicability is therefore considered too limited by these reviewers.
Issue: applicability. Unclear applicability to hot tap water	2, 3(1)	Executive Board, Georgiy	in 2: The fact that some residents may use a different heating system for hot tap water was highlighted as not dealt with. In 3: Conflicting statements in the methodology. This was fixed in version 2 of Proposal 3.
Issue: applicability. Formulas need more specific applicability conditions	3(2)	Meth Panel	The emission factor and the power loss coefficient (related to proportion of heat and power production) are defined in relation to a specific heat and power proportion output, which needs two added applicability conditions to be correct: Useful heat extracted from the power plant in the project activity may not exceed the "maximum heat extraction" for which the power loss coefficient is defined, which was provided in version 2 of Proposal 3, and "Power plant fuel consumption in CHP regime with steam extraction is the same as or less than that of condensing regime with maximum possible power production", capping emission reduction calculations to historical production from the power plant. The power loss coefficient was removed from version 3 of the proposal in favour of consumption of coal, electricity and heat, in accordance with a site visit, consultations with experts and existing approved methodologies.

Table 6.1: Summary of criticisms to the proposals.

Critique	**Proposal**	**Evaluators**	**Comment**
Issue: applicability. Heat-only boilers for new buildings should not be included	3(2)	Meth Panel	It adds uncertainties to the methodology. This was fixed in version 3.
Issue: baseline, applicability. No guide or weak guide on how to choose baseline	1, 2, 3(2)	Randall, Executive Board, Lambert, Meth Panel	This was fixed in Proposal 2, but not accepted by the reviewers: the guidance to choosing the baseline was found to produce limited alternative scenarios (e.g. oil-based heating or the project activity itself was not included), making the applicability too limited. In the same document (the tech query), however, the Executive Board considers the applicability was considered too broad. In 3(2), two additional alternatives were suggested.
Issue: barrier analysis. The barrier analysis should be expanded	3(1), 3(2)	Deborah, Meth Panel	It should include not only the existence of a barrier but why and why the barrier is a truly a barrier (For example why is a ‘first of its kind’ project a barrier rather than an opportunity?). This expansion can be found in version 3.

Table 6.1: Summary of criticisms to the proposals.

Critique	**Proposal**	**Evaluators**	**Comment**
Issue: boundary. Unclear boundary	1, 2, 3(1), 3(2)	Randall, Lambert, Georgiy, Meth Panel	In 1: unclear whether primary *and* secondary district heating network are included. If the secondary network is not included it should be treated as leakage. In 2: what is unclear was not stated. In 3: the lack of inclusion of emissions from power generation, in spite of the inclusion of the whole power plant as part of the boundary, is not appropriate. This was fixed in version 2 of Proposal 3, where the project emissions are the sum of emissions from heat supply only at the power plant, and the boundary corresponds to heat supply only. The Meth Panel considered this innapropriate and suggested a return to the whole (cogenerational part of the) plant being included in the boundary. Version 3 of Proposal 3 therefore includes all the cogenerational units from the power plant, which produce both heat and electricity. This point is connected to the point below:
Issue: boundary: methodological problems. Reconsider method for calculating emission reductions: include all emissions from the power plant	3(1)	Georgiy	Considering only CO_2 was praised by all other reviewers as conservative. It is unclear whether the reviewer means include all gases or all CO_2 emissions (e.g. from power generation as well as heat generation). The reviewer believes that emission calculations should be based on fuel used by local boilers for heat production and at the power plant for both heat and power production, compared in the project and baseline - not just fuel used by the local boilers compared to the heat extracted at the power plant. This would increase transparency and reduce complexity. Version 2 of the proposal addressed this and included all of the power plant in the boundary. This was criticized by the Meth Panel, and fixed in version 3 by using only the cogenerational units of the power plant as a basis for calculating emissions.

Table 6.1: Summary of criticisms to the proposals.

Critique	**Proposal**	**Evaluators**	**Comment**
Issue: conservativeness. Uncertain conservativeness	1, 2	Randall, Yvonne, Lambert	Conservative in 1: exclusion of efficiency improvements, coal mining and transport. Non-conservative in 1: exclusion of possible growth in heat loss, and new boiler data should be checked rather than estimated from equipment design figures. Non-conservative in 2: boiler efficiency values are low (rather than the stated high), method for calculating the heat extracted from plant yields lower result than other methods (thereby yielding more CERs). The latter was not addressed in Proposal 3. Also, parts of the methodology are structured in a way that they could lead to 'gaming', and baseline values are not conservative. This issue was not raised in Proposal 3, leading to the assumption that the issue has been solved.
Issue: conservativeness. Small text changes needed	3(1)	Deborah	For example the use of the word 'preferably' should be accompanied by an alternative requirement.
Issue: conservativeness. No use of monitored data for calculating emissions	2	Yvonne, Lambert	Some parameters can be taken from monitored data rather than calculated.
Issue: conservativeness (?) Formulas 1 and 2 are bad	2	Yvonne	These formulas refer to estimation of annual heat demand using the equipment design figures, and heated floor area. It is not stated why these formulas should be revised, except for the elsewhere mentioned over-use of design figures and the baseline being based on the heated floor area while the monitoring is not.

Table 6.1: Summary of criticisms to the proposals.

Critique	Proposal	Evaluators	Comment
Issue: conservativeness, applicability: methodological problems. Non-cogeneration extra fuel for heat generation is not included as an emission	3(1)	Georgiy	Fuel consumption grows in the CHP plant but adding fuel for heat production makes this part of the added fuel non-cogeneration. This is not accounted for by the methodology (emissions for this are not calculated). Therefore there are two missing applicability conditions for the methodology as it is: useful heat extraction from power plant is less than useful heat extracted from CHP plant, and fuel consumption is the same or less in CHP regime compared to full power production. This makes the methodology very limited and not applicable to the Hou Ma project. A different applicability condition was therefore added in version 2 of the proposal (response to preliminary feedback from the Meth Panel), which solves this problem and makes the methodology applicable to the project it was intended for.
Issue: leakage. Rebound effect not addressed	2, 3(2)	Executive Board, Meth Panel	The assumption that heat demand would be the same in the baseline and project scenarios is not appropriate, since the installation of valves in the apartments may reduce energy consumption. Version 2 of Proposal 3 gives several explanations for why the rebound effect is not considered. These explanations are not considered satisfactory on the grounds that changes in supply occur when rehabilitating old district heating systems. The suggested solution is to limit counting emission reductions up to the historical/design heat supply capacity. The authors of the proposal disagree with this suggestion because of practical issues (such as measuring where the cap is in actual production). Therefore this issue is still not settled.

Table 6.1: Summary of criticisms to the proposals.

Critique	Proposal	Evaluators	Comment
Issue: leakage. No leakeage treatment	1, 2, 3(1)	Ralph, Randall	From 1: changes to system efficiency could be considered leakage. From 2: changes in insulation of buildings or weather conditions could be considered leakage. Not addressing this is appropriate *but* can lead to gaming[7]. This is considered appropriate in Proposal 3, and version 2 of the proposal has added explanations.
Issue: methodological problems. Inconsistencies and unclear relationship between baseline and monitoring methodology	2, 3(1)	Yvonne, Lambert, Deborah	In 2: inconsistencies of whether heat supplied, fuel consumption, electricity supply and caloric value are monitored, and emission reductions in baseline were based on heated floor area, reductions were monitored via heat supplied and not heated floor area. In 3: the addition or removal of heat supply points should be monitored, and the methodology does not explicitly address this in spite of treatment of this topic elsewhere (e.g. the barrier analysis).
Issue: methodological problems. Method for calculating heat extracted from plant	2, 3(1)	Yvonne, Georgiy	The method for calculating the heat extracted from plant yields lower result than other methods (thereby yielding more CERs). This should be reconsidered.
Issue: methodological problems. Consider losses in distribution in the primary network	3(2)	Meth Panel	Since emissions are measured as heat supplied an overestimation of emissions due to losses in distribution is not desirable. This does not appear to have been addressed in version 3. It is unlikely that there will be significant heat losses in the new primary network, which will use state-of-the-art pipes pre-insulated pipes.

[7] Taking advantage of loopholes in the CDM that allow financial gain without reducing CO_2.

Table 6.1: Summary of criticisms to the proposals.

Critique	Proposal	Evaluators	Comment
Issue: methodological problems. Heat distribution efficiency should not be constant through all crediting periods	3(2)	Meth Panel	The baseline or project scenario heat distribution efficiencies (boilers, distribution network, CHP plant, etc) can be subject to changes considering it is a rehabilitation of old systems, and assuming maximum efficiency increases emission reductions. This was fixed by considering changes in subsequent crediting periods.
Issue: transparency. Missing formulas	1, 2	Ralph, Executive Board, Lambert	In 1: formula for additional fuel use for heat missing. This is unclear since the formula was in fact provided. In 2: formulas and steps for calculating emissions and heat demand, and for determining the baseline and project activity, were unclear or unprovided. This is confusing since there are formulas provided, and what was unclear has not been stated.
Issue: transparency. No source for emission factor	1	Naomi	This was fixed in Proposal 2 (the IPCC is used).
Issue: transparency. Which parameters are time dependent?	1	Naomi	This is not an issue anymore.
Issue: transparency. Bad description of parameters in PDD	1	Naomi	Parameters were described in measurable form in the baseline methodology, but not the PDD.
Issue: transparency. Not transparent	1, 2	Randall, Yvonne	In 1, no justification or method for choosing the baseline, no additionality test. In 2, unclear whether reference boiler efficiency values used in text are applicable, no source mentioned for efficiency of district heating system, and not all steps clear in calculating baseline emissions. It is unclear to me which steps the reviewer is missing.

Table 6.1: Summary of criticisms to the proposals.

Critique	Proposal	Evaluators	Comment
Issue: transparency. The adjustment factor for efficiency improvements in the secondary network is unclear	3(1)	Georgiy	The adjustment factor was introduced to allow energy efficiency improvements in the secondary network (e.g. insulated pipes). It may be correct but does not follow logic, and the explanation is therefore unclear. This was fixed in version 2 of the Proposal (response to preliminary feedback from the Meth Panel).
Issue: transparency. Additional definition for formula parameters needed	3(2)	Meth Panel	For non-measured heat demand and supply. This was adressed in version 3.
Issue: uncertainties. Incomplete assessment of uncertainties	1, 2, 3(2)	Naomi, Randall, Yvonne, Meth Panel	In 1, the lack of an additionality test and assumption of same baseline for all projects does not allow for assessing uncertainties. In general, uncertainties can come from measuring equipment, boilers (age, type, size, technology, manufacturing), magnitude of changes in system efficiency. While uncertainties have not been explicitly addressed considerations to reduce them have been made.
There should be an estimate of heat demand to reduce investment risk	3(1)	Deborah	This is not necessary for the methodology but would encourage use of the methodology. In version 2 of the PDD for Proposal 3, default values were used to illustrate the application of the methodology, to be changed once project activity starts. This serves to fulfill this request as well.
Timing of shift to new system missing	1	Naomi, Randall	This was fixed in Proposal 2.

6.3 Summary and Discussion

China is one of the countries with fastest growth in the world, and accordingly their greenhouse emissions are also growing. China uses coal for much of its fuel needs and is plagued by many old and inefficient systems. The growth in construction and in the associated need for heating or cooling in certain parts of country warrants wider use of CHP plants and district heating and cooling systems.

As a developing country China is host to many CDM projects. The CDM should contribute to sustainable development and reducing CO_2 emissions. District heating and cooling are technologies that bring these benefits, therefore it makes sense to have a methodology for CDM projects to be carried out in this field.

Danida has submitted three proposals for a district heating project to the CDM's Executive Board. The proposals have included a project design document, a new baseline methodology and a new monitoring methodology for district heating projects which use CHP plants. The project would reduce coal consumption in the currently decentralized heating system by making a centralized system supplied by the local power plant. The new system would include newer district heating technology and system administration tools, and training and capacity building. The CO_2 savings would generate CERs, which Denmark would purchase, to help it meet its Kyoto Protocol emission reduction target. Denmark is in a good position to help distribute this kind of technology, having had many years of experience with it.

The proposals all describe the situation of the town of Hou Ma in Northern China. They explain why such a project would not be carried out without the participation and funding from an Annex-I country, and why there would not be financial closure without the sale of CERs. Current practice is described, plus the specifics of the town: population, heat requirements, and the current system of both a small boiler-only inefficient district heating network and individual stove or furnace heating in homes. The current system causes CO_2 emissions and air pollution. Both of these would be reduced with the new system.

From this, it can be seen that such a system would be beneficial for reducing global CO_2 emissions. It would also reduce air pollution, be of demonstrative value to China, help Denmark meet its Kyoto Protocol obligations, help Danish businesses and the export of technology and expertise. Such a project fits right into the CDM and should qualify for issuing CERs. And yet, no proposal has been approved.

The criticisms in Proposal 1 were valid. The proposal reflected a lack of experience in the preparation and anticipation of what the evaluators would expect. The issues which needed addressing were additionality, leakage, how to determine the baseline scenario, how to determine the time frame for the change from one system to the other. It was also considered non-transparent, due to lack of explicit formulas and calculations, and non-conservative, due to the use of many estimated rather than measured variables.

Proposal 2: NM0096 showed a much higher level of detail and widely addressed the criticisms received, in the following manner: the additionality was shown using the additionality tool provided by the UNFCCC. This tool includes the "identification of alternatives to the project activity, investment analysis to determine that the proposed project activity is not the most economically or financially attractive, barriers analysis, common practice analysis and impact of registration of the proposed project activity as a CDM project activity" [Executive Board 2005a].

A method for determining the baseline was put forward, and emissions were calculated based on heat demand per m^2 of buildings, both existing and proposed. A method for determining the time frame of the change was included. The formulas and calculations were made more explicit to make the proposal transparent. Leakage was still considered negligible and was not calculated.

A technical query was requested by the Executive Board, stating that the method for determining of the baseline was weak, leading to limited applicability and limited alternative scenarios. At the same time the applicability was considered too broad. The Board stated that formulas and steps in the calculations were missing even though they were included, and disagreed that heat consumption in the baseline and in the project scenario should be considered the same (this refers to the rebound effect: changes in patterns of consumption as a result of the CDM project).

COWI, who prepared the proposal, addressed some of the points raised but was uncertain what was meant by the others. The gist of their response was that to make the methodology more widely applicable would make it too complicated, and that the formulas stated missing were in fact included. They requested an oral consultation, which was ignored, and the responses given were apparently not appropriate, judging by the critique of the desk reviewers.

This proposal was not approved with the following comments: the applicability is inadequate and the project boundary unclear, more should be measured rather than estimated (thereby adding conservativeness), leakage in the form of the rebound effect was not addressed, the baseline definition method was considered weak, and there were formulas missing (which reduces transparency), there were inconsistencies in the text and no assessment of uncertainties. Compared to the first proposal's evaluation, the additionality issue and the time frame for the transition were settled. The effort made at transparency and conservatiness was not considered adequate, and the same goes for the method to determine the baseline scenario. Leakage remains a point of disagreement. Uncertainties were not addressed.

Three rejections can severely damage the morale of the proposers of the project. The desk evaluators are very good at pinpointing errors but often do not propose the solutions. They seem to have a good grasp of the technicalities of district heating projects, and seem to have an idea of what such a project would look like in a CDM framework. The Executive Board can choose to fix the errors in the methodologies. However, the need for independent review limits the amount of changes the desk evaluators and the Meth Panel and Executive Board can make. It is unfortunate that all this drama cannot be avoided, for something that is a good thing in principle.

I am uncertain why the project boundary is considered unclear in this proposal. The boundary is defined as the power plant and the heating grid it is connected to. How should this be different? I also don't understand why the applicability being limited is a problem. While ideally a district heating methodology should address all possible district heating projects, methodology generation is a bottom up process, where methodologies are created according to the need of the project proposer. Given the complexity and past experience with methodology generation, it seems acceptable that this methodology does not address all manner of district heating projects. The Executive Board has the freedom to fix and help design a more general methodology, which while limited by the lack of funding, is still possible.

It is unclear why the baseline definition criteria was weak. While the alternatives presented may have been limited, that does not show a problem in the criteria for defining the baseline, as this criteria comes from the Executive Board itself. The problem of limited alternatives was mentioned separately from the weak baseline criteria - so what is weak about the baseline?

The technical query from the Executive Board was unclear and unfocussed in its criticisms, and the Executive Board was unresponsive to attempts at communication, explanation, and understanding their criticisms. These should have been stated more clearly, coherently, and explanation should be offered when requested. If not it becomes a guessing game, which is of value to no one.

The HWWI research paper "Lessons from the submission and approval process of energy-efficiency CDM baseline and monitoring methodologies" ([Müller-Pelzer and Michaelowa 2005]) contains an analysis of Proposal 1 and Proposal 2, along with other energy efficiency methodologies submitted for approval up to that point.

The points they highlight as lacking in Proposal 1 are concluded upon based on the project documentation and their own analysis, and they are in agreement with my own analysis of the proposals.

The deficiencies found in Proposal 2 are lack of conservativeness, no assessment of uncertainties, no quality assurance or control measures, inconsistencies in the methodology, inappropriate definition of applicability, the selection process for the baseline was not provided, "project participants should check whether all relevant gases have been included, and whether the physical and spatial definition covers all processes and areas under control", the algorithms provided were incomplete, the data was not high quality or low uncertainty, and the procedures for the monitoring methodology should be the same as for the methodology, the rebound effect was not dealt with, the load factor for hot water and the presence of individual heating systems was not considered [Müller-Pelzer and Michaelowa 2005].

Again, these points were arrived at based on the project documentation and the authors' analysis, and they are mostly in agreement with the analysis carried out here, except for the mentioning of lack of quality assurance or control measures, which I did not highlight. The applicability was considered inadequate, but the team preparing the proposal was confused by what was inadequate about it, since the Executive Board gave mixed signals on that. A method for determining the baseline was provided, but perhaps the criticism above refers to the reason the specific baseline was selected in the case of the Hou Ma project.

The criticisms this proposal received are related to how to design a district heating project in the framework of the Kyoto Protocol - the choices made are not questioned based on state-of-the-art in district heating technology, but based on the interpretation of the elements or rules that must be included in the design of a new CDM methodology. This illustrates the complication of the Kyoto system and highlights a reason behind the sectoral skewness of the Protocol. It takes a lot of funds and a lot of people to get it just right, and many poor countries do not have the necessary resources. However, they are the countries is most need of (sustainable) development.

Proposal 3: NM0181 was even more detailed and showed much more conservative estimates of the reduction of CO_2 emissions. The applicability section was better developed, conservativeness was also added in many equations by requiring *ex-post* measurement of estimated quantities. The method for determining the baseline was expanded and is similar to the UNFCCC's combined tool for this purpose[8]. The emission calculations are based on the heat supplied by the power plant to the buildings. Work was done on the formulas and on the inconsistencies in the text. Leakage and uncertainties were not addressed, and the project boundary was unchanged.

Critique of this proposal highlighted problems with the barrier analysis procedure, monitoring of substation/heat measurement points, and some inconsistencies between and in the monitoring methodology and the baseline methodology. One of the reviewers suggested some major changes to the way emission reductions are measured, the counting of both heat and electricity emissions and not just heat, calculations of emissions under certain proportions of fuel allocation in the CHP plant, and two additional applicability criteria, while mentioning how limited the applicability already was.

The Meth panel requested a preliminary review, which was responded to in the form of version 2 of the same proposal. The proposal reflected changes in the applicability conditions, barriers and the treatment of leakage and the rebound effect.

This was subsequently evaluated by the Meth Panel, which incorporated points from the reviewers' evaluations in their own, citing the following things that needed changing (the methodology was considered approved, pending these changes): the rebound effect must be considered since the project and baseline heat demand are not the same due to other possible conditions aside from demand-side measures (incidentally, showing that although the rebound or other leakage was still considered negligible, provisions for non-identical heat demand in the project and baseline scenario were included in the method). Also, losses in distribution in the primary network should be considered, baseline or project scenario efficiencies should not be constant through all the crediting periods, this baseline should not apply to heat-only boilers due to uncertainties, the heat demand of different consumer categories should be monitored, two alternative scenarios were suggested, and more specific guidance on two points of determining additionality should be given.

Proposal 3 showed a higher level of cohesion and quality, which in my understanding explains the grade B it received compared to Proposal 2.

Version 3 of the proposal was prepared, responding to the issues of alternative scenarios, additionality, use of heat only boilers in new buildings. The project developers continued disagreeing with the Meth Panel regarding the rebound effect and stated that a site visit and consultations with experts supported their position, aside from the approved methodologies that do not treat the topic. The Meth Panel has requested a subsequent preliminary review and the project developers had not responded at the time of writing. The outstanding issues from version 3 compared to version 2 of Proposal 3 are the rebound effect, the assessment of losses in the primary network and the assessment of uncertainties. The fact that the Meth Panel requested another preliminary

[8]Combined tool to identify the baseline scenario and demonstrate additionality (Version 02), EB 28

feedback indicates that there are other outstanding points that they have taken issue with.

General comments: It can be seen that except for the last reviewers, none of the others even checked the previous proposals or used them as a basis to assess the changes made[9] In general terms it was not necessary to check the previous proposals, both because a proposal should be evaluated on its own merit, and because some of recommended changes were consistent overall[10]. Still, consulting previous versions would have explained some of the choices that were made.

The most glaring inconsistencies were in the technical query by the Executive Board: It is surprising and embarassing for them to have so many inconsistencies. The issues raised by the query were similar to some of the problems identified by the reviewers.

In the three proposals, the way of estimating the emissions in the baseline and project scenarios was changed from being based on heat supplied by the power plant, to heat demand by floor area, and back to heat supplied by the power plant (measured at different points). These changes were each made in response to criticisms by the different desk reviewers. One of the reviewers for Proposal 3 suggested that the estimation by heat supply was not adequate in all cases and also was very limited. Danida is therefore understandably frustrated with the lack of consistency in the evaluation of the proposals. An IEA paper on district heating agrees with the emissions being based on heat supply, suggesting that:

> *"The most appropriate greenhouse gas emission allowance allocation system would be based on emissions per unit of product output"* [IEA DHC/CHP 2002].

The inclusion of only the secondary district heating in the baseline reduces the heated building area included to only 20-25% of the heated building area in the town of Hou Ma. This was done because the errors involved in determining the baseline for the individual heating systems were considered too large, leading to possible over-estimation of emission reductions. The underlying rationale is that if we cannot know the exact values of the emissions from individual boilers and furnaces with a very small error, then we consider them zero. While the intent may be to be conservative and guarantee credibility, this 'ivory tower' attitude can, in practice, undermine this same credibility and go against the objectives of the Kyoto Protocol and the CDM.

As mentioned previously, the lack of reaching sustainable development goals can undermine trust in the CDM system. Since expansion of the district heating network to homes with individual systems does not generate CERs, and this investment will not be made outside the CDM (as shown in the barrier analysis), a significant sustainable development benefit can be lost. Even if the district heating network is expanded to include individually heated homes, which is unlikely if the project is being funded by a profit-seeking private company, those emission reductions will not be counted. That the

[9] Reviewers must state what documentation they consulted aside from that directly submitted with the project. Georgiy Geletukha showed awareness of Proposal 2 in spite of not marking it as other bibliography consulted. Deborah Cornland stated that she consulted Proposal 2.

[10] Examples of this include the development of the criteria for determining the baseline and the additionality.

objective of the CDM is to reduce emissions, and yet emission reductions due to a CDM project will not be counted because the uncertainty can be too large, seems paradoxical and unfair. Perhaps the use of statistical sampling of individual boiler emissions and the acceptance of larger error margins can help solve this problem and establish trust in the fairness of the CDM system.

From a business perspective, this issue is a disincentive for private enterprise to be involved in promoting sustainable development and reducing emissions. The investment these methodology proposals have absorbed is huge, in terms of money and time, and no conclusion has yet been reached. Besides, since the substitution of ineficient boilers and furnaces for an efficient district heating system will not yield any financial return, since CERs are only generated from the substitution of heat only boilers connected to the existing district heating network for CHP-based district heating, this reduces the incentives for a private company to expand the district heating network and contribute to city-wide sustainable development.The effort to promote all of the objectives of the CDM, in the face of all the problems encountered, will stop being made (exemplified for instance by Danida's change of focus from encouraging methodology generation for sustainable development and technology transfer to simply purchasing credits on the market).

In essence, this undermines the role private enterprise can play in the CDM, limiting the efforts in some fields to non-profit organisations motivated by ideology.

The approach to defining the applicability here has followed the same approach as for most proposals: a power-plant specific ('engineering') approach rather than an empirical or performance parameter-based approach [Hayashi and Michaelowa 2007]. The applicability was considered alternately too broad or too limited by the different reviewers. Too limited means the methodology is not applicable to all kinds of power plants or district heating systems. Too broad means the criteria for determining where the methodology is applicable is not specific enough concerning each kind of power plant or district heating system - the equations for each of these variations may be different. There was no consistency in the evaluators' recommendations on whether the methodology should apply to all power plants and all district heating systems or to some specific types.

Based on the approved methodologies[11] it seems acceptable that a single methodology will not encompass all possible systems. In fact, "a drawback of this [bottom up] approach is that a methodology tends to have technology-/measurement-specific applicability by nature" [Hayashi and Michaelowa 2007]. Furthermore future consolidation of different district heating methodologies would solve the 'too limited' problem. While some of this is due to unclear definition of the applicability, the confusion caused by the different evaluations made it hard to glean what the right answer would actually be.

One analysis of the environmental legislation issue states that "there [are] a number of old-fashioned and inefficient distant heating systems in China, thus a significant potential for modernising and utilisation of heating from the production of electricity can be identified. However, this type of project requires substantial amounts of capital, which necessitates massive investments from the public administration, as these are typically in possession of the systems. An obvious scheme would be that the Chinese government introduces legislations on utilisation of excess heating from the electricity

[11] To be found on the UNFCCC's CDM website

production as well as technical specifications for modernising the distant heating supply. However, it is estimated that these measures alone will not be sufficient in order to overcome the economic barrier" [The Danish 92 Group 2005]. In any case, while providing those figures does not prove additionality, the Executive Board has decided that a programme of activities can include a policy, if it is not enforced, or if it is enforced to raise standards beyond the policy's goal [Executive Board 2006c]. While guidance for programmatic CDM is different from 'regular' CDM, this could indicate that the enforcement gap should not be a reason for ruling out certain CDM projects.

An explanatory note: Proposal 2 makes reference to a similar project in the city of Harbin, in Northern China. Documentation related to it was supplied for the Executive Board's evaluation, to show how the methodology could be applied elsewhere [Proposal 2: Harbin documentation 2005, Proposal 2: PDD 2005, Proposal 2: Methodology 2005]. The Harbin project was finished in January 2007 and the press release announcing this states that the Danish Government is buying CERs from the Huaneng district heating company [ABB 2007]. This project is being marketed as a showcase for the benefits of district heating in combating climate change, within the Kyoto Protocol framework [Automatik 2007]. What has actually happened is that Denmark has a agreement with China to purchase these CERs, and at the time of deciding on the project Danida had hoped that a methodology would be approved and that the project would generate CERs. Harbin is one of three district heating projects in China promoted by the Danish Mixed Credit loan programme. One of the other ones is the Hou Ma project, which was cancelled in 2005 [RDEB, UM 2004, UM 2005, UM 2006].

It is my assumption that Danida continued funding an attempt to have a district heating methodology in order to claim CERs, if possible, from the Harbin project. The project does in fact demonstrate district heating as a viable emission reducing project, and underlines the utility such a methodology could have, both for climate change and for Danish businesses, since district heating is a Danish export product. Also, financial records from this project could be used to show that it would not be viable outside of the CDM for smaller cities like Hou Ma. However the news related to Harbin is, at present, misleading, by claiming Denmark is buying CERs from this project. The project is not yet entitled to generate CERs.

Another issue that should receive comment is the environmental regulation one. Even if regulation were introduced, compliance is not assured. And in fact, funds may not be available for compliance even if regulation requires changes. But while it is claimed that financial closure cannot be obtained without the sale of CERs, it seems that is not true for the Harbin project. This may still be true for Hou Ma, which is a smaller town and subject to financial constraints on that basis. However the fact that the Harbin project is up and running, despite the claim of lack of financial closure without CER sales, casts shadow on the additionality of this project, as defined by the CDM Executive Board. Nonetheless, it is my belief that the project would not have been carried out under other circumstances, so it is additional even if it is financially viable on its own.

6.4 Conclusion

The idea of this chapter was to explore the case of the failed approval of a district heating methodology, in order to try to suggest solutions to the problem. Analysis has shown that the problems identified were a mix of mistakes on both sides (e.g. the Executive Board's unresponsiveness, the project developers' lack of attention), and problems coming from the structure of the CDM, the lack of funding, and the lack of defined policy and practical experience as to how to consider for example leakage, the rebound effect, or additionality. It has been difficult to identify a trend or consistent mistake: even when for instance the applicability is questioned it is usually for a different reason every time. Neither side is very right or wrong, the devil really is in the detail, However the Executive Board should also keep the sustainable development benefits of projects in mind - and evaluate methodologies on that basis as well as the methodological approach.

There seems to have been a change in the types of criticisms given from Proposal 1 to 2 to 3 and to versions 2 and 3 of Proposal 3. They have moved from being related to how to present a CDM methodology and ascertain the emission reductions to details related to conceptual disagreements on how should a district heating system be designed in order to facilitate and optimize counting emission reductions.

Under these conditions it is difficult to give advice. Changes that could be made pertain to the Kyoto Protocol in general and the CDM skewness and problems, and to the final phase where the haggling on how to design the system in order to correctly count emission reductions.

General guidelines for energy efficiency projects include: "first of all, a clear and reader friendly presentation of the methodology without gaps in data and argumentation has to be ensured. The methodology has to be prepared in a transparent and conservative manner. Transparency results from the design of the methodology, while conservativeness has to be demonstrated explicitly for assumptions and values. The methodology has to be laid out step-by-step in order to be applicable right away. It is further indispensable to include tools to select the baseline scenario and to prove additionality. Although not all approved methodologies contain a tool to select the baseline scenario, it is strongly recommended to provide one as the additionality tool does not cover this aspect. The project boundary has not always been explicitly defined in the approved methodologies. Nevertheless, it is necessary to specify the boundary regarding the gases, the physical limits and, if required, the system, as this constitutes the basis for the calculation of the emission reductions. Leakage should either be addressed or be explicitly excluded with justification. Data sources have to be specified, giving priority to high quality data with low inherent uncertainty. Equations illustrating the calculations should be provided and explained. Although it seems to be a safe path to use methodological settings from approved methodologies, they might not be appropriate under new circumstances". These are suggested by [Müller-Pelzer and Michaelowa 2005].

Specific points raised in connection with the district heating proposals include: "net improvements are difficult to calculate if dynamics have to be taken into account (e.g. the equipment, the level or the quality of production in the baseline or the project scenario may be subject to changes). Then, a simple before-after comparison is not valid. This can pose problems if the calculations and the monitoring would need to be very complex. Regarding rebound effects due to improved service levels, project participants should basically not be punished for their contribution to sustainable development. However, too many CERs may be issued when the increase in emissions due to the rebound effect is completely neglected. At this point, guidance from the Executive Board is needed" [Müller-Pelzer and Michaelowa 2005].

Some of problems identified, specific to these proposal-processes were:

- *Lack of experience:* the project developers clearly demonstrated this lack of experience in preparing the proposals, but to their credit they have learned much, as the re-writing of the proposals shows. The Executive Board and all the evaluators of the proposals also suffer from a lack of practical experience due to the design and the 'newness' of the Kyoto Protocol. Every situation encountered is new and requires quick analysis, decisions, and trial and error. It is inevitable, given the situation.

- *Lack of attention to detail:* Coupled with the inexperience of the project developers is the lack of attention to detail and lack of thoroughness displayed in parts of the proposals. While this is understandable to some extent, as it is very difficult to get an overview of such a large number of big documents, and perhaps this has to do with the contractual specifications of the amount of time and funds allocated to this project, this can and should be handled. The level of thoroughness expected was clearly not known but has been learned, as the evolution of the proposals shows. I am not aware if the project developers attempted to consult the AIJ projects carried out in the late 1990s-early 2000s. This should have been done in principle, but I must acknowledge the difficulty of getting these documents myself - my attempts at contact went unheeded, and the fact that the contact information is several years old may be partially responsible.

- *Lack of funding and time:* proposals are not evaluated based on the previous criticisms they received. While a proposal must be able to 'stand on its own feet' and approval should be given based on its merit rather than the ability of the proposer to respond to criticism, reading the previous requests would shed light on why certain choices were made and what alternatives have already been explored in order to solve the problem at hand. This problem has to do with the lack of compensation for the evaluators and therefore the little time they have to dedicate to the process along with carrying on their lives and their paying jobs. This bullet point is therefore related to the next one:

- *Lack of funding:* The Executive Board cannot itself spend the resources to develop all the methodologies and it cannot spend all its resources in paying experts to evaluate the submitted methodologies. But perhaps it could use more workers, and more full timer employees, to actually give the proposals the time they need. Those who prepare the proposals spend infinitely more time on them than those who evaluate them, and the proposals therefore deserve a thorough and clear evaluation. However, the time given to each evaluation is constrained by the funding available to the Executive Board and the UNFCCC. This depends on the funds countries are able to put towards fighting global warming, compared to their other priorities. This is not a problem of the functioning of the mechanism per se, but it affects everything and should be handled.

- *Lack of communication:* Requests for information and attempts to solve doubts should not be ignored. While it may be difficult to tell those made in good faith and those meant to corrupt, clarity and response in written form at least should be used in order to respect those who took the time to study the evaluations and comments and require supplementary information.

- *Lack of clear guidelines:* Although this is a bottom up process, some guidelines for the inclusion of leakage or rebound effect, for instance, should be made. Reviewers seem to take this is a matter of opinion and the Meth Panel seems to adopt what the reviewers say, making for a confusing set of guidelines.

Ideally I would have added more about counting emissions from district heating in the relevant chapter, except for the fact that what we are witnessing is the development of such a process. A deeper description of the engineering aspects of district heating does not solve the conceptual disagreements the experts are having regarding what is state-of-the-art and how should it be designed to facilitate counting emissions.

Chapter 7

Discussion and Conclusion

This Chapter presents answers to my research questions outlined in Chapter 1. More information can be gained from reading the previous Chapters.

1. *Are CHP, district heating and cooling able to contribute to reduce greenhouse gases? What are the benefits of CHP, district heating and cooling technologies, and can they be used for CDM projects?* This question is discussed in Chapter 5. District heating and cooling reduce the consumption of energy compared to individual home heating systems. Newer district heating and cooling technologies, with lower temperatures (in case of heat), insulated pipes and variable flow are more efficient than the older type of technology, which is still present in China, operated at high temperatures and fixed flow. Turning a conventional power plant into a CHP plant makes it 80-90% energy efficient, in contrast with 40-50% efficiency with power generation alone. The distribution of this heat to an area which requires heating in winter, and currently uses either individual heaters or a small old-fashioned district heating network, achieves the double benefit of finding an outlet for heat from the power plant, which would otherwise be cooled in cooling towers, and more efficiency in the district heating network. In this way these technologies can contribute to reducing greenhouse gases.

   Replacement of an old-fashioned district heating for a newer one can achieve reduced carbon emissions. A conversion of a power plant from a conventional to a CHP plant can achieve reduced carbon emissions. Both of these things can be accomplished in the form of a CDM project. The method for calculating these emissions has been discussed in the methodology proposals. The emission reductions have varied from between half and two-thirds less. Of course these values depend on the size of the system, the type of pipes, the fuel, the density of buildings, but even if a value cannot be immediately placed, it can be seen that these reductions would be significant.

2. *Can district heating and cooling impact sustainable development?* This question is also discussed in Chapter 5. A large district heating or cooling system can contribute in a positive way towards more local employment, more training and education for the involved workers, improved health and life quality for the residents of the area. It can reduce the overall use of coal and the use of energy,

reducing emissions of greenhouse gases and other pollutants. And it can increase savings on energy on the part of the population, assuming their energy use is not subsidised. Local suppliers of parts for the system will benefit while suppliers of fuel will not. And technology transfer may be stimulated. Therefore, district heating and cooling systems can contribute to sustainable development.

3. *What are the main problems of the CDM, related to energy efficiency?* This question was discussed in Chapter 4. The Kyoto Protocol and the CDM have many problems, both on their own and in connection with energy efficiency methodologies. The table below delineates the problems I have identified and covered in earlier chapters, and possible solutions. Some problems are due to the design of the mechanism but this design represents the best alternative as I see it. Some solutions apply to more than one problem.

Table 7.1: Problems and solutions: the Kyoto Protocol, the CDM and energy efficiency.

Problem:	The need to compromise the will of so many different countries, which reduces chances of stronger action against climate change;
Solution:	Continue working to fight climate change, eventually countries will 'see the light' and will have to act;
Problem:	The details of the Protocol took years to work out, limiting countries' will to commit to unfinished rules and limiting early action;
Solution:	Learn from this experience and make sure the rules for the post 2012-regime are ready by 2012;
Problem:	The necessary perception of integrity of the process can limit achieving some of the Protocol's objectives in a simple way;
Solution:	Increase communication between project developers and the Executive Board. This communication is stunted in an attempt to limit, for example, bribery, which can undermine integrity and credibility. Perhaps clearer rules against bribery could increase communication. Also, keep in mind sustainable development goals in evaluation of project methodologies and proposals. See below for more on sustainable development goals and criteria;
Problem:	The time frame of the current commitment period is small and the design of the post-2012 regime is uncertain;
Solution:	Include a long time frame the post 2012-regime, for example a 20 or 30 year horizon;
Problem:	Long term support for the Protocol hinges on sustainable development benefits and perception of integrity, among others;
Solution:	Put more focus on sustainable development benefits in proposal and methodology evaluation;
Problem:	The CDM projects present sectoral and geographical skewness, caused by the cost versus return of different types of projects and technologies, and related to government administrative capacity and presence of clear and stable rules;

Solution:	Countries should define their national guidelines more quickly and more clearly for the post 2012-regime. This will solve some of this problem, but unfortunately not all of it. Also, include more LULUCF in the post-2012 scenario, which will address both the potential for these projects and allow the benefits to spread to many least developed countries;
Problem:	Host countries can have numerous problems related to disorganisation and lack of administrative capacity, lack of expertise, technology or equipment, lack of appropriate policies, long and expensive approval processes for projects, institutional culture barriers and lack of education and awareness, poverty, financing problems and high investment risk;
Solution:	Increase sustainable development - this is a complex problem and needs a long term solution;
Problem:	CDM projects can have very high costs;
Solution:	This is just the tip of the iceberg, but a faster methodology approval process would diminish at least some of these costs, increasing accessibility by many poorer countries;
Problem:	Energy efficiency projects suffer from non-Kyoto Protocol problems: conflicting energy subsidies, grid connection problems, power purchase agreements, to mention a few;
Solution:	Again, time and awareness of the importance of solving climate problems, and sustainable development with coherent goals and policy, can solve this problem, but it is a long term solution;
Problem:	Energy efficiency projects are complex and have trouble dealing with monitoring, showing additionality (since they are economically feasible but often not taken up due to other reasons), and dealing with the rebound effect (changes in consumption patterns in response to project activity);
Solution:	As mentioned previously, expanding programmatic CDM can help, as it can encourage larger sectoral changes and decoupling between growth and emissions;
Problem:	Sustainability is not rewarded in the CDM;

Solution:	Establish a minimum-standards definition or compliance checking for sustainable development that all countries must adopt. This is difficult since what constitutes sustainable development is different for each country, but some standard is necessary to avoid a race to the bottom, or alternately some kind of compliance checking for the standards each country sets itself. The minimum standard definition for sustainable development can be based on UN-approved sustainability indicators, to be evaluated by a team of local and international experts. Projects that increase sustainable development could be rewarded with more CERs. They could be encouraged with special additionality criteria, for example less weight to the investment analysis or an added sustainability criteria. They could also be encouraged by higher leniency to uncertainty for projects that boost sustainable development, for example generating only 70% of CERs if uncertainties are high but below a certain level (perhaps 60-70%). This would avoid no reward for sustainable development, exemplified in the previous chapter by excluding individual heating systems from the project. Lastly, expand programmatic CDM, which can encourage larger sectoral changes and decoupling between growth and emissions;
	General solutions:
Solution:	Increase funding for the Executive Board and other administrative functions;
Solution:	Encourage the Meth Panel and the Executive Board to help fix problems identified in the methodologies;
Solution:	Use full time staff. This would change the set of influences each evaluator is under, since they are bound to be influenced by the necessity of having another job, and perhaps the nature of their 'day job'. This might limit fears about the integrity of the evaluators and the system and allow for more time and attention on their part and more communication;
Solution:	Reconsider the concept of additionality and how it is used in light of reaching the objectives of the CDM and the Kyoto Protocol. In theory the concept makes sense but in practice it has been limiting. One idea is for it be defined differently for different categories of projects: for example for projects that increase sustainable development this could be one of the additionality criteria, for projects that increase energy efficiency the investment analysis could be excluded since this has brought problems to this category of projects.

4. *Why have the previous district heating methodologies not been approved? What solutions have been discussed in order to get these methodologies approved? Can anything new be contributed?* This question is discussed in Chapter 6. The first methodology submitted was weak in several points and needed to be redone. Among the criticisms were the basis upon which carbon reductions were to be measured. The second methodology was much more complex and tried to answer all the criticisms of the first, including changing the basis for measuring the carbon reductions. However, the evaluators did not find it acceptable. They identified several inconsistencies and questioned the premise upon which the carbon reduc-

tion would be measured, again. The third methodology addressed the criticisms of the second, reverted back to the same premise for measuring carbon reductions of the first methodology, and was even more detailed and complex. The non-acceptance of this proposal came as a surprise to the developers of the proposal. Two subsequent versions were submitted and the latest is under consideration. The evaluators at each step were different and did not appear to deeply evaluate the previous criticisms. In some instances they severely criticised how the methodology dealt with a certain point, when they could have been much more helpful by simply suggesting a better way of doing it. The Executive Board was inconsistent in their requests for information and unresponsive to similar requests. Refer to Section 6.4 for more details.

I have outlined some of the problems in the conclusion of Chapter 6, solving these problems might enable a district heating methodology to be approved. They include having come further in the learning process about the CDM and the Kyoto Protocol and the associated procedures, more funding and more time to dedicate to the preparation and evaluation processes, better communication between all the involved parties, more attention to detail, and the establishment of clearer guidelines, this last point coupled with having more experience.

Also, changes to the additionality criteria should be considered. This criteria should not limit projects that boost sustainable development. Perhaps the criteria can include what sustainable development benefit the project brings, based on a minimum standard definition by the Executive Board and measured by local and international experts. Another approach would be to define different additionality criteria for different categories of projects: energy efficiency projects could have different additionality than industrial gas projects.

5. MAIN RESEARCH QUESTION: *How can the approval process of energy efficiency CDM methodologies, specifically targeting CHP and district heating, be improved?* The answer lies both in solving the problems identified in the proposals and in solving larger problems related to the CDM.

   Clearly, a district heating CDM methodology proposal needs to start by being transparently written and thoroughly justified. The assumptions should be conservative, and the design should follow the guidelines provided by Executive Board. The difficulty is in the interpretation of the rules and guidelines so far provided.

   The proposals have improved every time a new submission has been made. Version 3 of the proposal, as it stands today, should in my opinion receive approval. Uncertainties and losses in the primary network should in principle be addressed, and they have in practical terms been addressed by choosing a methodology and materials that minimise these effects. I agree with the justifications provided as to why the rebound effect was not valid, furthermore I agree with [Schneider 2007], when he says inclusion of this issue is a matter of policy. It should not be included. The contribution of these kinds of projects to sustainable development should not be neglected, and issues such as this should not keep these projects from happening, when they have many benefits.

   General problems related to the project developers and evaluators can be solved, mostly, with more access to money. This is obviously more easily said than done, but in any case more funds would increase the time spent on each proposal and evaluation and the attention to detail. Other issues include access and communication with Panel members and evaluators, which should be improved, and design of clearer guidelines, as experience from all parties builds up.

The Parties to the Protocol, in committing themselves to reach this goal, perhaps had not realised how high the cost would be. While it cannot be said how many of them are willing to take on the higher costs, in light of the possible consequences they should. "Climate change mitigation has created a new and evolving policy paradigm which introduces a huge element of regulatory and economic risk for energy investment" [McCracken 2007]. However, this is not a threat that will go away if ignored. The opportunity to use the CDM to promote investments into energy infrastructure and sustainable development should not be lost.

Reflections: The objectives of the Kyoto Protocol are worthwhile to achieve: reducing greenhouse gas emissions and taking the opportunity for encouraging sustainable development. While carbon taxes would be the easiest way (and perhaps the most effective way) of achieving the desired objectives, the idea of a carbon market is appealing to many. Despite the shortcomings of an imperfect market (and markets are always imperfect), such an approach can make a difference and make a dent in the problem.

District heating and cooling and CHP are technologies that can aid the objectives of the Kyoto Protocol and the CDM. They can reduce energy consumption, increase efficiency in the use of energy, reduce emissions of greenhouse gases and pollution, boost employment, health and local economies.

The differences in the criticisms of the three district heating proposals make it difficult to present a generalisation regarding district heating or energy efficiency methodologies. Some issues presented in this thesis are general to many methodologies, such as those discussed in Chapter 4. Others are specific to the writing and review processes and have to do with the people involved and their beliefs and interpretations of the rules and past experiences. The only way to reach a satisfactory conclusion is communication: more discussions and clearer requests and guidelines, always keeping the greater objective in mind (reducing greenhouse gas emissions and boosting sustainable development).

When I started this project, I had not realised how complicated it would turn out to be. I had expected to be able to solve the problem by appointing blame and clearly getting an overview of the problem, making a suggestion of solutions fairly straightforward. But in reality, things are not as black as white. Blame is found everywhere: in the design of the Kyoto Protocol and the CDM, in the lack of funding for fighting climate change, and also in the preparations of the proposals, due to inattention and perhaps lack of funding as well (I don't have access to the contract between Danida, COWI and the Öko-Institut, but it is possible that it was designed for a specific number of hours of work). Getting an overview of the problem is difficult, it has taken time, hard thinking and many re-readings of the documentation, and suggesting solutions has not been trivial. I know also that my suggestions are easier said than done. The conclusions I have reached are relevant to the intended target audience of this thesis, even if they are less clear cut that I would have liked.

To put this topic in perspective, I would like to remind my readers that a district heating CDM methodology is but a very small part of the Kyoto Protocol and the global effort to fight climate change. But every small effort counts. The discussion I have carried out here hints at larger problems with the Kyoto Protocol system, problems that should be addressed in the interests of coherence. The objective of fighting global warming is best served by a coherent set of rules and discourse, which gives focus to all of the actions carried out on behalf of fighting climate change. This objective should be kept in mind by everyone involved, to keep us from getting bogged down in all the details - and unfortunately, I believe that some of the nit-picking regarding this district heating methodology exemplifies a loss of sight of the big picture.

As mentioned in Chapter 2, the focus I used, of sustainable development as a long term goal, is appropriate, but other approaches could also have yielded interesting results. Volumes more information is available on every topic I have covered, and unfortunately that could not be included here, both due to time and space considerations, leaving room for further research.

Alternative approaches include doing a key-stakeholder analysis, evaluation of the monitoring methodologies, getting hold of additional documentation from the World Bank and the AIJ projects, and making a more general analysis of energy efficiency projects, among others.

I would like that my thesis can be used by whomever decides to continue pursuing the district heating CDM methodology issue. The comparison and analysis that I have made, and the sources that I have indicated in the text, can shed light on what went wrong and help future methodology developers avoid making the same mistakes.

Bibliography

[*Cover cartoon:*] Image adapted from stix1972.typepad.com/stix_blog/images/locher2.gif, June 2007

[ABB 1996] *ABB forms joint venture to manufacture district heating systems in China*, Press Release by ABB from Zurich, Switzerland, March 4, 1996

[ABB 2007] *ABB Harbin Daoli district heating project completed*, Press Release by ABB Denmark from Harbin, China, 31 January 2007

[ACH 2007] *General Information on Air Conditioning, Heating, Ventilation, and Refrigeration:* www.air-conditioners-and-heaters.com/air_conditioning_cooling_heat_information.htm, 23.01.2007

[Airtricity 2006] *European Offshore Supergrid Proposal: Vision and Executive Summary*, Airtricity, UK, 2006

[Andersen 2007] *Personal communication* with supervisor Jan Andersen, Spring and Summer 2007

[Automatik 2007] *Fjernvarmeprojekt reducerer CO_2 udledning med 500 000 tons årligt*, Automatik & Proces, vol 32 n. 3, March/April 2007, pg 28

[Avedøre 2007] *Visit to Avedøre power plant* in Denmark, 06.03.2007

[BBC 2007a] *Q&A: The Kyoto Protocol:* news.bbc.co.uk/1/hi/sci/tech/4269921.stm, 16.02.2005, viewed 18.05.2007

[BBC 2007b] Harrabin H, *China building more power plants*, UK, 19.06.2007

[Beck-Larsen 2004] Beck-Larsen N, *ASEAN cogeneration experiences*, presentation at 2004 Cogeneration week in Thailand

[Bell & Morse 1999] Bell S and Morse S, *Sustainability Indicators: measuring the immeasurable?*, Earthscan, UK, 1999

[Bernsen and Foged 2000] Bernsen E and Foged MI, *Planning before Project implementation*, News from DBDH (Danish Board of District Heating) 2/2000

[Bothe *et al* 2005] Bothe M and Rehbinder E: *Introduction*; Buchner B: *Chapter 1*, in Climate Change Policy, Eleven International, The Netherlands, 2005

[Bradley 2006] *IEA energy and climate change actions - the G8 challenge*, presentation at the Unep/Risø Centre seminar: The Global Energy Challenges, Copenhagen, January 2006

[Brewer 2004] Brewer M, *Internal Validity*, Lewis-Beck M *et al*, Eds., *The Sage Encyclopedia of Social Science Research Methods*, SAGE, California, 2004

[Bøhm 1999] Bøhm B, *Heat Losses from Buried District Heating Pipes*, Politeknisk Press, Copenhagen, Denmark, 1999

[CDM Guide: China 2005] *CDM Country Guide for China*, Ministry of the Environment, Japan, 2005

[CDM Pipeline Jan. 2007] Fenhann J, *CDM Pipeline overview*, January 2007, available at uneprisoe.org

[CDM Pipeline May 2007] Fenhann J, *CDM Pipeline overview*, May 2007, available at uneprisoe.org.

[China.org 2007] *Quick facts* and *China through a lens*, www.china.org.cn, 03.07.2007

[CHPA 2007] *Combined Heat and Power Association:* www.chpa.org, UK, 24.01.2007

[CIRIA 2007] *Sustainable Development* image: www.ciria.org/complianceplus/images/-sustainability2.gif, 20.06.2007

[COGEN 1999] *An introduction to Micro-cogeneration*, COGEN Europe Briefing 8, 25.01.99

[COGEN III 2007] *EU-ASEAN COGEN programme phase III:* www.cogen3.net/, 17.05.2007

[Cornland 2006] Cornland D, expert reviewer for *Desk Review of CDM project NM0181*, 9 July 2006

[DEM 2007] *CHP vs. conventional power generation:* www.danishmanagement.dk/C1BEE791-D2FB-4A73-9D0E-22D8D6B2D621, 25.01.2007

[District Energy Library 2007] *District Heating:* www.energy.rochester.edu/dh/, 23.01.2007

[DLSC 2007] *Drake Landing Solar Community (DLSC)*, Okotoks, Alberta, Canada: www.dlsc.ca/index.htm, 16.05.2007

[DRC-SC 2003] *China's National Energy Strategy and Reform*, background reports for the China Development Forum 2003, Development Research Center of the State Council, Beijing, November 15-17, 2003

[EC 1997] *Energy for the Future: Renewable Sources of Energy*, White paper for a Community strategy and action plan, European Commission - COM (97) 599, 1997

[Econ 2005] *CDM Methodology Status Report 2005 (Final report)*, Commissioned by World Bank Carbon Finance Business, ECON Analysis AS, Oslo, 2005

[EERE 2005a] *A consumer's guide to heat pump systems:* www.eere.energy.gov/consumer/your_home/-space_heating_cooling /index.cfm/mytopic=12610, last updated Sept 2005, viewed 17.05.2007

[EERE 2005b] *Consumer's guide to furnaces and boilers:* www.eere.energy.gov/consumer/your_home/-space_heating_cooling/index.cfm/mytopic=12530, last updated Sept 2005, viewed 23.01.2007

[EERE 2006] *Hydrogen, Fuel Cells and Infrastructure Technologies Program: Fuel Cells,* www1.eere.energy.gov/hydrogenandfuelcells/fuelcells/index.html, last updated December 2006, viewed 20.07.2007

[EnerGuide 2004] *Heating and Cooling with a Heat Pump* brochure, Natural Resources Canada's office for Energy Efficiency, EnerGuide team, rev. ed., Canada, 2004

[Environment and Economics 2007] Lecture notes from *Environment and Economics class*, RUC, Spring 2007

[EPA 2007] *Global Warming Potentials and Atmospheric Lifetimes (Years):* www.epa.gov/nonCO_2/-econ-inv/table.html, 18.03.2007

[Esdalle-Bouquet 2007] Esdalle-Bouquet T, *Cogeneration Projects within the CDM Framework*, T@W: Sustainable Energy Technology at Work, COGEN Europe, March 2007

[Euroheat and Power, undated (a)] *Renewables in District Heating and Cooling*, Euroheat and Power, Brussels

[Euroheat and Power, undated (b)] Constantinescu N, *The DHC sector - challenges and opportunities in Central and Eastern Europe,* Euroheat and Power, Brussels

[Eurostat 2007] *Total fertility rate*, ec.europa.eu/eurostat, 03.07.2007

[Executive Board 2004] *Seventeenth Meeting Report of the Executive Board of the Clean Development Mechanism*, Argentina, 6 December 2004

[Executive Board 2005a] *Tool for the demonstration and assessment of additionality (version 2)*, UNFCCC/CDM, CDM - Executive Board, 28 November 2005

[Executive Board 2005b] *Twentieth Meeting Report of the Executive Board of the Clean Development Mechanism*, Germany, 8 July 2005

[Executive Board 2006a] *Combined tool to identify the baseline scenario and demonstrate additionality (Version 02)*, EB 28, UNFCCC/CDM, CDM - Executive Board, December 2006

[Executive Board 2006b] *Twenty Eighth Meeting Report of the Executive Board of the Clean Development Mechanism*, Germany, 15 December 2006

[Executive Board 2006c] Twenty Eighth Meeting Report of the Executive Board of the Clean Development Mechanism, Annex 15: *Guidance on the registration of project activities under a programme of activities as a single CDM project activity (Version 01)*, Germany, 15 December 2006

[Executive Board 2007a] Twenty Ninth Meeting Report of the Executive Board of the Clean Development Mechanism, Proposed Agenda - Annotations, Annex 3: *Draft procedures for registration of a programme of activities as a single CDM project activity and issuance of CERs for a programme of activities*, February 2007

[Executive Board 2007b] Thirty First Meeting Report of the Executive Board of the Clean Development Mechanism, *Proposed Agenda - Annotations*, Germany, May 2007

[Executive Board 2007c] Thirty Second Meeting Report of the Executive Board of the Clean Development Mechanism, Annex 38: *Guidance on the registration of project activities under a programme of activities as a single CDM project activity (Version 02)*, Germany, June 2007

[Executive Board 2007d] Press Release *Way cleared for Kyoto mechanism to boost green investment in developing countries CDM Executive Board*, Bonn, 27 June 2007

[Fearnside 2001] Fearnside P, *Comment: Environmentalists split over Kyoto and Amazonian deforestation*, Environmental Conservation, Vol 28 Issue 4, pgs 295299, 2001

[Fenhann 2003] Fenhann J, *Overview of the general conditions and timeframes in the flexible Kyoto mechanisms: Clean Development Mechanism (CDM), Joint Implementation, and Emission Trading*, SEREIN working paper 43:2003

[Fenhann 2007] Interview with Jørgen Fenhann, Unep Risø Centre, January 26, 2007

[Fermbäck 1995] Fermbäck G, *District cooling in Stockholm using sea water*, 1995 IDEA Cooling Conference, Miami Florida

[Figueres and Bosi 2006] Figueres C and Bosi M, *Achieving greenhouse gas emission reductions in developing countries through energy efficient lighting projects in the clean development mechanism (CDM)*, the Carbon Finance Unit of the World Bank, Washington DC, November 2006

[Flannery 2005] Flannery T, *The Weather Makers*; Harper Collins; Canada; 2005

[Foged and Skov 1999] Foged MI and Skov M, *District Cooling in Copenhagen*, News from DBDH (Danish Board of District Heating) 3/1999

[Frechtling *et al* 1997] Frechtling J, Sharp L, Westat, Eds., *User-Friendly Handbook for Mixed Method Evaluations*, National Science Foundation, US, 1997

[Geletukha 2006] Geletukha G, expert reviewer for *Desk Review of CDM project NM0181*, 23 July 2006

[Gore 2006] Gore A, movie *An Inconvenient Truth*, Lawrence Bender Productions, US, 2006

[Greenpeace 2005] *The environmental impacts of coal*, briefing, New Zealand, May 2005

[GRI 2007] *The global reporting initiative*, http://www.globalreporting.org/Home, 7 april 2007

[Grue and Meyer 2005] Grue L and Meyer C, *Flexible climate mechanisms and district heating*, News from DBDH (Danish Board of District Heating) 2/2005

[Gulf Coast CHP] *CHP Fuels:* www.gulfcoastchp.org/Technologies/Fuels, 24.01.2007

[Gulf News 2006] Mathias A, *"Making an efficient choice"*, archive.gulfnews.com/supplements/-air_conditioners/more_stories/10042912.html, United Arab Emirates, 27.05.2006

[Hammersley 2004] Hammersley M, *Case Study*, Lewis-Beck M *et al*, Eds., *The Sage Encyclopedia of Social Science Research Methods*, SAGE, California, 2004

[Harthan, undated] Harthan R, author of public comment on *CDM project NM0058*, undated

[Hawken *et al* 1999] Hawken P, Lovins AB, Lovins LH, *Natural Capitalism: the next industrial revolution,* Earthscan, UK, 1999

[Hayashi and Michaelowa 2007] Hayashi D, Michaelowa A, *Lessons from submission and approval process of large-scale energy efficiency CDM methodologies*, Research paper 4-11 for the International Climate Policy HWWI Research Programme, Germany, 2007

[Helsinki: DC 2007] *District cooling in Helsinki:* www.helsinginenergia.fi/kaukojaahdytys/en/, 17.05.2007

[Herbert 2004] Herbert J, *Cogeneration:* kelcroft.com.hk/cogeneration.htm, December 2004, viewed 25.01.2007

[Hofman 2005] Hofman Y, expert reviewer for *Desk Review of CDM project NM0096*, 28 April 2005

[Holmboe 2006] Holmboe N, *Programmatic CDM - opportunities and barriers*, Master thesis at DTU, Denmark, 2006

[HTN 2007] *Beijing HTN Pipeline Equipment Co.:* www.htn.com.cn/enhtn/index.asp, 24.01.2007

[IEA 1983] *District heating and combined heat and power systems: a technology review*, OECD/IEA, Paris, 1983

[IEA 2005] *30 Key energy trends in the IEA & Worldwide: 30th Anniversary of the IEA*, OECD/IEA, Paris, 2005

[IEA 2006] *Key wold energy statistics*, OECD/IEA, Paris, 2006

[IEA 2007a] *Energy Security and Climate Policy: assessing interactions*, OECD/IEA, Paris, 2007

[IEA 2007b] *Tackling investment challenges in power generation in IEA countries*, OECD/IEA, Paris, 2007

[IEA DHC/CHP 2002] *District Heating and Cooling: Environmental Technology for the 21st Century* policy paper, IEA DHC/CHP, May 2002

[IEA Heat Pump Centre 2004] *IEA Heat Pump Centre: How heat pumps achieve energy savings and CO_2 emissions reduction - an introduction*, March 2004

[IISD 2007] *Compendium: A Global Directory to Indicator Initiatives*, at www.iiisd.org, viewed 24.08.2007

[IPCC 1996] *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual (Volume 3)*

[IPCC 2001] *Climate Change 2001: Synthesis Report - Summary for policy Makers*, IPCC, 2001

[IPCC 2007a] *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report, Summary for Policymakers, Brussels, April 2007

[IPCC 2007b] *Climate Change 2007: Mitigation of Climate Change*, Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report, Summary for Policymakers, Bangkok, May 2007

[Iversen 2006a] Iversen J, *Turning CO_2 emissions into valuable project finance contribution*, News from DBDH (Danish Board of District Heating) 3/2006

[Iversen 2006b] Iversen J, *CO_2 finance contribution to waste-to-energy projects*, News from DBDH (Danish Board of District Heating) 4/2006

[James 2005] James K, *Methodological issues arising across different types of energy efficiency projects,* presented at "Expert workshop on CDM methodologies and technical issues associated with power generation and power saving project activities," Montreal: World Bank, 2005

[Januário and Semino 2006] Januário C and Semino S, *Britain and Offshore Windpower: How to make the dream become a reality?*, project for MSc Environmental policy and the Global Challenge: International, Regional and Local Perspectives, Roskilde University, Denmark, 2006

[Jones 2006] Jones S *et al*, *Negotiating the complexities of qualitative research in higher education: fundamental elements and issues*, Chapter 4: continuity and congruence in the research process, Routledge, New York, 2006

[Jürgen 2007] Interview with Anita Jürgen, Danish Ministry of Foreign Affairs, Copenhagen, January 26, 2007

[Kaneko *et al* 2006] Shinji Kaneko, Asaka Yonamine, Tae Yong Jung, *Technology choice and CDM projects in China: case study of a small steel company in Shandong Province*, Energy Policy 34 (2006) 1139 - 1151

[Kopp *et al*, undated] Kopp R, Krupnick A, Toman M, *Cost-Benefit Analysis and Regulatory Reform: An Assessment of the Science and the Art*, for the Commission on Risk Assessment and Risk Management, Resources for the Future, undated

[Liang 2007] Liang Y, *personal comm.*, January 2007

[Lorenzen 2007] Phone interview with Kirstine Lorenzen, COWI, Lyngby/Copenhagen, 14 February 2007

[Lybæk 2003] Lybæk R, *Guideline for implementing Co-generation based on Biomass waste from Thai Industries - through implementation and organisation of Industrial Materials Networks*, PhD thesis, Teksam, Roskilde University, Denmark, 2003

[Lyytimäki & Rosenström 2007] Lyytimäki J and Rosenström U, *Skeletons out of the closet: effectiveness of conceptual frameworks for communicating sustainable development indicators*, Sustainable Development, in press, 2007

[Matsuo, undated] Matsuo N, expert reviewer for *Desk Review of CDM project NM0058*, undated

[McCally 2002] McCally M, Ed., *Life Support: the environment and human health*, MIT, 2002

[McCracken 2007] McCracken R, *Liberalized markets and non-commercial policy goals: scope for peaceful co-existence?*, Platts Energy Economist, Issue 307, May 2007

[Merriam Webster Dictionary 2007a] *Technocracy* entry in the online dictionary, 20.06.2007

[Merriam Webster Dictionary 2007b] *Indicator* entry in the online dictionary, 24.08.2007

[Meth Panel 2004] *Meth Panel Recommendation to the Executive Board regarding project NM0058*, 8-10 November 2004

[Meth Panel 2005] *Meth Panel Recommendation to the Executive Board regarding project NM0096*, 22 June 2005

[Meth Panel 2006a] Report of the Twenty First Meeting of the Methodologies Panel, Annex 21: *Issues related to implementing project activities under a programme of activities*, Germany, June 2006

[Meth Panel 2006b] *Meth Panel Recommendation to the Executive Board regarding project NM0181*, 5 December 2006

[Meth Panel 2007] *Report of the Twenty Eighth Meeting of the Methodologies Panel*, Germany, 9-13 July 2007

[Michaelowa 2005] Michealowa A, *CDM: current status and possibilities for reform*, Research paper 3 for the International Climate Policy HWWI Research Programme, Germany, 2005

[Miljøministeriet 2007] Press release by the Environment Ministry of Denmark: *Danmark vært for FN's klimatopmøde* (Denmark host to UN's climate summit), 21.03.2007

[Miller 2003] Miller T, *Environmental Science: working with the earth*, Brooks/Cole, 9th edition, Canada, 2003

[Müller-Pelzer and Michaelowa 2005] Müller-Pelzer F, Michaelowa A, *Lessons from the submission and approval process of energy-efficiency CDM baseline and monitoring methodologies*, Research paper 1 for the International Climate Policy HWWI Research Programme, Germany, 2005

[Munasinghe and Swart 2005] Munasinghe M and Swart R, *Primer on Climate Change and Sustainable Development: Facts, Policy Analysis and Applications*, Cambrigde University Press, UK, 2005

[New Scientist 2007] Brahic C, *Global warming will increase world death rate*, NewScientist.com news service, 28.06.2007

[New Venture Tools 2007] *Technology assessment*, http://www.newventuretools.net/ technology_assessment.html, 6 april 2007

[Nolt 2007] *Cost benefit analysis*, http://web.utk.edu/ nolt/courses/costbene.html, 6 april 2007

[Nordqvist 2005] Nordqvist J, *Climate change and industrial technology transfer: a study of Chinese conditions*, PhD Thesis (Engineering) for Environmental and Energy Systems Studies at Lund University, Sweden, 2005

[Nordvärme 1995] Nordvärme, *Environmental Benefits from District Heating in the Nordic Capitals*, 16^th Congress of the World Energy Council, Tokyo, 1995.

[Norman and MacDonald 2004] Norman W and MacDonald C, *Getting to the Bottom of "Triple Bottom Line"*, Business Ethics Quarterly, Vol 14 n.2, April 2004

[NPPC 2002] *Natural gas combined cycle gas turbine power plants* (New resource characterization for the fifth power plan), Northwest Power Planning Council, Western Governors' Association, US, August 2002

[NRC 1985] *District Heating and Cooling in the United States: Prospects and Issues*, Committee on District Heating and Cooling, Energy Engineering Board and Building Research Board, Commission on Engineering and Technical Systems, National Research Council, Washington DC, 1985, pgs 11-13, 22-23, 82

[Öko-Institut 2007] *The institute*, www.oeko.de/the_institute/dok/594.php, 18.07.2007

[Olsen 2006] Olsen OJ, lecture in *Energy and Environment course*, Roskilde University, Spring 2006

[Olsen, undated] Olsen KH, *The Clean Development Mechanism's Contribution to Sustainable Development: a review of the literature*, Unep Risø Centre, undated

[Olsen and Pedersen 2005] Olsen PB, Pedersen K, *Problem-Oriented Project Work - a workbook*, Roskilde University Press, Denmark, 2005

[Oslo Airport 2007] *District Heating at Oslo Airport, Norway:* www.aboutbioenergy.info/Oslo.html, 16.05.2007

[Overgaard *et al* 2005] Overgaard J, Woods P and Riley O, *Large or small-scale CHP/DH - a comparison*, News from DBDH (Danish Board of District Heating) 3/2005

[Pellet Stoves 2007] www.pelletstoveweb.com, 24.01.2007

[Pielke *et al* 2007] Pielke Jr.R, Prins G, Rayner S, Sarewitz D, *Climate change 2007: Lifting the taboo on adaptation*, Nature, 02.08.2007, Vol. 445 Issue 7128, p597-598

[Platts 2007] *Divisions remain over future of carbon markets,* Platts.com news feature on emissions trading, www.platts.com/Electric%20Power/Resources/News%20Features/emission/-kyoto.xml?src=energybulletin#2, May 25, 2007

[Proposal 1: PDD 2004] *CDM PDD NM0058: Energy Efficiency Improvements - Hou Ma District Heating, Shanxi Privince, China*, Danida, June 2003, issued June 2004.

[Proposal 2: Calculations 2005] *Hou Ma CDM - PDD Calculation of CO_2 reductions, Hou Ma District Heating Project*, Details, Danida, 2005

[Proposal 2: Harbin documentation 2005] *CDM PDD Harbin District Heating Project, Dao Li District*, Danida, 2005

[Proposal 2: Methodology 2005] *CDM Proposed New Methodology: Baseline (CDM NMB): Energy Efficiency improvements in district heating production and distribution*, Danida, 2005

[Proposal 2: PDD 2005] *CDM PDD NM0096: Energy Efficiency Improvements - Hou Ma District Heating, Shanxi Province, P.R.C.*, Danida, 2005

[Proposal 2: Tech Query Response 2005] Energy Efficiency Improvements - Hou Ma District Heating, Shanxi Province, P.R.C., NM 0096: *Comments and reply to questions raised by the CDM Team* on 12 April 2005, COWI, April 2005

[Proposal 3: Calculations 2006] *Houma CDM - PDD Calculation of CO_2 reductions for project activity*, Danida, 2006

[Proposal 3: Calculations 2007] *Houma CDM - PDD Calculation of CO_2 reductions for project activity*, Danida, 2007

[Proposal 3: Methodology 2006a] *CDM Proposed New Methodology: Baseline (CDM NMB): Introduction of a new primary district heating system, Version 01*, Danida 10 May 2006

[Proposal 3: Methodology 2006b] *CDM Proposed New Methodology: Baseline (CDM NMB): Introduction of a new primary district heating system, Version 02*, Danida October 2006

[Proposal 3: Methodology 2007] *CDM Proposed New Methodology: Baseline (CDM NMB): Introduction of a new primary district heating system, Version 03*, Danida, 3 June 2007

[Proposal 3: PDD 2006a] *CDM PPD NM0181: Introduction of a new primary district heating system - Houma District Heating project, Shanxi Province, P.R.C., Version 01*, Danida, 10 May 2006.

[Proposal 3: PDD 2006b] *CDM PPD NM0181: Introduction of a new primary district heating system - Houma District Heating project, Shanxi Province, P.R.C., Version 02*, Danida, October 2006.

[Proposal 3: PDD 2007] , *CDM PPD NM0181-rev: Introduction of a new primary district heating system - Houma District Heating project, Shanxi Province, P.R.C.*, Danida, 3 June 2007

[Randløv 2001] Randløv P, *Preconditions for district heating development*, News from DBDH (Danish Board of District Heating) 2/2001

[Randløv 1997] Randløv P, *District Heating Handbook*, European District Heating Pipe Manufacturers Association, Denmark, 1997

[RDEB] *Danish Mixed Credits to China* brochure, Royal Danish Embassy Beijing, December 2003

[Reuters 2007a] Beck L, *China to invest blns in energy saving buildings*, Reuters, Beijing, 18.01.2007

[Reuters 2007b] Graham-Harrison E and Buckley C, *China says climate policy must make room for growth*, Reuters, Beijing, 04.06.2007

[Reuters 2007c] Lyon A, *Global warming to multiply world's refugee burden*, Reuters, Beirut, 18.06.2007

[Rohde 2005] Rohde RA, *2000 Year Temperature comparison*, Global warming art: www.globalwarmingart.com/wiki/Image:2000_Year_Temperature_Comparison.png#file, 10.01.2006

[Sawyer 2007] Sawyer S, *Re: Report [to GWEC] for Board Meeting in Los Angeles on 5 June 2007*, Brussels, 28.05.2007

[Schneider 2005] Schneider L, expert reviewer for *Desk Review of CDM project NM0096*, 02 May 2005

[Schneider 2007] Phone interview with Lambert Schneider, Öko-Institut, Berlin/Copenhagen, February 14, 2007

[Schrank 2006] Schrank A, *Chapter 2: case studies* and *Chapter 9: Essentials for the Case study method*, in Perecman E, Curran S, Eds., *A handbook for social science field research: essays and bibliographic sources on research design and methods*, SAGE, California, 2006

[Science Daily 2007] *Adaptation To Global Climate Change Is An Essential Response To A Warming Planet*, from Arizona State University, 08.02.2007

[Sequoien 2007] *Combined heat and power (CHP), and district heating:* www.sequoien.com/chp.html, 24.01.2007

[Siddiqi and Lee 2001] Siddiqi T, Lee MK, *The Roles of Capacity Building and Technology Transfer in the Clean Development Mechanism*, GEE-21 Discussion Paper 2001/1

[Sierra Club 2007] *Clean Air: Dirty Coal Power,* www.sierraclub.org/cleanair/factsheets/power.asp, 26.06.2007

[Smith 2004] Smith J, *Reliability and Validity in qualitative research*, Lewis-Beck M *et al*, Eds., *The Sage Encyclopedia of Social Science Research Methods*, SAGE, California, 2004

[Spalding-Fecher, undated] Spalding-Fecher R, expert reviewer for *Desk Review of CDM project NM0058*, undated

[Stokke *et al* 2005] Stokke OS, Hovi J and Ulfstein G, Eds., *Implementing the climate regime: international compliance*, Earthscan, London, 2005

[Stroh 2000] Stroh M, *Qualitative Interviewing*, in Burton D., Ed., *Research Training for Social Scientists*, Sage, 2000

[Sustainable Management Dictionary 2007] *Ecological Footprint* entry: www.sustainabilitydictionary.com/e/ecological_footprint.php, 20.06.2007

[Sutter and Parreño 2005] Sutter C and Parreño JC, *Does the current Clean Development Mechanism deliver its sustainable development claim?*, Climate or Development? conference, HWWA, Germany, October 2005

[Sweheat 2007] *Why district heating?:* www.sweheat.com/sidor/adh.htm, 17.05.2007

[Sørensen 2006] Interview with Jens Brandt Sørensen, Carl Bro, Glostrup, November 2006

[T@W 2007] *CDM Project development*, Sustainable energy technology at work: www.setatwork.eu/cdm_projects.htm, 13.08.2007

[The Danish 92 Group 2005] *Analysis of the Danish JI and CDM projects*, Copenhagen, October 2005

[The Economist 2005a] *The Oiloholics*, Vol 376, n.8441, August 27-September 2, 2005, pg 11

[The Economist 2005b] *No safety net: Katrina and oil prices*, Vol 376, n. 8443, September 10-16, 2005, pg 27

[The Economist 2006] *Special Report: Energy Security*, Vol 378, n. 8459, January 7-13, 2006, pgs 12 and 72-74

[The Economist 2007] *Trading thin air*, part of a Special Report on Business and Climate Change, Vol 383, n. 8531, June 2-8, 2007, pgs 30-32

[The Grist 2007a] *Baoxing Match: Fast developing China to push for $200 billion energy efficiency investment*, www.grist.org, 19.01.2007

[The Grist 2007b] *The Grist:* www.grist.org, 18.05.2007

[The Guardian 2007] Vidal J and Adam D,*China overtakes US as world's biggest CO_2 emitter*, special report on China, 19.06.2007

[The World Bank 2007] Capoor K and Ambrosi P, *State and trends of the carbon market 2007*, Washington DC, May 2007

[Thorne 2000] Thorne S, *Data analysis in qualitative research*, EBN notebook, Evidence-Based Nursing 2000, 3:68-70.

[Tietenberg 2006] Tietenberg T, *Environmental and Natural Resource Economics*, 7^{th} edition, Pearson Addison Welsley, US, 2006

[Tschirley 1996] Tschirley J, *Use of Indicators in Sustainable Agriculture and Rural Development*, SD Dimensions: Environment: Environmental policy and integrated management, available at www.fao.org/sd/EPdirect/EPan0001.htm, FAO, March 1996

[Unep Risø, undated] *Introduction to the CDM* booklet, Unep Risø Centre, Denmark, undated

[UNFCCC 2001] *Report of the Conference of the Parties on the second part of its sixth session,* (decision 5/CP.6), Bonn, Germany, 25.09.2001

[UNFCCC 2005] First session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (COP/MOP 1), *Further guidance to the CDM*, Montreal, Canada, Nov-Dec 2005

[UNFCCC 2006] Second session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (COP/MOP 2), *Further guidance to the CDM*, Nairobi, Kenya, November 2006

[UNFCCC 2007] unfccc.int, January through July 2007

[UNRISD 2004] *Technocratic Policy Making and Democratic Accountability*, Research and Policy Brief: 3, August 2004

[US CHPA 2007] *United States Combined Heat and Power Association:* www.uschpa.org, 24.01.2007

[UM 2004] *Beretning fra udvalget for blanded kreditter*, Danida, Denmark, 2004

[UM 2005] *Beretning fra udvalget for blanded kreditter*, Danida, Denmark, 2005

[UM 2006] *Beretning fra udvalget for blanded kreditter*, Danida, Denmark, 2006

[UM 2007] *About DANIDA*, www.um.dk/da/menu/Udviklingspolitik/OmDanida, 18.07.2007

[Vaessen and Thielens 2007] Vaessen P and Thielens D, *Distributed Generation: policy and incentives on distributed generation*, Leonardo Energy, May 2007

[Varming 2005] Presentation *Practical issues in identification and development of CDM projects*, by Sren Varming, AIT, Bangkok, 20 October 2005

[WADE 2007] *World Alliance for Decentralized Energy:* www.localpower.org, 24.01.2007

[Warren 2004] Warren C, *Interviewing in qualitative research*, Lewis-Beck M *et al*, Eds., *The Sage Encyclopedia of Social Science Research Methods*, SAGE, California, 2004

[Watkins 2007] *Cost benefit analysis*, http://www.sjsu.edu/faculty/watkins/cba.htm, 6 april 2007

[WB-CFU 2006] *Methodological barriers to develop energy efficiency projects under simplified modalities and procedures for small-scale CDM project activities*, Submission of the Carbon Finance Unit of the World Bank, to the Executive Boards call for public inputs on type II small-scale CDM, Washington DC, August 10, 2006

[Weiss 2005] Weiss j, *China and its neighbours: partners or competitors for trade and investment*, in China in a Globalizing World, UNCTAD, UN, New York and Geneva, 2005

[Werner 2006] Werner S, interview on *District Heating Systems Technology*, at www.chalmers.se/en/sections/research/professors/interwievs/interview-with-adjunct4434, April 2006, viewed 25.01.2007

[WIC 2006] Presentation *Can sectoral approaches to the CDM promote renewable energy technologies?*, by the Wuppertal Institute for Climate, Environment and Energy, SB 24 Side event, 22 May 2006.

[WRI 2000] *World greenhouse gases Emissions Flow Chart*, World Resources Institute, data from 2000.

[Young 1998] Young CW, *Book Review: Sustainability indicators - Report of the project on indicators of sustainable development. Edited by Bedrich Moldan and Suzanne Billharz, 1997. Wiley, 415pp, 65 (hardback). ISBN 0471973521*, Sustainable Development journal, Vol. 6 Issue 2, August 1998

[Yin 1994] Yin RK, *Case study research: design and methods*, 2^{nd} ed., SAGE, California, 1994

Appendix A

The Kyoto Protocol

"It's clear that an overstressed world with 6.3 billion people is a risky place to be carrying out uncontrolled experiments with the climate" [UNFCCC 2007]

A.1 The Science

Energy is one of main drivers of life on Earth. Energy from the Sun hits the Earth and gets converted to heat, emanating back to the atmosphere. This is what warms the atmosphere. Greenhouse gases absorb this heat and keep it from escaping to space, permitting warmth and life on Earth. Gases such as water vapor, carbon dioxide (CO_2), and methane (CH_4), among others, are greenhouse gases [Miller 2003].

Since the Industrial Revolution, the Earth's average temperature has been slowly increasing. The main culprits have been "the burning of ever-greater quantities of oil, gasoline, and coal, the cutting of forests, and the practice of certain farming methods". Global warming is therefore the effect that these *extra* gases are having on the planet. Global temperature and levels of greenhouse gases have fluctuated over time, but never this quickly, and never so much, as can be seen by Figure A.1, without causing major events such as mass extinctions. The last few years have included several of the warmest years on record [Miller 2003, UNFCCC 2007].

Global warming will cause numerous changes to our environment, such as the ones cited below, and this in turn will cause changes to many human populations, societies and civilisations [Miller 2003, UNFCCC 2007]:

- extinctions of plants and animals, affecting biodiversity and the ability of ecosystems to survive;
- rising sea level due to warmer and expanding oceans and melting glaciers;
- changing weather patterns and more severe weather events such as floods, storms, draughts and wildfires;
- plant and animal migrations and expansion of vector borne diseases such as malaria;
- dropping agricultural yields;

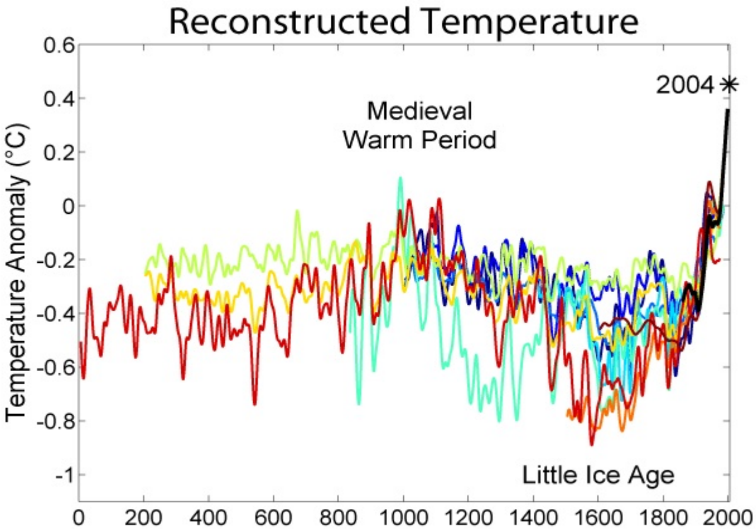


Figure A.1: Graph comparing different studies of average global temperatures over the several thousand years, showing that they agree with historical records such as the Medieval warm period, that they mostly agree with each other, and showing the tendency for the future. Al Gore made clear in his movie 'An Inconvenient Truth' that questioning the science of global warming was something that was done only in the popular press, not in the scientific community [Gore 2006]. Image source [Rohde 2005].

- fouling of and dwindling freshwater supplies;
- changes and growth in incidence of hunger and malnutrition;
- generalized conflict over resources causing migrations and environmental refugees.

A.2 The politics

> *"There is a delicate balance to international treaties. Those appealing enough to gain widespread support often aren't strong enough to solve the problems they focus on. (Because the Framework Convention was judged to have this weakness, despite its many valuable provisions, the Protocol was created to supplement it.) Yet treaties with real 'teeth' may have difficulty attracting enough widespread support to be effective."* [UNFCCC 2007]

The global nature of these problems requires global concerted action to try to avert the bad consequences of them. Since 1988 the IPCC (Intergovernmental Panel on Climate Change) has attempted to provide research, advise governments and has tried to be an indisputable source of information for all nations on climate change. In the 1992 'Rio Earth Summit' many countries signed the UNFCCC (United Nations Framework Convention on Climate Change). The countries are the Parties to the Convention, and they meet regularly in COPs (Convention of the Parties). This treaty is a success in recognizing the problem, committing the developed nations to cutting their emissions while helping the developing nations [UNFCCC 2007, The Grist 2007b].

In 1997, the Kyoto Protocol was drawn up as an amendment to the UNFCCC treaty, with legally binding requirements for all governments to reduce greenhouse emissions, bound by a time frame and offering mechanisms to help nations do this. There are a number of committees, financial outfits and 'observer' organizations that are involved with the UNFCCC Secretariat and the COP/MOP meetings [UNFCCC 2007]. Some countries have not agreed to sign this last amendment, which requires a 5% drop in world emissions according to 1990 levels, as an average in the 2008-2012 period. Each country has specific emission targets, and the EU has an 8% target (distributed among the Member states). The Kyoto Protocol countries (Parties) meet regularly in MOPs (Meeting of the Parties) [The Grist 2007b]. In 2001 the Marrakesh Accords were signed, which is meant to be an operating manual for the Kyoto Protocol and its mechanisms, since the functioning of the mechanisms was not worked out at the time of signing the Protocol [UNFCCC 2007, Unep Risø, undated, Holmboe 2006].

These mechanisms are emissions trading (based on AAUs, assigned amount units) (article 17 of the Protocol), the CDM (Clean Development Mechanism) (trading CERs, certified emission reductions) (article 12) and JI (Joint Implementation) (based on ERUs, emission reduction units) (article 6). Emissions trading is meant to give a price to the emissions which have been an externality up to now. The basic idea is that each country will receive an amount of assigned emissions, and if it comes above or below that level it can trade on a market for certificates. It can also purchase compliance by paying a fine. This is supposed to stimulate more energy efficiency and less use of energy, thereby reducing emissions. Adding to this flexibility is the possibility of carrying out JI projects with fellow developed countries or transition economies, and the possibility of carrying out CDM projects in developing countries (where it is cheapest to achieve reductions). All this flexibility comes at the price of monitoring emissions, guaranteeing that these are correct, and keeping track of the trading and banking, which poses considerable problems and requires a lot of personnel [UNFCCC 2007, Fenhann 2003].

A pilot phase (AIJ) was started in 1995 to test the mechanism and some projects (started after 2000) will even be eligible to generating ERUs, as of 2008. JI has two tracks, one for countries that meet all the eligibility requirements[1], and two for countries that meet only the first three eligibility requirements (see previous footnote) [UNFCCC 2007, Fenhann 2003].

ERUs, CERs and AAUs can be traded as of 2008. JI and CDM projects can be started before the trading period, but CERs are the only certificates that can be generated before 2008 (from 2000). The EU and some countries have set up emission trading systems in advance of the Protocol to stimulate the development of the market and gain experience [UNFCCC 2007, Fenhann 2003].

After the end of the first commitment period (2008-2012), each country must tally their emissions in that period (independently verified and certified) and compare to their emission targets (based on 1990 emissions). The certificates generated by that

[1] They are: "1. It is an Annex-I Party and a Party to the Kyoto Protocol; 2. Its assigned amount has been calculated and recorded; 3. It has in place a national registry; 4. It has in place a national system for estimation of greenhouse gas emissions; 5. It has submitted annually a greenhouse gases inventory report; 6. It submits the supplementary information on assigned amounts" [Fenhann 2003].

country in the period will then be compared to the emission reduction target, leaving the country with more or less certificates than they need. They can then trade, or alternately purchase compliance by paying a fine. Countries are required to keep a reserve of certificates and can bank them for further commitment periods, but they are not allowed to bank all their certificates [Fenhann 2003].

The US and Australia have refused to ratify the Kyoto Protocol (even though Australia was allowed an 8% *increase* in emissions). This has caused many conflicts since they are some of the biggest per capita emitters, and the US alone accounts for nearly a quarter of world emissions [Flannery 2005]. Before the ratification of Russia in 2004 the Protocol was thought to have been stillborn [The Grist 2007b]. Figure A.2 shows the global status of ratification.

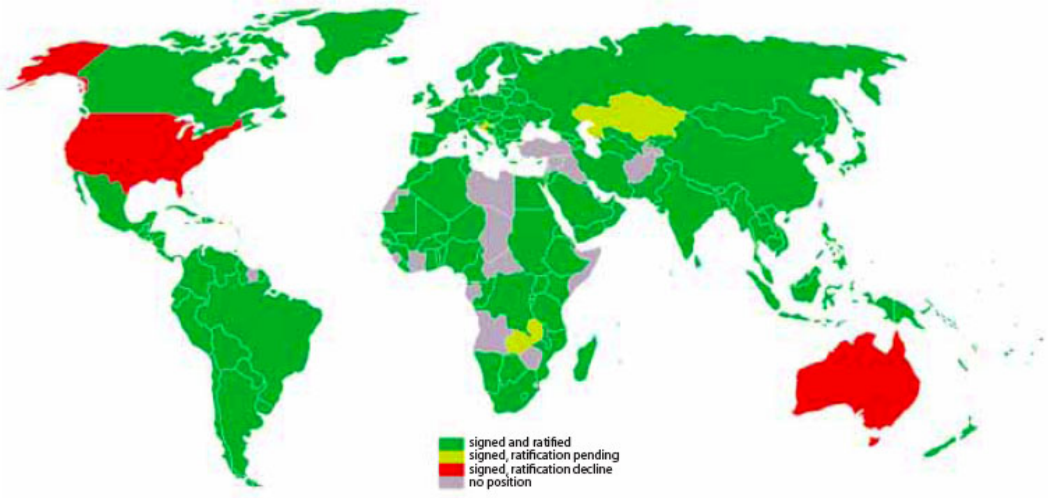


Figure A.2: Map showing the countries that have signed the UNFCCC convention and ratified the Kyoto Protocol, countries that have not ratified the Kyoto Protocol, countries with ratification pending and countries that have no position on the matter. Image source [Vaessen and Thielens 2007].

"The EU has been one of the main driving forces of the Kyoto Protocol and has attempted to incorporate environmental concerns into their policies" [Januário and Semino 2006], for example by creating a directive that calls for cleaner and more sustainable bio-fuels. Environmental protection is also linked with security of energy supply, job creation and market competitiveness, among other things. With regards to energy, current concerns include making energy use more sustainable, which means slower depletion of resources, using more renewable energy and increasing energy efficiency, securing the supply of energy in places within the EU instead of in politically problematic and unstable regions. These measures are also meant to generate jobs and increase the EU's competitiveness in the world market [EC 1997].

Many scientists believe that a 5% reduction will not achieve much and that the needed reductions to avoid the worst effects of climate change are of a much larger scale. But the strength of the Protocol is that so many countries have at least managed to agree, and it sets the scene for new negotiations, whereas it might take a decade to reach a new consensus, if we had to begin anew today [BBC 2007a]. Seen in this light, it becomes obvious the Kyoto Protocol was not supposed to solve the problem, but simply *start* outlining a solution [Environment and Economics 2007].

A.3 The CDM

The CDM will have this dedicated section since this thesis deals actively with it. Unless otherwise stated this section has been copied verbatim from this source: [Unep Risø, undated].

Developing countries have no binding targets but do have growing emissions. For this reason the CDM allows for low-emission projects in these countries, stimulating technology transfer and sustainable development. Certificates generated by these projects can help the paying country to reach its targets or trade them away. Certificates can also be banked. The CDM began being developed even before the Protocol took effect in 2005, and the certificates can also be banked outside the trading period, 2008-2012 [UNFCCC 2007].

"The CDM allows an Annex I Party [basically, developed countries] to implement a project that reduces greenhouse gas emissions or, subject to constraints, removes greenhouse gases by carbon sequestration, or 'sinks', in the territory of a non-Annex I Party [basically, developing countries]. The resulting certified emission reductions, known as CERs, can then be used by the Annex I Party to help meet its emission reduction target. CDM projects must be approved by all Parties involved, lead to sustainable development in the host countries, and result in real, measurable and long-term benefits in terms of climate change mitigation. The reductions must also be additional to any that would have occurred without the project"

"In order to participate in the CDM, there are certain eligibility criteria that countries must meet. All Parties must meet three basic requirements: voluntary participation in the CDM, the establishment of a National CDM Authority, and ratification of the Kyoto Protocol. In addition, industrialized countries must meet several further stipulations: establishment of the assigned amount under Article 3 of the Protocol [AAUs], a national system for the estimation of greenhouse gases, a national registry, an annual inventory, and an accounting system for the sale and purchase of emission reductions".

"The CDM will include projects in the following sectors: end-use energy efficiency improvements; supply-side energy efficiency improvement; renewable energy; fuel switching; agriculture (reduction of CH_4 and N_2O emissions); industrial processes (CO_2 from Cement etc., HFCs, PFCs, SF_6); sinks projects (only afforestation and reforestation). Annex I Parties must refrain from using CERs generated through nuclear energy to meet their targets. In addition, for the first commitment period (2008-2012), the only sink projects allowed are those involving afforestation or reforestation, and Annex I Parties can only add CERs generated from sink projects to their assigned amounts up to 1% of their baseline emissions for each year of the commitment period. Further guidelines for carbon sink projects will be developed to ensure they are environmentally sound."

"Public funding for CDM projects must not result in the diversion of funds for official development assistance". A levy will be taken from the CERs generated to contribute to the administrative costs of the CDM and another to add to the Adaptation Fund, for the non-least developed countries.

"The CDM is supervised by an Executive Board, which itself operates under the authority of the Parties. The Executive Board is composed of 10 members, including one representative from each of the five official UN regions (Africa, Asia, Latin America and the Caribbean, Central and Eastern Europe, and OECD), one from the small island developing states, and two each from Annex I and non-Annex I Parties. The Executive Board held its opening meeting at the Marrakech talks in November 2001, marking the launch of the CDM. The Executive Board will accredit independent organizationsknown as operational entities that will validate proposed CDM projects, verify the resulting emission reductions, and certify those emission reductions as CERs. Another key task is the maintenance of a CDM registry, which will issue new CERs, manage an account for CERs levied for adaptation and administrative expenses, and maintain a CER account for each non- Annex I Party hosting a CDM project."

The CDM project cycle is illustrated in Figure A.3. "The first step in the CDM project cycle is the identification and formulation of potential CDM projects. A CDM project must be real, measurable and additional. To establish additionality, the project emissions must be compared to the emissions of a reasonable reference case, identified as the baseline. The baseline is established by the project participants according to approved methodologies on a project specific basis". Figure A.4 shows the necessary steps for the baseline and additionality. CDM projects must have a "monitoring plan, which constitutes the basis of future verification. ... Together with the investor, the host country must prepare a project design document. ... A designated operational entity [DOE] will then review the project design document and, after public comment, decide whether or not it should be validated. ... If validated, the operational entity will forward it to the Executive Board for formal registration.... The carbon component of a mitigation project cannot acquire value in the international carbon market unless submitted to a verification process designed specifically to measure and audit the carbon component. ... Verification is the independent ex-post determination by an operational entity of the monitored reductions in emissions [2]. The operational entity must make sure that the CERs have resulted according to the guidelines and conditions agreed upon in the initial validation of the project. Following a detailed review, an operational entity will produce a verification report and then certify the amount of CERs generated by the CDM project. ... Unless a project participant or three Executive Board members request a review [of the report] within 15 days, the Executive Board will instruct the CDM registry to issue the CERs." The methodology approval process is shown in diagram form in Figures A.5 and A.6.

CDM project approval is based on a PDD, project design document, which follows the template: "A. General description of project activity; B. Baseline methodology; C. Duration of the project activity; D. Monitoring methodology and plan; E. Calculation of greenhouse gases emission by sources; F. Environmental impacts; G. Stakeholder Comments; Annex 1. Contact information on project participants; Annex 2. Information regarding public funding; Annex 3. New baseline methodology; Annex 4. New monitoring methodology; Annex 5. Table of baseline data" [Fenhann 2003].

These processes are well explained in [Holmboe 2006].

[2] [The period can be up to 10 years or 7 years, the latter with the possibility of renewal twice, making for a total of 21 years [Fenhann 2003].]

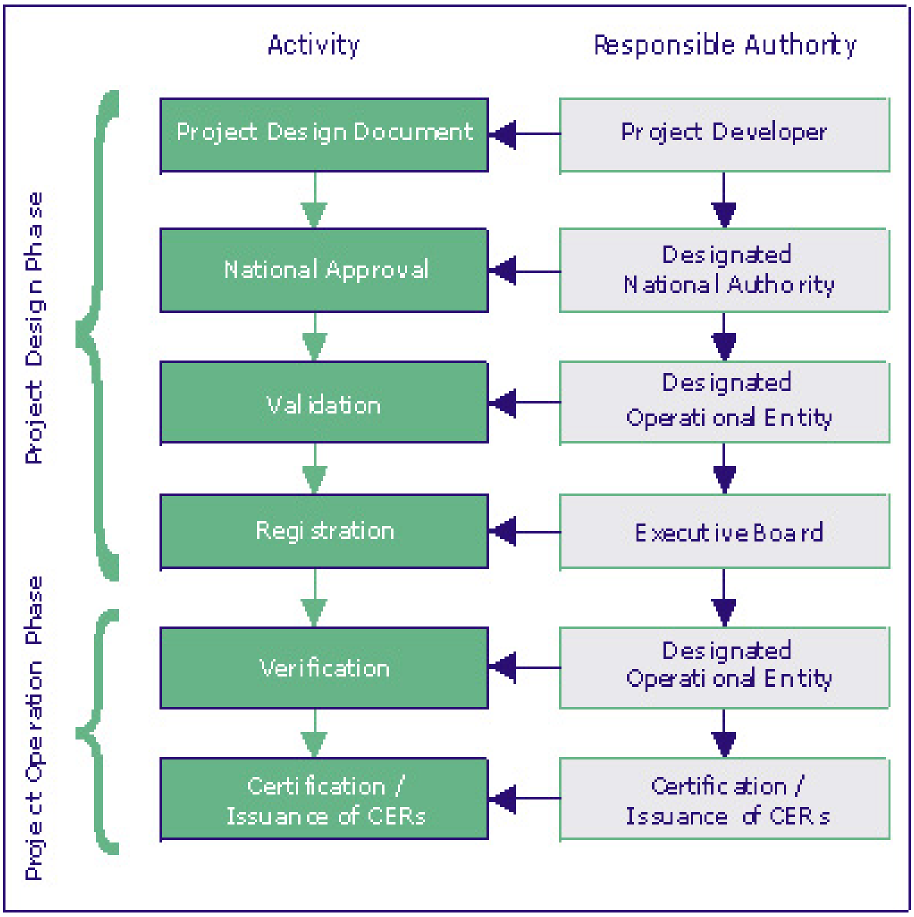


Figure A.3: Overview of CDM project cycle [T@W 2007]

The CDM includes a small-scale modality (SSC), where the methodologies for projects are designed top down rather than bottom up, as in the 'regular' CDM. SSC projects are divided into three types: type I for renewable energy projects below 15MW, type II for energy efficiency projects reducing no more than 15GWh/year, and type III for other projects reducing less than 15 tonnes of CO_2e per year [Fenhann 2003].

A.4 The Solutions

There are many ways of dealing with the global warming problem. Reducing emissions is one of them. This can be done by switching to renewable sources of energy, reducing overall consumption of energy and investing in energy efficiency, and researching whether carbon capture is an alternative [UNFCCC 2007].

Another solution is to increase forests, since vegetation absorbs carbon in its growing phase. This has the added benefit of preserving biodiversity. Agricultural practices can also be changed to minimize carbon losses from the soil and fertilizer applications that end up in the atmosphere [UNFCCC 2007].

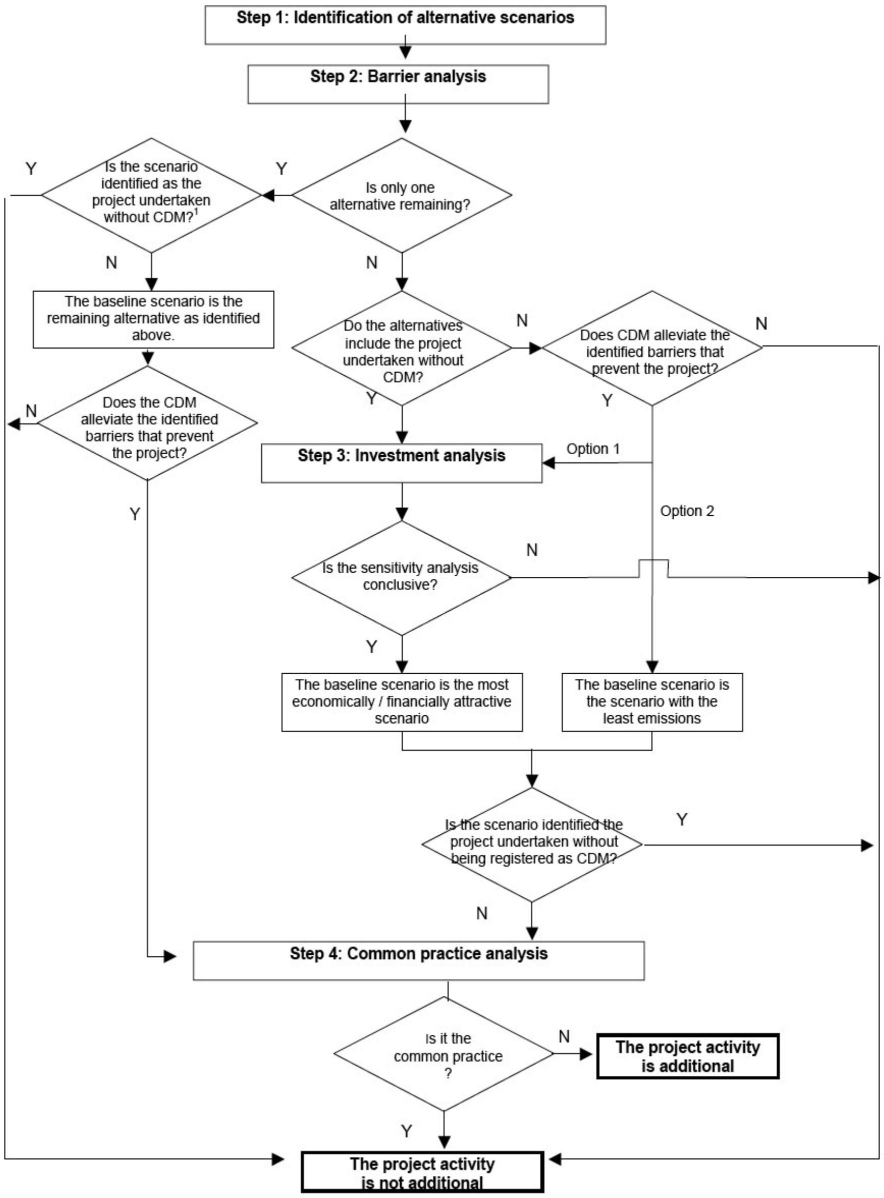


Figure A.4: Flow chart illustrating steps in defining baseline scenario and testing additionality of proposed CDM project [Executive Board 2006a]

People's lifestyles and habits can also make a difference. People can make conscious choices regarding transportation and the energy efficiency of their cars and homes. Governments can help with laws and regulations on taxes, minimum standards and a variety of policy mechanisms to encourage the population to reduce their emissions [UNFCCC 2007].

Adaptation is also something that needs to be given attention. Prevention and planning are difficult when the effects of something are not fully known, and neither is the timing or the intensity of the onslaught. But rational decisions on the location

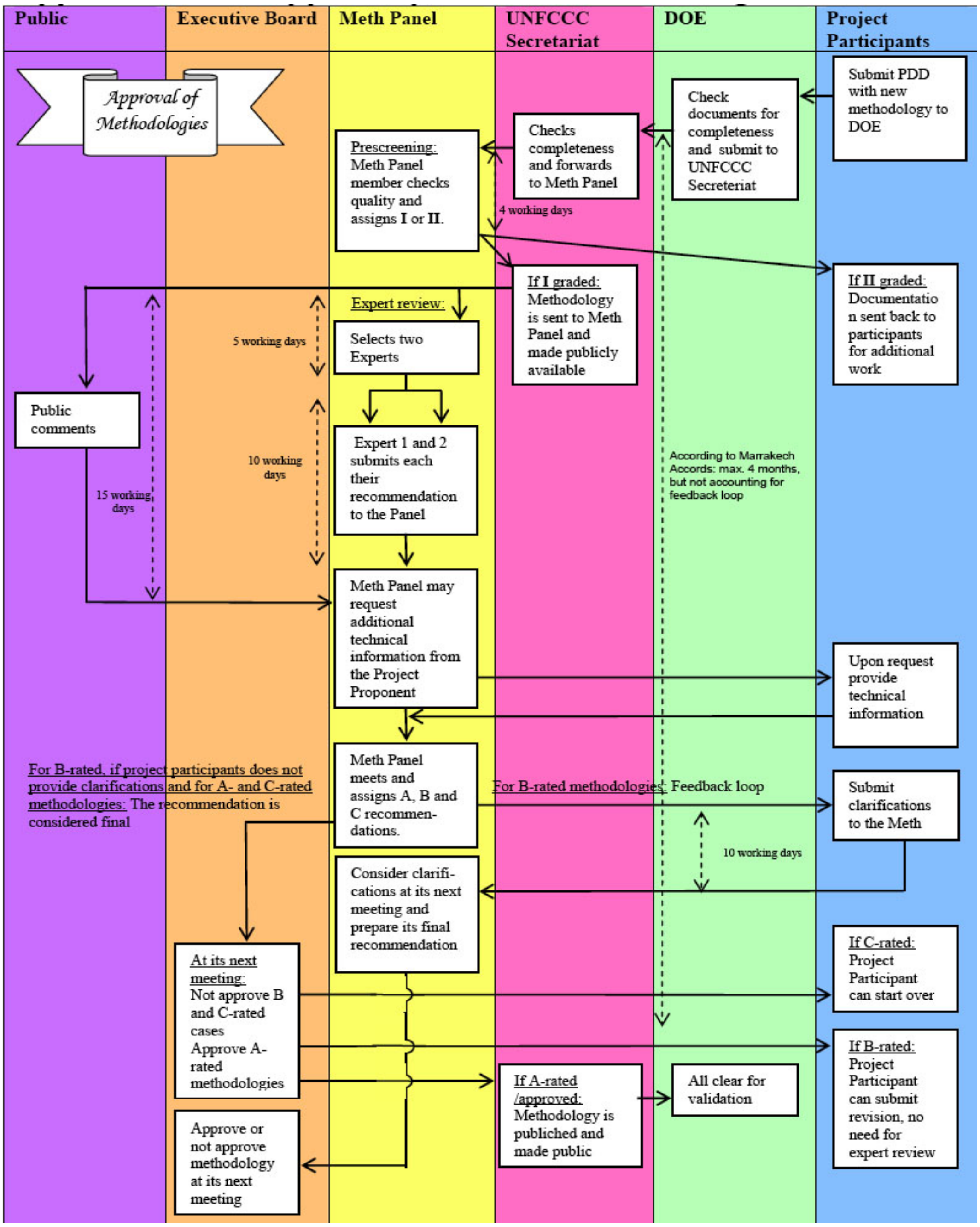


Figure A.5: Diagram showing the approval process for a CDM methodology - part 1 of 2. Source [Holmboe 2006].

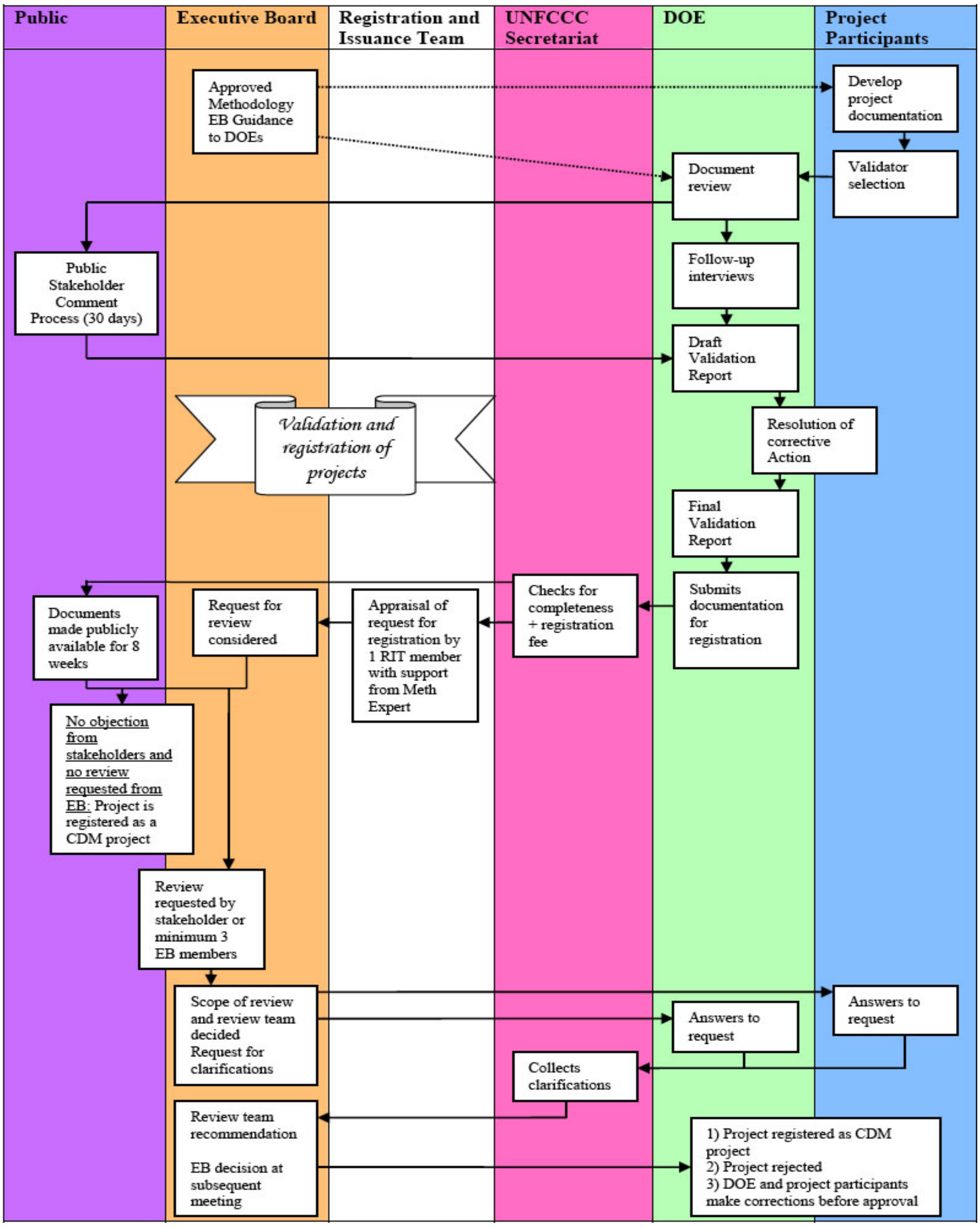


Figure A.6: Diagram showing the approval process for a CDM methodology - part 2 of 2. Source [Holmboe 2006].

of new buildings and infrastructure, for example, are one way of preparing for climate change. Some change is, at this point in time, inevitable [UNFCCC 2007].

Progress has been made but there is a long way to go.

A.5 Beyond the carbon market

This section is verbatim from [The World Bank 2007]:

"There is a tendency to believe that the carbon market is somehow a magic bullet that will alone save the world from global warming. While the authors recognize the enormous strength and potential of the market to achieve results, it would be wise not to assume the market will provide a painless, magical way to mitigate climate change".

"First, the market does not set the level of a cap, policy-makers do. The market can only be a tool to help achieve that target. It cannot be a surrogate for a target and policy makes should not expect to be let off the hook from their jobs making sensible policy."

"Second, policy makers need to set targets and support mechanisms that meet two massive challenges. They have the responsibility of taking into account the risks of climate change, especially on the poorest, as well as the opportunity of expanding clean development choices to meet the basic needs and aspirations of billions worldwide, many without access to electricity or clean water."

"Third, there is no free lunch. The exuberance of creating value and enormous wealth in a new market should not mask the fact that there are costs for mitigation."

"Fourth, the integrity of a market rests on the clarity and simplicity of its rules, the transparency of information and on institutions that guard against fraud and manipulation."

"Fifth, it is not fair to expect 'cap-and-trade' or emissions trading to work in all sectors globally; clearly, housing and transport are sectors that do not lend themselves easily to an elegant emissions cap-and-trade approach. There may be other policies including other market-based approaches or removal of subsidies that may be more suitable in some contexts."

"Finally, a solution to urgent problem of the climate change problem will require sustained effort by all of us. Policy has a role, as does individual action by each of us. It will also require applying market based principles to the likely need for society especially its most vulnerable members to adapt to climate change."

Challenges for the future include making the political commitment and biting the economic bullet of investing in technologies that are already existent and are better for the environment, but still are more expensive than what's currently used. The costs as well as the benefits need to be fairly distributed somehow. A minimum global standard needs to be somehow developed to avert a 'race to the bottom'. 'No-regret' options are needed but not sufficient. Political and personal will are key [UNFCCC 2007].

Appendix B

GRI Core Indicators of Sustainability

"The Global Reporting Initiative (GRI) is a multi-stakeholder process and independent institution whose mission is to develop and disseminate globally applicable Sustainability Reporting Guidelines. These Guidelines are for voluntary use by organisations for reporting on the economic, environmental, and social dimensions of their activities, products, and services. The GRI incorporates the active participation of representatives from business, accountancy, investment, environmental, human rights, research and labour organisations from around the world. Started in 1997, GRI became independent in 2002, and is an official collaborating centre of the United Nations Environment Programme (UNEP) and works in cooperation with UN Secretary-General Kofi Annans Global Compact" [IISD 2007].

"The GRI provides a general set of Sustainability Reporting Guidelines, in addition to sector specific reporting guidance for" some sectors [IISD 2007]. Quantification of the 'triple bottom lines' is relatively new, problematic and often subjective. The rationale behind using a bottom line approach is to attempt to reduce variables to a common measurement of some kind. An analysis of sustainability can give decision-makers the big picture related to a decision they need to make, but much of the information will not be comparable and may become an undigested and garbled mess. Clearly a bottom line is not sufficient as a basis for decisions, as the variables used to estimate social, environmental and economical sustainability are all different, both within and outside their 'sphere' (even if they can be computed into a bottom line). Therefore, a bottom line approach is a powerful tool that should be used as a *part* of a broader analysis [Tietenberg 2006].

Many of the guidelines provided are actually descriptive, making them no different that what commonly goes into a corporate social responsibility report. "Indeed, many uses of 'Triple Bottom Line' are simply synonymous with 'corporate social responsibility"' [Norman and MacDonald 2004]. However, they serve as a handy checklist for what is meant, in more practical terms, with sustainability. An exhaustive list of indicators, comprising many more than I used in Chapter 3 can be found on the GRI website [GRI 2007].

Relevant indicators for a district heating CDM project, showing social, environmental and economical sustainability, include:

Table B.1: Sustainability indicators.

Sphere	**Indicator**
Social	Employment: total workforce employed in the project and for operation and maintenance;
Social	Training and education: average hours of training per year per employee by employee category;
Social	Improved health and quality of life;
Environmental	Materials used by weight of volume;
Environmental	Direct energy consumption by primary energy source;
Environmental	Indirect energy consumption by primary source;
Environmental	Total water withdrawal by source;
Environmental	Total direct and indirect greenhouse gas emissions by weight;
Environmental	NOx, SOx, and other significant air emissions by type and weight;
Environmental	Total water discharge by quality and destination;
Environmental	Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation (This is relevant if district heating is attempted as part of a larger programme for environmentally friendly products and services);
Economic	Economic value generated and distributed, including revenues, operating costs, employee compensation, donations and other community investments, retained earnings, and payments to capital providers and governments;
Economic	Financial implications and other risks and opportunities for the organization's activities due to climate change;
Economic	Significant financial assistance received from government;
Economic	Policy, practices, and proportion of spending on locally-based suppliers at significant locations of operation;
Economic	Procedures for local hiring and proportion of senior management hired from the local community at significant locations of operation;
Economic	Development and impact of infrastructure investments and services provided primarily for public benefit through commercial, in-kind, or pro-bono engagement;
Economic	Technology transfer.

Appendix C

Interviewees

- Jens Brandt Sørensen, Energy consultant, Grontmij Carl Bro, November 2006
- Jørgen Fenhann, Kyoto Protocol expert and author of CDM pipeline, Unep Risø, January 2007
- Anita Jürgen, Mixed Credit Office, Danish Ministry of Foreign Affairs, January 2007
- Kirstine Lorenzen, Consultant: PDD and methodology developer for first proposals, COWI, February 2007 (by phone)
- Lambert Schneider, Consultant: PDD and methodology developer for Proposal 3 and previously expert evaluator for Proposal 2, currently member of the Meth Panel, Öko-institut, February 2007 (by phone)