Carbon Credits: Origins, Effectiveness & Future

Takeuchi Waldegren, Linn

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Origins, Effectiveness & Future

Linn Takeuchi Waldegren
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LUND UNIVERSITY
Institute of Technology
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To Marley

Preface

The research presented in this doctoral dissertation was carried out at the Department of Environmental and Energy System Studies (EESS), Faculty of Engineering, Lund University, primarily between 2003 and 2011. The work was mainly conducted within the research projects *'The role of measures and policy mechanisms within the framework of flexible mechanisms'* and *'ClimateColl: Effective climate collaboration for clean development'*. Both were funded by the Swedish Energy Agency. While the former predominantly involved researchers at EESS, the latter was a collaborative project between EESS and the Department of Political Science at Lund University. In 2006 and 2007 time was also spent writing validation and verification manuals for the Gold Standard: *'Gold Standard Validation and Verification Manual CDM Projects'* (2006, 2007) and *'Gold Standard Validation and Verification Manual for Voluntary Offsets Projects'* (2007).

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Abstract

Carbon credits are used as an instrument for climate change mitigation. Each credit represents a reduction in greenhouse gas emissions (GHGs) equivalent of 1 ton of carbon dioxide. Crediting mechanisms and the Clean Development Mechanism (CDM) of the Kyoto Protocol in particular have been important for the international efforts to limit GHG emissions and the engagement of developing countries in mitigation activities. The CDM (or similar mechanisms) is also expected to be valuable in the continued international efforts necessary to limit global warming. However, the environmental credibility of the credits has been questioned. A key concern is that the credits do not represent 'real' or additional emission reductions. This doctoral dissertation critically examines the effectiveness and environmental credibility of credits through studies of additionality and the CDM, which has largely dominated the carbon credit market. In-depth case studies of methodologies applicable and applied to large-scale electricity generation CDM projects are included. The primary research questions are 'What is an effective carbon credit?' and 'Do Certified Emission Reductions (CERs) earned through the CDM represent additional emissions reductions?' Conceptually, additionality and effectiveness are closely related. Additionality is essentially a measure of effects and effectiveness relates to the achievement of some end (*e.g.* emissions reductions). The effectiveness of CERs can be interpreted in various ways and tends to be a politicized issue. Environmental additionality is certainly not the only concern affecting the effectiveness of credits, but it is an important one. To answer the research questions, this dissertation seeks to broaden the understanding of additionality compared with how it is currently approached under the CDM and examines its relationship to effectiveness. Furthermore, the following are examined: (a) the generally accepted idea or theory of emissions reductions in carbon crediting (b) how this or some other theory (or theories) is followed through in practices, and (c) the appropriateness or credibility of this approach in relation to the expected emissions reductions. This is also compared with historical experiences with credit-based systems preceding carbon crediting and what can currently be envisioned as the path ahead for carbon crediting. The research findings show that the environmental integrity of the CDM can be improved. Furthermore, the findings suggest that the sector-specific standardized baselines officially agreed at the climate negotiations in 2010 can significantly improve the environmental integrity of CDM. However, both in the current context and in the continued development of the CDM (or similar mechanisms), findings show that it is important to give more attention to the plausibility of the theory of emissions reductions underlying the creation of credits.

Populärvetenskaplig sammanfattning

En kolkredit motsvarar i teorin en minskning av växthusgaser motsvarande ett ton koldioxid. Dessa krediters miljömässiga trovärdighet har varit en het diskussionsfråga i akademiska och politiska sammanhang i många år men blev mer allmänt uppmärksammat i tv och nyheter efter att FNs Kyotoprotokoll trädde i kraft 2005. Kyotoprotokollet är ett internationellt klimatavtal där i-länder åtagit sig bindande utsläppsmål avseende växthusgaser. Dessa bidrar till klimatförändring som kan få mycket negativa konsekvenser för många människor genom exempelvis långvarig torka i redan torra regioner men även ökad nederbörd och översvämning på andra håll, samt havsnivåhöjning till följd av isavsmältning. Den typ av kredit som dominerat kreditmarknaden kan erhållas mot utsläppsminskande åtgärder i u-länder via FN sanktionerade projekt. Dessa projekt kallas för Clean Development Mechanism (CDM) projekt. CDM är en mekanism som introducerades genom Kyotoprotokollet och som gett projekt i u-länder möjlighet att tjäna krediter sedan 2000.

CDM är ett viktigt instrument i det internationella arbetet att minska människans påverkan på klimatet. Majoriteten av CDM-projekten återfinns i länder som Kina och Indien vilka har betydande utsläpp men som inte har några utsläppsåtaganden under Kyotoprotokollet. Förutom att krediter ger i-länder som Sverige möjlighet att nå utsläppsmål kostnadseffektivt bidrar CDM-projekt till klimatarbete i u-länder. CDM-krediter brukar anses främja kostnadseffektivitet då det kan vara billigare att utföra utsläppsminskande åtgärder i u-länder. Genom att krediter kan säljas till aktörer med utsläppsmål kan kostnaderna minskas samtidigt som målen nås. Detta förutsätter dock att krediterna är miljömässigt trovärdiga. Krediter har varit viktiga för Kyotoprotokollet som löper ut 2012, men förväntas även vara viktiga i det fortsatta internationella klimatarbetet där det är angeläget att engagera u-länder. Dessa förväntas stå för en betydande del av de framtida utsläppen och för att kunna nå det politiska målet att begränsa den globala uppvärmningen med mindre än 2 °C räcker det inte att minska utsläpp bara i-länder.

I denna avhandling står krediters miljömässiga trovärdighet i fokus. Vad är egentligen en utsläppsminskning? Särskilt svår blir frågan i samband med nybyggnation av exempelvis elproducerande verk. Förutsatt att inget befintligt verk ersätts eller att en förnybar energikälla utnyttjas så innebär ökad elproduktion att det blir mer utsläpp jämfört med vad som fanns. Genom CDM projekt kan dock denna typ av projekt tjäna krediter som sedan kan säljas vidare till bl.a. länder och företag med utsläppsmål under Kyotoprotokollet och EU. Om inte krediterna motsvarar den

förväntade utsläppsminskningen urholkas miljömål. Krediters bidrag till reellt klimatarbete i u-länder kan då också ifrågasättas.

För att en utsläppsminskning ska anses vara verklig måste den vara ”additionell” jämfört med vad som annars skulle ha skett. Detta är ett viktigt krav och det finns metoder för att säkerställa additionalitet och beräkna hur mycket ett projekt verkligen bidrar till minskade utsläpp. Dessa metoder granskas ingående i denna avhandling genom fallstudier av både CDM metoder och CDM projekt som godkänts av FN. Särskilt elproduktion studeras. En betydande andel av CDM projekten är just elproducerande projekt. Elsektorn är viktig då den står för en betydande del av växthusgasutsläppen och beräknas också vara en viktig framtida källa till fortsatt ökade utsläpp.

Viktiga frågor i denna avhandling är ”Vad är en effektiv kredit?” och ”Vad är additionalitet och hur är detta kopplat till effektivitet?” Krediter har beskrivits som en succé men även som ett misslyckande. Detta antyder att de är både effektiva och ineffektiva. Additionalitet kan i sin tur beskrivas som ett mått på effekter. Det finns alltså en tydlig koppling till effektivitetsbegreppet. Dock verkar detta ha fått relativt lite uppmärksamhet. En viktig målsättning med avhandlingen är att bidra till en bredare förståelse av additionalitet. Inom CDM har additionalitet diskuterats och tolkats ganska snävt som ”investeringsadditionalitet”, där projekts additionalitet varit en central fråga. Forskningen kan ses som viktig då additionalitet varit en stötesten för kolkrediter. Vidare är det en viktig framtidsfråga. Idag utvärderas additionalitet på projektbasis men för att kunna skala upp kreditmekanismer vilket anses nödvändigt för det fortsatta klimatarbetet behöver man ett annat angreppssätt.

Forskningsresultaten visar att det finns svagheter i de nuvarande metoderna avseende att säkerställa additionella utsläppsminskningar. Det handlar ytterst om att det finns behov att stärka den miljömässiga additionaliteten och om att metoderna kan förbättras för att säkerställa att det som ämnas mätas också verkligen mäts. Dock kan de flesta av problemen åtgärdas ganska enkelt. I fallstudierna studeras flera metoder som är applicerbara på flera projekt, s.k. standardiserade metoder. Detta innebär att resultaten är relevanta för arbetet som nu pågår att försöka skala upp CDM genom standardisering och sektorsansats. Sektorsansats antyder att utsläppsminskande åtgärder ämnas säkerställas på sektorsnivå snarare än projektnivå.

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Abbreviations & Glossary

AAU	Assigned amount unit	Permits assigned under the KP
ACM	Approved consolidated methodology	CDM methodology
Additionality		Measure of effects
AIJ	Activities implemented jointly	Precursor to CDM and JI
Allowance	(*c.f.* permit)	
AM	Approved methodology	CDM methodology
AT	Additionality tool	"Tool for the demonstration and assessment of additionality" (methodological tool under the CDM)
Baseline scenario	(BAU scenario)	Reflects 'what would have happened otherwise' *i.e.* BAU (in the absence of a CDM project)
BAU	Business-as-usual	
BE	Baseline emissions	Emissions of the sources included in the baseline scenario
BM	Build margin	Reflects capacity additions (e.g. plants to be built/recently built)
Cap-and-trade	(*c.f.* permit-based system)	
CCX	Chicago Climate Exchange	
CDM	Clean development mechanism	Mechanism under the KP
CER	Certified emissions reduction	Credit earned through the CDM
CH_4	Methane	GHG covered by the KP
CM	Combined margin	Weighted average of BM and OM
CMP	Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol	
COP	Conference of the Parties to the UNFCCC	
CO_2	Carbon dioxide	GHG covered by the KP
Credit	(emissions reduction credit (ERC) offset, tradable credit)	Credits are earned for emission reductions relative *e.g.* an emissions baseline or rate-based standards
Credit-based system	(credit-based trading)	Emissions trading system based on credits
DNA	Designated national authority	
DOE	Designated operational entity	
EB	(CDM) Executive Board	Supervisory body of the CDM
EF	Emissions factor	Measure of emission intensity (emissions per output, *e.g.* tCO_2/MWh)
Effectiveness		Degree of achievement of some end (*e.g.* achieved effects in relation to expected effects)
Emissions right		Credit/permit
ER	Emissions reduction	Difference between baseline emissions and project emissions (*ER=BE-PE*)
ERU	Emissions reduction unit	Credit earned through the JI

ET	Emissions trading	Mechanism under the KP
ETS	Emissions trading system	Refers to credit and/or permit-based system
EU	European Union	
GHG	Greenhouse gas	
GS	Gold Standard	
HFC	Hydrofluorocarbons	GHG covered by the KP
IRR	Internal rate of return	
JI	Joint implementation	Mechanism under the KP
KP	Kyoto Protocol	International agreement to limit emissions of GHGs 2008-2012
L	Leakage	
LCA	Life cycle assessment	Environmental systems analysis tool
MPB	Multi-project baseline	MPBs are applicable to multiple projects
MWh	Megawatt hour	
N_2O	Nitrous oxide	GHG covered by the KP
OM	Operating margin	Reflects what is operating on the margin of the electricity grid
PDD	Project design document	
PE	Project emissions	
Permit-based system	(permit-based trading)	Emissions trading system based on permits where aggregated emissions are capped
Permits	(tradable permits)	Permits are allocated
PFCs	Perfluorocarbons	GHG covered by the KP
Project-based mechanism	CDM/JI	
SF_6	Sulfur hexafluoride	GHG covered by the KP
SHR	Station heat rate	
Source (of emissions)	Facility, plant, and/or unit	
tCO_2e	Metric ton(s) of carbon dioxide equivalents	
UNFCCC	United Nations Framework Convention on Climate Change	
VER	Voluntary emissions reduction	

Contents

1

INTRODUCTION

This doctoral dissertation critically examines the environmental credibility and effectiveness of carbon credits. This is primarily pursued through in-depth studies of the environmental credibility of methodologies for creating credits under the Clean Development Mechanism (CDM) of the Kyoto Protocol (KP). The CDM was the first international carbon crediting mechanism to be implemented and has thus far dominated the carbon credit market. It has been hailed as a success beyond expectations, but also criticized as fundamentally flawed. As with carbon credits in general, a key concern is environmental credibility. Are the greenhouse gas (GHG) emissions reductions they supposedly represent real? Credits are earned for emission reducing activities. Whether the effectiveness of credits is approached narrowly as cost-effective target achievement under the KP or more broadly as environmental effectiveness and GHG mitigation in the long term, the environmental credibility of credits is a relevant topic. The CDM has supplied significant amounts of credits which can be used by countries to reach their emissions targets under the KP cost-effectively. However, this requires that the credits are environmentally credible. The CDM has also engaged developing countries with significant GHG emissions in emission-reducing activities. This is of potential long-term value because most of the future emissions of GHGs are expected to be caused by developing countries, but these countries have no emissions targets under the KP. China is already the greatest GHG emitter in the world, but it is also the largest host country of CDM projects. Environmental credibility can be seen as creating meaning and value for developing country participation. A problem is that *environmental credibility* is an elusive concept in carbon crediting. In this dissertation, *environmentally credible credits* are understood as reflecting *additional emissions reductions*. It is commonly acknowledged that 'real' emissions reductions are additional to 'what would have happened otherwise' or business-as-usual (BAU). Additionality has been a highly contentious issue since the inception of the CDM, and it remains one of the major challenges for the future of

crediting mechanisms. An ambition of this dissertation is to facilitate knowledge development by bringing together relevant theory and practice. This is primarily pursued through an integration of literature on additionality and effectiveness, and in-depth empirical studies of CDM methodologies which are applied to determine that emissions reductions are environmentally additional. The findings in this dissertation indicate that there can be more than one plausible *theory of emissions reductions* in the context of crediting. These 'theories' represent ideas or conceptualizations of how emissions can be reduced. These can also be understood as plausible 'theories of change', where the 'change' addressed in this dissertation is emissions reductions. The theory-of-change approach to evaluation has been referred to using many different terms, but a key element is to establish a cause-and-effect sequence. Findings from the empirical examination of methodologies applied by CDM projects for earning credits indicate that there is room for improvement. More specifically, the research found that the links between the crediting project and the claimed emissions reductions are rather weak. Furthermore, the definition of emissions reductions applied tends to rely on unsubstantiated assumptions. In other words, the theories of emissions reductions underlying the creation of CERs could benefit from further development.

1.1 Carbon Credits & Environmental Credibility

Carbon credits (or *offsets*) can be earned by projects which reduce GHG emissions. One carbon credit represents a reduction in GHG emissions equivalent to one ton of carbon dioxide (tCO_2e), and credits can be used by countries or companies to offset their emissions for the purpose of reaching binding emissions targets. They can also be purchased by companies or individuals who wish to offset their GHG emissions voluntarily. Carbon crediting activities can currently be pursued in three broad forms: Clean Development Mechanism (CDM), Joint Implementation (JI), and Voluntary Emissions Reduction (VER) activities. The CDM and JI are international crediting mechanisms under the KP, which is an international agreement under the United Nations Framework Convention on Climate Change (UNFCCC) to limit GHG emissions. The KP sets binding GHG emissions targets for industrialized countries (known as 'Annex B countries'), amounting to an average of 5% compared with 1990 levels over the commitment period 2008-2012 (UNFCCC, 2011a). The idea with the international crediting mechanisms is that countries with relatively high costs for emissions reductions have the option of buying credits that are less costly than domestic reductions. This promotes the achievement of emissions targets at least cost (*i.e. cost effectiveness*), assuming that credits are environmentally credible. In contrast to the international crediting mechanisms, VER is a private sector initiative beyond

the sphere of environmental policy. As the name suggests, VER credits are purchased not to attain binding targets, but on a voluntary basis.

The carbon credit market is dominated by the CDM, which is an important component of international climate policy. The CDM accounted for 96% of the carbon credit market (in value) in 2004-2010 (Linacre *et al.*, 2011). CDM projects take place in developing countries and can earn *Certified Emissions Reductions (CERs)*. The estimated supply of CERs 2008-2012 totals 1,366 $MtCO_2e$ (Linacre *et al.*, 2011). This represents almost 53% of the estimated GHG emissions reductions required under the KP relative to the base year.[1] Total emissions reductions under the KP amount to 2,591 $MtCO_2e$, relative to the base year (UNFCCC, 2010a). Furthermore, total estimated demand for *emissions rights* under the KP is estimated to be 1,392 $MtCO_2e$ (2008-2012) (Linacre *et al.*, 2011).[2] CERs could potentially supply most of this demand. Developing countries, where CERs are created, have no emissions targets. This implies that without environmental credibility, CERs could put a serious dent in the envisioned target of the KP. Furthermore, between 2004 and 2010, transactions of primary CERs amounted to $US 26.5 billion and secondary trade was valued to $US 68.2 billion (Linacre *et al.*, 2011).[3] Through the CDM, significant amounts of financial resources are being shifted from domestic efforts to reduce GHG emissions in Annex B countries. Environmental credibility of carbon credits is ultimately not only an environmental issue but also an economic one. Without environmental credibility, the idea of cost effectiveness does not hold. This would render the CDM a money-moving exercise rather than a credible mechanism for climate change mitigation.

Environmental credibility is a general concern. The issue is whether carbon credits can be reasonably assumed to represent what is claimed. One credit supposedly represents a reduction in the amount of 1 tCO_2e. Whether credits are used to reach explicit GHG emissions targets, for example under the KP, or used to offset GHG emissions on a voluntary basis, environmental credibility is valuable. Without it, emissions targets risk being undermined, limited resources may be wasted and buyer confidence in the value of offsetting could be lost (*e.g.* UK Parliament, 2007; Wara, 2008; Schneider, 2009; Hamilton *et al.*, 2010b). Environmental credibility can also be seen as relevant for building confidence in market-based mechanisms and promoting knowledge development necessary for effectively reducing emissions. It also creates meaning and value in the participation of developing countries in carbon

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[1] The base year is generally 1990, but there are exceptions and it depends on the country and gas in question.

[2] *Emissions rights* include *permits* and *credits*. The former are allocated and the latter are earned (*e.g.* through the CDM) (see Ch. 2).

[3] *Primary* CERs are purchased directly from original owner (or issuer). *Secondary* CERs are purchased from sellers that are not the original owner (or issuer) (Linacre *et al.*, 2011).

crediting activities. This suggests that environmental credibility is related to the concept of *effectiveness* more broadly.

1.1.1 Clean Development Mechanism

With the 1997 KP, carbon crediting mechanisms and the CDM in particular emerged as potentially important instruments in the international efforts to mitigate climate change. To address climate change and facilitate sustainable development, decarbonizing the global economy is desirable and necessary. Emissions trends between 1970 and 2004 underline the difficulty ahead (IPCC, 2007). During this period, emissions of the six GHGs covered by the KP increased by 70%. Carbon dioxide (CO_2) was the largest source, growing by approximately 80%. By 2004, CO_2 represented 77% of total anthropogenic GHG emissions. Mitigation efforts can aid sustainable development by reducing the risk of adverse impacts of climate change and providing co-benefits, such as improved health outcomes (IPCC, 2007:98). However, the CDM has been heavily criticized and a central issue is its ability to redirect investments toward projects that entail 'additional' or 'real' emissions reductions (*e.g.* Pearson and Loong, 2003; Castro and Michaelowa, 2008; Wara, 2008; Paulsson, 2009; Schneider, 2009). Additionality is described as the primary shield against 'fake' emissions reductions which would undermine the emissions target of the KP. It is specifically evaluated under the CDM, but the additionality assessment has been found to be in need of substantial improvement (Michaelowa and Purohit, 2007; Castro and Michaelowa, 2008; Schneider, 2009). Furthermore, the project-by-project approach to evaluation has been identified as a constraint, limiting the scale of the CDM (OECD/IEA, 2009; Grubb *et al.*, 2011).

While criticized, the CDM has also been acknowledged as successful in engaging developing countries and mobilizing private finance. Much of future increases in GHG emissions is expected to come from developing countries (OECD/IEA, 2009). The CDM is seen as important for globalizing the climate change issue, creating acceptance for market-based mechanisms despite initial strong resistance and mobilizing finance for mitigation technology investments in developing countries (Grubb *et al.*, 2011). It has been proclaimed "a success beyond the wildest dreams of its early architects" (Grubb *et al.*, 2011:556). However, environmental credibility is relevant for building confidence in market-based mechanisms as effective environmental policy instruments. It is also relevant in the development and dissemination of knowledge about how emissions can be effectively reduced through crediting mechanisms. The CDM can be viewed as a first tentative step towards meaningful global participation in combating climate change. It has encouraged the participation of the greatest GHG emitters among developing counties (*e.g.* China

and India). However, to create meaning and value in this participation, environmental credibility is valuable. Effectiveness relies on both the quality and quantity of the credits - if one is dehydrated, a small glass of water, however full, is of little comfort, as are a thousand if empty. Carbon credits that are not environmentally credible, *i.e.* environmentally additional, are essentially 'empty'.

1.1.2 Recent Developments & Looking Ahead

The warming of the climate system is now unequivocal, with many natural systems being affected. Furthermore, "[m]ost of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations" (IPCC, 2008:5). The stabilization of GHG concentrations in the atmosphere to prevent dangerous anthropogenic interference with the climate system is an explicit and central aim of international climate change policy since the early 1990s (UN, 1992). There is now a broad political and scientific consensus regarding the necessity of reducing GHG emissions, but there is less agreement on how this is to be achieved. Reducing emissions enough to limit the global mean temperature rise at below 2 °C, as was agreed at the Copenhagen climate negotiations in 2009, is a challenge and will require global efforts (OECD/IEA, 2009; UNFCCC, 2009). In a resource-restrained reality with large disparities, the questions of who is to pay and how much are politically sensitive issues subject to ongoing negotiations. Climate policy can affect *e.g.* food and fuel security, private investment flows, trade and economic development. This complicates the multilateral climate negotiations. Nevertheless, developed countries have an acknowledged responsibility as the largest historical emitters of GHGs and crediting mechanisms are valuable for co-financing abatement in developing countries (UN, 1992; OECD/IEA, 2009).

A problem for the international policy community is how to move forward in addressing climate change post-2012. Despite years of intense UN negotiations and the post-Kyoto (*i.e.* post-2012) commitment period knocking at the door, the prospect for a globally binding agreement on curbing climate change seems bleak. At the moment, a global cap (or emissions target) on GHGs seems highly unlikely. At the same time, there is a growing number of international, national, and regional cap-and-trade systems (also referred to as emissions trading systems, ETSs). In these systems, aggregated emissions are limited by a 'cap' and tradable permits allocated (see Ch. 2). In this dissertation cap-and-trade systems are also referred to as permit-based. In addition, the private sector has increasingly engaged in VER activities and voluntary offsetting (Linacre *et al.*, 2011). In the light of the market fragmentation and a possible future where the global carbon market is increasingly fragmented, there is an academic and political interest in linking different ETSs. An expectation seems to be

that the carbon market will develop through a bottom-up approach, where domestic cap-and-trade systems will be linked over time; and carbon crediting is seen as an important steppingstone towards introducing cap-and-trade in developing countries (EC, 2010). Furthermore, crediting mechanisms are valuable for significantly reducing mitigation costs in regions with emissions caps (OECD/IEA, 2009).

Amidst optimistic developments and expectations concerning the role of carbon credits, the credit market has been on the decline after several years of growth. Trade in carbon credits peaked in 2008 at $US 33.6 billion. By 2009 it was down to 20.9 and by 2010 to 21 (Linacre *et al.*, 2011). This fall was primarily due to the CDM market shrinking. This is largely attributed to the financial crisis and the increasing uncertainty over the future of the CDM caused by the lack of a post-2012 agreement (Capoor and Ambrosi, 2009; Kossoy and Ambrosi, 2010; Linacre *et al.*, 2011). Although the credit market transactions were roughly on a par in 2009 and 2010, primary CER transactions have steadily declined since 2007. Between 2007 and 2010, these transactions fell from $US 7.4 billion to 1.5 billion. The 2010 transactions were at a record low for the period 2005-2010 (Linacre *et al.*, 2011). The EU ETS has been an important source of demand for CERs. However, in the absence of an international agreement on climate change, CERs from projects registered post-2012 will be eligible for the EU ETS only if generated in the least developed countries (LDCs) (EC, 2009). This suggests that the current largest CDM countries, *e.g.* China, India and Brazil, may be excluded. It is possible that other emerging ETS will fill some of the demand gap, but this remains to be seen.

Despite the recent turmoil and considerable uncertainty in the CDM market, the expectation seems to be that the CDM (or similar crediting mechanisms) will be an important part of future efforts to reduce GHGs and mitigate climate change (*e.g.* OECD/IEA, 2009; EC, 2010; UNFCCC, 2010c and d). However, environmental credibility is a commonly acknowledged concern and it is a key issue in the critique of the CDM (Wara, 2008; Paulsson, 2009; Schneider, 2009; Grubb *et al.*, 2011). Additionality has been a key challenge for crediting mechanisms since their inception and it remains so today, more than a decade later. Additionality is one of the major challenges if crediting mechanisms are to fulfill their potentials in the future (Grubb *et al.*, 2011).

1.1.3 Towards a Broader Concept of Additionality

Stripped to the bones, *additionality* can be described as a measure of effects (*e.g.* emissions reductions), as opposed to 'what would have taken place otherwise' (without intervention such as the CDM). Various concepts of *additionality* have been addressed in both the climate policy literature and the innovation policy literature (hereafter

jointly referred to as the *additionality literature*, in brief). Yet, these sets of literature appear to be largely separated (see *e.g.* Buisseret *et al.*, 1995; Sugiyama and Michaelowa, 2001; Georghiou, 2002; Bode and Michaelowa, 2003; Greiner and Michaelowa, 2003; Falk, 2004; Dutschke and Michaelowa, 2006; Schneider, 2009). Furthermore, although there is an implied relationship to *effectiveness*, which relates to the degree of achieving some end, the additionality literature does not appear to have been linked to the policy-related literature on effectiveness (*e.g.* Victor *et al.*, 1998; Young and Levy, 1999; Vedung, 2009). Both *additionality* and *effectiveness* are relative concepts, related to effects (*i.e.* outputs, outcomes, or impacts), but little attention appears to have been paid to possible conceptual links between the concepts of *additionality* and *effectiveness*. These links are explored in this dissertation and this is accompanied by a critical examination of the environmental credibility of CERs. An intention of this dissertation is to extend the existing understanding of additionality in the context of carbon crediting.

1.2 Aim & Research Questions

The aim is to critically examine the effectiveness and environmental credibility of carbon credits. This is pursued through studies of additionality and the CDM. Carbon crediting methodologies for determining that emissions are truly reduced (*i.e.* that emissions reductions are additional) developed largely under the CDM. As the first commitment period is drawing to a close, it is time to reflect upon these methodologies. 'What is an effective carbon credit?' and 'Do CERs represent additional emissions reductions?' can be described as the primary research questions, which encompass several sub-questions. These can be grouped under three themes as follows:

- Effectiveness
  - What is effectiveness and how is it approached in the critique of carbon credits?
- Additionality
  - What is additionality and how does it relate to the concept of *effectiveness*?
- Environmental Additionality
  - Are CDM methodologies valid and reliable?
  - Is there a plausible theory (or theories) of emissions reductions underlying the creation of CERs?

1.3 Themes & Key Concepts

1.3.1 Effectiveness

Effectiveness is a central concept in this dissertation, but what does it mean in the context of carbon credits? This is explored in Ch. 3. Various concepts of effectiveness underlie the broader critique of carbon credits, but these are rarely made explicit. In the climate policy literature, the critique primarily deals with the CDM. It is a special case of carbon credits in that it includes the explicit objectives of promoting sustainable development in developing countries and helping Annex B countries reach their emissions targets (UN, 1998: Art. 12 §2). The CDM is a complex mechanism and this is reflected in the critique which displays widely differing views on its effectiveness (and thus how to fix it). The broader climate change debate (at the climate negotiations, carbon conferences, as well the public media) is in turn highly politicized, reflecting the interest of countries and various stakeholder groups, including *e.g.* environmental NGOs and organizations representing businesses, women's rights, indigenous people, and climate skeptics.[4] There is not one concept of *effectiveness* or one view, but many.

The critique can be linked to the concepts of *effectiveness* found in the policy-related literature (*e.g.* cost effectiveness, goal achievement, and political effectiveness) (Victor *et al.*, 1998; Young and Levy, 1999; Vedung, 2009). Nevertheless, it is helpful to expand the concept. Two useful concepts for this dissertation are *output* and *outcome effectiveness*. The former is a useful concept for the critical examination of the critique included in Ch. 3. This is because a large share of the reviewed literature tends to address either the quality or quantity of the *outputs*, namely crediting projects and/or credits. In this dissertation, *output effectiveness* is understood as the outputs of a program (*e.g.* CDM) relative to expected outputs. Similarly, *outcome effectiveness* is also defined in this dissertation as a relative concept, but which depends on the expected *outcomes.* The outcome of interest in this dissertation is emissions reductions.

In this dissertation, the concept of *effectiveness* is primarily approached from a policy perspective. This is because the CDM is an international policy instrument (case selection is further explained in section 1.4.3). While acknowledging that both the quality and quantity of the outputs (as well as *indirect effects*, such as *carbon leakage*) are important in relation to outcome effectiveness (further explained in Ch. 3), the research performed for this dissertation examined the quality of the outputs, namely the environmental credibility (or integrity) of the CERs (see next section). The focus is on how to promote outputs (projects) that will in turn promote expected

[4] As part of the research, various carbon conferences were attended over the years including, *e.g.*: Carbon Expo (2005-2010), Carbon Market Insights (2005-2010) and climate negotiations in Nairobi (2006) and Bali (2007).

outcomes (emissions reductions) at sector level (electricity generation), rather than expected project level outputs.

While quality in terms of environmental credibility is a broadly acknowledged concern, the quantity of CDM projects and CERs has surpassed expectations (Grubb *et al.*, 2011). Nevertheless, there is an acknowledged need to scale up the CDM as part of the continued efforts to mitigate climate change, where scaled-up CDM(s) can replace or complement the current project-by-project approach (see *e.g.* OECD/IEA, 2009; Grubb *et al.*, 2011). The CDM is estimated to avoid almost 1.4 $GtCO_2e$ during 2005-2012 (Linacre *et al.*, 2011). However, it is predicted that energy-related CO_2 emissions in developing countries alone will need to be cut by 8.8 Gt by 2030 relative to projected emissions, if global GHG concentrations are to be limited to 450 parts per million (ppm) of CO_2e (OECD/IEA, 2009).[5] This concentration offers a 50% chance of limiting temperature rise to approximately 2 °C. Some initiatives to scale up the CDM have been taken. However, if crediting mechanisms are to play a greater role in expanding global mitigation efforts, additionality is one of the main issues which must be addressed. What is needed is "a broader understanding of the challenge of additionality which moves the emphasis from project-by-project additionality to a broader focus on whether the mechanisms are channeling investment flows towards lower carbon choices on a large scale" (Grubb *et al.*, 2011:563).

1.3.2 Additionality

Environmental credibility in the context of carbon credits is concerned with the question of whether or not emissions reductions are 'real'; but what does this mean? It is commonly acknowledged that a 'real' emissions reduction is additional to 'what would have happened otherwise' (without the crediting activity). To promote environmentally credible credits (based on additional emissions reductions), the theoretical creation of CERs relies upon the concepts of *additionality* and *emissions reductions*, both of which are relative concepts related to the *baseline scenario*.

The 'Theory of Emissions Reductions' under the CDM

Emissions are reduced if a project is additional and if the emissions of the baseline scenario (*i.e. baseline emissions*) exceed those of the CDM project activity (*i.e. project emissions*). An *additional project* would not take place without the CDM, *i.e.* it is not the *baseline scenario* ('what would have happened otherwise').

[5] More specifically, 'non-OECD+' countries, *i.e.* non-OECD and non-EU countries (OECD/IEA, 2009:201). 8.8 $GtCO_2e$ = 13.8 (needed reduction) - 5.0 (reduction by OECD+ countries) (OECD/IEA, 2009:207, 222).

Under the CDM, additionality is primarily assessed through some type of barrier analysis and/or an economic analysis. What is evaluated is the viability of the project in the absence of the CDM. This concept of *additionality* is therefore referred to as *investment additionality* in this dissertation.[6] *Emissions reductions* are calculated as the difference between the baseline emissions and project emissions. Both investment additionality and emissions reductions are evaluated *ex ante*, *i.e.* prior to *registration*, (*i.e.* approval) as a CDM project, by applying methodologies approved by the *CDM Executive Board (EB)*. The EB is an intergovernmental body which supervises and carries out the day-to-day operation of the CDM. Only registered CDM projects can earn CERs. While the idea of a carbon credit is relatively straightforward, it is in practice difficult to determine both investment additionality and emissions reductions. Hence, ensuring additional emissions reductions is a challenge.

'Additionality' has been widely debated at the climate negotiations and in the climate policy literature for many years (*e.g.* Grubb *et al.*, 1999; Shrestha and Timilisina, 2002; Bode and Michaelowa, 2003; Greiner and Michaelowa, 2003; Pearson and Loong, 2003; Asuka and Takeuchi, 2004; Paulsson, 2009; Schneider, 2009; Grubb *et al.*, 2011). However, the discussions have tended focus on the interpretations and the intentions of the KP and the Marrakesh Accords (which were rather unclear), and on the fine-tuning of the CDM's (investment) additionality assessment.[7] In this highly specialized and technical debate, studies referring to the application of additionality criteria outside the CDM are few (for an exception see Sugiyama and Michaelowa, 2001).

To broaden the conceptual understanding of additionality, *investment additionality* is compared with other concepts of *additionality* found in the innovation policy literature (see *e.g.* Buisseret *et al.*, 1995; Georghiou, 2002; Falk, 2007). This comparison shows that 'additionality' as applied under the CDM is relatively narrow and limited. Furthermore, possible links between the various concepts of *additionality* and *effectiveness* are explored. There is an implicit link between additionality (which is essentially a measure of effects) and effectiveness, but this appears to be largely unexplored (or is at least not made explicit) in the climate policy and innovation policy literature on additionality or the policy-related literature on effectiveness. This conceptual discussion on additionality will help clarify that the concept of *investment additionality* as applied under the CDM is concerned with projects, *i.e.* effects at the output level. In contrast, *environmental additionality* as applied in this dissertation is concerned with emissions reductions, *i.e.* effects at the outcome level. Furthermore, it

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[6] Under the CDM, the term used is simply 'additionality'. In the CDM literature, the concept of *additionality* as applied under the CDM has been referred to as *e.g.* 'financial additionality', 'investment additionality', and 'project additionality' (see *e.g.* Sugiyama and Michaelowa, 2001; Greiner and Michaelowa, 2003; McNish *et al.*, 2009).

[7] The Marrakesh Accords contains detailed rules on the implementation of the KP (see Ch. 2).

will help clarify the importance of establishing a clear conceptual link between outputs and outcomes for the purpose of promoting additional emissions reductions. This link appears to have been largely overlooked in the CDM literature, as well as the CDM methodologies.

While the importance of investment additionality in carbon crediting is now broadly accepted in practice and in the climate policy literature, it does not appear to have been an issue in earlier crediting programs (*e.g.* the Emissions Trading Program and the Lead Phase-Out Program in the US) or in the theory of *tradable credits* (or *offsets*) (Solomon and Gorman, 2002; Tietenberg, 2006; Boom and Dijkstra, 2009). This difference is briefly noted by Tietenberg (2006), but it appears to be largely unexplored. *Investment additionality* emerged as a key concept with the inception of the CDM. This suggests that there are fundamental differences in how carbon credits are created and how environmental additionality is aimed to be achieved. A comparative discussion of carbon credits and earlier credits is included at the end of this dissertation (see Ch. 8), following the empirical examination of the CDM methodologies (Ch. 5-7).

1.3.3 Environmental Additionality

Although the idea of a carbon credit is broadly understood, there appears to be a lack of empirical studies which examine either the theory of emissions reductions underlying the creation of credits or the credibility of CDM methodologies. Carbon credits are theoretical constructs. Chadwick (2006) described them as 'administratively created goods'. Unlike a computer manufacturer, a CDM project may successfully remove GHGs from the atmosphere but the title to the corresponding CERs cannot be secured without engaging in further legal and administrative processes (*ibid.*). The emissions reductions that CERs claim to represent are not observed and directly measured. Both investment additionality and emissions reductions are evaluated against a counterfactual baseline scenario. Only the CDM project's emissions can be measured. This means that the environmental credibility of carbon credits largely relies on the *credibility of the methodology*. The latter depends on the plausibility of the theory of emissions reductions and the credibility of the methods (*e.g.* for assessing investment additionality, identifying the baseline scenario, and measuring, calculating and verifying emissions reductions).

Before CERs can be issued to a project, *approved CDM methodologies* are applied by project developers to show that emissions will be reduced by a proposed CDM

project in a *Project Design Document (PDD)*.[8] The PDD represents the official account of how emissions are envisioned to be reduced by the project, and it is the basis for the validation performed by a *Designated Operational Entity (DOE)*. These entities are private companies accredited by the CDM EB and are responsible for the on-the-ground supervision of the projects. Hence, in the creation of CERs, CDM methodologies and the supervisory system are key components for promoting environmental additionality. The credibility of the supervisory system has been examined by Lund (2010), but the credibility of the CDM methodologies remains to be analyzed.

CDM methodologies developed in practice through a bottom-up approach where methodologies were proposed by project developers (see Ch. 2). The relationship between the concepts of *investment additionality* and *emissions reduction* is generally accepted in the CDM literature on these topics, but few papers have approached them both. Methods for assessing investment additionality (or complementing it) and calculating emissions reductions in electricity generation projects have been addressed separately in the CDM literature (*e.g.* Kartha *et al.*, 2004; Kartha *et al.*, 2005; Schneider, 2009). Bode and Michaelowa (2003) is an exception, but their paper examined impacts on investor decisions. Examination of the theory of emissions reductions requires an integrated analysis including both the assessment of investment additionality and the calculation of emissions reductions. This suggests that the theory of emissions reductions underlying the creation of CERs has yet to be critically examined. Credible methods are invaluable, but so is a plausible theory. The latter explains how emissions can be reduced; and clarifies the value of specific methods and how these conjointly determine that emissions are reduced (or not).

This dissertation critically examines the plausibility of the *theory (or theories) of emissions reductions* underlying the creation of CERs and the *credibility* of the CDM methodologies (Ch. 5-7) (further explained below). This was pursued through a number of case studies of selected CDM methodologies. These were applicable or applied to large-scale electricity generation CDM projects. The case studies cover a total of 47 CDM methodologies (case selection is further described in section 1.4). These case studies primarily examined the CDM *ex ante evaluation* (pre-registration assessment) which includes two key evaluations for determining that emissions reductions are additional (see below). In this dissertation, the former is referred to as the '*ex ante* evaluation of investment additionality' and the latter as the '*ex ante* evaluation of emissions reductions'.

[8] For brevity, 'approved CDM methodologies' is used in this dissertation to refer to various methodologies and methodological tools approved under the CDM, see 'Empirical Material' under section 1.4.3. The methodologies examined are further described in Ch. 5-7.

- Assessment of investment additionality [a]
- Calculation of expected emissions reductions [b]

[a] *In the PDD, this is addressed in section 'B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality)'.*

[b] *In the PDD, this is addressed in section 'B.6.3. Ex-ante calculation of emission reductions'.*

Source: EB (2006)

The majority of the studies are framed as examining the *theory (or theories) of emissions reductions* embedded in the methodologies examined (Ch. 6-7). The terminology is borrowed from the theory-of-change approach to evaluation. In this dissertation, the 'change' of interest is the emissions reductions. The 'theory of emissions reductions' can be understood as 'how emissions are envisioned as reduced'. In the theory-of-change approach a central idea is that a *program theory* (see Fig. 3.1 in Ch. 3) should be plausible and stipulate the cause-and-effect sequence (Coryn *et al.*, 2011) (further explained in Ch. 6). Ch. 6 in particular leans towards being abstract, and a theory-of-change approach is useful to elucidate the significance of the relatively detailed and specific analyses in relation to the program (CDM) and the target (emissions reductions).

Credibility is approached through validity and reliability. What is examined in terms of *validity* is the logical correctness of the (explicit/implicit) argument (or claim) that emissions reductions are achieved through the CDM methodologies studied. Another way of describing the case studies is that they examine the believability or soundness of the claim that emissions are reduced. *Reliability* relates to the reproducibility of the results obtained through a methodology. For example, a methodology that allows a single project (or comparable projects) to achieve different results is not reliable. However, a reliable methodology is not necessarily a valid methodology. *Valid methodologies* are necessary for creating credits that are based on believable emissions reductions. *Reliable methodologies* are necessary for creating credits that are based on comparable emissions reductions. The *credibility* of credits depends on methodologies being both valid and reliable.

1.4 Methodological Considerations

1.4.1 Problem-Oriented Research

The research presented in this dissertation is problem-oriented. It was conducted at the Environmental and Energy Systems Studies (EESS), which is a division of the Department of Technology and Society at the Faculty of Engineering, Lund University. As a discipline, engineering traditionally focuses on solving problems. This is also a prominent feature of the research conducted at the EESS. Since its establishment in 1969, this research has studied the interactions between energy, environment, technology, economy, security, and development. The current research can broadly be described as involving systems studies, with a life cycle perspective, and policy studies. There is a long tradition of conducting interdisciplinary research and empirical studies. This has influenced the research presented in this dissertation.

The broader problem is global warming and the research on carbon credits addresses issues that are relevant for their ability to curb GHG emissions, *i.e.* their ability to contribute towards solving this problem. Research is often distinguished as either applied or basic (or theoretical). *Applied research* addresses practical problems using primarily existing concepts, theories and methods. *Basic* (or *theoretical*) research in social sciences strives to create "new knowledge about social phenomena, hoping to establish general principles and theories with which to explain them" (Miller and Salkind, 2002:3). It can be used to solve problems, but this is not the main aim of basic research. However, applied research can also lead to new knowledge. This suggests that the theoretical classification of research as either applied or basic is not so much of practical significance for conducting research. Furthermore, the difference appears to be grades-and-shades rather than black-and-white. Both applied and basic research can lead to new insights and solve problems. However, the distinctions can be seen as valuable tools for describing, discussing, and understanding research.

This dissertation addresses the topic of carbon credits. While the theory of emissions trading was introduced in the latter half of 1960s, this was largely ignored when emissions trading was introduced in the 1970s. It was introduced to solve a practical problem and it was firmly based in the tradition of command-and-control (based on air quality standards, see Ch. 2). However, over the years, theory and practice refined one another. Similarly, when carbon credits were introduced internationally for the first time through the CDM, existing knowledge in crediting also seems to have had marginal influence. The design and implementation of the CDM was largely influenced by the political reality and the multilateral context rather than the existing theory and the practical experiences. With the introduction of carbon crediting, new issues which had never been addressed in earlier crediting rose to the forefront. Three of the key issues were additionality, project-based baselines and

Annex I private company participation. While the latter was perhaps primarily considered an issue before *unilateral CDM projects* were allowed in early 2005, the former two remain important questions in the carbon crediting context in general.[9]

By addressing additionality and project-based baselines in carbon crediting, the research involved largely unexplored subjects. As a consequence, the problem-oriented research did lead to new insights. However, due to the ongoing research on carbon credits and continuous development of CDM methodologies and rules, some of these insights are now considered common knowledge. This is an inevitable hazard of conducting research on a moving target. For example, most now agree that there is a need to move away from or at least complement the project-based approach (*e.g.* OECD/IEA, 2009).

Nevertheless, this dissertation includes some insights that do not appear to have been addressed or adequately appreciated. For example, it is theoretically possible to determine environmental additionality without investment additionality. However, the current approach to the *ex ante* evaluation of crediting projects needs to be rethought, particularly when involving *multi-project baselines (MPBs)* (or *standardized baseline methodologies*). MPBs are applicable to multiple projects, and it is commonly agreed that MPBs are advantageous as they are less costly and require less effort (Kartha *et al.*, 2004; Murtishaw *et al.*, 2006; Steenhof, 2009). However, the present research shows that the appropriateness of MPBs for the CDM *ex ante* evaluation of investment additionality is uncertain. Furthermore, findings in this dissertation suggest that the environmental criterion embedded in the *ex ante* calculations and the treatment of system boundaries need more attention. As others have already pointed out, 'additionality' in the carbon crediting context needs to be rethought, and this is supported by the research findings (further discussed in Ch. 8).

The questions addressed in applied policy research can broadly be divided into four categories: *contextual*, *diagnostic*, *evaluative*, and *strategic*; and "most research attempts to address more than one of these groups of questions" (Huberman and Miles, 2002:307). In this respect, the research presented in this dissertation is no exception. According to Huberman and Miles, *contextual research* aims to identify the form and nature of what exists; *diagnostic research* examines the reason for, or causes of, what exists. Miller and Salkind (2002) describe *evaluation research* as a separate third category, but others perceive it as a form of applied research (Clarke and Dawson, 1999; Huberman and Miles, 2002). *Evaluation research* aims to "determine the value or impact of policy, program, practice, intervention or service, with a view to make recommendations for change" (Clarke and Dawson, 1999:vi). Finally, *strategic research* aims to identify new theories, policies, plans, or actions. Strategic questions ask *e.g.* What types of services are required to meet needs; what actions are needed to

[9] In *unilateral CDM projects* there are no Annex I participants involved prior to registration.

make programs or services more effective; how can systems be improved; and what strategies are required to overcome newly defined problems? (Huberman and Miles, 2002:307).

The present research can be described as predominantly evaluative and strategic. The broader research question of this dissertation 'What is an effective carbon credit?' is largely strategic; and 'Do CERs represent additional emissions reductions?' is largely evaluative. While the aim was not to evaluate the value or impact of carbon crediting, by critically examining an important aspect (environmental credibility) for the effectiveness of carbon crediting, it is in some aspects evaluative. In addition, the research on environmental credibility is mainly concerned with the CDM *ex ante* evaluation. While the broader question in this dissertation can be described as primarily evaluative and strategic, the more specific research questions reflect all four categories. For example, the 'form and nature' of carbon credits is discussed and contrasted to earlier credits; and the 'reasons for, or causes of', the key role of additionality in carbon crediting are briefly addressed.

1.4.2 Interdisciplinary Research

There is not one form of *interdisciplinarity*, but many (Frodeman *et al.*, 2010). The terms *multidisciplinary*, *interdisciplinary*, and *transdisciplinary* constitute the core vocabulary and are used to differentiate between different types of interdisciplinary research. These terms tend to be applied to describe the level of integration, where multidisciplinary is the least and transdisciplinary the most integrated. While some recognize that interdisciplinary work can be pursued by individual researchers, others perceive it as a collaborative effort including interaction between researchers schooled in different disciplines and society. More detailed descriptions of different forms of interdisciplinary research are available in for example Frodeman *et al.* (2010), which also includes a taxonomy of interdisciplinarity. This is not reiterated here. Instead, Schmidt's (2008) paper on the philosophy of interdisciplinary offering a classification framework is used to reflect upon the research conducted for the purposes of this dissertation. Schmidt proposes that *interdisciplinarity* be regarded as a plurality spanning four dimensions: (a) objects ('ontology'), (b) knowledge, theories and concepts (epistemology), (c) methods/practices, and (d) problem perception/problem solving. The present research was pursued through an interdisciplinary approach which integrated theories and concepts from different disciplines within the social sciences (economics and political science), interdisciplinary studies (policy studies), and interdisciplinary research related to climate policy. This was largely because of the interdisciplinary nature of the object of inquiry and because the aim was to address a

complex real-world problem. Therefore, attention was given to (a) and (d) rather than analyzing all dimensions.

Interdisciplinary objects are thought of as objects or constructions located on boundaries between different cosms or disciplines (Schmidt, 2008). To argue that interdisciplinary objects/constructions exist presupposes some form of ontological realism "interlaced with a layered concept of reality, and, based on this, an ontological non-reductionism" (Frodeman *et al.*, 2010:39). *Ontological realism* acknowledges the existence of a mind-independent reality. It is compatible with various theories which characterize the elements of reality as objects, events, processes, fields, or systems, because ontological realism does not say anything about the nature of the mind-independent reality (Niiniluoto, 2002). *Ontological non-reductionism* implies that an object or construction cannot be reduced to fundamental material entities or mental entities (Schmidt, 2008).

What is the main object of inquiry in the present research? A carbon credit represents an emissions reduction in GHGs, equivalent to 1 tCO_2e. In this dissertation, emissions reductions as currently embodied in carbon credits are perceived as a *construction (or creation)*, which approximates the (unobservable) emissions reduction which exists beyond the human mind. This construction is created through projects and human conceptions of a future in which these projects never took place – emissions reductions in crediting activities are the difference between the emissions of the project and those of a counterfactual baseline scenario. This implies that the construction cannot be reduced to a single material or mental entity.

The counterfactual baseline scenario (and the ability of the additionality assessment to differentiate the project from this baseline scenario) underlies the contentious debate on the 'credibility' of carbon credits. Explicit in this debate is that emissions reductions can be more or less 'credible' or 'real'. There is, however, no suggestion that this debate questions the existence of emissions reductions or the existence of future emissions beyond the human mind. Some may question the emissions reductions (claimed by projects) due to the counterfactual baseline scenario as the future cannot be truly known. However, "it is no objection to the intelligibility [or meaningfulness] of a statement that it is counter-factual. Indeed it is only because it is intelligible that we can say that it is counter-factual" (Scotford Archer and Bhaskar, 1998:35). Baseline scenarios can be more or less meaningful in relation to specific contexts and more or less valid and reliable, but I do not believe carbon credits can be rejected due to baseline scenarios being counterfactual. If this were the case, environmental policy as such would be in serious trouble, as it is essentially about addressing future (counterfactual) environmental problems through actions today. In fact, such logic would result in a rejection of any type of action that would change the *status quo*.

An emissions reduction in carbon crediting is a construction created through an integration of scientific and social scientific disciplines. The disciplinary specifics (of the current construction) depend on the additionality assessment, the baseline scenario and the crediting project. For example, in electricity generation CDM projects, an emissions reduction is a socio-economic and technical construction. In contrast, in a forestry CDM project an emissions reduction is a socio-economic and biological construction. These constructions cannot be reduced to a single discipline. Furthermore, they cannot be reduced to a single material or mental entity. To summarize, an emissions reduction in crediting can be seen as an ontologically interdisciplinary construction. In the study of these emissions reductions, an interdisciplinary approach can be useful.

The problem approached in this dissertation is the effectiveness of carbon credits, focusing on environmental credibility. Although carbon credits were influenced by economic theory on tradable credits, where *cost effectiveness* is a key concept, the development of carbon credits was significantly affected by the international climate policy context and the knowledge development under the CDM. The CDM includes multiple explicit and implicit objects and involves multiple actors with varying interests. Economic theory and concepts alone cannot address the governance problem, which involves economic, environmental, political, and social dimensions. Even if the problem is narrowly approached, as in this dissertation, it still stretches beyond the scope of economics. The problem is a societal and multidimensional problem which demands an interdisciplinary approach. An interdisciplinary approach that integrates aspects and concepts of different disciplines "enables a broader or 'thicker' understanding of environmental decisions" (Adger *et al.*, 2003:1097). 'Decision-making' refers both policy process and outcome. In addition, Adger *et al.* see an interdisciplinary approach as advantageous in that it can accommodate a pluralist view of environmental decision-making. Sensitivity to pluralism is important because environmental decision-making may involve tradeoffs between different objectives, interests of actors, and values.

1.4.3 Case Study

Research Approach

The research performed for this dissertation predominantly relied on case studies (Ch. 5-7). *Case study* has been in use since the 1920s within the sciences, social sciences and humanities, but it is not defined (Mills *et al.*, 2009). Case study has been applied across various disciplines, embracing qualitative and quantitative research strategies, positivist and post-positivist approaches, and practice-oriented fields. Due to the versatility of case study, it cannot be reduced to method, or even methodology which

can refer to specific method(s) and the theoretical framework that informs its use. Mills *et al.* (2009) prefer to view case study as a research strategy. The following definition was described by Mills *et al.* as guiding the understanding of case study rather than a definitive or authoritative definition:

- A focus on the interrelationships that constitute the context of a specific entity (such as an organization, event, phenomenon, or person);
- Analysis of the relationship between the contextual factors and the entity being studied; and
- The explicit purpose of using those insights (of the interactions between contextual relationships and the entity in question) to generate theory and/or contribute to extant theory.

The entity of interest in this dissertation is the CER (more specifically what they are claimed to represent, namely 1 tCO_2e), which is a theoretical construct. CERs are created in a specific context. Key contextual factors affecting this construction include the baseline scenario and the project. Both are applied in the *ex ante* evaluations of additionality and emissions reductions, and the approved CDM methodology determines how these evaluations are to be performed. This dissertation includes case studies of selected CDM methodologies applicable and applied to CDM projects (Ch. 5-7). These were pursued for the purpose of critically examining the credibility of the CDM methodologies and the plausibility of the theory (or theories) of emissions reductions underlying the creation of CERs in electricity generation projects. This appears to have received relatively little attention in the climate policy literature, although the principle of what a carbon credit constitutes is commonly understood.

As a research strategy, case study has a distinct advantage "when a 'how' or 'why' question is being asked about a contemporary set of events over which the investigator has little or no control"; and can be used for both exploratory and explanatory purposes (Yin, 2003:9). Social systems are complex and intrinsically open, which implies that there is an "absence of crucial or decisive test situations in principle" (Scotford Archer and Bhaskar, 1998: xvii). *Exploratory case studies* are "very often applied as a preliminary step of an overall causal or explanatory research design exploring a relatively new field of scientific investigation…" (Mills *et al.*, 2009). This type of study investigates entities which are, for example, characterized by a lack of detailed preliminary research. *Explanatory case studies* are used to explain phenomena (Mills *et al.*, 2009).

At the commencement of the research, due to the novelty of the CDM, the case study was useful for exploring approved CDM methodologies and methodologies of registered CDM projects. This work was also an important part of building a theoretical framework for analyzing the credibility of CDM methodologies. The

research questions started from 'How are CERs created, additionality assessed, and emissions reductions calculated?' and progressed to 'How is environmental additionality approached or pursued?' and 'Why is a CER more or less valid and reliable?' The case studies were exploratory in that they answer 'how' questions. The key 'why' question ('Why is a CER credible or not?') was primarily answered through critical thinking in combination with existing knowledge regarding comparative studies in *life cycle assessment (LCA)*.

All the case studies employed an *embedded multiple-case study design*. According to Yin (2003), single- and multiple-case study designs can be viewed as variants within the same methodological framework; and *multiple-case studies* follow 'replication' logic, rather than sampling logic. Replication logic is comparable to multiple experiments (Yin, 2003). The reason for opting to study multiple CDM methodologies applicable or applied to similar projects was that methodologies showed significant variation, *e.g.* in terms of how additionality, baseline scenario, and emissions reductions are defined and determined. An *embedded design* uses multiple units of analysis, rather than a single unit as in a *holistic design* (Yin, 2003). The key units of analysis in the case studies include: *ex ante* evaluations of investment additionality and emissions reductions, *ex ante* environmental additionality criterion, baseline scenario and project (although the individual studies did not necessarily include all units).

A series of multiple-case studies were conducted over time, primarily due to the continuous methodological development under the CDM. Furthermore, over time, it became possible to study registered CDM projects. When the first study was conducted, there was no registered electricity generation CDM project, and there were only a total of two registered CDM projects. Subsequently, registered CDM projects were included for the second study. In the third study, an aim was to compare methodologies of registered CDM projects applying different types of baselines. This required a different case selection compared with the second study.

Relevant case-study methodologies were developed for the purpose of the case studies. This was necessary due to the lack of previous systematic comparisons of CDM methodologies and their *ex ante* evaluations of investment additionality and emissions reductions. Furthermore, there was a lack of previous empirical studies of the theory (or theories) of emissions reductions underlying the creation of CERs. The case-study methodologies were developed largely based on empirical studies of CDM methodologies (conducted for this purpose) and a systems perspective influenced by comparative studies in LCA.

The case study methodology evolved over time. The first was by necessity designed to study the creation of CERs more broadly (see Ch. 5). The second was focused on key factors identified as affecting the credibility of the CERs (see Ch. 6). For the third study, the case study methodology was extended to take into

consideration not only the *ex ante* evaluations but also the 'project-specific context' in the examination. This examination considered the project characteristics and the project-specific narrative of how emissions are envisioned as reduced when analyzing the CDM project's *ex ante* evaluations (Ch. 7). The research process was characterized by repeatedly going back and forth between the various sources, the research methodologies applied and the empirical data collected. The research methodology was re-evaluated and refined over time.

Case Selection & Limitations

An overview of the CDM methodologies and PDDs (*cases*, in brief) selected for the case studies on the credibility of the CDM methodologies in Ch. 5-7 is provided in Table 1.1. While more specific information about the cases and the case selection is included in the respective chapters, the reasons for focusing on the CDM and electricity generation are described below. General limitations are also addressed.

Table 1.1
Overview of the CDM Methodologies and PDDs Selected for the Case Studies in Ch. 5-7

Chapter	Selected Methodologies	Available by	Selection Criteria in Brief
5	6 approved CDM methodologies	1 Dec. 2004	All CDM methodologies applicable to electricity generation projects
6	8 approved CDM methodologies	21 Aug. 2006	All CDM methodologies applicable to electricity generation projects with a single output (electricity)
	Methodologies applied in the PDDs for 30 registered CDM projects	2 Dec. 2009	The 10 most recently registered electricity generation CDM projects located in China, India and Brazil, respectively. These three were the largest CDM countries
7	Methodologies applied in the PDDs for 3 registered CDM projects	5 Nov. 2010	The electricity generation CDM projects were primarily selected for applying different types of baseline scenarios. The projects were located in China, India and Jordan.

Due to its early start in 2000, the CDM was a natural starting point for the research conducted for this dissertation. Its continued dominance and influence in the carbon credit market implies that the CDM continues to be a relevant research subject. The JI did not start operations until 2008. Although VER activities predate CDM and JI activities, they were largely unnoticed until 2006, when voluntary offsetting increased exponentially (Hamilton *et al.*, 2007) (Ch. 2). Furthermore, the CDM has influenced the carbon market at large in terms of *e.g.* methodological development; CDM methodologies are also applied in VER projects (Kollmuss *et al.*, 2008). The CDM can also be seen as of particular importance as CDM projects take place in developing countries. Looking forward, to address climate change it is necessary to wean the global economy from fossil-fuel dependence and to engage developing countries in

mitigation efforts. The examples of China and India suggest that rising carbon intensities accompany the early stages of the industrialization process. This process is closely linked to increased electricity generation, mainly based on fossil fuels (primarily coal) (IPCC, 2007:109). Without additional policies, global GHG emissions (including those from deforestation) are projected to increase 25%-90% between 2000 and 2030 (IPCC, 2007:111). Developing counties are expected to contribute up to 75% of the projected increase in CO_2 emissions.

Climate change mitigation is very much about decarbonizing the global economy and the power generation sector in particular. This sector accounted for the largest growth in CO_2 emissions between 1970 and 2004 (Fig. 1.1). Since 1970, the energy supply sector (electricity and heat) increased its GHG emissions by 145%. In 2004, fossil fuels accounted for 81% of total energy use in the energy supply sector. Without a change in energy policies, the energy mix supplied to run the global economy 2025-2030 will essentially remain unchanged (IPCC, 2007:109). Furthermore, by 2004, power generation accounted for over 27% of the total anthropogenic CO_2 emissions and was the greatest source of CO_2 emissions (IPCC, 2007:104).

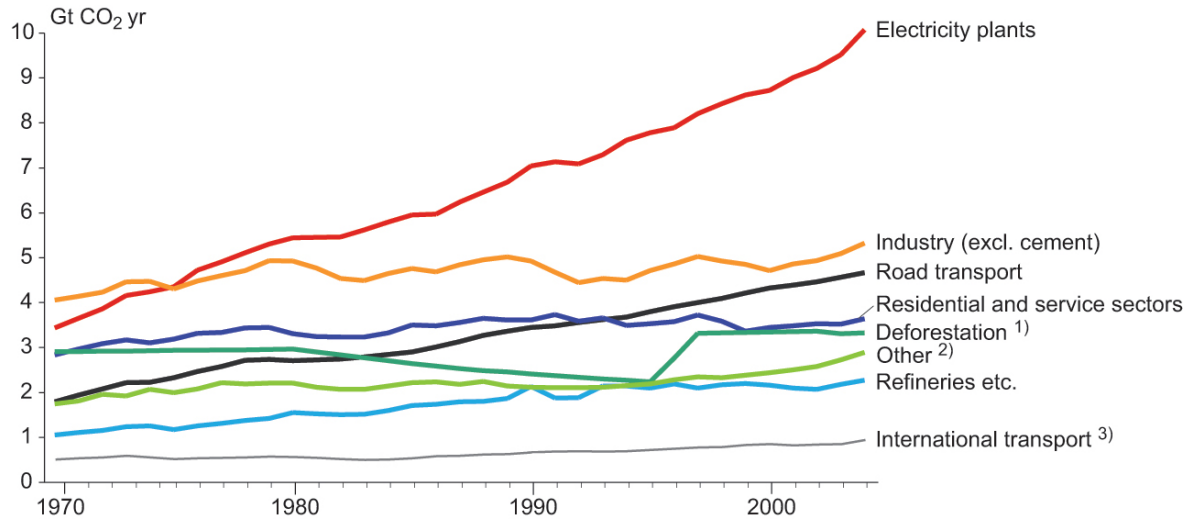

Fig. 1.1 Sources of global CO_2 emissions, 1970-2004 (only direct emissions by sector).

1) Including fuel wood at 10% net contribution. For large-scale biomass burning, averaged data for 1997-2002 are based on the Global Fire Emissions Database satellite data (van der Werf et al., 2003). Including decomposition and peat fires (Hooijer et al., 2006). Excluding fossil fuel fires.

2) Other domestic surface transport, non-energetic use of fuels, cement production and venting/flaring of gas from oil production.

3) Including aviation and marine transport.

Source: IPCC (2007), Fig. 1.2, p.104

Electricity generation projects dominated the CDM from the start and thus early on offered the opportunity to empirically study multiple approved CDM methodologies. Under the CDM, electricity generation projects are sorted under 'Sectoral scope 1: Energy industries (renewable and non-renewable)'. When the research was initiated, this was one of the few scopes that offered an opportunity to compare several approved CDM methodologies applicable to similar projects (see Ch. 5). This continues to be a prominent scope. By 17 Oct. 2011, 79% of the 3521 registered CDM projects were found in this scope and it is the single largest scope in terms of registered projects ('CDM in Numbers' database). The second largest scope (13 Waste handling and disposal) accounted for 16% in 2011.

This dissertation is limited to examining electricity generation, *i.e.* the electricity supplied by a project to a grid and electricity supplied by a grid. Other components (*e.g.* heat, waste, alternative use of biomass, *etc.*) are not addressed. In the CDM context, addressing multiple components (*e.g.* electricity, heat, methane destruction, *etc.*) suggests that multiple baseline scenarios would need to be addressed in a single methodology. This would complicate an already complex analysis. Nevertheless, CDM methodologies applicable to multifunctional projects do exist and may benefit from further research. However, multifunctionality and allocation procedures are not addressed in this dissertation.

The case studies performed primarily examined the CDM methodologies for *ex ante* evaluation. This research does not address actual contributions *ex post*, *i.e.* monitoring and verification of emissions reductions. In addition, the studies are qualitative. No attempt is made to quantify for example how many of the CDM projects or CERs are environmentally credible. Furthermore, what is primarily examined is the theory (or theories) of emissions reductions underlying the creation of CERs. The aim is not to examine the environmental credibility of specific CDM projects included in case studies and this dissertation does not evaluate *e.g.* the plausibility of the baseline scenario, the correctness or plausibility of the investment analysis, or the correctness of data and information in the PDD. Finally, it should be noted that over time CDM methodologies are continuously revised and replaced, and new CDM methodologies are introduced. This continuous change needs to be kept in mind. The results presented in this dissertation depend on methodologies existing or applied at a specific time and may become less relevant over time. However, irrespective of the time of the case selection, an effort was made to primarily focus on methodological issues which appeared to be of relevance by late 2010.

1.4.4 Empirical Material

The method used for collecting empirical data was mainly document studies of primary sources. Various primary sources were included in the studies, but the main sources were the PDDs for registered CDM projects and various approved CDM methodologies. The latter included: Approved Methodologies (AM), Approved Consolidated Methodologies (ACM), and Methodological Tools for CDM projects. Approved methodologies provide official guidance on how it is to be determined or shown that a project truly reduces emissions. The PDD for a registered CDM project offers the official account of how emissions are reduced. Based on the information included in the PDD, proposed CDM projects are validated by DOEs. Once registered, emissions reductions are calculated according to specifications included in the PDD. In the case studies performed, PDDs were consulted in all the cases involving registered CDM projects. Other sources included *e.g.* validation reports by DOEs, the KP, proceedings of the Conference of the Parties (COP) to the UNFCCC and the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP), and meeting reports of the EB. Both qualitative and quantitative data were collected. All the referred to documents are publicly available from the UNFCCC website, which includes links to *e.g.* the CDM website (see references). Various CDM related databases were also used and these are listed at the end of the references.

Numerous informal discussions and interviews were also conducted over the years with various actors, including *e.g.* credit buyers, DNAs, negotiators, NGOs, validators, project developers, and researchers. These were largely pursued while attending carbon conferences and workshops, which were attended over the years including, *e.g.*: Carbon Expo (2005-2010), Carbon Market Insights (2005-2010) and climate negotiations in Nairobi (2006) and Bali (2007). More formal semi-structured interviews were also conducted, but primarily for other research purposes (concerning Annex I private company participation in CDM projects). Nevertheless, this research was also CDM related and some material from one of these interviews was used in this dissertation (see Ch. 8). Information about the relevant interview is found in Appendix 2, but the interview guideline is not included due to its limited relevance for the aim and research questions here.

1.5 Outline of Dissertation

The introduction (Ch. 1) presents the aim of the dissertation and the research questions. The latter are grouped under three themes: effectiveness, additionality, and environmental additionality. Ch. 1 also includes a discussion of the methodology. Ch.

2 provides an overview of the carbon credit market as well as theoretical and practical background on carbon credits. This includes a brief description of the creation of credits in earlier credit-based systems (*i.e.* those preceding carbon crediting). In Ch. 3 various concepts of effectiveness are introduced and the critique of the effectiveness of carbon credits is critically examined. In addition, there is an explanation of how effectiveness is approached in this dissertation. In Ch. 4, the concept of *additionality* is examined and broadened. Ch. 5-7 present the case studies. These studies examine the credibility of the CDM methodologies. A key question is whether CERs can be claimed to be environmentally credible, *i.e.* represent additional emissions reductions. In Ch. 5 the creation of CERs is critically examined through studies of approved CDM methodologies. This chapter presents the first case study conducted, which examined how CERs are created more generally. The following topics are addressed: baseline scenario, (investment) additionality assessment, and calculation of emissions reductions. Both validity and reliability are addressed. Ch. 6 and 7 present later case studies, which are primarily focused on addressing validity. These are framed as examining the theory (or theories) of emissions reductions embedded in the methodologies examined. Compared with Ch. 5, the study included in Ch. 6 is more specific (or abstract) and includes: (a) a critical examination of the *ex ante* environmental criterion; and (b) a comparison of the (baseline) scenario(s) applied or reflected in the *ex ante* evaluations of investment additionality and emissions reductions. This is pursued through studies of both approved CDM methodologies and methodologies applied in PDDs for registered CDM projects. The study in Ch. 7 examines the validity of the environmental additionality argument, *i.e.* the claim that emissions reductions are achieved, in three registered CDM projects. These were selected to represent the use of different types of baselines in the methodologies. Compared with Ch. 6, the analysis in Ch. 7 is more sensitive to the 'project-specific context'. The question is whether the selected PDDs provide a valid or plausible argument that emissions are reduced. Ch. 8 includes a brief summary of the research findings and a synthesizing discussion which relates the research findings to the historical experiences with crediting and the recent efforts to scale-up the CDM through sector-specific standardized baselines. Finally, the conclusions are presented in Ch. 9.

2

OVERVIEW & ORIGINS OF CARBON CREDITS

2.1 Introduction

This chapter introduces carbon credits. It offers background and key concepts which have not already been introduced in the preceding chapter. Repetition is largely avoided, but may occur to provide a more comprehensible context. A list of acronyms and glossary are offered at the beginning of this dissertation. The outline is as follows. Section 2.2 provides an overview of carbon credits and explains why carbon credits are framed as policy instruments in this dissertation. It also provides an overview of the carbon market and describes the development of the international carbon crediting mechanisms under the Kyoto Protocol (KP). Some background on the KP is included. Lastly, the development of voluntary emissions reduction (VER) and the voluntary market is briefly described. Section 2.3 and 2.4 describe the theoretical and practical origins of carbon credits, respectively. Section 2.5 describes the methodological origins of carbon credits. What is described is the development of methodologies applied to create carbon credits. This chapter concludes with a brief summary (section 2.6)

2.2 Overview of Carbon Credits

2.2.1 Carbon Credits as Policy Instruments

A c*arbon credit* can be earned for reducing emissions of GHGs in the amount of 1 tCO_2e, and can be used to offset emissions elsewhere. Hence, credits are also known as *offsets.* Emissions trading preceding the carbon trading appears to have developed largely in the US. Emissions trading covers both *credit-based* and *permit-based systems* (further described later), which are closely related; and an advantage of emissions trading is that pollution targets can be achieved at least cost, *i.e. cost-effectively*. In the

carbon trading context, *credits* are earned on a project basis and are bought on a voluntary basis. *Permits* (or *allowances*) are issued and demand is driven by an emissions cap. Cost effectiveness was an important reason for including international crediting mechanisms (CDM and JI) in the KP. Furthermore, the CDM in particular was crucial for allowing a breakthrough in the climate negotiations in Kyoto, Japan (see below). While sharing similarities, CDM projects take place in the territory of *non-Annex I Parties* and JI projects in *Annex I Parties*. The non-Annex I Parties are developing or newly industrialized countries (NIEs) (generally simply referred to as developing countries).[10] The Annex I Parties are industrialized countries.[11] These have emissions targets under the KP, but the non-Annex I Parties do not. CDM projects could earn *Certified Emissions reductions (CERs)* for emissions reductions as of 2000. JI projects could earn *Emissions reduction Units (ERUs)* as of 2008. Annex I Parties with emissions targets under the KP (also known as *Annex B Parties*) can use CERs and ERUs towards achieving their targets.[12] Cost effectiveness is envisioned as countries with relatively high domestic mitigation costs being able to minimize the cost of meeting their GHG commitments by counting emissions reductions achieved in countries with lower mitigation costs against their own commitments (OECD, 2000).

In parallel to the CDM, VER activities also developed. Credits from these activities are collectively known as *VER credits* or simply *VERs*. The *voluntary market* is defined by a lack of regulatory drivers, but it is heavily influenced by the *compliance market* (Hamilton *et al.*, 2007). This market (unlike the former) serves buyers who are regulated. However, as in the compliance market, both credits and permits can be traded in the voluntary market. Just like the CDM, most voluntary carbon standards include an additionality requirement; and they tend to use CDM methodologies or similar methodologies (Kollmuss *et al.*, 2008). There are today a number of carbon standards, governing carbon crediting activities, *e.g.* CDM, Gold Standard, VER+, VCS, *etc*. A full-fledged *carbon standard* includes (1) accounting standards; (2) monitoring, verification and certification standards; and (3) registration and enforcement systems (Kollmuss *et al.*, 2008). In contrast to CERs or ERUs, credits from VER activities cannot be used to reach KP emissions targets. VER is a private initiative and is pursued outside the policy dimension (see below).

Credit-based systems were originally introduced as environmental policy instruments in the US. This is one reason for defining carbon credits as a policy

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[10] *Non-Annex I Parties*: Parties that are not listed in UNFCCC Annex I.

[11] The Annex I Parties are listed in Annex I of UNFCCC. The Annex I Parties include industrialized countries that were members of the Organization for Economic Co-operation and Development (OECD) in 1992, and countries with economies in transition (EITs), such as the Russian Federation, the Baltic States, and several Central and Eastern European States.

[12] *Annex B Parties*: Individual emissions targets of the Annex I Parties are listed in Annex B of the KP. Parties with targets are also referred to as *Annex B Parties*. These are listed in Annex B of the KP.

instrument in this dissertation, but perhaps more importantly it facilitates the analysis of the critique of effectiveness of carbon credits (in Ch. 3). While including a voluntary component, the carbon credit market is largely dominated by the CDM. An alternative perspective could have been for example to view credits as commodities and carbon crediting activities as business opportunities. However, this would have required a dissertation with a different aim. A business perspective cannot adequately capture the critique that exists related to for example *goal achievement* (see Ch. 3). Nevertheless, the business perspective is relevant, because carbon credits are a market-based instrument, but it is a component in the larger picture. The international crediting mechanisms were introduced as climate policy instruments and these pushed the development of the carbon market.

2.2.2 Global Carbon Market

The creation of a global carbon market was driven by the adoption of the KP and its 'flexibility mechanisms'. Today, in the global carbon market, carbon credits and carbon permits are traded much like any other commodity such as coffee, gold, or grain. These credits and permits represent common denominators in a complex market. Table 2.1 gives an overview of the global carbon market by credit and permit markets (2008-2009).

Despite its name, as can be seen in Table 2.1, the *carbon market* consists of a plethora of markets. These are commonly divided into the *compliance market* and *voluntary market*. The former serves buyers who are regulated under various mandatory international, national, and regional emissions reduction agreements and programs, *e.g.* the KP, EU Emissions Trading System (ETS), Western Climate Initiative (WCI), New Zealand ETS, Regional Greenhouse Gas Initiative (RGGI), New South Wales (NSW) Greenhouse Gas Abatement Scheme, and the Tokyo ETS. The latter serves buyers who wish to offset emissions on a voluntary basis and examples include *e.g.* the Chicago Climate Exchange (CCX), Gold Standard (GS), VER+, and Voluntary Carbon Standard (VCS). Currently, the EU ETS is the largest permit-based system in the world and the CDM is the largest credit program.

Table 2.1
The Carbon Market at a Glance, by Credits and Permits (2008-2009)

	2008		2009	
	Volume ($MtCO_2e$)	Value ($US million)	Volume ($MtCO_2e$)	Value ($US million)
Credit markets				
Primary CDM	404	6511	211	2678
JI	25	367	26	354
Voluntary market	57	419	46	338
Subtotal	*486*	*7297*	*283*	*3370*
Spot and Secondary Kyoto credits	*1072*	*26277*	*1055*	*17543*
Permit markets				
EU ETS	3093	100526	6326	118474
RGGI	62	198	805	2179
AAU	23	276	155	2003
NSW	31	183	34	117
CCX	69	309	41	50
Subtotal	*3278*	*101492*	*7362*	*122822*
Total	**4836**	**135066**	**8700**	**143735**

Note: Original information was reorganized and the heading 'Credit Markets' was added. Rather than using the term allowance markets given in the original table, permit market was used here for more consistent terminology in this chapter. In the primary market new credits are sold for the first time. In the secondary market the seller is not the original owner (or issuer) of the carbon asset.

Source: Kossoy and Ambrosi (2010), Table 1, p. 1

While the compliance market and the voluntary market tend to be described as separate markets in the more specialist literature (*e.g.* academic literature and carbon market reports), the public media has not always differentiated between the various credits and permits. This is most likely due to fundamental similarities and, in theory, all carbon credits and permits represent *emissions rights*, equivalent to 1 tCO_2e. However, not all credits and permits are *fungible* (interchangeable). While some markets overlap, others do not. For example, VERs cannot be used for compliance purposes under the KP or the EU ETS; but *e.g.* CERs and EUAs can be bought by individuals and organizations wishing to offset emissions voluntarily and for corporate social responsibility (CSR) purposes through organizations such as My Climate, Tricorona and Naturskyddsföreningen (see respective organization's website, listed in the references).

The carbon market has been described as the fastest growing market in financial history and some expect it to be the largest global commodity market within the next decade (see *e.g.* Kanter, 2007; Manea, 2011). In 2009, the global carbon market grew by 6% to $US 144 billion (€103 billion), despite a global financial crisis and global gross domestic product falling 0.6% (Kossoy and Ambrosi, 2010). In 2009 the traded volume reached 8700 $MtCO_2$, an increase of 180% compared with 2008.

The CDM market is by far the largest credit market in 2004-2010 (see Ch. 1). Furthermore, as can be seen in Table 2.1, in value and volume, respectively, CERs accounted for 97% and 95% of all credit transactions in 2009.[13] Other credits in the global credit market are ERUs and various VER credits. In value, the JI and VER market were roughly on a par in 2009. However, in volume, the latter was 1.8 times that of the JI market. The financial crisis affected the credit market's share of the global market's value, which fell from 25% in 2008 to 15% in 2009. In volume, the decline was even greater, falling from 32% to 15%.[14] The decline was largely caused by a contracting primary CDM market.[15] This was a result of financial institutions and private investors opting for less risky investments and safer assets and markets. Furthermore, the CDM market was hobbled by structural issues in the CDM process causing long lead times (Kossoy and Ambrosi, 2010).

2.2.3 International Crediting Mechanisms under the Kyoto Protocol

'Project-Based Mechanisms' & 'Kyoto Surprise'

The CDM and JI are also known as *project-based mechanisms*. In addition to promoting a cost-effective achievement of the Kyoto target, carbon credits were flexible enough to gain necessary political support in a multilateral context with widely diverging demands and positions. The CDM was of particular importance. It was a last minute outcome of intense multilateral negotiations, and the CDM became known as the 'Kyoto surprise' (Werksman, 1998). The CDM allowed a breakthrough in the negotiations and was crucial in bridging the interest gap between developed and developing countries. This was made possible by a merger of the US position on allowing 'project-based joint implementation' and the 'Brazilian proposal' for a 'clean development fund' (CDF) which was backed by the G-77 and China.[16] The result was the following negotiated text:

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[13] Percentages were calculated based on data in Kossoy and Ambrosi (2010) Table 1, p. 1 and p. 17.

[14] Percentages were calculated based on data in Kossoy and Ambrosi (2010) Table 1, p. 1.

[15] In the *primary market* new credits are sold for the first time.

[16] "The Group of 77 (G-77) was established on 15 June 1964 by seventy-seven developing countries signatories of the 'Joint Declaration of the Seventy-Seven Countries' issued at the end of the first session of the United Nations Conference on Trade and Development (http://www.unctad.org) in Geneva" (http://www.g77.org), (accessed 11 April 2011).

The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments...

UN (1998), Article 12, §2

The 'ultimate objective' of the UNFCCC is to achieve stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (UN, 1992:Art. 2).

The project-based mechanisms were innovative in that crediting projects applied project-specific baselines. Earlier credit-based systems, preceding carbon crediting, were characterized by applying pre-determined regulatory standards. This created both opportunities and challenges. On the one hand, the project-based mechanisms were instrumental in facilitating the adoption of the KP in 1997. Furthermore, the CDM is the only Kyoto mechanism which engages developing countries in climate mitigation activities and it "has been an important catalyst of low-carbon investment in developing countries" (Kossoy and Ambrosi, 2010:42). The CDM has also been described as "an instrument of mutual benefit for industrialized and developing parties through supporting project activities that create win-win situations for project participants" (Streck, 2004:302). On the other hand, the lack of experience meant various institutional, methodological, and procedural challenges needed to be overcome to ensure 'effectiveness' or 'success'. As shown by the broader critique of carbon credits in the literature, climate negotiations, and public media, there are concerns including *e.g.* lack of environmental integrity and lack of incentives for sustainable development and technology transfer necessary to allow a low carbon development. These concerns in turn suggest that the notion of effectiveness in the context of carbon credits goes beyond the notion of cost effective emissions reductions (see Ch. 3).

The Kyoto Protocol & 'Flexibility Mechanisms'

The KP includes three market-based mechanisms, namely the CDM, JI, and Emissions Trading (ET) (UN, 1998: §6, 12, and 17). These are also known as the 'flexibility mechanisms' (or 'flexible mechanisms') and they enable Annex B Parties to the KP to count emissions reductions (or emissions sequestration through sink enhancements) irrespective of the geographical location of the GHG mitigation activities.

The KP was adopted in 1997 at the third Conference of the Parties (COP 3) to the UNFCCC in Kyoto, Japan. Detailed rules on implementation of the KP were

adopted in 2001 at COP 7 in Marrakesh, Morocco. These rules are known as the 'Marrakesh Accords'. The KP came into force on 16 February 2005 and the first Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (CMP) was held in late 2005. The COP and the CMP are the supreme bodies of the Convention and the KP, respectively (UNFCCC website).[17]

Although the KP did not come into force until later, CDM project activities could officially earn credits as of 2000. The *CDM Executive Board* (EB), which supervises the CDM under the authority and guidance of the CMP, held its first meeting in 2001 and the first CDM methodologies were proposed in 2003. Subsequently, the first CDM project was registered (or approved) in 2004 and there were 3569 CDM projects registered by19 Aug. 2011 (CDM website).[18] JI projects could earn credits as of 2008, coinciding with the commencement of the first commitment period (2008-2012) of the KP. The JI Supervisory Committee (JISC), which supervises the JI, held its first meeting in 2006, and by 19 Aug. 2011 there were 314 JI projects listed on the JI website (JI website).[19]

Under the KP, Annex I Parties commit to binding GHG emissions targets, amounting to a total average reduction of 5% over the period 2008-2012 compared with 1990 (UNFCCC website).[20] The KP covers six GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), which are measured by their global warming potentials (GWP), in tCO_2e. Over the five-year commitment period, Annex B Parties are allowed to emit certain amounts of tCO_2e, which are divided into *assigned amounts units* (AAU). *Removal units* (RMUs) can be earned through land use, land use change and forestry (LULUCF) activities which result in net removal of GHGs. These activities (*i.e.* projects that increase removals by sinks) can also be implemented under the *project-based mechanisms* (described earlier); but under the CDM, LULUCF activities are limited to afforestation and reforestation (A/R) activities. The credits earned through A/R activities under the CDM are known as *temporary CERs* (tCERs) and *long-term CERs* (lCERs) (UNFCCC, 2006b: Decision 5/CMP.1). Each Kyoto unit, whether it is an AAU, CER, ERU or RMU, equals 1 tCO_2e. The allocated permits (AAUs) and the credits earned (various CERs, ERUs, and RMUs) can be

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[17] 'Bodies', http://unfccc.int/bodies/items/6241.php (accessed 23 Dec. 2011)

[18] Meeting reports of the EB and data on projects can be found on the following pages: 'CDM Executive Board' http://cdm.unfccc.int/EB/index.html (accessed 23 Dec. 2011) and 'Project search' http://cdm.unfccc.int/Projects/projsearch.html (accessed 23 Dec. 2011), respectively.

[19] Data on JI projects include projects listed under Track 1 and Track 2 and JI Programmes implemented jointly, 'Project overview' http://ji.unfccc.int/JI_Projects/ProjectInfo.html; information on JISC meeting: 'Meetings' http://ji.unfccc.int/CritBasMon/Sup_Committee/Meetings/index.html (accessed 23 Dec. 2011)

[20] 'Kyoto Protocol', http://unfccc.int/kyoto_protocol/items/2830.php (accessed 23 Dec. 2011)

traded by Parties with targets through ET (UN, 1998, Art. 17; UNFCCC, 2002b: Annex, Art. 2).

CDM Procedures in Brief

The project participants prepare the Project Design Document (PDD) and make use of a methodology approved by the CDM Executive Board (EB) (supervisory body of the CDM), which includes an approved baseline and monitoring methodology. They also need to secure a letter of approval by the Designated National Authority (DNA) and a statement that the project promotes sustainable development from the host county's DNA. Once a project has been validated by a Designated Operational Entity (DOE) it can be *registered* (*i.e.* approved) by the EB as a CDM project. A DOE is a private third-party certifier accredited by the EB. These are listed on the CDM website and examples include Japan Quality Assurance Organization (JQA), DNV Climate Change Services AS (DNV), and TÜV SÜD Industrie Service GmbH (TÜV SÜD) (CDM website).[21] Projects entering the validation process and registered CDM projects are listed on the CDM website and project information can be accessed from there. Emissions are monitored by the project participants in accordance with the monitoring methodology. Once the reductions have been verified and certified by a DOE, the CERs can be issued by the EB. An overview of the entire CDM project cycle is presented below and more detailed information is available on the CDM website.

CDM Project Cycle		Responsible Entity
1)	Project design	Project participant
2)	National approval	DNA
3)	Validation	DOE
4)	Registration	EB
5)	Monitoring	Project participant
6)	Verification	DOE
7)	CER issuance	EB

Source: CDM website, 'CDM Project Cycle': http://cdm.unfccc.int/Projects/diagram.html (accessed 9 Dec. 2011)

The PDD is an important document. It is used by project participants to submit information on their proposed CDM project activity. The key elements of the PDD are shown below. On the basis of the PDD, the project is validated by a DOE against

[21] 'List of DOEs', http://cdm.unfccc.int/DOE/list/index.html (accessed 23 Dec. 2011)

the requirements of the CDM. Furthermore, the PDD describes the monitoring methodology according to which emissions are monitored by the project participants (CDM website).[22] The PDD can be viewed as a rather detailed product specification or declaration of contents for CERs; it essentially describes how CERs are created by a project.

CDM Project Design Document (PDD)

A.	General description of project activity
B.	Application of a baseline and monitoring methodology
C.	Duration of the project activity / crediting period
D.	Environmental impacts
E.	Stakeholders' comments

Source: EB (2006)

JI Procedures in Brief

Host Parties that fulfill certain eligibility requirements can apply a 'simplified' JI procedure, known as 'Track 1'. This means that the host country can verify that reductions in anthropogenic emissions by sources or enhancements of anthropogenic removals by sinks (*emissions reductions*, in brief) from a JI project are *additional* ('to any that would otherwise occur') and issue ERUs. Those that do not meet the eligibility requirements apply 'Track 2', which involves verification procedure under the JISC. Host countries that fulfill the eligibility requirements can also choose Track 2 (UNFCCC, 2006b: Decision 9/CMP.1, Annex, §23 and §25; JI website).[23]

The JI Track 2 procedure is similar to the CDM project cycle (see above), but terminology differs to some extent. Under Track 2, project participants are required to prepare a PDD. The project must (a) be approved by the Parties involved, (b) result in additional emissions reductions, and (c) have an approved baseline and monitoring plan. This is *determined* (*c.f.* CDM: validation) by an *accredited independent entity (AIE)* (*c.f.* CDM: DOE). These are companies accredited by the JISC, *e.g.* DNV, JQA and KPMG Advisory N.V. (KPMG). These are listed on the JI website. Project participants monitor and report on the emissions reductions to an AIE, which verifies the reported emissions reductions. ERU are issued and transferred by the host Party (UNFCCC, 2006b: Decision 9/CMP.1, Annex, §30-45; JI website).[24] Both Track 1

[22] 'CDM Project Activity Cycle', http://cdm.unfccc.int/Projects/pac/index.html (accessed 23 Dec. 2011)

[23] 'Eligibility Requirements', http://ji.unfccc.int/Eligibility/index.html (accessed 23 Dec. 2011); 'List of AIEs' http://ji.unfccc.int/AIEs/List.html (accessed 23 Dec. 2011)

[24] 'Eligibility Requirements', http://ji.unfccc.int/Eligibility/index.html (accessed 23 Dec. 2011); 'Determinations' and 'Verifications' http://ji.unfccc.int/JI_Projects/DeterAndVerif/index.html (accessed 23 Dec. 2011)

and Track 2 projects are listed on the JI website and project information can be accessed from there.[25] The ERUs transferred from a Party are subtracted from the Party's assigned amount (UNFCCC, 2006b: Decision 13/CMP.1, Annex, §12). Due to this subtraction, an ERU does not increase the total amount of emissions rights (in tCO_2e) in the Kyoto context. This is a significant difference compared with the CDM.

Important Difference between CDM and JI: Environmental Credibility of Credits

CDM projects take place in countries without Kyoto targets. A CER is issued by the EB and is not subtracted from any Party's assigned amount. This means that the environmental credibility of CDM projects is a greater issue in the Kyoto context, because if CERs are not environmentally credible, the KP's emissions target will be eroded.

JI projects take place in countries with Kyoto targets. Assuming that there is a working national system for the estimation of anthropogenic emissions by sources and anthropogenic removals by sinks of all GHGs, the host country will be interested in ensuring that the JI projects lead to additional emissions reductions. Otherwise, the JI host country may end up having to compensate for the 'empty' ERUs. These considerations indicate that environmental credibility can also be an issue in the JI context.

2.2.4 Voluntary Emissions Reductions

VER activities are not governed by policy-makers. However, while VER is not a policy instrument in a strict sense, this does not necessarily imply that VER activities are ungoverned. The voluntary market is largely governed through various carbon standards; but these are not governed by policy-makers. VER activities are wholly a private-sector initiative. However, this does not mean that there are no links between policy actions and the voluntary market. Pre-compliance buying (see below) is an example of how policy (or rather expected policy) can affect this market, but the links are indirect.

While the voluntary market is at times described as emerging in parallel to the CDM, VER activities predate CDM activities. The first carbon offsetting activities were voluntary investments in CO_2 sequestration (forestry projects) in the late 1980s. Hence, these activities predate not only the 1997 KP, but also the 1992 UNFCCC (Moura-Costa and Stuart, 1998; Hamilton *et al.*, 2007). Despite its earlier start, the voluntary market was fairly anonymous until 2006 when it started to grow

[25] 'Project Overview' http://ji.unfccc.int/JI_Projects/ProjectInfo.html (accessed 23 Dec. 2011)

exponentially. Around this time, the KP came into force (2005), the EU ETS started operations (2005), and the CDM mark*et al*so grew exponentially. Furthermore, public awareness of climate change and carbon trading increased (Hamilton *et al.*, 2007).

The voluntary carbon market used to be divided into two segments: the CCX and the voluntary *over the counter (OTC)* market. The CCX was the world's only voluntary (but legally binding) cap-and-trade system (Kollmuss *et al.*, 2008; Hamilton *et al.*, 2010b). The CCX operated as a cap-and-trade program with an offsets component 2003-2010. In 2011 it launched the Chicago Climate Exchange Offsets Registry Program to register VERs (CCX website).

According to Hamilton *et al.* (2010b), the voluntary credit market is based on bilateral deals and they referred to it as the OTC market. Of the 91.9 $MtCO_2e$ traded in the voluntary market in 2009, 45% were traded through the CCX and 55% were traded on the OTC market. The latter figure also includes CCX credits (5.5 $MtCO_2e$) that were transacted bilaterally. In the OTC market, the US overtook Asia as the primary source of VERs in 2009, accounting for 56%. Latin America came second, accounting for 18% of the VERs supplied followed by Asia accounting for 16%. *Pure voluntary buyers* dominated the OTC market with a 48% market share of the transactions taking place in 2009. These buyers intend to immediately retire the credits. Businesses with a pre-compliance motive came second with a 23% market share, followed by the non-profit sector offsetting at 7%. *Pre-compliance buyers* focus on buying credits that might be eligible in a future compliance market (Hamilton *et al.*, 2010b). [26]

2.3 Theoretical Origins

The theoretical idea of emissions trading can be traced back to economic literature published in the mid and late 1960s: a paper on atmospheric pollution by Thomas Crocker (1966), in the US; and a book on water pollution by John Dales (1968), in Canada. The groundwork was laid by Coase, in 1960. He argued that rather than taxing sources of pollution based on damage to receptors, it could make more sense to let participants negotiate the best possible solution. However, rights to use air were not seriously considered at the time (Oates, 2000). More concrete theoretical arguments for establishing and structuring 'markets in pollution rights' did not

[26] Information is based on the fourth annual 'State of the Voluntary Carbon Markets' report. It is designed to give a market-wide perspective on trading volumes, credit prices, project types, locations, and the motivations of buyers in this market. It should be noted that the report's findings are based on data voluntarily reported by 200 credit suppliers, as well as exchanges and registries; and due to the challenges of inventorying and obtaining data from this disaggregated marketplace, numbers should be considered conservatively.

emerge until later with Crocker's and Dale's independent contributions. They "emphasized the benefits of auctioning off pollution rights to the highest bidder, the results of which would reflect the correct social value to place on the pollution at the desired total quantity" (Solomon and Gorman, 2002:297). The (economic) efficiency of tradable permits was demonstrated later by Montgomery in 1972, and "the instrument appears to have evolved just as much from the actual experience of regulation as from academic analysis" (Sterner, 2003:82). Crocker's and Dale's contributions initiated debates among various economists in the 1970s over the pros and cons of taxes versus emissions trading. However, these economists did not specify what emissions limits to set, how to allocate permits beyond auctioning, or how to monitor and verify emissions (Solomon and Gorman, 2002:297-298).

While policy instruments can be categorized in many ways, tradable credits are commonly categorized as *economic incentives* or *market-based instruments.* They are also known as *market-creating instruments* (Sterner, 2003). *Tradable credits* are a form of *tradable permits*. These are often distinguished based on how they are either acquired or produced. The acquisition-based distinction is common in the climate policy literature and notes that *credits* are earned for not emitting, while *permits* (or allowances) are allocated. Permits can be allocated through *e.g.* auctioning (*i.e.* through bidding) or grandfathering (*i.e.* free of charge). In this dissertation, the terms *credits* and *permits* refer to *tradable credits* and *tradable permits*, respectively.

A production-based distinction is commonly applied in economic literature. According to this distinction, *credits* (or 'emissions reduction credits', ERC) are based on relative or performance standards and *permits* on absolute caps based on aggregated emissions (see *e.g.* Boom and Dijkstra, 2009). For credits, traditional technology-based standards act as baselines and emissions reductions beyond these are certified (Tietenberg, 2006). While credits depend on a technology-based baseline, *i.e.* pre-determined regulatory standards; permits do not. Permits can be allocated in many different ways once the aggregate number of permits has been defined. They can be allocated based on a historical technology-based standard, but are not restricted to such an allocation (*ibid.*).

Policy instruments based on economic incentives promote a desired behavior through price signals. To achieve a cost-effective allocation of the pollution control burden, it is required that the marginal cost of abatement be equalized across all sources. An advantage of such instruments is that pollution targets can be achieved at least cost (*i.e. cost-effectively*) without regulators knowing the marginal abatement costs of individual polluters; it is sufficient to have knowledge of aggregated abatement costs. In contrast, achieving the same result using *command-and-control* instruments (see below) requires information about abatement costs of individual polluters. Another example of an economic-incentives instrument is the *Pigouvian tax*, a pure environmental charge used to correct negative externalities. A key difference between

taxes and tradable permits is how uncertainty in aggregate abatement costs affects the outcomes. While permits are dependable in terms of the pollution level, permit price (*i.e.* cost to polluters) will fluctuate. Under taxes, cost to polluters is predictable but the pollution levels will vary. However, in the selection of policy instrument(s) there are a range of criteria and conditions (states of the world) to consider (Sterner, 2003).

Since the 1970s, when the standard approach to environmental policy was *command-and-control*, *e.g.* standards and (non-tradable) permits (or quotas), which regulate the pollution level directly rather than through prices, a dramatic change has taken place where market-based approaches are increasingly preferred (Oates, 2000). Nevertheless, "policies often have a regulatory or command-and-control flavor" (Dixon and Toman, *cit.* Sterner, 2003: xiii). Furthermore, experience with incentive-based instruments in developing countries is limited and "significant skepticism remains about the applicability of incentive-based policies for the developing world" (*ibid.*). Despite some experiences with emissions trading (involving credits or permits) in the US and in some other countries, emissions trading was still considered to be in its infancy when the CDM officially became operational (UNCTAD, 1992; Solomon and Gorman, 2002).

Although an international carbon tax was considered, emissions trading emerged as the instrument of choice in international climate policy with the adoption of the KP. In addition, an increasing number of regional, national, and bilateral trading schemes are being introduced, recently in *e.g.* Japan and New Zealand. In the early 1990s, carbon/energy taxes were introduced in some Scandinavian countries and there was a proposal for a carbon tax at the EU level. Yet, it was never implemented due to strong opposition from Member States and industry, the latter being particularly vocal (Jordon and Rayner, 2010:58). In an UNCTAD report from 1992, an international carbon tax to address climate change was described as improbable. The reason being that countries were not expected to willingly transfer to UN control the large amounts of tax revenues that would be involved (Grubb in: UNCTAD, 1992). More recently, however, uncertainty in carbon prices, 'credit fraud', and windfall profits (due to overallocation of permits) have sparked a vigorous public debate between tax and trade in for example Canada (Kramer, 2010:27).

Another distinction between emissions trading and taxes is that taxes do not create markets. While this is noted in Sterner (2003), market creation is not addressed further. An interesting aspect of market creation in the case of the carbon market is the engagement of the private sector and the emergence of new interest groups. As a consequence of the international carbon market, advocates in the private sector for stronger regulation and clear targets emerged (Newell and Paterson, 2010). This is unlikely to have been achieved through taxes. Furthermore, the emergence of private sector actors with strong and vested interest in climate mitigation can possibly generate greater political support for, and stability, in the system.

2.4 Practical Origins

2.4.1 Emissions Trading Preceding Carbon Trading

Emissions trading was introduced in practice for the first time in the late 1970s in the US. Yet, when the first trading programs were introduced, the "economic perspective on environmental management…was, in fact, ignored" (Oates, 2000). While the theory of emissions trading was based on tradable permits, emissions trading developed in practice based on tradable credits. However, "emission trading…is a policy tool in which theory and practice have helped refine each other over the last several decades" (Solomon and Gorman, 2002:296)

Emissions trading was an unanticipated consequence of the Clean Air Act of 1970, which established air quality standards based on health (Solomon and Gorman, 2002). Under this Act, states were required to meet air quality standards set by the Environmental Protection Agency (EPA) for pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NO_x) and carbon monoxide (CO). It was thus firmly based in the tradition of command-and-control. Offsetting was introduced in the US through the 1977 Amendments to the Clean Air Act. It was introduced to resolve a practical problem. Offsetting allowed new emissions sources to be introduced in areas which did not meet federal air quality standards.

Emissions trading preceding carbon trading appears to have developed largely in the US. "The tradableleable entitlement or permit approach to pollution control was first introduced in the United where it has received its most vigorous application up to date" (Tietenberg in: UNCTAD, 1992:37). There, two main forms of trading systems have been observed: uncapped emissions (or effluent) reductions credit (ERC) systems, and capped allowance systems (also referred to as 'cap-and-trade' and permit-based systems) (Anderson, 2001). In this dissertation these systems are referred to as *credit-based* and *permit-based*, respectively. In the former, 'uncapped' system, pollution limits are rate-based and sources earn credits by releasing less pollution than their legal limit or other defined baseline. In the latter, 'capped' system, aggregated emissions are limited by an overall ceiling (or cap) and permits are allocated in quantities consistent with the cap (Anderson, 2001).

Table 2.2 provides an overview of various trading systems in the US existing prior to the development of carbon trading and when CDM projects could officially start earning credits (in 2000). As can be seen in the table, a number of programs allow *emissions averaging*, which is a form of intra-firm trading over product lines (Anderson, 2001). Actual trade under the various programs has varied considerably (Anderson, 2001; Solomon and Gorman, 2002). In the following sub-sections the early development of emissions trading is described. The following programs are included: the Emissions Trading Program (ETP), the Lead Phase-Out Program,

Montreal Protocol and the reduction in ozone-depleting substances, and the Acid Rain Program. The first two are credit-based systems which were important for the development of emissions trading. The latter two are permit-based systems. These are briefly described as contrasting examples to credit-based systems. They can also be seen as important examples of emissions trading. Through the Montreal Protocol, emissions trading was introduced at the international level for the first time. The acid rain program (or the sulfur allowance program) has been described as "the most successful version of emission trading to date" (Tietenberg, 2006:10).

Table 2.2
Emissions Trading Prior to Carbon Trading

Trading Program		Additional Information	Duration	Form of Trade
Emissions Trading Program (ETP) (1986)		Offset program	1977 -	Credit
		Bubble program	1979 -	Credit
		Banking program	1977 -	Credit
		Netting program	1974 - [a]	Credit
Corporate Average Fuel Economy (CAFE) Standards		Intra-firm trading (akin to banking)	1978 -	Credit
Lead Phase-Out Program		Inter-refinery averaging	1982-1985	Credit
		Banking	1985-1987	Credit
Effluent Trade (emissions to water)		Bubble (operates identically to the air emissions bubble); trade in discharge permits (rights), effluent rights (capped), credits	1987-	Credit/permit
Montreal Protocol on Substances that Deplete the Ozone Layer		Chlorofluorocarbon (CFC) production allowance trading	1989-1999[b]	Permit
Heavy-duty truck engine emission averaging		Emissions averaging, banking, and trading	1990 (?) -	Credit
Gasoline constituents	Wintertime oxygenated gasoline program	Credit trade	1992 -	Credit
	Reformulated gasoline program	Emissions averaging and trading	1995 -	Credit
Hazardous Air Pollutant (HAP)	HAP Early Reduction	Intertemporal trade [c]	1992 -	Credit
	Petroleum Industry National Emission Standard for Hazardous Air Pollutants (NESHAP)	Emissions averaging	1995 -	Credit
	Hazardous Organic Chemical NESHAP	Emissions averaging	1995 -	Credit
State programs	California's Regional Clean Air Incentives Market (RECLAIM)		1994 -	Permit
	Other state programs (in *e.g.* Illinois, Michigan, New Jersey, Texas, Pennsylvania, Colorado, and Washington)	Various forms	1995 -	Credit/permit
Acid rain program			1995 -	Permit
Wetland mitigation banking		(see notation [d])	1995 -	Credit
NOx Regional Ozone Programs			1999 -	Permit

[a] *According to Solomon and Gorman (2002), netting was introduced in 1974. According to Anderson (2001) netting was introduced in 1980, but included data on trade prior to 1977.*

[b] *US trade.*

[c] *Sources exchange their early reductions for their later reductions, but different from banking.*

[d] *Credits (usually denominated in terms of acres of habitat values) can be earned for enhancing and preserving wetland and may only be used to mitigate development within the same watershed.*

Source: Anderson (2001), Solomon and Gorman (2002), and Tietenberg (2006)

Emissions trading has been introduced outside the US, but no other country has as much experience with it as the US. The following were mentioned by Stavins (2001), Tietenberg (2006) and in a report from UNCTAD (1992):

International	1987 Montreal Protocol on Substances that Deplete the Ozone Layer, permit-based trading (entry into force 1989)
Chile	Permit-based trading in bus licenses (introduced in 1991)
Chile	Permit-based system to control particulates in Santiago (introduced in 1992)
Canada	'Intra-utility trade' (similar to the US bubble concept) in Ontario (date of introduction was not offered) [27]

The list only includes programs not concerned with GHGs. Stavins (2001) also mentions that several European national authorities have increased flexibility under a number of national and EU emissions standards. Denmark and the Netherlands were mentioned. However, none involved inter-firm financial transfers. In addition, pilot projects in credit- or permit-based system in Canada, Germany, and Poland were mentioned. Furthermore, Tientenberg (in: UNCTAD, 1992) mentioned that China had adopted a 'transferable entitlement system', but information was very limited.

2.4.2 Emissions Trading Program

Emissions trading developed from offsetting (*i.e.* credit-based trading), which was introduced through the 1977 Amendments to the Clean Air Act (Solomon and Gorman, 2002). *Offsetting* was a requirement, allowing new emissions sources to enter a 'non-attainment' area, *i.e.* a geographical area which does not meet federal air quality standards. A new source was to adopt the most effective abatement technology available and offset its emissions by 120% to ensure a net improvement in the air quality in the non-attainment area (Oates, 2000; Tietenberg, 2006). Offsetting was a means to solve air quality problems while allowing economic growth (Tietenberg, 2006). The idea was that existing sources in non-attainment areas would voluntarily reduce emissions below legal requirements. Emissions reductions could be certified by the EPA; and once certified, the credits could be transferred to new sources wishing to enter a non-attainment area.

Beyond offsetting, what later became known as the ETP also included the following components: bubbles, netting, and banking. Whereas *offsetting* allowed new sources to acquire credits from existing sources, *bubbles* allowed existing sources to

[27] Information was too limited to e valuate whether the system was credit or permit based. However, the reference to a system similar to the US bubble suggests it may have been a credit-based system.

acquire credits from other existing sources (Tietenberg, 2006). Through bubbles, multiple emissions sources could treat emissions as exiting through a single stack. *Netting* allowed firms to avoid the stringent New Source Performance Standards of the 1970 Clean Air Act if they reduce emissions elsewhere in their facility when modifying existing equipment. *Banking* allowed facilities to bank their emissions reductions as credits for future netting, offsets, and bubbling (Solomon and Gorman, 2002). The national credit-based system became a model for several subsequent state programs (Tietenberg, 2006). The programs created flexibility by allowing emissions averaging in different forms. Both offsetting and bubbles allowed inter-firm emissions averaging through inter-firm trading. Netting allowed intra-firm emissions averaging through what has been described as 'internal trading' (Solomon and Gorman, 2002). Banking can in turn be seen as a form of intertemporal emissions averaging by allowing intra-firm trade over time.

While credit trade was theoretically possible under the ETP, actual trade between firms was limited. Inter-firm trading was limited as most firms secured offsets by replacing older, less efficient equipment (Solomon and Gorman, 2002). While netting was more common than offsetting until 1990, since 1991 it appears that offsetting far exceeds netting in terms of trading activity (Anderson, 2001). According to Anderson (2001), between 1985 and 1992, over 10,000 tons of pollutants were traded in the offset program. Total expenditure on credits was estimated to be in the order of $2 billion and the average price of traded pollutants was believed to be approximately $200 per ton. However, trades under the ETP were fewer and offset prices lower than expected. Nevertheless, the introduction of the ETP subsequently led to a broader application of the emissions trading approach (Tietenberg, 2006). Practical experience with trade came not with the ETP, but with the lead phase-out program (Solomon and Gorman, 2002).

2.4.3 Lead Phase-Out Program

The lead phase-out program aimed to ensure availability of unleaded gasoline for cars with catalytic converters (Solomon and Gorman, 2002). These were installed in cars as a consequence of the Clean Air Act requiring a 90% cut in certain emissions by 1975. To ensure an adequate supply of unleaded gasoline, the EPA required that unleaded gasoline be offered by all major service stations by July 1974. In addition, refiners were required to meet increasingly stringent lead level targets (in g/gallon of gasoline). In 1979, because of the impracticability of continuous monitoring, refiners were allowed to average their lead levels in gasoline produced over a three-month period (US EPA, 1973; Solomon and Gorman, 2002; Tietenberg, 2006). Furthermore, in 1982, as part of eliminating the favorable treatment of small

refineries, inter-refinery averaging of leaded gasoline was introduced. A refinery that did not meet its targets could secure the right to use additional lead from a refinery that exceeded its targets. Through these changes in 1979 and 1982, a market for lead credits was created. In 1985, the program was extended to allow banking of credits (US EPA, 1985; Solomon and Gorman, 2002). Tietenberg (in: UNCTAD, 1992:40) described the system as a 'banking program', where "refiners reducing lead more than required by the applicable standard in one quarter of the year could bank the credits for use or sale in some subsequent quarter."

Through the lead phase-out program, emissions were controlled indirectly (Solomon and Gorman, 2002; Tietenberg, 2006). The lead phase-out and subsequent elimination of leaded gasoline controlled an input (lead) rather than emissions through 'production rights'. From the refiner perspective it was thus not so much an issue of pollution control but rather a change in production specification. Although what was traded was the right to use lead, the lead added to the gasoline would eventually end up as emissions.

There is some uncertainty as to whether the lead program was a credit- or permit-based system. While Solomon and Gorman (2002) referred to the lead program as a case of 'credit trading', they appear to use 'tradable credits', 'tradable permits', and 'tradable emissions rights' more or less interchangeably. They also mentioned that 'tradable credits' were 'allocated'. Tietenberg (2006) referred to the lead program as a prominent example of the application of a 'tradable permit approach'. However, this term was also used to describe the ETP, which was a credit-based system (see *e.g.* Sterner, 2003). More importantly, however, Tietenberg (2006) wrote that a fixed amount of 'credits' was 'allocated' under the lead program. The references to allocation appear to suggest that the lead program was a permit-based system. However, Solomon and Gorman (2002) described a problem which seems inconsistent with a system under which the aggregate use of lead was capped, *i.e.* a permit-based system. Although the lead program was generally considered a success, some enforcement problems were uncovered; one example involved several companies exaggerating their gasoline sales to comply with their averaged lead targets. This does not appear to be consistent with a system which caps the aggregated use of lead. Furthermore, Solomon and Gorman (2002) described the emergence of 'cap-and-trade', but did not refer to the lead program as such a program. In addition, while the EPA describes the lead phase-out program as based on rate-based standards, caps were not mentioned (US EPA, 1973; 1985). Anderson (2001) described the program as a credit-based program, and not a cap-and-trade program. In summary, the conclusion here is that the lead program was a credit-based system.

2.4.4 Reduction in Ozone-Depleting Substances

The lead phase-out program later served as a model for the US program for phasing out chlorofluorocarbons (CFCs) and other ozone-depleting chemicals, which was a response to the signing of the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer (Solomon and Gorman, 2002). The Protocol was originally aimed to cut production of CFCs by 50% by 1998 compared with 1986 levels. Subsequently, other ozone-depleting chemicals were also included and agreement was reached on a complete phase-out of CFCs and halons (Tietenberg, 2006). Trading of production rights was similar to that in the lead program and trading began in 1989. Although trade was allowed between and within countries, in practice it was limited to a small number of sources. Most of the trading occurred primarily between US and Canadian plants of DuPont and Dow Chemicals in 1991-1995, before production of CFCs in developed nations was phased out in 1996 (Solomon and Gorman, 2002).

To implement the Montreal Protocol, the US used a transferable permit system (Tietenberg, 2006). The EPA issued regulations by 1988. Initially, all major US producers and consumers of the controlled substances were allocated production and consumption allowances. These allowances were allocated based on 1986 production and consumption. Trade was allowed within the production and consumption categories, and allowances could be traded across national borders. Due to price inelasticity, the supply restriction led to large windfall profits among producers. However, a tax was introduced to soak up the rents created by the regulation-induced scarcity. Over time, the tax rate increased and controlled the level of production and use. This meant that not only were allowances traded internationally for the first time, but emissions trading and taxes were applied simultaneously for the first time *(ibid.)*.

2.4.5 Acid Rain: Sulfur Allowance Program

Expectations notwithstanding, nation-wide experience of emissions trading (rather than trade in production rights) came not with the effort to manage non-attainment areas, but with the effort to control acid rain (Solomon and Gorman, 2002). The sulfur allowance program (or the SO_2 program) has been described as "the most important application ever made of a market-based instrument for environmental protection" (Stavins, 2001:27). Under this program, to cut emissions during the first phase (1995-1999), the EPA capped the aggregated emissions of SO_2 among 263 large, coal-fired power plants. To this end, a baseline of actual emissions was established; and allowances (representing one ton of SO_2) matching those emissions were created. Initially, power plants received allowances covering their existing emissions. Reductions were subsequently achieved by gradually tightening the cap through a reduction in available allowances. In the second phase (2000-2009), deeper

cuts were introduced and the program was extended to cover more plants. Despite intentions of reducing the number of allowances allocated to each power plant by a fixed percentage, a more complex formula was applied due to various exceptions and special provisions (Solomon and Gorman, 2002).

2.5 Methodological Origins

2.5.1 Methodologies for Creating Carbon Credits

The development of methodologies for creating carbon credits has been characterized by learning-by-doing, largely under the CDM. In the carbon credit context, emissions reductions are quantified by comparing a project's emissions with the baseline emissions (Kollmuss *et al.*, 2008). The baseline emissions are predominantly project-specific (established on a project-by-project basis) rather than performance standards. Furthermore, to determine baseline emissions, several carbon standards apply CDM methodologies *(ibid.)*.

A review of the literature describing crediting preceding the CDM (see above) and the CDM literature on additionality (Ch. 3 and 4) and early literature on calculating emissions reductions in GHG mitigation projects (Kartha *et al.*, 2004) suggests that there was relatively limited knowledge about how to operationalize the concept of *additionality* and project-specific baselines prior to the introduction of the CDM. Neither additionality nor project-specific baselines for calculating emissions reductions were mentioned in the literature describing the theory on tradable permits or the credit-based systems prior to carbon crediting (see above). Furthermore, when the research in this dissertation was initiated, at the end of 2004, no empirical studies of CDM methodologies or CDM projects were found when the academic literature was reviewed.

Additionality had been implemented in other contexts, but it had never been applied as intended under the CDM (Sugiyama and Michaelowa, 2001). It had never succeeded in being quantitatively analyzed for practical and commercial use. At most it had been used more conceptually, qualitatively or semi-quantitatively, as either a part of reporting formality or a guiding principle (*ibid.*). Furthermore, by the end of 2004, few studies in the CDM literature appeared to have addressed practical approaches for assessing additionality (Greiner and Michaelowa, 2003 is an exception). Additionality had been addressed in the non-CDM literature, but this appears to have been largely overlooked in the CDM literature (see Ch. 4). Furthermore, in the innovation policy literature on additionality, it appears that the concept has been primarily approached as a means to establish whether policy

instruments have any effects *ex post* (see Ch. 4). In contrast, the CDM's additionality assessment represents an *ex ante* evaluation of projects.

Studies of project-specific baselines had been conducted under the Activities Implemented Jointly (AIJ) pilot phase and other early carbon credit trading projects, but these were not particularly transparent or consistent (Kartha *et al.*, 2004). Furthermore, the studies tended to be costly. While there was a substantial literature and lessons learned related to electricity baseline methodologies, there was no general method for identifying the baseline scenario (*ibid.*). Rather, various methods had been applied; some were done on an *ad hoc* basis, which was often the case for AIJ projects, or others used various more well-defined and reproducible methods, *e.g.* regulatory and policy assessment, investment analysis, market barrier analysis, risk analysis, and conservatism principles. *Ad hoc* project-specific methods tended to result in inconsistent and non-transparent baselines (*ibid.*).

2.5.2 CDM Methodologies

CDM methodologies developed bottom-up. Project participants were responsible for proposing new methodologies (NMs). These were approved and later consolidated by the EB. Other actors, such as NGOs and individuals with various backgrounds, were also engaged in the methodological development process. These provided public inputs on NMs and acted as experts appraising the validity of the proposed NM through desk reviews under the EB's *Methodologies (Meth) Panel.* However, instead of receiving a few proposals for each Sectoral scope, the EB received multiple NMs for only some. CDM methodologies are sorted by 'Sectoral Scope' as defined by the CDM accreditation panel (CDM-AP).[28] As a result, as is visible in Table 2.3, the distribution of AMs across the various scopes was uneven. Some scopes included very few or no AMs at all.

[28] '*List of Sectoral Scopes*', http://cdm.unfccc.int/DOE/scopelst.pdf (accessed Jan. 2005); also see 'Methodologies linked to sectoral scopes', https://cdm.unfccc.int/DOE/scopes.html#11 (accessed 13 June 2011)

Table 2.3
All AMs and ACMs (available by 1 December 2004)

Sectoral Scope		CDM Methodology	
1	Energy industries (renewable - / non-renewable sources)	AM0004 AM0005 AM0007 AM0010 AM0014 AM0015 ACM0002	Industrial sectors
2	Energy distribution		
3	Energy demand		
4	Manufacturing industries	AM0007 AM0008 AM0014	
5	Chemical industries		
6	Construction		
7	Transport		
8	Mining/mineral production		
9	Metal production		
10	Fugitive emissions from fuels (solid, oil and gas)	AM0009	Sectors based on sources of GHG emissions
11	Fugitive emissions from production and consumption of halocarbons and sulfur hexafluoride	AM0001	
12	Solvent use		
13	Waste handling and disposal	AM0002 AM0003 AM0006 AM0010 AM0011 AM0012 AM0013 AM0016 ACM0001	
14	Afforestation and reforestation		
15	Agriculture	AM0006 AM0016	

Source: 'Approved Baseline and Monitoring Methodologies for Large Scale CDM Project Activities' (CDM database) (accessed 1 Jan. 2005); CDM website, 'List of Sectoral Scopes', http://cdm.unfccc.int/DOE/scopelst.pdf *(accessed 16 Jun. 2011).*

The largest concentrations of AMs were found in Sectoral Scope 1 and 13. Due to this, the EB initiated work to consolidate methodologies in late 2003 (EB, 2003d; 2004c). The first consolidations concerned AMs applicable to landfill gas projects and grid-connected electricity generation projects. In the latter, what was considered was the possibility of providing criteria for choosing different approaches, *e.g. build margin (BM)*, *operating margin (OM)*, or *combined margin (CM)* methods (further described in Ch. 5). Subsequently, two approved consolidated methodologies (ACMs) were agreed on by the EB in September 2004, namely ACM0001 and ACM0002. In addition, the 'Tool for the demonstration and assessment of additionality' was agreed upon by the EB in October 2004 (EB, 2004a). The latter is a general framework demonstrating and assessing additionality and it is applicable to a wide range of project types.

- Definitions that are required to apply the methodology
- Description of the applicability of the methodology
- Description of the project boundary
- Procedure to identify the baseline scenario
- Procedure to demonstrate and assess additionality
- Procedure to calculate emissions reductions
- Description of the monitoring procedure

Source: UNFCCC (2010b), p. 30

The creation of CERs relies upon the key concepts of *investment additionality* and *emissions reductions*, which are both relative concepts related to the *baseline scenario*. The latter describes what would occur in the absence of the CDM project. It can refer to either a single *source* (*i.e.* facility, plant, unit, *etc.*) or multiple sources of emissions. Furthermore, the baseline scenario is required to be project-specific. A project that is *investment additional* would not take place without the CDM, *i.e.* it is not the baseline scenario. Under the CDM, additionality is addressed through the additionality assessment. This is primarily pursued through some type of barrier analysis and/or economic analysis. *Emissions reductions* are calculated as the difference between the emissions of the baseline scenario (*i.e. baseline emissions*) and those of the CDM project activity (*i.e. project emissions*). The calculation of emissions reductions must also take into account leakage. *Leakage* is defined as the emissions that are attributable to the CDM project, but which occur outside the project boundaries. The *project boundaries* are defined as encompassing the emissions attributable to the CDM project. In contrast to investment additionality, emissions reductions are not only an *ex ante* requirement, but also an *ex post* requirement.

2.6 Conclusions

The carbon market consists of a plethora of markets, where both credits and permits are traded much like any other commodity. Commonly, *credits* (or *offsets*) are described as earned (relative to a project-specific emissions baseline) and *permits* (or *allowances*) as allocated (in quantities consistent with an emissions cap). A credit represents a reduction in greenhouse gases (GHGs) equivalent of one metric ton of carbon dioxide (tCO_2e). A permit allows the holder to emit 1 tCO_2e. Permit-based systems are commonly referred to as *cap-and-trade systems*. The carbon market is commonly described as consisting of a *compliance market* and a *voluntary market*. The former serves buyers who are regulated and the latter serves buyers who wish to offset

their emissions on a voluntary basis. While various credits and permit in theory are equivalent in that they represent 1 tCO_2e, these are not necessarily fungible.

The development of the global carbon market was largely driven by the adoption of the Kyoto Protocol (KP) and its flexibility mechanisms: Clean Development Mechanism (CDM), Joint Implementation (JI), and Emissions Trading (ET). The CDM, due to its early introduction was particularly important. While there existed theoretical knowledge and practical experience with credit-based systems prior to 2000 when projects could officially start earning Certified Emissions reductions (CERs) under the CDM, the ideas of requiring (investment) additionality and applying project-specific baselines were novel in a crediting context. 'Additionality' is not mentioned in the literature examined describing either the theory of emissions trading or the experiences with credit-based systems preceding carbon credit trading. Furthermore, earlier credit-based systems generally relied on rate-based standards, not project-specific baselines.

Methodologies for creating carbon credits developed largely under the CDM. CDM methodologies developed bottom-up and project participants were responsible for proposing new methodologies which were subsequently approved by the CDM Executive Board (EB). There are a range of different types of carbon credits, but the CDM and other most carbon standards require an assessment of additionality and that the emissions reductions are quantified by comparing a project's emissions to a project-specific emissions baseline. The CDM has by far dominated the carbon credit market (see also Ch. 1) and CDM methodologies are also applied under other carbon standards.

3

CARBON CREDITS & EFFECTIVENESS

3.1 Introduction

The primary aim of this chapter is to critically examine the critique of the effectiveness of carbon credits. The questions pursued are: 'What is effectiveness, and how is it approached in the critique of carbon credits?' The chapter starts with a discussion of various more general policy-related concepts of *effectiveness* (section 3.2). This is useful because the critical examination of the broader critique of carbon credits performed for this chapter found that the critique is not neatly based on one concept of *effectiveness*, but many. These are not necessarily articulated. Furthermore, it appears that few, if any, papers have examined how effectiveness has been approached in the critique. To obtain a better understanding of how effectiveness is approached, the following are examined: (a) the concepts of effectiveness underlying (i) the explicit critique of the CDM in the climate policy literature, and (ii) the implicit critique of the CDM embodied in the existence of VER activities; and (b) the link between effectiveness and the political and public critique of VERs and carbon credits (section 3.3). This chapter ends with a concluding discussion (section 3.4).

The carbon credit market is largely dominated by the CDM (Ch. 1 and 2) and it has been discussed extensively in the climate policy literature (Paulsson, 2009). In contrast, relatively little has been written about JI or VER in the academic literature.[29]

[29] A literature search using ScienceDirect for articles including the key-word 'clean development mechanism' excluding ('AND NOT') 'joint implementation' gave 322 hits. Search criteria: 'Journals'; 'Title, Abstract, Keywords'; published 2000 or later. The year 2000 was used because in the late 1990's 'joint implementation' was used to refer to project-based emission reducing activities more generally (see *e.g.* Michaelowa, 1998; Rentz, 1998). Conversely, 'joint implementation' excluding 'clean development mechanism' returned 38 hits. The search was performed during the spring of 2011. Note that the search results were not further examined. Hence, it is possible that the number of articles on JI is overestimated. The search for 'voluntary emission reductions' 'OR' 'voluntary emissions reductions' gave 2 hits; 'voluntary market' AND 'carbon' gave 11 hits and 'voluntary carbon market' gave 4. ScienceDirect is a full-text scientific database offering journal articles from more than 2,500 peer-reviewed journals.

The relatively large interest in the CDM can perhaps also be explained by its relative complexity. For example, in contrast to the CDM, the JI does not include the objective of sustainable development; and the environmental credibility of ERUs is not crucial for the Kyoto target (see Ch. 2). VER activities have received increasing political and public attention since the mid-2000s, but it is not a policy-governed instrument (see Ch. 2). This may explain why it appears to have received little consideration in the academic climate policy literature. By addressing VERs in this chapter (see below), it appears that a gap in the literature has been filled.

Effectiveness can be understood as related to the achievement of some end, *e.g.* emissions reductions, sustainable development, long-term climate change mitigation. Nevertheless, there are many concepts of *effectiveness* and these are not necessarily compatible. For example, some define *effectiveness* as the achievement of the stated objectives and the ability to address the problems that led to the treaty (Brown Weiss and Jacobson, 1998). Others opt for a slightly different interpretation which focuses on the extent to which behavior of targets is changed in a way that furthers the goals of an agreement (Victor *et al.*, 1998; Young and Levy, 1999). There are also several commonly acknowledged concepts (*e.g. goal achievement* and *cost effectiveness*) which are related to the policy intervention and its effects (Vedung, 2009). This chapter will not go into the conceptual disagreements. Instead, various concepts are introduced for the purpose of building a foundation necessary for examining how effectiveness is primarily approached in the critique of the CDM.

The critique of the CDM is wide-ranging. It has been described both as a 'raging success' as well as 'flawed' and 'Alice in the Wonderland make-believe' (Wara, 2008; The Economist, 2009; Grubb *et al.*, 2011). While some of the key topics in the critique are briefly discussed, the aim is not to offer a comprehensive review. This has already been done in other studies which have addressed topics including *e.g.* sustainable development, emissions reductions, technology transfer, excessive profits, equity, leakage, pipeline delays, transaction costs, and 'successes' (Paulsson, 2009; Grubb *et al.*, 2011). Instead this critique was critically examined to study how effectiveness was approached. In addition, the critique concerning VER and its relevance for the compliance market was examined. Furthermore, Kramer (2010:153) mentioned that the existence of the voluntary market can be viewed as indirect critique of the compliance market. If the compliance credit market (basically the CDM) work well, there would be no need for voluntary crediting as compliance credits (such as CERs) can be, and are, traded for non-compliance purposes.

3.2 Concept of Effectiveness

Effectiveness is a relative concept, relating to the degree of achieving some end. Table 3.1 offers an overview of the four different concepts of *effectiveness* in policy evaluation mentioned by Vedung (2009). These are related to *inputs*, *outputs*, *outcomes*, or *impacts* of policy intervention (these terms are explained further below), as suggested by Table 3.1 and shown more clearly in Fig. 3.1. The term *impact*s was not used by Vedung, but he noted that *outcomes* can be differentiated as 'immediate', 'intermediate' and 'final'. *Final outcomes* are comparable to the term *impacts* used in this dissertation.

Table 3.1
Four Concepts of Effectiveness in Policy Evaluation

Measure	Description [a] (numerator/denominator)
Effectiveness 1: 'Effectiveness', degree of goal achievement (not considering costs)	Expected & unexpected outcomes / Expected outcomes
Effectiveness 2: Productivity	Outputs / Costs of outputs
Effectiveness 3: 'Efficiency' (cost-benefit analysis)	Monetary value of outcomes / Costs of intervention
Effectiveness 4: 'Efficiency' (cost-effectiveness analysis)	Outcomes in physical units / Costs of intervention

[a] *Contents of the cells should be read as: 'numerator' in relation to (or divided by) 'denominator'.*

Source: Based on Vedung (2009), Table 6.10 (p. 151), and pp. 91-92

Fig. 3.1 illustrates the relationship between environmental policy intervention and its impact on human behavior and the environment through the key elements of *inputs*, *implementation process*, *outputs*, *outcomes* and *impacts* (Vedung, 2009; Premfors, 1989; Guedes Vaz *et al.,* 2001). It also illustrates the concepts of productivity, cost effectiveness, and goal achievement and the respective elements to which these are linked. In contrast to Vedung (2009), Guedes Vaz *et al.* (2001) did not differentiate between productivity and cost effectiveness.

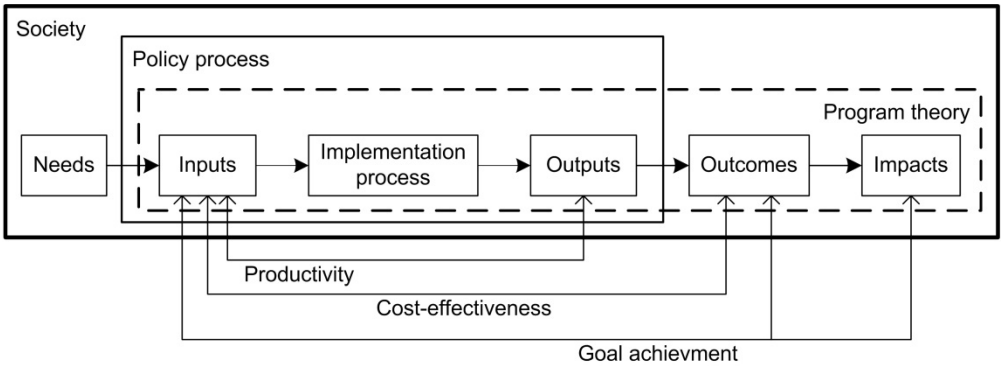

Fig. 3.1 Program Theory and Concepts of Effectiveness

Source: Based on Fig. 6 Policy Evaluation in Guedes Vaz et al. (2001), p. 20; Vedung (2009) and Coryn et al. (2011).

Inputs refer to the problem identification, decisions, and resources dedicated to the design and implementation of an intervention, *e.g.* administrative structures, awareness raising, financial investment, staff, training, *etc*. *Implementation* can be defined as the process starting with the decision to make an intervention and ending with outputs. Legislation alone is not enough to affect behavior. Through the *implementation process* intent gets translated into action and it determines the practical influence of a commitment (Victor *et al.*, 1998:1-2). While it can be seen as covering various elements (Vedung, 2009), in this dissertation *implementation* is understood as taking place between inputs and outputs. *Outputs* refer to the tangible results, *e.g.* number of power plants constructed, number of CDM projects registered, number of CERs issued, *etc*. The responses of target groups to these outputs are in turn referred to as *outcomes*, *e.g.* reduction in GHG emissions from industry, increased energy efficiency among households, and shifts in the use of different transport modes. *Impacts* refer to the effect of these changes in behavior on the environment and human health.

Goal achievement may be compatible with the Brown Weiss and Jacobson (1998) concept of *effectiveness*. However, this will largely depend on how 'expectations' are interpreted in the definition of *goal achievement*. Brown Weiss and Jacobson clarify that *effectiveness* should not be equated with *compliance*. The latter is traditionally interpreted as whether or not behavior conforms to the letter of an agreement (Victor *et al.*, 1998). Compliance does not necessarily mean that objectives will be attained (Brown Weiss and Jacobson, 1998). Furthermore, the achievement of objectives does not necessarily mean that the problem(s) intended to be addressed will be resolved. The Brown Weis and Jacobson concept relates to 'objectives' and 'problems'. This suggests that inputs and impacts are considered.

Both the Victor *et al.* (1998) and Young and Levy (1999) definitions of *(political) effectiveness* agree that specific regulatory rules, protocols, and operational targets are a means to an end and not ends in themselves. Institutions that spur measures that go beyond what is required for compliance are considered more effective than those that elicit the minimum behavioral change. The focus is on the extent to which the behavior of targets is changed in relation to the goals of an agreement. However, effectiveness is not equated to the ability to eliminate the environmental threat (Victor *et al.*, 1998; Young and Levy, 1999). This suggests that *political effectiveness* stops short of the impact level and that inputs and outcomes are considered.

There are numerous concepts of *effectiveness* in the policy-related literature. An important differentiating factor appears to be the relationship of the concept to the elements of the *program theory*. This is made up of the *program process theory* (inputs and implementation) and the *program impact theory* (outputs, outcomes and impacts) (Coryn *et al.*, 2011). Among the concepts of *effectiveness* reviewed in the literature, the numerator is an element found in the program impact theory. Most seem to be concerned with outcomes. The denominator appears to be inputs in the form of objectives and sometimes also costs.

However, the critique of the CDM in the climate policy literature is not limited to primarily considering outputs, outcomes and impacts. For example, Ma (2010) argued, largely based on an analysis of the legal institutions (inputs), that the CDM was defective and flawed in terms of promoting technology transfer. There are studies addressing *e.g.* the CDM methodologies (Sharma and Shrestha, 2006; Schneider, 2009) and the CDM supervisory system (Lund, 2010). The methodologies and the supervisory system are components of the CDM implementation process. Furthermore, studies did not necessarily address goal achievement, cost effectiveness or productivity. For example, there are studies on technology transfer (*e.g.* Dechezleprêtre *et al.*, 2008; Schneider *et al.*, 2008; Seres, 2008) that focused on outputs (projects and CERs) and output quality (qualities of the projects). Another example of such a study, but which studies additionality, is Schneider (2009).[30] These observations indicate that it is meaningful to conceptualize *effectiveness* as related to the elements of the program theory at large.

The following concepts of *effectiveness*, which correspond to different elements of the program theory, are introduced for the purpose of examining how effectiveness is approached in the critique of the CDM: *input effectiveness, implementation effectiveness*, *output effectiveness*, *outcome effectiveness*, and *impact effectiveness*. These are applied here

[30] The study by Schneider (2009) is based on an analysis of the applied methodologies of registered CDM projects. The conclusion is that the CDM additionality assessment ('tools for demonstrating additionality') needs to be improved. Hence, the study also addresses the implementation process.

as heuristic tools for organizing the critique of the effectiveness of the CDM. They are not intended to replace existing concepts, and are introduced as supplementary tools. Examples of questions linked to these concepts include:

- *Input effectiveness*: Are the inputs sufficient for attaining certain outputs or outcomes?
- *Implementation effectiveness*: Is the implementation process conductive to achieving certain outputs or outcomes?
- *Output effectiveness*: How well do the outputs correspond to the expected outputs?
- *Outcome effectiveness*: How well do the outcomes correspond to the expected outcomes?
- *Impact effectiveness/ environmental effectiveness*: How can the environmental impact of an intervention be increased or safeguarded?

Papers addressing impact effectiveness in the CDM literature tend to apply the term 'environmental effectiveness' (see *e.g.* Kallbekken *et al.*, 2007; Francois and Hamaide, 2011). Impact effectiveness and environmental effectiveness are used interchangeably in this dissertation.

3.3 Approaches to Effectiveness in the Critique of Carbon Credits

3.3.1 Goal Achievement

In the CDM literature, a large number of papers and reports examine whether the mechanism is fulfilling its dual objective, *i.e.* emissions reductions and sustainable development (Paulsson, 2009). This appears to suggest that a large share of the CDM literature addresses *goal achievement*. An assessment of goal achievement considers the degree of goal achievement and causality. Furthermore, when considering the latter, both *direct* and *indirect effects* should be taken into account (Vedung, 2009). *Direct effects* are linked to the objectives, and are always expected. [31] In a policy intervention context, 'effectiveness' is often interpreted and evaluated in relation to such effects. Vedung (2009) define these as 'primary effects' intended and anticipated by decision-makers and which an intervention has at least indirectly and partially contributed towards. In the CDM context, direct effects are emissions reductions and sustainable development. *Indirect effects* (also known as *spin-off effects* and *auxiliary effects*) can be

[31] Vedung used the term *"huvudeffekter"* or 'primary effects'.

unexpected, as well as expected, and objectives. Indirect effects can be understood as effects which are beyond the space encompassing the direct effects anticipated by decision makers and which an intervention has at least indirectly and partially contributed towards (*ibid.*). Examples of indirect effects of the CDM can be *e.g.* technology transfer and *carbon leakage*. The latter is generally understood as an effect where mitigation efforts are offset by increased emissions elsewhere. For example, this can be caused by emissions sources moving locations, from a regulated to a less regulated country. As is further discussed below, while many studies found in the CDM literature address direct and indirect effects, few, if any, can be described as an assessment of goal achievement in the broader sense. Direct and indirect effects tend to be addressed separately, and studies tend to address a specific topic.

Direct Effects

Many studies address a topic related to emissions reductions, but few actually address emissions reductions. Key topics include additionality (*e.g.* Shrestha and Timilisina, 2002; Greiner and Michaelowa, 2003; Kartha *et al.*, 2005; Michaelowa and Purohit, 2007; Schneider, 2009) and baseline emissions (*e.g.* Michaelowa and Fages, 1999; Ellis and Bosi, 2000; Kartha *et al.*, 2004; Fischer, 2005; Sharma and Shrestha, 2006; Steenhof, 2009). Carbon leakage is also related to emissions reductions, but is addressed under 'Indirect Effects' (see below). As is commonly acknowledged, to achieve emissions reductions the question of additionality ('Is the project additional to normal practice?') cannot be separated from that of baseline emissions ('What are the emissions of normal practice?') (see *e.g.* Kartha *et al.*, 2004; Schneider, 2009). Despite this, there appear to be no studies which examine emissions reductions through an integrated examination of both additionality and baseline emissions. While *e.g.* Chomitz (2002) and McNish *et al.* (2009) addressed both, additionality and baseline emissions/emissions reductions were treated separately. In contrast, Michaelowa and Bode (2003) included an integrated analysis, but for the purpose of examining *perverse effects* (unexpected negative indirect effect) on investment decisions.

The environmental credibility of CERs is criticized based on analyses of the (investment) additionality of CDM projects (registered and/or in the pipeline) (Michaelowa and Purohit, 2007; Castro and Michaelowa, 2008; Schneider, 2009). While Castro and Michaelowa also included expert views, the focus was on (investment) additionality of the projects. By examining additionality with a sector-level perspective, Wara (2008) appears to be an exception. He questioned the effectiveness of the CDM based on analyses of sectoral effects of the CDM and addressed *e.g.* hydrofluorocarbon-23 (HFC-23) projects in developing countries and windpower in China.

Early on, in the literature on emissions baselines, it was noted that there are incentives to overestimate the emissions reductions in carbon crediting projects. Emissions baselines are crucial for the calculation of emissions reductions and credible baselines were seen as crucial for environmental integrity. Project-specific baselines were recommended over country-based baselines due to the uncertainties involved in the latter; but project-specific baselines raised the issue of carbon leakage (Michaelowa, 1998). Over time, a range of baseline approaches were considered and transaction costs were also taken into account (Michaelowa and Fages, 1999; Puhl, 1999; Ellis and Bosi, 2000). It was recognized that baseline setting would need to balance concerns for accuracy and environmental integrity on the one hand, and transaction costs on the other (Ellis and Bosi, 2000; Fischer, 2005). The literature on emissions baselines for electricity sector projects recognizes as key issues the counterfactual nature of the baseline and the development of accurate, consistent, transparent and practical methods that promote cost minimization (Kartha *et al.*, 2004; Murtishaw *et al.*, 2006; Steenhof, 2009). To accomplish this, they commonly stress the development and use of *standardized baseline methodologies*, applicable to multiple projects. Baselines applicable to multiple projects are generally referred to as *multi-project baselines* and *standardized baselines*. While these can involve a sector-level approach to baseline setting, this will depend on the baseline determination (Kartha *et al.*, 2004).

Despite quite harsh critique leveled against the environmental credibility of the CDM (*e.g.* Wara, 2008; Schneider, 2009), the mechanism has been described as successful.

> *It is a much more massive success than ever expected. Frankly speaking, we are suffering from the success of the CDM.*
>
> *Lex de Jonge, Chair of the CDM EB (at the time)*
> *COP 15 (Dec. 2009)*

The 'success' referred to by the Chair was the number of registered CDM projects and the volume of credits. Grubb *et al.* in turn note that "the CDM has resulted in a flood of projects" despite concerns regarding high transaction costs (Grubb *et al.*, 2011:560). Due to the impact of transaction costs on the concept of cost effectiveness (see next sub-section), this view suggests a closer link to goal achievement. The quantities of the projects and CERs are relevant as they will influence the extent of the effects at the outcome level. However, the focus is on the outputs (projects and CERs).

Assessing the degree of goal achievement under the CDM in relation to sustainable development is a challenging task. The definition of sustainable

development is not regulated under the KP and it is the host Party's prerogative to confirm whether CDM projects promote sustainable development (UN, 1998: Art. 12; UNFCCC, 2002a:20). Regardless of project type and location, there is no single, authoritative, and universally accepted approach or methodology for assessing sustainable development impacts (Olsen, 2005). Furthermore, contrary to emissions reductions, sustainable development benefits are not monetized under the CDM (Sutter and Parrenño, 2007). This induces a race-to-the-bottom in terms of sustainability criteria if there is competition for CDM projects among host countries (Sutter, 2003). For example in Chile, the third largest CDM host country in South America, there is no additional framework for assessing the sustainability of CDM projects and there is a lack of clear criteria (Rindefjäll, 2008). An environmental impact assessment is the only formal requirement of CDM projects. The CDM is seen as a mechanism for promoting investments and a way to attract foreign capital rather than an instrument for promoting sustainable development in the wider sense of the word (*ibid.*).

Although the assessment of the CDM's degree of goal achievement in relation to the objective of sustainable development is problematic, many question the CDM's contribution to sustainable development (see *e.g.* Paulsson, 2009). It is commonly acknowledged that there is little incentive to promote sustainable development, and that the CDM is biased towards promoting cost effectiveness (further addressed in section 3.3.2) (Sutter and Parrenño, 2007). Cole (2010) appears to be one of the few suggesting that sustainable development perhaps was not necessarily intended to extend beyond the mere existence of CDM projects. According to Cole, the intention of the CDM's Brazilian architects was to coerce compliance by Annex I countries with their emissions caps as an alternative means of achieving compliance. The sustainable development objective reflected the vision of these architects "that the CDM would foster projects that would reduce developing country GHG emissions, thereby enabling a decoupling of GHG emissions growth from economic growth" (Cole, 2010:18). As a result, Cole found that the CDM has largely achieved the original policy intent. This original vision is in stark contrast with the bulk of the CDM-related literature, which advocates broader notions of sustainable development.

Indirect Effects

In the CDM literature, the 'effectiveness' or 'success' and 'failure' of the mechanism have not only been related to direct effects, but also to what can be described as expected and unexpected indirect effects. For example, Grubb *et al.* (2011) note the scale of engagement and describe the CDM as "a success beyond the wildest dreams of its early architects" in terms of globalizing the climate change issue and creating acceptance for market-based mechanisms (Grubb *et al.*, 2011:556). These are not

explicit objectives of the CDM or mentioned in the Marrakesh Accords, and could be described as unexpected indirect effects.

According to Grubb *et al.* (2011), the CDM has also been very successful in mobilizing finance for mitigation technology investments in developing countries. They note that it vastly exceeds a decade's efforts through the Global Environment Facility (GEF) and other multilateral fund programs. In contrast, Ma (2010) found the CDM to be flawed, defective, and unsuccessful in terms of "implementing a part of the overall objectives of the Protocol – to promote technology transfer" (Ma, 2010:9/23). "Without effective institutions and enforcement mechanisms, international technology transfer is unlikely to take place on a scale sufficient to make any measurable difference. The obligations imposed on developed countries are simply 'soft' law and will evaporate in the competitive environment of self-interest" (Ma, 2010:11). Empirical analyses of the PDDs show that technology transfer is claimed in 33-43% of the cases but significant variation exists depending on *e.g.* geography, technology and project size and type; and technology transfer is more common for projects with foreign partners and large-scale projects (Haites *et al.*, 2006; Dechezleprêtre *et al.*, 2008; Seres, 2008; Seres *et al.*, 2009).

However, the CDM has no explicit technology transfer mandate and this is commonly acknowledged. Furthermore, the definition of technology transfer under the CDM is unclear. Despite this, technology transfer cannot be described as unexpected. Technology transfer is not an explicit CDM objective expressed in the KP, but the Marrakesh Accords 'emphasizes' that:

> *CDM project activities should lead to the transfer of environmentally safe and sound technology and know-how…*
>
> *UNFCCC (2002a), p. 20*

Developing countries see the CDM as a means to attract new, foreign capital and possibly to stimulate technology transfer. China, for example, has indicated that it will prioritize projects that bring technology transfer (Ellis *et al.*, 2007). Although the formal status of technology transfer within the CDM as well as its definition is ambiguous, the CDM is often referred to as a means to transfer technology.

CDM literature on leakage mentions *environmental effectiveness* (Chomitz, 2002; Kallbekken *et al.*, 2007). However, the CDM is not designed to promote emissions reductions beyond the KP. Therefore it tends to be difficult to talk about enhancing the environmental effectiveness of the CDM within the existing framework. Nevertheless, Kallbekken *et al.* (2007) see the CDM as a potential means to significantly reduce carbon leakage. In their view, the CDM, by lowering price differentials between Annex I and non-Annex I countries, can reduce the magnitude

of carbon leakage from countries with commitments under the KP to those without. Thereby, the CDM can potentially improve the environmental effectiveness of the KP. In contrast, Chomitz (2002) perceives that carbon projects will necessarily result in leakage and that this effect needs to be neutralized. In Chomitz's view, most energy-related carbon projects result in reduced demand for fossil fuels and thus falling prices. This leads to increased consumption of fossil fuels among those not participating in CDM projects and those without commitments under the KP. While the first perspective sees the CDM as potentially mitigating leakage effects in the Kyoto framework, the second considers the potential leakage effects as arising due to CDM activities. In two empirical studies of carbon leakage in the context of N_2O abatement projects, leakage was foreseen as a possible outcome of these projects being profitable under the CDM (Kollmuss and Lazarus, 2010; Schneider *et al.*, 2010). Due to low abatement costs relative to the price of CERs, these projects can generate very large profits under the CDM. Carbon leakage was foreseen as a possible consequence of production of adipic acid and nitric acid (where NO_2 is a byproduct) shifting from non-CDM plants to CDM plants. Despite differences in how leakage is conceptualized in the CDM literature, the various studies point to the difficulty of addressing climate change through local rather than global action (*c.f.* Sovacool and Brown, 2009). It has for example been argued that the environmental effectiveness of the CDM could be improved through the introduction of the discounting of CERs (*e.g.* Francois and Hamaide, 2011). This was seen as a possible way of enhancing climate change mitigation beyond the Kyoto commitments of the Annex I countries and improving the geographical distribution of CDM projects.

The distribution of CDM projects has been a concern since the inception of the CDM (Grubb *et al.*, 2011; Lütken, 2011). Suggestions for improving the geographical distribution include *e.g.* capacity building, discounting of CERs, and allowing the use of ODA as a complement to private investment (Paulsson, 2009). Equitable geographical distribution of CDM projects is not an explicit objective of the KP, but it is mentioned in the Marrakesh Accords.

> *Bearing in mind the need to promote equitable geographic distribution of clean development mechanism project activities at regional and subregional levels…*
>
> *UNFCCC (2002a), p. 20*

However, as with 'transfer of environmentally safe and sound technology and know-how' as well as 'sustainable development', 'equitable geographical distribution' is not defined under the CDM. An unclear definition implies that the distributional disparities can be perceived differently. While the distributional disparity has been noted in the CDM literature, few appear to have approached the issue of how to

interpret equitable distribution (*e.g.* Michaelowa, 2005; Jung, 2006; Boyd *et al.*, 2007; Paulsson, 2009; Grubb *et al.*, 2011). Although not defining equity, Cole (2010), Jung (2006) and Lütken (2011) can possibly be seen as exceptions of sorts. Cole compared the distribution of CDM projects and CERs across host countries with the proposed distribution of clean development fund (CDF) proceeds as proposed by the Brazilian proposal and concluded that the CDM has largely achieved the original policy intent. Jung (2006) compared the distribution of expected CERs to be issued by 2012 with an analysis of host country attractiveness for non-sink projects (*i.e.* excluding forestry), based on three indicators: mitigation potential, institutional CDM capacity, and general investment climate. In a similar study, it was noted that the CDM "is becoming remarkably equal, even in LDCs" (Lütken, 2011:1). Based on a simple numerical analysis, Africa is still struggling to catch up with Asia and Latin America. However, when correlating economic growth, carbon emissions, and CDM project development, Africa and particularly LDCs are no longer the 'lost world' (Lütken, 2011). The distribution appears to be largely accepted as a consequence of the market-based nature of the CDM. Furthermore, it seems that 'equitable distribution' tends to be perceived as a difficult issue to address, largely because the CDM is a market-based mechanism which tends to promote low cost emissions reductions (*e.g.* UNFCCC, 2006a; Lütken, 2011).

3.3.2 Cost Effectiveness

Cost effectiveness was an important reason for introducing the market-based mechanisms in the KP and it is a central concept in the rhetoric of carbon credits. *Cost effectiveness* can be seen as an economic interpretation of effectiveness; and it relates to the cost of achieving a given target (Adger *et al.*, 2003). Cost effectiveness is a prerequisite for *(economic) efficiency*, which is an important concept in (welfare) economics (see *e.g.* Perman *et al.*, 2003). According to Vedung (2009), the efficiency criterion is the most important criterion in public administration. It involves maximizing the attainment in government objectives employing strictly limited resources.

In principle, an evaluation of cost effectiveness should consider effects more broadly (Green, 2008; Vedung, 2009). Despite this, a trade-off between cost effectiveness and sustainable development is commonly acknowledged in the CDM literature. 'Cost effectiveness' also appears to be viewed as being in opposition to technology transfer and equitable geographical distribution. These trade-offs seem to be perceived as arising largely because only emissions reductions have a market price – neither technology transfer nor sustainable development is reflected in the CER price. Studies related to emissions reductions (*e.g.* additionality, baselines, leakage) rarely

mention the value of environmental integrity in relation to promoting cost effectiveness (*e.g.* Kartha *et al.*, 2005; McNish *et al.*, 2009; Schneider, 2009) (for exceptions see Sutter and Parrenño, 2007; Alexeew *et al.*, 2010). Instead, in the CDM literature on transaction costs, the ascertainment of environmental integrity is largely perceived as a source of transaction costs, which have negative effects on cost effectiveness. There is no consensus on the definition of *transaction costs*; but based on studies of transaction costs in carbon crediting, it can be tentatively understood as consisting of (a) costs involved in bringing credits to the market, but which are not attributed to the physical process of reducing or removing GHGs, and (b) costs involved in the market exchange (Fichtner *et al.*, 2003; Michaelowa *et al.*, 2003; Krey, 2005; Michaelowa and Jotzo, 2005; Chadwick, 2006; Antinori and Sathaye, 2007).

However, CERs by nature demand vigilant approval, monitoring, and evaluation procedures. "[W]ithout these processes, CERs would cease to be a believable commodity, defeating the purpose of the CDM both as a method of technology transfer and as a method of reducing greenhouse gases at least cost" (Chadwick, 2006:271). Unlike computers, carbon credits are administratively created goods; and ensuring the environmental integrity of the credits creates transaction costs (Chadwick, 2006). The environmental integrity of the CERs affects the cost effectiveness of the CDM and the KP. This is because 'empty' or 'fake' credits mean that targets will not be reached; and target achievement is an integral part of the concept of *cost effectiveness*. In principle, the trade-off is between transaction costs and cost effectiveness, rather than environmental integrity (or environmentally credible CERs) and cost effectiveness.

Although it is commonly agreed that the CDM is biased towards promoting cost effectiveness, few appear to have studied the cost effectiveness of the CDM (for exceptions see Sutter and Parrenño, 2007; Green, 2008; Alexeew *et al.*, 2010). Green (2008) noted the importance of goal achievement more broadly for the concept of *cost effectiveness*. Nevertheless, his empirical analysis was limited to comparing CER prices and costs for producing CERs. Sutter and Parrenño's (2007) analysis and definition of 'cost-efficient' emissions reductions only covered emissions reductions. In contrast to Green (2008), they addressed emissions reductions (outcomes) rather than CERs (outputs). The Sutter Parrenño analysis measured the likelihood of the emissions reductions claimed by projects really occurring. They approached the issue of cost effectiveness by analyzing the environmental credibility of CERs. This was done by examining the (investment) additionality of CDM projects through an analysis of the internal rate of return (IRR). The approach introduced by Sutter and Parrenño was also applied by Alexeew *et al.* (2010). More commonly, it appears that 'cost effectiveness' is approached indirectly or partially in papers on transaction costs in the CDM literature. These studies tend to consider the effects of transaction costs on the cost of generating CERs, on CER prices and on CER volumes. Higher transaction

costs lead to lower trading volumes and higher credit prices (Michaelowa and Jotzo, 2005; Chadwick, 2006). Transaction costs reduce the CDM's ability to promote cost-effective achievement of the Kyoto target. One interpretation is that 'cost effectiveness' in the CDM literature tends to be approached in a relatively narrow sense. Another is that studies are more closely related to the concept of *productivity* rather than *cost effectiveness*, due to the focus on outputs rather than outcomes (see Table 3.1).

In the CDM literature, 'cost effectiveness' has been approached directly through analyses of CER price and cost differentials and the environmental integrity of the CERs and indirectly through studies of transaction costs. This implies that studies focus on *low-cost* credits or emissions reductions, depending on whether outputs or outcomes are addressed. In the CDM debate and literature, 'cost-effective' and 'low-cost' tend to be used interchangeably. However, *cost effectiveness* implies target achievement at least cost. Therefore, in this dissertation a distinction is made between 'cost-effective' and 'low-cost'. In addition, to avoid ambiguity the following are also differentiated: *low-cost credits* and *low-cost emissions reductions*. *Credits* can be earned through various carbon standards and they are based on assessments of *emissions reductions*. *Low-cost emissions reductions* are valuable as they can promote cost effectiveness in the contexts of the CDM and the KP by promoting target achievement at least cost. *Low-cost credits* do not necessarily reflect low-cost emissions reductions, and this depends on the environmental integrity or credibility of the credits. The credibility of the credits depends on the methodologies and the supervisory system. Ideally, carbon credits and emissions reductions are in principle interchangeable in that each credit is equivalent to a reduction or removal of 1 tCO_2e. However, the environmental integrity of the CERs is questionable due to weaknesses in the additionality assessment (*e.g.* Schneider, 2007). This implies that the CERs and emissions reductions are not necessarily interchangeable in practice.

The CDM has been criticized for excessive profits (Grubb *et al.*, 2011). One concern expressed by Wara (2008) relates to the large 'windfall profits' enjoyed by HCFC-22 producers through the CDM. In the production of HCFC-22, HFC-23 is produced as a byproduct. It is a very potent GHG. One ton of HFC-23 is the equivalent of 11700 tCO_2. By capturing and destroying HFC-23 under the CDM, a developing country HCFC-22 producer can earn more than twice what it can from selling its primary product. It appears that virtually all HCFC-22 production in developing countries as of 2005 was participating in the CDM. While abating all developing world HFC-23 emissions would cost approximately $31 million per year, it will cost between €250 and €750 million to abate 2005 non-Annex B HFC-23 emissions. This is a remarkably inefficient path to an environmental goal (Wara, 2008:1789). This critique has been countered by arguments that HFC-23 was previously vented into the atmosphere and abatement entails increased costs. This

means that the additionality of these gas capture-and-destruction projects was relatively clear and straightforward. Furthermore, the CDM was designed to identify and realize low-cost abatement opportunities not otherwise being realized. Hence, many have commented that the CDM is merely doing its job (*e.g.* Grubb *et al.*, 2011).

It is not uncommon to hear that 'the CDM is doing what it was designed to do', *i.e.* promote low-cost emissions reductions (*e.g.* Grubb *et al.*, 2011). This view appears to suggest that the CDM can be regarded as effective considering its design. A problem with this argument or statement and its implied conceptualization of effectiveness is that it is difficult to fail to achieve 'what it was designed to do'. In the argumentation, outputs or outcomes are essentially excused by the design. As such, the statement may appear as a way to deflect critique. However, what Wara (2008) referred to as 'windfall profits' is in economic theory more commonly known as *producer surplus* (see *e.g.* Perman *et al.*, 2003). Those who can reduce emissions at lower cost will reap greater benefits from the sales of CERs. This does not mean that cost effectiveness cannot be achieved. Furthermore, excluding the low-cost abatement projects as proposed by Wara (2008) would in theory lead to a higher CER price. This suggests that the comment by Grubb *et al.* (2011) is in principle correct. However, in the CDM context it is prudent to question whether 'low-cost emissions reductions' was the only goal and expectation. Furthermore, the critique concerning environmental credibility challenges the assumption that the 'emissions reductions' are real to begin with. This implies that the 'emissions reductions' may not be as low-cost as perhaps believed.

In summary, within the CDM there appears to be tension between the following: (a) low-cost CERs and the cost effectiveness of the CDM (which is exacerbated by the KP only creating demand for low-cost CERs); and (b) low-cost emissions reductions and the cost effectiveness of the CDM. While the first conflict is an issue, it is not perceived as representing a *goal conflict* in this dissertation. This is because while low-cost emissions reductions are believed to be a goal, low-cost CERs are not. This distinction arises as a direct consequence of the questionable environmental integrity of the CERs. The second conflict suggests that there is a goal conflict within the CDM. Furthermore, as low-cost emissions reductions are related to the ability to achieve the Kyoto target at least cost, a trade-off between the cost effectiveness of KP and the cost effectiveness of the CDM appears also to exist. As suggested by Sutter and Parrenño (2007), to promote broader goal achievement it is desirable that anticipated effects (such as sustainable development) are better reflected in the CERs.

3.3.3 VER Activities & Implicit Critique of the CDM

The CDM is commonly referred to as part of the compliance market and this market is usually distinguished from the voluntary market (see *e.g.* Lovell and Liverman, 2010; Linacre *et al.*, 2011). This appears to suggest that the CDM and voluntary market are largely separate markets. However, in reality there is a complex relationship between the two. The CDM and voluntary market are associated in several ways, and the former has affected developments in the latter. A rather concrete example is the development of the Gold Standard (GS). This was triggered by the perceived lack of incentives for promoting sustainable development in the CDM. Work on developing the *'Gold Standard Rules and Procedures for CDM'* was initiated in 2001 as a response to the establishment of the CDM rules and procedures at the climate negotiations in Marrakesh. This work was led by the World Wide Fund for Nature (WWF), SouthSouthNorth (SSN) and Helio International. The key aim was to "ensure that [CDM] project implementation led to real and verifiable emissions reductions and made a measurable contribution to sustainable development" (Gold Standard"About Gold Standard", 15 Feb. 2011). The methodology was launched in 2003 and the Gold Standard Foundation was established in 2006 and is owned by its NGO supporters (numbering over 60 NGOs worldwide) (*ibid.*). Today, the GS is a labeling scheme applicable to various crediting activities. The development of the GS and the implicit critique it represents can be linked to the critique of additionality and sustainable development in the CDM literature. The GS can be viewed as an effort to promote higher quality outputs.

There are also other links between the CDM and the voluntary market. Firstly, while voluntary credits cannot be used in the compliance market, CERs are sold in the voluntary market. In 2009, of the carbon standards applied in the voluntary market, the CERs/ERUs (sold to voluntary buyers) appear to have fetched the highest average price in the voluntary market (Hamilton *et al.*, 2010b). CDM methodologies have influenced several voluntary carbon standards and CDM methodologies are also applied to voluntary offsetting projects (Kollmuss *et al.*, 2008; Hamilton *et al.*, 2010b). In 2009, of the carbon standards used in the voluntary market, the CDM/JI accounted for 0.4% of the traded volume (OTC). In addition, according to a market survey, with regards to standards used by suppliers, 35% of the participants intend to use the CDM. It was, however, unclear which suppliers intend to use such standards in the voluntary carbon markets (Hamilton *et al.*, 2010b). The high price and interest in the CDM appears to suggest that CERs, despite the critique in the CDM literature, are acknowledged by the market as credits with relatively high quality. However, the share of the traded volume is very small. The reason for this cannot be given without further investigation. It could perhaps be explained by the relatively high price relative

to other credits, but it could also be due to *e.g.* the supply not matching the output quality demanded.

Secondly, in 2007 there was a move to *originate* (create) VERs from projects awaiting CDM registration and this appears to be a continuing feature (Hamilton *et al.*, 2008:8; Hamilton *et al.*, 2009). This development coincided with the removal of *retroactive crediting* under the CDM (*i.e.* the ability to earn credits for emissions reductions prior to registration). Retroactive crediting was only available for projects which started between 1 January 2000 and 18 November 2004 and which were validated before the end of 2005 and submitted to registration by 30 April 2007. However, pre-registration credits, also known as 'pre-CDM VERs', can be earned through various voluntary carbon standards, *e.g.* the Gold Standard, VER+, VCS, and many more (Kollmuss *et al.*, 2008). The Gold Standard developed a rule in 2007 which allowed projects to earn credits prior to registration in recognition of unpredictable delays in the CDM registration process (GS, 2007). These credits are a major source of credit supply. This is because they provide an early revenue stream crucial for project development (GS, 2009). The voluntary market is no longer only a means for consumer action; it is also an alternative source of carbon finance (Hamilton *et al.*, 2009). By acting as a sort of temporary substitute market to the compliance market, the voluntary market appears to have supplemented the CDM by mitigating risk. The implicit critique suggests that there are problems in the CDM's implementation process. This interpretation appears to be supported by reports of troublesome pipeline delays in the CDM (see *e.g.* Grubb *et al.*, 2011). "It now takes an average of 572 days for a CDM project to go through validation and registration and another 607 days until first issuance (*i.e.*, over three years in total)" (Kossoy and Ambrosi, 2010:47). Delays involve increased transaction costs. Transaction costs in the CDM have been linked to complex and evolving regulations, regulatory inefficiencies, and capacity bottlenecks (Kossoy and Ambrosi, 2010).

Finally, there are indications suggesting that projects that have found it difficult to register as CDM projects have turned to the voluntary market. Personal communications with project developers of forestry and small-scale renewable projects revealed that they have chosen the voluntary market over the CDM due to *e.g.* complexity and costs involved in getting through the CDM process, lack of methodologies (which take time and money to develop and get approved, see below), and difficulty in getting new methodologies approved.[32] Similar observations are reported by Merger and Pistorius (2011). It can also be noted that the OTC voluntary market is the largest market for forestry-based credit transactions (Hamilton *et al.*, 2010a; Merger and Pistorius, 2011). By the end of 2008, 74% of the accumulated

[32] Informal private conversations and discussions with project developers while attending various carbon conferences (Carbon Expo and Carbon Market Insights, 2005-2010).

forest deals (15.3 $MtCO_2$) were reported as occurring in the OTC voluntary carbon markets. In comparison, the CDM market only represented 2% (0.5 $MtCO_2$).[33] In addition, CDM data show that forestry projects are underrepresented. By 3 November 2011, only 32 afforestation and reforestation projects were listed as registered (CDM 'Project Search' database). This is less than 0.9% of the total number of registered projects (3557) at the time.

The disadvantage of small-scale projects in the CDM has been noted in the CDM literature and at the climate negotiations (Michaelowa *et al.*, 2003; Krey, 2005; Michaelowa and Jotzo, 2005; Chadwick, 2006; UNFCCC, 2006b: Decision 4/CMP.1). A broader study of project-based GHG emission reducing projects found that small-scale projects were generally disadvantaged (Antinori and Sathaye, 2007). In this study, transaction costs were found to range between 0.03 $\$/tCO_2e$ for larger projects to 4.05 $\$/tCO_2e$ for smaller ones.

There appears to be agreement that a large share of the transaction costs arise between project design and registration in the project cycle (referred to as 'pre-implementation' or 'upfront' costs) (see section 2.2.3, 'CDM Project Cycle', Step 1-4) (Michaelowa *et al.*, 2003; Krey, 2005; Michaelowa and Jotzo, 2005; Chadwick, 2006). Later studies of transaction costs in CDM projects appear to agree that the CDM's administrative process, which projects must pass through to obtain CERs, gives rise to a significant share of the transaction costs (Krey, 2005; Chadwick, 2006). Important sources of transaction costs include the completion of the PDD, validation and methodology development. However, to avoid disproportionately high transaction costs for small-scale projects, there are now simplified modalities and procedures in place for these projects. In addition, for example the registration fee is differentiated depending on the size of the project and projects with expected average annual emissions reduction over the crediting period below 15,000 tCO_2e are exempt (UNFCCC, 2006b: Decision 4/CMP.1; UNFCCC, 2011c). The number of small-scale projects has increased over the years. By 1 April 2010, 43% of the registered CDM projects were small-scale (CDM 'Project Search' database). The implicit critique and that in the CDM literature suggest that there may be problems in the CDM implementation process which are reflected in the outputs (project type).

3.3.4 Critique of VER & Effectiveness

There was significant growth in the voluntary market in 2006 and carbon trading was increasingly noticed in the public media. By 2007, VER became a target for political

[33] Percentages were calculated based on data provided by Hamilton *et al.* (2010a: VI). This was the most recent forest carbon market report available (by 9 Sep. 2011).

concern and action. The voluntary market's "lack of clarity and integrity" became a political issue as "offsets as a whole…risk this taint from a few failed projects" (UK Parliament, 2007:3). Through carbon emissions trading, GHG emissions now have a price. Most agree that this is an important step towards reducing our dependence on fossil fuels and addressing climate change. At the same time, carbon credits in particular have received a lot of negative media attention over the past few years. Mounting reports have been brought to the public eye about 'carbon credit fraud', windfall profits, and investment in dubious projects (*e.g.* Burnett, 2009; Europol, 2009; Gupta, 2010; Mason, 2010; Rogers, 2010; SVT, unknown publication date). However, permits have also been targeted (Mason, 2009; EurActiv, 2010; Mason, 2010). Due to an often seemingly *ad hoc* use of the terms 'allowances', 'credits', 'offsets' and 'permits' in the media, these emissions rights have at times been portrayed as equivalents; and the carbon market's complexity has not been conveyed unambiguously. While the primary target of concerns in this international debate has been credits, emissions trading as a whole risks losing credibility in the public eye (see *e.g.* UK Parliament, 2007; 2008).

Credits have been compared with letters of indulgence, a simple and convenient way for the rich to ease their carbon-ridden conscience. The main purposes have been described as assuaging guilt and image-polishing (The Economist, 2006). However, as was also noted in The Economist, to fulfill these purposes, carbon credits must be environmentally credible.

Fig. 3.2 Illustration of Carbon Credits
Source: The Economist (2006), (artist unknown)

A key concern is the environmental credibility of the credits, *i.e.* output quality. As noted at the Carbon Expo 2010, while fraudulent behavior needs to be addressed it is not a problem specific to carbon credits. A specific and important concern for carbon credits in general is 'additionality' and the difficulty of showing that emissions

reductions would not have taken place with or without credits (The Economist, 2006; 2009).

VER is a private sector initiative. This means that it is difficult to apply effectiveness concepts related to the program theory and program objectives in particular. Due to this, goal achievement and cost effectiveness are less relevant, but an effectiveness concept related to outputs is applicable and meaningful. This is because *outputs* are not necessarily limited to being an element in the impact theory, but can also be conceptualized as a commodity (*e.g.* coffee, gold and grain). In addition, *environmental credibility* (or *environmental additionality*) is a meaningful concept in relation to carbon credits in general, and it can be linked to output effectiveness and to other effectiveness concepts (further discussed in Ch. 4).

3.4 Conclusions from Examining the Critique of Carbon Credits

The critique of the effectiveness of carbon credits was examined through a study of the explicit critique of the CDM in the climate policy literature, the implicit critique of the CDM embodied in the existence of VER activities, and the political and public critique of VERs. In the CDM literature it appears that effectiveness is not approached in a wider sense, *e.g.* as *goal achievement* or *cost effectiveness*, but often in a topic-specific context. Many do, however, address topics that are related to one or both of these two effectiveness concepts, including *e.g.* investment additionality and emissions baselines (which are related to emissions reductions), sustainable development and technology transfer. Furthermore, the critique of CDM can be linked to concerns about effectiveness related to the different elements of the program theory. In this dissertation, the following terms were introduced: *input effectiveness*, *implementation effectiveness*, *output effectiveness*, *outcome effectiveness*, and *impact effectiveness* (or *environmental effectiveness*). The analysis of the critique of the CDM suggests that all of these can be seen as represented. This indicates that effectiveness can be interpreted in various ways.

It appears that *output effectiveness* can be a meaningful concept for describing the critique of carbon credits more generally. Although there is variation, it seems that a relatively larger share of the studies in the CDM literature tend to focus on projects and/or CERs, *i.e.* on the *outputs*. Critical literature appears to be largely concerned with the quality of the outputs and those claiming that the CDM is a success with the quantity of the outputs. Some of the implicit critique of the CDM as manifested by developments in the voluntary market and the critique of VERs can also be linked to output quality. Environmental credibility of carbon credits is a common and central concern. Nevertheless, the CDM, which dominates the carbon credit market, has also made notable achievements. Outputs in terms of number of projects and volume of

credits appear to have far surpassed expectations. The reason for political and public interest in the VER market was in turn the rapid growth in the voluntary market.

The CDM is a project-based mechanism. It results in CDM projects and CERs. Intuitively, focusing on these outputs makes sense. Studies in the CDM literature relating to the topics of emissions reductions, sustainable development and technology transfer seem inclined to address outputs. The quality and the quantity of the outputs influence the scope of the effects at the outcome level, *i.e.* they affect outcome effectiveness. However, from a policy perspective it is also relevant to keep in mind not only outputs but the other elements included in the program impact theory. Among the concepts of *effectiveness* reviewed in the policy-related literature, most seem to be concerned with outcomes. However, this element appears to have been addressed by relatively few CDM studies. The examination of the concept of *effectiveness* and the critique of carbon credits in this chapter suggests that the concepts of *output effectiveness* and *outcome effectiveness* can be useful in that they reflect differences in the level of analysis. In this dissertation, studies (or statements) which are concerned with outputs (*e.g.* projects and CERs) and their quality or quantity are categorized as related to output effectiveness; and those concerned with responses of target groups to these outputs (*e.g.* emissions reductions) are categorized as related to outcome effectiveness.

Emissions reductions are (expected) outcomes of the CDM. In this context, to promote real (or environmentally additional) emissions reductions it is commonly recognized that (investment) additionality and emissions baselines are important. Investment additionality has primarily been addressed through studies of projects, *i.e.* outputs, and emissions baselines through studies concerning emissions reductions, *i.e.* outcomes, primarily at project and sector level. A *project-level approach* (or *project-specific approach*) implies that outcomes are measured at project level and a *sector-level approach* implies that outcomes are measured at sector level. However, no CDM study appears to have approached environmental additionality, the topics of investment additionality and emissions baselines being generally addressed separately in the CDM literature. Environmental additionality is further examined in the remainder of this dissertation, and the following chapter examines the concept of *additionality* and its links to the concept of *effectiveness*.

Despite the CDM being described as a success in terms of output quantity, over the past few years the number of project registrations has been falling (Ch. 1 and 2). While environmental additionality can be fostered through improved governance (*e.g.* methodologies, standards, and procedures for validation of projects and verification of emissions reductions), the private-sector engagement which is necessary to achieve greater outputs is less easily addressed. Participation of firms in carbon crediting or offsetting, as producers or buyers of credits, is voluntary. It is not regulated in the current context. Crediting (or credit creation) is affected *e.g.* by how much time and

money it takes to become a carbon crediting project and expectations of the future (will there be demand for credits, and what price can be expected?). Improved governance can *e.g.* reduce pipeline delays and reduce barriers by making applicable methodologies available. However, future demand largely depends on the international negotiations for a post-2012 agreement on climate and the economic situation in the world. These are not as easily addressed. Some of the governance problems in the CDM context appear to have been addressed through private initiatives and the voluntary market, but it remains to be seen whether there is enough demand in this market to counteract the uncertainty about the future of CDM. The significant decline in annual CDM registrations since 2008 suggests that this is not the case. While output quantity is relevant for effectiveness, this is not further addressed in this dissertation.

4

ADDITIONALITY & CARBON CREDITS

4.1 Introduction

The primary aim of this chapter is to extend the understanding of 'additionality' in the CDM context. In the creation of carbon credits, investment additionality and baselines are instrumental. Investment additionality is generally acknowledged as crucial for environmental credibility in the literature on carbon credits (see Ch. 3). In contrast, 'additionality' is not mentioned in the literature describing earlier credit-trading programs (see Ch. 2). This difference implies that there is a fundamental difference in how environmental credibility or environmental additionality is approached. By extension, effectiveness is also pursued quite differently. An ambition of this chapter is to lay the necessary foundation relating to the concept of *additionality* for discussing these differences later in Ch. 8. This discussion follows an in-depth empirical examination in Ch. 5-7 of how environmental additionality is approached under the CDM.

The present chapter seeks to broaden the understanding of additionality in the CDM context through a critical examination of the concept of *additionality* and how it relates to that of *effectiveness*. This was pursued through a review of the literature on additionality. It was found that there are several relevant studies in the innovation policy literature which discuss various additionality concepts (*e.g.* Buisseret *et al.*, 1995; Georghiou, 2002; Falk, 2004; Georghiou *et al.*, 2004). These concepts are briefly reviewed in section 4.2. This is of relevance because although the CDM-related debate on additionality has been heated and ongoing since the inception of the mechanism, the conceptualization has been rather narrow and limited (see below). Furthermore, in section 4.2, the relationship between additionality and effectiveness is examined. *Additionality* is a measure of effects (*e.g.* emissions reductions, investments, *etc.*) (see *e.g.* Buisseret *et al.*, 1995). These effects are essential for determining

effectiveness (see Ch. 3). While there seems to be a rather obvious relationship between the concepts of *additionality* and *effectiveness*, this relationship does not appear to have been made explicit in either the CDM literature or innovation policy literature on additionality.

The discussions in the CDM literature and at the climate negotiations have largely focused on the interpretation of additionality as defined under the Marrakesh Accords and on the so-called 'Additionality tool' proposed by the EB. Furthermore, these discussions have largely centered on the concept of *investment additionality*. Little attention appears to have been paid to how additionality has been approached outside of the CDM context (for an exception see Sugiyama and Michaelowa, 2001). This suggests that this chapter fills an important gap in the CDM literature on additionality. Section 4.3 first offers a brief review of the lively debate on 'additionality' in the CDM. This is followed by a comparison of the concept of *investment additionality* to the concepts of *additionality* found in the innovation policy literature. Conclusions drawn from this chapter, which is largely concerned with integrating the climate policy literature and the innovation policy literature on additionality and linking the concepts of *additionality* and *effectiveness*, are presented in section 4.4.

4.2 Concepts of Additionality & Effectiveness

4.2.1 Background

Despite the controversy that has surrounded the meaning of *additionality* in the CDM context, it is not a new concept. The additionality principle was invoked already in 1972 by the European Commission (McAleavey, 1993). In an HM Treasury publication from 1988, *additionality* is referred to as "the amount of output from a policy as compared with what would have occurred without the government intervention" (cited in Mceldowney, 1997). The terms 'additionality' and 'incrementality' are sometimes used interchangeably (Lipsey and Carlaw, 2002). Furthermore, as shown by Sugiyama and Michaelowa (2001), additionality has been applied in other contexts. However, according to them the concept had never served as a reliable quantitative scientific base. Instead, it had been used as part of reporting formality or a guiding principle. Therefore Sugiyama and Michaelowa believed that there were two options available under the CDM. These were to either use additionality as a means to only incorporate high cost options (projects), or to forget about operationalizing a strict scientific assessment. They proposed that at least for an interim period, so as not to 'throw the baby out with the bathwater', the parties (investor and host) be allowed to use their discretion for additionality determination

in the context of operating the CDM. Others saw investment additionality as crucial for environmental credibility (see *e.g.* Pearson and Loong, 2003). What can be noted is that early on in the CDM-related literature, there appears to have a been tendency to conceptualize 'additional' as equivalent to high-cost projects (Grubb *et al.*, 1999; Sugiyama and Michaelowa, 2001). A strict economic interpretation of additionality which excludes all economically no-regrets projects would in turn limit the effectiveness of the CDM (Shrestha and Timilisina, 2002). Even if a project appears to be economically attractive, it may still not be realized. Excluding projects that are economic no-regret projects which have difficulty finding funding would "severely limit the effectiveness of the CDM as a vehicle for cost-effective GHG mitigation" (Shrestha and Timilisina, 2002:76). However, in contrast to the CDM literature, which tends to conceptualize additionality rather narrowly, additionality is conceptualized more broadly in the innovation policy literature.

4.2.2 Concepts of Additionality in the Innovation Policy Literature

Additionality answers the question "What difference does it make?" (Buisseret *et al.*, 1995). The question of additionality deals with identifying and measuring effects of policy intervention (Georghiou, 2002). Conceptually, additionality involves a comparison with a null hypothesis or counterfactual, *i.e.* what would have happened without policy intervention. There are many additionality concepts which offer means to establish whether policy instruments have any effects. These have been proposed as means to measure the effects of public assistance on the innovation activities of firms (see *e.g.* Falk, 2007). The various concepts have been categorized somewhat differently in the literature. Here, the categorization largely follows that of Georghiou and others (Davenport *et al.*, 1998; Cameron *et al.*, 2002; Georghiou, 2002; Georghiou *et al.*, 2004) while incorporating additionality concepts mentioned by *e.g.* Buisseret *et al.* (1995), Davenport *et al.* (1998), and Falk (2007).

Project Additionality

Project additionality is mentioned in relation to several of the additionality concepts reviewed below. Davenport *et al.* (1998) describe it as concerned with whether or not the project would have taken place without public support. It is also described as 'full additionality'. However, rather than full additionality, empirical evidence shows that 'partial additionality' is more common (Buisseret *et al.*, 1995; Davenport *et al.*, 1998). Rather than simply allowing a project to be carried out or not, public support tends to have more subtle effects allowing changes in the scope, scale and speed of the work.

Input Additionality

Input additionality can be seen as concerned with the level of project additionality and considers whether 1€ provided in assistance translates to at least 1€ on the target activity (Buisseret *et al.*, 1995). Georghiou (2002) mentions two noteworthy scenarios. The first is that the assistance translates to less than 1€ on the target activity and public funds are used to enhance profits. This is possible when the assistance is allowed for the entire rather than the incremental expenditure. The second is that the subsidy is accepted for an activity that would have taken place anyway and resources are spent on another project. The problem is that it is very difficult for policy-makers to judge the initial intentions of a firm. The main critique against input additionality is that it relies on the assumption of an oversimplified linear model. The assumption of a clear link between inputs and outputs is not empirically well founded (Georghiou *et al.*, 2004; Falk, 2007). A view expressed by some is that input additionality is related to *output additionality* (see below) and that it is within this framework that it really makes sense (Cameron *et al.*, 2002; Falk, 2007). Rather than seeing it as a relevant concept to assess 'additionality as a whole', it has been proposed as a second order condition (see *e.g.* Falk, 2007).

Output Additionality/ Result-Based Concepts

Output additionality is concerned with the proportion of outputs which would not have been achieved without public support (Georghiou, 2002). Examples of outputs include reports, patents, prototypes, business plans, and new partnerships. Under this category of concepts, Georghiou also mentions *outcome additionality*, which reflects a shift towards addressing improved business performance as a result of new or improved products, processes or services. When considering outcome additionality, the following also need to be included: unintended effects (including negative effects) and all types of spillovers. The timing of the assessment is also relevant, as outcomes may be manifested over time. Falk (2007) categorized these concepts as 'result-based concepts' and also included *impact additionality* concerned with *e.g.* increased productivity or competitiveness. There appears to be a rather obvious relationship between the concepts of *output additionality*, *outcome additionality* and *impact additionality* and the elements of the program impact theory (*i.e.* outputs, outcomes, and impacts). Furthermore, both Georghiou and Falk mention similar problems described in the policy-related literature addressing effectiveness (see Ch. 3), namely that outputs do not necessarily translate to outcomes. At the same time they recognize that it becomes increasingly difficult to attribute the effect to the intervention the further away from the outputs one moves. The main problem with all of these concepts is that "while the counterfactual scenario is simple in concept, it requires

major assumptions about the connection between intervention and what is measured" (Georghiou, 2002).

Behavioral Additionality

This category was introduced by Buisseret *et al.* (1995) "following the observation that a common effect of innovation policy was not to alter a stop-go decision by the firm in respect of the project but rather to modify in some way the way in which the project was carried out" (Georghiou, 2002:40). These modifications have been described using the following three concepts by the UK Department of Trade and Industry: *scale additionality*, *scope additionality*, and *acceleration additionality* (Georghiou, 2002). *Scale additionality* is concerned with the scale of the project. It exists if public funds allow for a project to be conducted at a larger scale (possible creating economies of scale). Falk (2007) described it as the gradual variant of the binary project additionality. *Scope additionality* is concerned with expansion of the coverage of an activity to a wider range of applications or markets with policy intervention. This concept also considers the creation of collaborative efforts in place of a single-company effort. *Acceleration additionality* considers whether an activity is introduced significantly earlier in time. Davenport *et al.* (1998) found empirical evidence which led them to suggest that less attention should be centered on project additionality. Instead, they proposed that indicators of behavioral additionality should be sought to be exploited by managers and policy administrators. By exploiting and optimizing behavioral additionality, it was believed that sustained behavioral change could be achieved. Davenport *et al.* also argued that behavioral additionality is inextricably linked to 'output additionality' in terms of improved competitiveness (*c.f.* impact additionality above).

4.2.3 Additionality & Effectiveness

In the innovation policy literature, additionality concepts are associated with firms and their inputs and outputs, but an alternative way of conceptualizing these concepts is to view them as associated with the elements of the program impact theory described in the policy evaluation literature (Vedung, 2009). This represents a shift in focus, but it does not appear to be a very large shift. As noted by for example Georghiou (2002), additionality deals with identifying and measuring effects of policy intervention. To describe these effects, the terms outputs, outcomes, and impacts are applied in this dissertation. These three elements are in turn related to various concepts of effectiveness (see Ch. 3). This shift in focus makes it easier to see the relevance of the various additionality concepts in relation to the CDM. It also makes it easier to link the concepts of additionality and effectiveness. For example, output

additionality can then be conceptualized as measuring the outputs of an intervention and output effectiveness and productivity are relative concepts which depend on these measured (additional) outputs (see Ch. 3). Similarly, the other concepts of additionality and effectiveness can be linked in a similar fashion (see Table 4.1).

Table 4.1
Concepts of Additionality and Their Links to Effectiveness in the CDM Context

Concepts of Additionality	'Linking Element'	Concepts of Effectiveness
Project additionality Input additionality Output additionality Behavioral additionality	Outputs	Output effectiveness Productivity
Outcome additionality	Outcomes	Outcome effectiveness Goal achievement Cost effectiveness
Impact additionality	Impacts	Impact effectiveness

When the additionality concepts are linked to the results of the policy intervention (rather than those of the firm), there are a few issues which need to be addressed. Firstly, as projects can be outputs of the intervention, it becomes less clear that the concepts of project additionality and output additionality are separate entities. A reason for not treating these concepts interchangeably in the CDM context is that projects are not the only outputs. CERs are also outputs; and output additionality makes sense in this context whereas project additionality does not.

Secondly, it seems appropriate to reconsider the relationship between input additionality and output additionality established in the innovation policy literature. In this literature, input additionality is conceptualized as focusing on the subsidy and to what extent this is spent on the 'target activity'. However, in the CDM context, the target activity can be viewed as the emissions reduction project. As such, it appears to make more sense to link input additionality to project additionality (rather than output additionality). There is also some empirical support for making this connection in the CDM context (see section 4.3.3).

Finally, in the innovation policy literature, scale additionality, scope additionality and acceleration additionality are all described as concerned with the project. In the CDM context, because projects are outputs of the intervention, it appears that behavioral additionality can be seen as concerned with outputs. This connection makes sense in the CDM context, but projects are not necessarily outputs of an

intervention more generally. The suggested relations are thus not necessarily generally applicable.

4.3 Additionality under the CDM

4.3.1 Conceptual Debate on Additionality under the CDM

Additionality was a contentious issue from the start. In the early days of the CDM, the additionality concept was ambiguous. While the KP requires that a CDM project be 'additional', it does not define the concept (KP, Article 12, § 5c). Some early CDM-related literature spoke of 'environmental additionality' and the importance of emissions baselines in ensuring environmental integrity (see *e.g.* Ellis and Bosi, 2000). Further guidance was not offered until 2001, a year after CDM projects could officially earn credits; according to the Marrakesh Accords, a project is *additional* if anthropogenic emissions of GHGs by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (UNFCCC, 2002a:§43). In Aug. 2002, the EB clarified that "a CDM project activity is additional if its emissions are below those of its baseline" (EB, 2002:§5). This appeared to suggest that projects that reduced emissions compared with an emissions baseline were additional. However, later that month, the EB provided the first version of the PDD, which required project participants to describe "how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (*i.e.* explanation of how and why this project is additional and therefore not the baseline scenario)" (CDM-PDD Version 01, in effect as of 29 August 2002; emphasis added).

The first new methodologies submitted to the EB for approval included different interpretations of additionality (EB, 2003e):

> *Interpretation 1*
> The proposed project activity would be, or would have been, unlikely to occur without the ability to register under the CDM. A baseline methodology evaluates *a priori* whether the project activity is the baseline scenario.
>
> *Interpretation 2*
> If the proposed CDM project activity is not implemented, a less GHG-friendly activity would have been initiated or be continued instead. A baseline methodology does not evaluate *a priori* whether the project activity could be the baseline scenario.

The EB's Meth Panel recommended that the first interpretation should be the only one used; and since 2003, *additionality* means that a project is different from the

baseline scenario (EB, 2003a:§2). Examples of tools that could be used, among others, to demonstrate additionality were provided in July 2003 and are presented below (EB, 2003b).

Additionality Tools suggested by the EB in 2003

a) A flow-chart or series of questions that lead to a narrowing of potential baseline options; and/or

b) A qualitative or quantitative assessment of different potential options and an indication of why the non-project option is more likely; and/or

c) A qualitative or quantitative assessment of one or more barriers facing the proposed project activity (such as those laid out for small-scale CDM projects); and/or

d) An indication that the project type is not common practice (*e.g.* occurs in less than [<x%] of similar cases) in the proposed area of implementation, and not required by a Party's legislation/regulations.

Source: EB (2003b)

The first "Tool for demonstration and assessment of additionality" (hereafter referred to as the *Additionality Tool*, in brief) was introduced by the EB on 22 Oct. 2004 (EB, 2004a). It was a result of the work of consolidating methodologies which was initiated by the EB in late 2003 (EB, 2003d; 2004c). The tool provided a general framework for demonstrating and assessing additionality (of a project) and a step-wise approach. The main steps involved are offered below.

Steps in the 'Tool for the demonstration and assessment of additionality' (version 1)

0) Preliminary screening based on the starting date of the project activity;

1) Identification of alternatives to the project activity consistent with current laws and regulations;

2) Investment analysis to determine that the proposed project activity is not the most economically or financially attractive;

3) Barrier analysis;

4) Common practice analysis; and

5) Impact of registration of the proposed project activity as a CDM project activity.

Source: EB (2004b)

Prior to the agreement on the Additionality Tool, public comments were invited. Reactions varied (EB, 2004b).[34] Some, representing organizations such as the Hamburg Institute of International Economics (HWWA) and the CDM Watch, welcomed the development of a universal tool as it would increase credibility and ensure 'project additionality'. Others questioned the tool or parts of it as a reintroduction of the 'project additionality' discussion and remarked that the KP and the Marrakesh Accords only address 'environmental additionality'. The final tool agreed upon was not mandatory and this was reaffirmed at the COP 10, in December 2004. India fiercely attacked the EB for its work to ensure 'project additionality' and echoed the business representatives' criticism of the process for its complexity (Brouns *et al.*, 2004; JIKO Info 1/05, 2005). At the following CMP 1 in 2005, the International Emissions Trading Association (IETA), representing the business interests, opposed the adopted interpretation of additionality (as 'project additionality') (IETA, 2005). This was countered by the WWF's strong support for the Additionality Tool, stating that "Without additionality, the CDM results in increased global emissions" (WWF, 2005:3). Despite controversies, the original interpretation still applies, although the steps included in the Additionality Tool have been revised over the years.

4.3.2 Additionality in the CDM Literature

In the early days of the CDM, the issue debated was whether additionality should be interpreted as either 'environmental (emissions) additionality' or 'project additionality' (see *e.g.* Paulsson, 2009). This was reflected in the CDM literature, which largely recognized the importance of the latter (Shrestha and Timilisina, 2002; Pearson and Loong, 2003; Asuka and Takeuchi, 2004). More recently, it appears that the CDM literature on additionality has been mainly concerned with the CDM's (investment) additionality assessment (Michaelowa and Purohit, 2007; Tanwar, 2007; Castro and Michaelowa, 2008; Schneider, 2009; Yunna and Quanzhi, 2011). Few efforts appear to have been made in terms of conceptual work or towards broadening the approach to additionality that reflects the complexity of the concept. However, Kartha *et al.* (2005) did propose the use of technology penetration rates as an alternative means to infer additionality and as a potentially useful complement to other methods.

While additionality is commonly agreed to be the most important prerequisite to ensure the environmental credibility of the CDM, it is not very clear what type of additionality it is. In the CDM literature, it has been referred to as 'additionality' 'project additionality', 'financial additionality' 'investment additionality' (see *e.g.*

[34] The original public comments on draft consolidated tools for the demonstration of additionality referred to in the report were also examined.

Sugiyama and Michaelowa, 2001; Greiner and Michaelowa, 2003; McNish *et al.*, 2009). Assessing additionality has been described as the primary shield against 'fake' emissions reductions that would undermine the emissions target of the KP (*e.g.* Greiner and Michaelowa, 2003; Paulsson, 2009; Schneider, 2009). Other negative effects of allowing non-additional (*i.e.* business-as-usual, BAU) projects in the CDM include crowding out additional projects and reducing benefits to developing countries (Pearson and Loong, 2003; Asuka and Takeuchi, 2004). It has also been described as important for the cost effectiveness (Sutter and Parrenño, 2007; Alexeew *et al.*, 2010). These descriptions, while perhaps informative, offer little insight about how 'additionality' is conceptualized.

4.3.3 Discussion on 'Additionality' under the CDM

What is assessed under the CDM can be described as '*ex ante* additionality' (as opposed to '*ex post* additionality') (Cameron *et al.*, 2002:105). Under the CDM, additionality is assessed *ex ante* (not *ex post*), *i.e.* additionality is assessed before a project is registered (*i.e.* approved) as a CDM project. The additionality assessment is part of the implementation process and aims to weed out projects that would have been realized without the CDM. The conceptual discussion in section 4.2 suggests that what is assessed as 'additionality' under the CDM can be described as *ex ante project additionality*. The key tools for assessing additionality among large-scale projects under the CDM include: identification of the baseline scenario (*i.e.* the counterfactual), and the investment and/or barrier analysis. The common practice analysis complements the former two as a credibility check (Schneider, 2009; also see Ch. 5-7). Furthermore, both the investment analysis and the barrier analysis are applied to determine whether a proposed CDM project is a viable investment (see Ch. 5-7). The viability of the project is assessed by considering the profitability of the project relative to the baseline scenario and/or by analyzing barriers that hinders the project. If viable, and thus likely to be realized without the CDM, it is not additional. Hence, there is a clear focus on the project as an investment. Furthermore, projects are deemed as either additional or not (*c.f. project additionality*, section 4.2.2). The *baseline scenario* is the most 'credible' and 'plausible'/'realistic scenario' that would occur in the absence of the proposed project activity.[35] It is required to be established on a project-specific basis according to the Marrakesh Accords (UNFCCC,

[35] See *e.g.* 'Combined tool to identify the baseline scenario and demonstrate additionality' (Version 02.2), http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v3.0.1.pdf/history_view (accessed 28 Dec. 2011); 'Tool for the demonstration and assessment of additionality' (Version 05.2), http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v6.0.0.pdf/history_view (accessed 28 Dec. 2011)

2002a:§45(c)). What is assessed as 'additionality' under the CDM can be described as *ex ante investment additionality* and it is assessed on project level.

For a while, input additionality seems to have been considered to some degree in the CDM context. The 'Tool for the demonstration and assessment of additionality (version 2)' required project participants to explain how the registration of the project as a CDM activity would alleviate the economic and financial hurdles or other identified barriers and thus enable the project activity to be undertaken. The effect of CERs could be considered in this assessment, but this was not mandatory. Furthermore, the requirement of considering the impact of registration was removed with the introduction of the third version of the additionality tool, on 16 Feb. 2007 (EB, 2005; 2007).

4.3.4 Challenges of Determining Investment Additionality at Project Level

Assessing investment additionality at project level is difficult, because the baseline scenario is counterfactual and assessing project viability is not hard science. Risk aversion and perception vary among project developers and investors, and thus profitability requirements also vary. This affects what individual project developers perceive as BAU profitability and thus what the baseline scenario comprises. In addition, projects have different risks, and countries vary in terms of economic and political risks (Rentz, 1998). Hence, evaluating which projects are BAU investments at project level is difficult. Furthermore, the CDM's additionality assessment, and the barrier analysis in particular, has been found to be in need of substantial improvement (Schneider, 2007; 2009). Examples of shortcomings include subjective assessments and lack of evidence to support additionality claims. Based on an empirical analysis of 93 registered CDM projects, Schneider (2007) estimated that additionality was questionable in roughly 40% of the registered CDM projects expected to generate 20% of the CERs. If only 80% of the CERs are environmentally credible, the real price per tCO_2e would in principle be given by dividing the CER price by 0.8. At a price of \$10/CER, what is actually paid per tCO_2e of emissions reduction is \$12.5. This is 25% more than what is indicated by the price of the CERs. Although this does not appear to have been explicitly mentioned in the CDM literature on additionality (*e.g.* Schneider, 2009), the environmental credibility of the credits is directly linked to the cost of emissions reductions; and low-cost credits do not necessarily imply low-cost emissions reductions. McNish *et al.* (2009) recommended that all CDM projects be required to perform an investment analysis and that barriers should be taken into account. Under current practices, a project can choose to apply either an investment or a barrier analysis (or both). However, it does little to address the inherent difficulty of evaluating investment additionality on project level.

4.4 Concluding Discussion on Additionality

4.4.1 Additionality under the CDM

What is assessed under the CDM can be described as '*ex ante* investment additionality', and it is assessed on project level. However, this is only one conceptualization among many of additionality more generally. Furthermore, under the CDM, the approach taken is that a project is either additional or not. In the innovation policy literature on additionality, this is referred to as 'project additionality'. Under the CDM, additionality is a pre-registration requirement. It is assessed *ex ante*. This means that what is assessed can be more specifically described as *ex ante* additionality. *Additionality* is a relative concept. Under the CDM, an additional project is different from the baseline scenario. This scenario determines the level of approach pursued in the assessment. According to the official regulatory requirements, the baseline scenario is to be established on a project-specific basis.

The CDM literature generally acknowledges the importance of ensuring additionality for environmental credibility of the CDM. However, it is also acknowledged that it is difficult to determine investment additionality at project-level; and the empirical studies have found the CDM additionality assessment in need of substantial improvement. This suggests that there is reason to reconsider the approach taken to additionality under the CDM. What the insights from innovation policy literature suggest is that:

- Additionality can be approached through outputs, outcomes, and impacts.
- An either-or-approach to additionality may be an overly simplistic approach to a relatively complex issue.

Under the CDM, additionality is approached through outputs (projects). However, it could also be approached through outcomes. Examples of outcomes that are potentially relevant in the CDM context include *e.g.* emissions reductions, sustainable development benefits, and technology transfer. This is because *additionality* is essentially a measure of effects. Under the CDM, emissions reductions are assessed *ex ante* and *ex post* (*i.e.* before and after registration); and relative to the baseline scenario (Ch. 5-7). While baselines are required to be project-specific according to the Marrakesh Accords (UNFCCC, 2002a:§45(c)), standardized baselines are *de facto* applied under the CDM (Ch. 5-7). These can be technology-specific (see Ch. 6-7) or sector-specific (Kartha *et al.*, 2004). This implies that outcome additionality can be, and is, assessed at various levels. The level of approach will depend on the baseline scenario. In principle, technology transfer and sustainable development benefits could also be evaluated. However, these are not evaluated through the CDM methodologies

(in the current context). These methodologies evaluate 'additionality' and 'emissions reductions'. In this dissertation these are referred to as *investment additionality* and *environmental outcome additionality*.

Through empirical evaluations of several UK and EU R&D programs and participating firms, Buisseret *et al.* (1995) found that public support tend to have a more subtle effect than simply allowing a project to be carried out or not. Instead, support often allows changes to the scope, scale, and speed of the work. These findings indicate broad differences in the level of additionality, which suggests a need to consider qualitative effects of public funding. To address these effects, Buisseret *et al.* introduced the concept of *behavioral additionality*. In comparison, the approach taken under the CDM appears rather limited and blunt. This does not yet appear to have been adequately considered in the CDM context or climate policy literature on additionality. Whether or not the various additionality concepts introduced in the innovation policy literature are relevant in the carbon crediting context is largely an empirical question. Buisseret *et al.* (1995), Falk (2007), and Georghiou (2002) addressed innovation policy and engagement by firms in R&D projects. It may be the case that such projects are more flexible and thus relatively easier to adjust in terms of size, time, and scale compared with *e.g.* investment in a new large-scale power plant.

4.4.2 Causality: Linking Inputs, Outputs & Outcomes

The CDM literature on additionality appears to be as largely concerned with what can be conceptually understood as *project additionality* (*e.g.* Michaelowa and Purohit, 2007; Sutter and Parrenño, 2007; Schneider, 2009; Alexeew *et al.*, 2010). In this literature, studies are commonly framed as addressing emissions reductions (outcomes) and the environmental credibility of the CDM. However, Sutter and Parrenño (2007) and Alexeew *et al.* (2010) evaluated the impact of CERs on the IRR of CDM projects for the purpose of determining the additionality of the project. Both were framed as concerned with emissions reductions (outcomes) and cost effectiveness. Furthermore, in contrast for example to Schneider, who analyzed what can conceptually be understood as *project additionality*, these two studies appear to evaluate *input additionality*.

A legitimate question that could be put forward is whether (a) input additionality or (b) project additionality (or more specifically project-level investment additionality) can address environmental outcome additionality (see Table 4.1). For this to be possible, a clear conceptual link needs to be established between (a) inputs and outcomes, or (b) outputs and outcomes. What seems to be a serious weakness in the studies of additionality in the CDM literature is that they do not tend to address outcomes. To address these, it is necessary to address the calculation of emissions

reductions. More specifically, what is missing in the studies is a discussion of how the assessment of investment additionality is conceptually linked to the calculation of emissions reductions. Without a clear conceptual link explaining causality, outcome additionality is assumed, based on an assessment of output additionality, but this assumption is not justified.

The problem can be illustrated with the following example. Assume that a new (greenfield) electricity generation project is proposed as a CDM project. This project is determined to be less profitable than some benchmark indicator value (this is an accepted approach under the CDM). The question is: 'Do the emissions of this project represent additional emission or additional emissions reductions?' This cannot be answered without addressing the calculation of the emissions reductions. The conceptual link (or rather lack thereof) between the CDM's additionality assessment and calculation of emissions reductions is a key issue in the following three chapters (Ch. 5-7).

4.4.3 Environmental Additionality

In brief, what is examined in this dissertation is referred to as 'environmental outcome additionality'. Using the concepts introduced in this chapter, this dissertation can be more specifically described as concerned with *ex ante environmental outcome additionality*. The primary concern is the CDM's ability to promote intended environmental outcomes in terms of GHG emissions reductions. Hence, a specific intended effect at the outcome level is of interest and the primary focus is outcome additionality. Georghiou (2002) describes outcome additionality as encompassing both intended and unintended effects (*c.f.* direct and indirect effects, Ch. 3). This wider conceptualization suggests that there is an implicit but rather clear link to the concept of *goal achievement* (see Ch. 3). However, this dissertation does not address outcome additionality in this wider sense. Firstly, for example sustainable development, which is commonly acknowledged as an intended effect of the CDM, is not addressed. What is examined in this dissertation is what is evaluated *ex ante* through the CDM methodologies.

Secondly, this dissertation primarily examines the CDM's *ex ante* evaluation. The purpose of *ex ante evaluation* is to optimize the allocation of resources and to improve the quality of programming (EC, 2006:1). However, addressing unintended effects in an *ex ante* context is somewhat challenging - what is unintended can be difficult to anticipate (at least initially). Nevertheless, as unintended effects are manifested over time (and thus become anticipated), these can be addressed through feedback processes aimed to improve the program (Vedung, 2009). For example, under the CDM, leakage is addressed (to some extent) as part of the CDM *ex ante*

evaluation (see Ch. 5 and 7). Furthermore, restrictions were included for greenfield HFC-23 projects once concerns were raised regarding perverse incentives leading to increased GHG emissions (Grubb *et al.*, 2011). However, addressing unintended effects will tend to require an examination of *ex post* additionality. This is not pursued in this dissertation.

As the term '*ex ante* environmental outcome additionality' suggests, additionality is approached somewhat differently in this dissertation compared with how it is approached under the CDM. What is evaluated under the CDM can be described as '*ex ante* project-level investment additionality'. The key difference is that while the CDM's additionality assessment is concerned with the investment, or more specifically the viability of the project (output), this dissertation is primarily concerned with an effect at the outcome level (emissions reductions). Here, 'environmental outcome additionality' is examined through an analysis of the following three components: the *ex ante* evaluations of 'additionality' (outputs) and 'emissions reductions' (outcomes), and the causal link between outputs and outcomes. How this is approached is further explained in Ch. 5-7.

5

CREDIT CREATION

A CRITICAL ANALYSIS OF CDM METHODOLOGIES

5.1 Introduction

The idea of a CER is relatively straightforward. To earn CERs, a project must be investment additional and reduce emissions compared with the baseline scenario. The basic idea appears simple, but it is in practice a challenge to determine investment additionality and emissions reductions (see *e.g.* Kartha *et al.*, 2004; Schneider, 2009). Determining investment additionality on project level is challenging for policy-makers as firms' intentions are difficult to know (see Ch. 4). How does one determine what would occur in the absence of the CDM project (*i.e.* the counterfactual baseline scenario) and that the project is not the baseline scenario? Furthermore, as shown by for example Kartha *et al.* (2004), calculating emissions reductions for grid-connected electricity generation projects is very difficult. Greenfield projects are particularly challenging to evaluate. While *brownfield projects* imply a modification or retrofit at an existing plant, *greenfield projects* represent investments in capacity additions (and thus more emissions compared with the *status quo*). In the latter, the baseline scenario is less obvious. In contrast to the CDM, under the US Emissions Trading Program, credits were earned by brownfield projects, while greenfield projects were required to offset their emissions (see Ch. 2). Under the CDM, both brownfield and greenfield projects can earn credits.

This chapter includes a critical examination of the credibility of CDM methodologies involved in the practical creation of CERs, focusing on their ability to promote environmental outcome additionality. Both validity and reliability are addressed. To promote credible credits, CDM methodologies need results that are credible, *i.e. valid* (logically correct) and *reliable* (*i.e.* reproducible) (see Ch. 1). The topics addressed in this chapter include: baseline scenario, investment additionality, and emissions reductions. The examination of CDM methodologies primarily

concerns the *ex ante* (pre-registration) criteria concerning investment additionality and emissions reductions. In contrast, Kartha *et al.* (2004) addressed the *ex post* evaluation of emissions reductions. Methodologies for creating carbon credits developed largely under the CDM, and by the end of 2004, when the methodologies were selected for this study, there were few if any empirical studies of approved CDM methodologies. In addition, this study was the first case study to be performed for the purposes of this dissertation. For these reasons, the key topics of baseline scenario, investment additionality, and emissions reductions are approached more generally compared with in subsequent chapters.

Key questions relating to the baseline scenario include: Why do baseline scenarios vary across CDM methodologies applicable to similar projects; and is the same baseline scenario applied to assess additionality and emissions reductions? These questions are relevant for the validity and reliability of the results of the additionality assessment and calculations of the emissions reductions. To ensure valid and reliable results, CDM methodologies must ensure that comparable projects apply comparable baseline scenarios. Furthermore, methodologies individually need to apply the same baseline scenario in the evaluations of investment additionality and emissions reductions. This is because both *investment additionality* and *emissions reductions* are relative concepts which relate to the *baseline scenario*. The latter is what conceptually links the evaluations of investment additionality (outputs) and emissions reductions (outcomes).

Other important questions related to the *ex ante* evaluations include: how is the concept of *investment additionality* and *emissions reductions* operationalized in the CDM methodologies; and what are the *ex ante* criteria for investment additionality and emissions reductions, *i.e.* how is environmental outcome additionality pursued under the CDM? These questions were pursued through a study of CDM methodologies applicable to large-scale grid-connected electricity generation projects (listed in Table 5.1).

The outline of the remainder of this chapter is as follows. Section 5.1 includes a list of the CDM methodologies selected for the case study. The baseline scenario is examined in section 5.2. Additionality is examined in section 5.3. Emissions reductions are examined in section 5.4. Sections 5.2-5.4 are relatively specific and detailed. Some mathematical formulae are included, but these are relatively simple and are also explained. The primary findings are summarized in section 5.5.

5.1.1 Overview of the Selected CDM Methodologies

The CDM methodologies examined include five Approved Methodologies (AMs) and the Additionality Tool (AT), available by 1 Dec. 2004. The selected AMs include all

the AMs found in Sectoral Scope 1 which were applicable to grid-connected electricity generation projects (see Ch. 1). AM0010 and AM0015 also address methane destruction and thermal energy generation, respectively, but these components are not addressed (see Ch. 1). The AT was included because one of the selected AMs required its use for assessing additionality. For brevity, the selected cases are hereafter jointly referred to as the 'CDM methodologies'. The selected methodologies are listed in Table 5.1. It also includes references to the respective PDD for the project responsible for proposing the respective AM. In this chapter, the PDDs are referred to as *e.g.* PDD(AM0004), in brief. These were consulted as practical examples of the application of the AMs. When available, the PDD published at the validation stage was consulted (availability was last checked by 1 Dec. 2004). By 1 Dec. 2004 there were only two registered CDM projects and neither applied any of the selected AMs. Hence, PDDs for registered projects were not included because they were not available.

For the case study, the baseline methodology of the AMs was examined. Under the CDM, an approved baseline methodology is applied *ex ante* to determine that a project is investment additional and reduces emissions. The AMs examined generally included the following components:

Overview of Components Generally Included in the AMs examined

Selected approach from §48 of the CDM modalities and procedures	Describes the baseline approach (see Table 5.1)
Applicability	Description of the applicability of the methodology
Baseline (scenario)	Description of the baseline scenario or how to identify it, and how to calculate baseline emissions
Additionality	Description of how to determine additionality
Project activity	Description of project activity and how to calculate the project emissions (if any)
Emissions reductions	Description of how to calculate emissions reductions
Leakage	Description of the leakage scenario and how to account for leakage
Project boundaries	Description of the project boundaries

Source: AMs listed in Table 5.1.

Table 5.1
List of Methodologies included in Case Study

AM	BA	PDD
AM0004 (version 2.0): Grid-connected biomass power generation that avoids uncontrolled burning of biomass (in effect 2004/04/06-2005/11/27; replaced by ACM0006)	B	NM0019: A.T. Biopower Rice Husk Power Project (July 2003); submitted: 2003/09/10
AM0005 (version 1.0): Small grid-connected zero-emissions renewable electricity generation (in effect : 2004/04/13-2006/03/01; replaced by ACM0002)	B	PDD at validation stage: El Gallo Hydroelectric Project (21 April 2004)
AM0007 (version 1.0): Analysis of the least-cost fuel options for seasonally-operating biomass cogeneration plants (in effect: 2004/06/13-onwards; still in effect by 2011/06/13)	B	NM0028: TA Sugars co-generation and fuel-switch project (Sep. 2003); submitted: 2003/09/10
AM0010 (version 1.0): Landfill gas capture and electricity generation projects where landfill gas capture is not mandated by law (in effect : 2004/07/12- 2007/11/01; replaced by ACM0001)	B	NM0010-rev: Durban Landfill Gas to Electricity (Revised Draft July 2003); submitted: 2003/09/10
AM0015 (version 1.0): Bagasse-based cogeneration connected to an electricity grid (in effect : 2004/09/21- 2005/11/27; replaced by ACM0006)	A	NM0001-rev: Vale do Rosário Bagasse Cogeneration (VRBC) project (Revised July 2003); submitted: 2003/09/10
Tool for the demonstration and assessment of additionality (version 1) (in effect : 2004/10/22-2005/11/24; replaced by a revised version)	-	-

Acronyms: Approved methodology (AM); Approved consolidated methodology (AM); Baseline approach (BA); New methodology (NM); Project design document (PDD)

Baseline approaches (UNFCCC, 2002a: Annex §48 a-c):

(a) Existing actual or historical emissions as applicable;

(b) Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment; and

(c) The average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category.

Sources: The AMs, NMs, PDD for El Gallo Hydroelectric (made available at the validation stage) and the AT listed in the Table; CDM website.[36] The AMs, NMs, and PDD were tracked through the following databases on the CDM website: 'Approved Baseline and Monitoring Methodologies', 'Validation projects', and 'Proposed New Methodologies'. Direct links to the relevant documents are also listed in the references.

[36] 'Methodologies linked to sectoral scopes', https://cdm.unfccc.int/DOE/scopes.html#11 (accessed 14 June 2011)

5.2 Baseline Scenario

5.2.1 Definition of Baseline Scenario

Under the Marrakesh Accords, the *baseline* is defined as "the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity" (UNFCCC, 2002a:§44). It is to be considered as 'reasonable' if it is derived using a baseline methodology which complies with the requirements of an approved methodology (2002a:§37, 38, 44). The baseline is to be established by project participants on a project-specific basis and in accordance with the requirements on approved methodologies (UNFCCC, 2002a:§45). The definition provided by the Marrakesh Accords indicated that 'baseline' was synonymous with 'baseline emissions'. This in turn created some controversy regarding the interpretation of additionality. However, the guidance provided by the EB in 2003 established that 'baseline' is synonymous with 'baseline scenario' (see Ch. 3). This is reflected in the methodologies examined; and the baseline (scenario) reflects a *source* or *sources of emissions*, *i.e.* facilities, plants, and units.

5.2.2 Guidance regarding the Baseline Scenario for Electricity Generation

Most of the methodologies examined briefly describe (or define) the baseline scenario to be applied, and do not provide guidance allowing project developers to identify the baseline scenario. However, AM0010 neither defines nor offers guidance for identifying the baseline scenario for electricity generation. Despite this, it does include emissions from grid electricity generation in its baseline emissions. This is not satisfactory. Four of six describe the baseline scenario (AM0004, AM0005, AM0007, and AM0015). Only two provide a method for identifying the baseline scenario (AM0007 and the AT). AM0007 defines the baseline scenario as the least-cost fuel option, but provides guidance that allowed project participants to identify the relevant option (AM0007:1, 3-6).

A possible explanation for why AMs tend to define the baseline scenario rather than provide guidance for identification it is that the applicability of an AM is limited. The AMs examined are highly project-specific. Applicability is restricted through project-specific criteria (*e.g.* 'refurbishment and fuel-switch of biomass cogeneration projects' and 'bagasse-based cogeneration power plants'), as well as context-specific criteria (*e.g.* the project's impact on the average grid emission factor, fuel availability, and alternative). This is most likely explained by the fact that an AM is developed by project participants with the intention of applying it to a specific project. In contrast to the AMs, the AT is a general framework applicable to a wide range of project types;

and it is the only one of the methodologies examined to not define the baseline scenario and only offer guidance for identifying it.

5.2.3 Issues among the Methodologies that Define the Baseline Scenario

Vague Definitions and the Issue of System Boundaries

The examination of methodologies shows that the description of the baseline scenario for electricity generation is vague in the methodologies – the information provided is not enough to determine the system boundaries. Experiences from Life Cycle Assessments (LCAs), an environmental systems analysis tool, show that the following dimensions need to be addressed: geographical coverage, technological coverage, and time-related coverage (Tillman *et al.*, 1994; ISO, 14040:2006). These dimensions determine the *system boundaries.* System boundaries are crucial for ensuring valid and reliable results in the calculation of emissions reductions. Valid results require that the emissions of the baseline scenario and those of the project are comparable. This entails comparable system boundaries. For example, if fuel transports is accounted for in the baseline emissions, then it should as a general rule also be accounted for in the project emissions. Reliable results imply that, for example, the system boundaries of the baseline scenario are comparable even if a methodology is applied to different projects; and that similar projects apply comparable system boundaries.

None of the methodologies provide sufficient guidance regarding the system boundaries in their description of the baseline scenario. For example, AM0004 defines the baseline scenario for electricity generation as 'other (electricity generating) facilities'. Does this refer to other facilities in the same region as the project, the same country or something else, *i.e.* what are the *geographical boundaries*? What processes are to be included (*e.g.* production of raw material and fuel, transport, construction of power plant, electricity generation), *i.e.* what are the *technological boundaries*? In AM0005, the baseline scenario is described as 'the electricity grid generates electricity by operation of the connected power plants and adjusts power development plan to compensate for the electricity generated by the project'. What is the *timeframe* considered in AM0005? Is it comparable to the *crediting period* to be chosen by the project participants? These can choose either a 10-year or 7-year crediting period. The former is fixed, but the latter can be renewed twice, adding up to 21 years (UNFCCC, 2002a:§49). Alternatively, is the timeframe related to the lifetime of the electricity generation project, or something else? To find more information about the system boundaries it is necessary to analyze the AMs' requirements regarding the calculation of emissions reductions and the PDDs. System boundaries are further addressed in 5.4.4.

The Baseline Scenario to be Applied Differs Widely across the Methodologies

The AMs examined are all applicable to large-scale renewable grid-connected electricity generation. Despite this, the AMs require that different baseline scenarios be applied (see Table 5.2). However, this is not necessarily apparent when examining the descriptions of the baseline scenario. For example, the descriptions of the baseline scenario in AM0004 and AM0005 are not specific enough to identify differences. Both suggest the baseline scenario will reflect other facilities (vis-à-vis the proposed project). However, an examination of the baseline scenarios applied to estimate the baseline emissions showed that AM0004 and AM0005 apply different baseline scenarios (see Table 5.2). *Baseline emissions* are defined as the product of the baseline emission factor (EF_b) and the output of the project (Q_p) (*e.g.* in megawatt hours (MWh) of electricity) (further explained in Ch. 5.4). The *emission factor (EF)* is a measure of emissions intensity (*i.e.* emissions per output), and was generally measured in tCO_2e/MWh per year.

Table 5.2
Baseline Scenario applied to Calculate Baseline Emissions

Approved Methodology		EF_b for Electricity Generation		Source(s)
AM0004 [a]	AM0010	EF_{SAv}	System average emission factor [f]	Multiple
AM0004 [a]		EF_{OM}	Emission factor of the operating margin (OM)	Multiple
AM0004 [a]		EF_{BM}	Emission factor of the build margin (BM)	Multiple
AM0005 [b]	AM0015 [c]	EF_{CM} [d]	Emission factor of the combined margin (CM)	Multiple
AM0007		EF_{LCF}	Emission factor of the least-cost fuel	Single
AM0015 [e]		EF_{Ex}	Emission factor of the existing facility	Single

[a] *The lower of EF_{SAv} or EF_{OM}. EF_{BM} is an option if the project is located in a country/region with suppressed demand.*
[b] *The following weights are applied* $w_{OM} = w_{BM} = 0.5$ *(see d, below)*
[c] *Any weights can be used as long as* $w_{OM} + w_{BM} = 1$ *(see d, below)*
[d] $EF_{CM} = w_{OM} \cdot EF_{OM} + w_{BM} \cdot EF_{BM}$*; where* w *is the weight factor*
[f] *Includes all plants connected to the grid (system)*

Source: Respective methodology, but the abbreviations EF_{SAv} and EF_{Ex} were not specifically mentioned in the methodologies.

The examination of the EF_b established that the baseline scenarios differ widely across the AMs. For example, to estimate EF_b some account for emissions from fossil fuel-fired power plants connected to the grid (AM0005, AM0015), others for emissions from all plants connected to a grid (AM0004, AM0010). Some account for plants on the *operating margin (OM)*; capacity additions, *i.e.* plants to be built/recently built,

known as the *build margin (BM)*; or the weighted average of OM and BM, known as the *combined margin (CM)*. EF_b could also be based on the least-cost fuel option. The various EF_b represent different selections of plants for the baseline scenario. Another difference is that some reflect a single-source baseline scenario and others a multiple-source baseline scenario (see Table 5.2). Table 5.2 offers an over view of the various EF_b which could be applied in the methodologies examined.

The question is whether the applicability of the AMs (and thus the project characteristics) can explain the variation. If not, the validity and reliability of the AMs can be questioned. To investigate possible reasons for why baseline scenarios diverge across the methodologies, the baseline scenarios of methodologies applicable to similar projects were identified and compared. AM0007 and AM0015 which both appear to be applicable to brownfield projects were selected. Both were proposed by projects which implied increases in capacity and efficiency in terms of electricity generation at existing bagasse-fired cogeneration power plants connected to a grid (PDD(AM0007); PDD(AM0015)). The key difference appears to be that AM0007 applies to fuel-switch projects; no fuel-switch was mentioned in AM0015 or PDD(AM0015).

AM0007	The baseline scenario reflects the least-cost fuel use.
AM00015	The baseline scenario may reflect the existing facility to the extent that the project activity does not increase the existing facility's output or lifetime.

A reasonable question is why the baseline scenario of AM0007 does not reflect the fuel consumed at the existing facility prior to the proposed fuel-switch. This would have been more consistent with the baseline scenario described in AM00015. Or, conversely, why does the baseline scenario of AM0015 not reflect the least-cost investment option? The applicability criteria of these AMs do not explain why the baseline scenarios diverge as much as they do. A possible explanation was instead found by examining the baseline approaches. While AM0007 applies baseline approach (b) 'Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment', AM0015 applies approach (a) 'Existing actual or historical emissions as applicable' (see Table 5.1). When compared with each other, the requirements of these AMs regarding baseline scenarios are arbitrary.

5.2.4 Issues among the Methodologies that Identify the Baseline Scenario

Criteria for Selecting Plausible Alternatives are Unclear

The issue among methodologies that identify the baseline scenario is that the guidelines for the selection of plausible alternatives are unclear. Both AM0007 and AT require project participants to identify plausible alternatives that can be the baseline scenario. For example, AM0007 requires that project participants select plausible fuel options before identifying the least-cost option (*i.e.* the baseline scenario). The selection of alternatives affects the outcome of this assessment. An arbitrary selection implies that the baseline scenario will also be arbitrary. The sampling criteria limit the possible outcomes of the identification of the baseline scenario. Arbitrary sampling criteria introduce uncertainty regarding the validity and reliability of the baseline scenario. This in turn means that the validity and reliability of the results of the assessment of additionality and emissions reductions can be questioned.

Examples of relevant questions regarding the selection criteria include *e.g.* what is the level of approach (*e.g.* project or sector), what are the geographical boundaries (*e.g.* local, national or international), and what is the age of the alternatives (if plants/facilities)? For example, in AM0007, should only fuel options available to the project participants be considered as possible options, or should options available to similar developers or the power sector more generally be considered – what is the *level of approach*? The baseline scenario is to be established on a 'project-specific basis' but does this imply specific for the project participants or the project type? Could the latter be interpreted as projects with same output, size, same technology, same fuel, or something else? The alternatives described in the AT suggest that two levels are considered: project participant and project type. Neither AM0007 nor the AT provides clear guidelines regarding the sampling criteria. This suggests that project participants have a relatively high degree of freedom in defining what constitutes plausible scenarios.

5.2.5 Linking Outputs & Outcomes

To earn CERs a project must be investment additional and reduce emissions. Both are required to be determined relative to the baseline scenario. It is logical to expect that the baseline scenario identified or described is used to evaluate investment additionality and calculated emissions reductions. Hence, consistency between the baseline scenario and the baseline emissions can be logically expected. However, not all methodologies appear to ensure such consistency. A possible lack of consistency between the baseline scenario and baseline emissions is a concern, because it is what links the assessment of additionality to the calculation of emissions reductions.

Without this conceptual link, it is difficult to see how the additionality of the project (output) will ensure additional emissions reductions (outcomes). The AT does not deal with baseline emissions, but it specifically requires the baseline scenario to be consistent with the baseline emissions (AT:2).

AM0004, AM0005, and AM0007 are, or appear to be, consistent. AM0004 and AM0007 establish consistency by clearly linking the concepts of *baseline scenario* and *baseline emissions* in the methods applied to assess additionality and calculate emissions reductions. For example, AM0004 requires that the baseline emission factor be determined as part of the additionality assessment (see Table 5.3, AM0004, Step 2). This is explicitly referred to as a method that "determines what will happen in the absence of the project – the baseline scenario" (AM0004:3). However, the baseline scenario is not used to assess additionality. This was also the case in AM0005 (see Ch. 5.3). This raises the question of what additionality is determined against. Nevertheless, in AM0005, the description of the baseline scenario is consistent with the method applied to calculate the baseline emissions (AM0005:2-3). In AM0007 it is explicitly stated that the least-cost fuel option identified through the additionality assessment as the baseline scenario is to be used to calculate the baseline emissions (AM0007:1).

Consistency is less certain in two methodologies, namely AM0010 and AM0015. As mentioned earlier, AM0010 does not describe or identify the baseline scenario for electricity generation. To examine consistency, the following were compared:

AM0010

(a)	The 'continued electricity generation by the grid' [a]
(b)	The average annual CO_2 emissions intensity of the electricity displaced by the project [b]

[a] *Applied to determine that the project is additional (see Step 3, Table 5.3; AM0010:3)*
[b] *Applied to calculate baseline emissions of the grid (AM0010:2)*

The examination of AM0010 could not conclusively determine whether (a) and (b) were consistent. Therefore the PDD(AM0010) was consulted and this review found that the following were used to estimate (a) and (b):

PDD(AM0010)

(a)	Existing capacity and capacity additions utilizing natural gas from Mozambique [a]
(b)	The applicable average annual grid CO_2 emission factor based on Eskom's reported CO_2 data [b]

[a] *PDD(AM0010):9-10 and its accompanying Baseline Study:13-15*
[b] *PDD(AM010):14-15, 18, 28. Eskom is a utility company. It owns and operates 92 % of South Africa's generation and transmission capacity (PDD(AM010):8, 18).*

In contrast to (a), there is no mention of capacity additions in (b). However, the grid emission factor is to be calculated annually (PDD(AM0010):18); AM0010:2). This suggests that actual capacity additions will *de facto* be accounted for. Hence, if the actual capacity additions utilize natural gas from Mozambique, then (a) and (b) will most likely be consistent, but otherwise not. This analysis suggests that AM0010 does not ensure consistency.

AM0015 applies the AT to assess additionality. A comparison of AM0015 and the AT suggests that these methodologies may be incompatible. The latter requires the identification of "realistic and credible alternatives to the project activity(s) that can be (part of) the baseline scenario" (AT:2). These alternatives are required to be "available to the project participants or similar project developers that provide outputs or services comparable with the proposed CDM project activity" and must include the following:

AT : Possible Baseline Scenario

(a)	The proposed project activity not undertaken as a CDM project activity
(b)	All other plausible and credible alternatives to the project activity that deliver outputs and on services (*e.g.* electricity, heat or cement) with comparable quality, properties and application areas
(c)	Continuation of the current situation (no project activity or other alternatives undertaken)

Source: AT:2

Under AM0015, the baseline emissions can reflect the CM scenario (AM0015:3-7). This implies that the baseline scenario can consist of a wide range of power plants – all existing fossil fuel-fired power plants and recently built/to be built plants connected to a grid. Whether or not all these can be considered as 'available to the project participants or similar project developers' will depend on the project participants. However, the CM may be compatible with alternative (c). The key question is whether the CM scenario will be used to determine additionality by those applying AM0015. The PDD(AM0015) was consulted, but it was published before the AT was introduced (see Table 5.1). It was thus not possible to examine this question in more depth (this issue is further addressed in Ch. 6 and 7).

5.3 Additionality

5.3.1 Definition of Additionality

To register as a CDM project, a project is required to be additional (UN, 1998: Article 12 §5c). Despite controversy and uncertainty regarding the interpretation of the concept (see Ch.4), according to guidance provided by the EB it is to be "demonstrated that a project activity is additional and therefore not the baseline scenario" (EB, 2003c:§1(a)). Although it was clarified that *additional* means "different from the baseline scenario", it was not decided how a project should be different (EB, 2003a:§2). The definition provided by the EB implies that additionality is a relative concept which relates to the baseline scenario. Additionality can be formally expressed as shown below.

Additionality Criterion: Single-Source Baseline Scenario (x_b)

Eq. 1 $x_p \neq x_b$

This simple expression states that the project (x_p) is different from the baseline scenario (x_b) when the latter reflects a single source of emissions.

Additionality Criterion: Multiple-Source Baseline Scenario ($X_b = \{x_{b_1}, x_{b_2}, \dots x_n\}$)

Eq. 2 $x_p \notin X_b$

This expression states that the project is different from baseline scenario, when the baseline scenario includes more than one source. Eq. 2 is mathematically equivalent to Eq. 1.

Neither criterion defines how the project is to be different compared with the baseline scenario, *i.e.* both Eq. 1 and Eq. 2 are in complete accordance with the guidance and clarification offered by the EB. However, these expressions, Eq. 1 and Eq. 2, are not officially applied under the CDM.

5.3.2 Evaluating Additionality: Approaches & Criteria

Table 5.3 provides brief descriptions of the additionality assessments found in the methodologies examined here. All use different step-wise approaches. Furthermore, most address the baseline scenario (in some sense) in the additionality assessment (the

only exception is AM0005). How the baseline scenario is addressed in the methodologies is studied below as part of examining the additionality assessment.

Table 5.3
Additionality Assessments in the Methodologies

AM/AT	Brief Description	Is x_b addressed?
AM0004	1. Determine whether project is BAU through a barrier analysis 2. Determine the baseline scenario by determining the appropriate CO_2 emission factor for the electricity supplied to the grid	Yes
AM0005	1. Analyze prohibitive barriers to the proposed project (a): Identify relevant barriers (b): Explain how only the approval and registration as a CDM project would enable the proposed project to overcome the identified barriers 2. Analysis of other activities similar to the proposed project	No
AM0007	1. Identify possible fuel options for the baseline scenario 2. Select plausible fuel options 3. Estimate profit margin from sales of electricity using each plausible fuel (without CER revenue) 4. Compare the unit margin/ unit NPV of the proposed project and the other plausible options 5. Analysis of other activities similar to the proposed project	Yes
AM0010	1. Provide a convincing justification that there is no plausible baseline scenario except the project and the BAU scenario. 2. Calculate the cost of a kWh of electricity generated by the project. 3. Determine the long run marginal cost (LRMC) of continued electricity generation by the grid (expressed as a cost per kWh). 4. Demonstrate that the cost of the electricity generated by the project (Step 2) is higher than the LRMC (Step 3).	Yes
AM0015	(see AT)	
AT	0. Preliminary screening based on the starting date of the project activity 1. Identification of alternative scenarios to the project activity consistent with current laws and regulations 2. Investment analysis, or 3. Barrier analysis 4. Common practice analysis 5. Impact of CDM registration	Yes

Acronyms; Additionality Tool (AT); Baseline scenario (x_b); Business-as-usual (BAU); Certified Emissions reduction (CER), Net present value (NPV)

Source: Respective AM/AT.

The methodologies examined include one or more methods for assessing additionality; and one or more of the following analytical approaches were applied.

Analytical Approaches to Assessing Investment Additionality

(a)	Determine that the project faces prohibitive barriers
(b)	Determine that the project is not economically viable (without CERs)
(c)	Determine that there are no other similar activities to the project
(d)	Determine that the project would not be realized without CDM registration
(e)	Determine that the project is different from the baseline scenario

The primary methods for assessing additionality apply analytical approaches (a) or (b). In addition, in some cases, (c) supplements the former two as a credibility check. The role of (d) is less clear. Finally, (e) is embedded in some of the methods applying either (a) or (b). It is *embedded* in the sense that some methods entail a comparison of the project and baseline scenario. Hence, although additionality as defined by the EB was clearly a relative concept related to the baseline scenario, this is not reflected in all methodologies. Findings from the examination of the methods included in the methodologies are presented below.

(a) Determine that the project faces prohibitive barriers

Methods for barrier analyses are included in AM0004, AM0005 and the AT. AM0004 requires a barrier analysis to be applied in Step 1 and the baseline scenario to be determined in Step 2 (AM0004:3). Hence, additionality is determined before identifying the baseline scenario. Furthermore, the barrier analysis only addresses barriers faced by the project (AM0004:4), *i.e.* approach (a) was pursued on its own.

AM0005 requires that the barrier analysis (Step 1) only addresses barriers faced by the project (AM0005:4). However, in contrast to AM0004, AM0005 requires an explanation of how the approval and registration as a CDM project would enable the project to overcome the identified barriers and thus be undertaken (Step 1-b). Hence, analytical approaches (a) and (d) are combined.

The barrier analysis of the AT (Step 3) requires that it is shown "that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity)" (AT: Sub-step 3b). *Alternatives* implies "realistic and credible alternative [scenarios] to the project activity(s) that can be (part of) the baseline scenario" (AT:2 and footnote 3). Hence, the analytical approaches (a) and (e) appear to be combined. (However, in practice this is not necessarily the case, see Ch. 6).

In AM0005 and the AT, the barrier analysis is supplemented by a common practice analysis/analysis of similar activities which shows that other projects similar to the proposed CDM project are not widely observed and carried out. Hence, (a) is

supplemented by (c). These methodologies acknowledge that if similar activities are widely observed and carried out, it calls into question the claim that the project activity faces prohibitive barriers (AM0005:5; AT:7).

A possible issue with analytical approach (a) is that it may in practice be difficult to show that the barrier(s) prevents the project from being realized. If this is not possible, it does not help that it is either shown that the barrier(s) are alleviated as in AM0005, or that they do not prevent an alternative (*i.e.* the baseline scenario) from being realized. Furthermore, the analysis of similar activities/common practice analysis does not prove that barriers are prohibitive (only that they are most likely not prohibitive).

(b) Determine that the project is not economically viable (without CERs)

Methods for economic analyses are included in three of the methodologies examined, namely AM0007, AM0010, and the AT (Step 2). Furthermore, in AM0007 and the AT, the economic analyses are supplemented by an analysis of similar activities/common practice analysis. Hence, in these methodologies, (b) is supplemented by (c).

AM0007 requires that the project is compared with the baseline scenario using an economic indicator (Table 5.3, AM0007, Step 1-4; AM0007:3-6), *i.e.* the analytical approaches (b) and (e) are combined. AM0010 requires a comparison of the project's cost of electricity generation and the 'continued electricity generation by the grid' (AM0010: Step 2-4). A problem with AM0010 is that it does not describe or identify the baseline scenario for electricity generation (AM0010:2). If (i) 'continued electricity generation by the grid' is the same as the (ii) baseline scenario used to estimate baseline emissions for electricity generation, then AM0010 compares the project and the baseline scenario in its additionality assessment; but otherwise not. The question is thus whether (i) and (ii) are consistent. AM0010 is not necessarily inconsistent, but it does not ensure consistency (see Ch. 5.2.5). Hence, it does not ensure that the project is compared with the baseline scenario (*i.e.* it is possible that the analytical approaches (b) and (e) are combined, but it is not certain).

The investment analysis (Step 2) of the AT requires the following: "Determine whether the proposed project activity is the economically or financially less attractive than other alternatives without the revenue from the sale of certified emission reductions (CERs)" (AT:3). This appears to suggest that the project is compared with the baseline scenario. However, there are several options for conducting the investment analysis.

(I) Simple cost analysis
(II) Investment comparison analysis
(III) Benchmark analysis

Source: AT, sub-step 2b

Under Option I, it must be demonstrated that the project has no economic benefits other than CDM-related income (AT:3). The project is not directly compared with the baseline scenario. Whether or not this method indirectly compares the project with the baseline scenario depends on whether or not the sources included in the baseline scenario used to estimate baseline emissions for electricity generation all have benefits other than CDM-related income.

Under Option II, it must be demonstrated that the project is less financially attractive compared with the alternatives, using a suitable financial indicator (*e.g.* IRR, NPV, unit cost per service ($/kWh)) (AT: 4-5). Hence, the analytical approaches (a) and (e) appear to be combined. (However, in practice this is not necessarily the case, see Ch. 6).

Under Option III, it must be demonstrated that the project is less financially attractive compared with a benchmark, using a suitable financial indicator and some benchmark value. The latter can be derived from (i) government bond rates, (ii) increased by a suitable risk premium, estimates of the cost of financing and required return on capital or (iii) a company internal benchmark (AT:4). Again, the project is not directly compared with the baseline scenario. Whether a project will be indirectly compared with the baseline scenario when applying (i)/(ii)/(iii) depends on whether or not the applied benchmark is representative for the facility(-ies)/investment(s) included in the baseline scenario used to estimate baseline emissions for electricity generation (this is further examined using registered CDM projects in Ch. 6).

A possible issue with the methods that do not compare the project with the baseline scenario is that inconsistencies may arise. If the baseline economic/financial attractiveness is not representative for the baseline scenario used to calculate the emissions reductions, this implies that a different scenario is applied to assess additionality. This means that there is a risk that a single project *de facto* applies different baseline scenarios depending on whether additionality or emissions reductions are assessed. This creates validity problems in both assessments.

(c) Determine that there are no other similar activities to the project

Methods for analyzing other similar activities to the project are included in three methodologies: AM0005 (Step 2), AM0007 (Step 5), and the AT (Step 4). These

analyses are included to supplement (complement/reinforce) a barrier analysis and/or an economic analysis (AM0005:5; AM0007:6; AT:1, 7). Hence, when analytical approach (c) was applied, it was always applied in combination with either (a) and/or (b). The methods for analyzing other similar activities did not compare the project with the baseline scenario in any of the methodologies. The stringency of this method (and thus its ability to effectively supplement other methods meaningfully) will depend on how narrowly 'similar projects' and 'widely observable and carried out' is defined. Extremely narrow definitions imply that it is less likely that a 'similar project' will be identified.

(d) Determine that the project would not be realized without CDM registration

Methods for analyzing the impact of CDM registration are included in two methodologies: AM0005 (Step 1-b) and the AT (Step 5) (see Table 5.3). These methods are described as proving that barriers "are indeed prohibitive" (AM0005) or as "a credibility check to complement" a barrier analysis and/or an economic analysis (AT). The methods are not limited to considering the economic benefits of a CDM registration. AM0005 mentions "the institutional benefits of collaborating with partners in the emissions reductions *transaction*" and "the technical and capacity building benefits provided by partners in the emissions reductions transaction" (AM0005:4). The AT mentions benefits and incentives, *e.g.* "anthropogenic GHG emissions reductions, attracting new players who are not exposed to the same barriers, or can accept a lower IRR (for instance because they have access to cheaper capital), attracting new players who bring the capacity to implement a new technology, and reducing inflation/exchange rate risk affecting expected revenues and attractiveness for investors" (AT:8). Due to the range of diverse benefits, the general aim and value of this analytical approach are unclear. Furthermore, the methods for analyzing the impact of CDM registration do not compare the project with the baseline scenario.

It is reasonable to question whether the financial assistance (CERs) offered by the CDM really would help a project to be realized. It is possible that the CDM offers other types of benefits, but these need to be tangible if this assessment (d) is to be credible. It is pertinent to require that a project shows how the relevant economic obstacles identified through approach (a) or the prohibitive barriers identified through approach (b) are concretely overcome through the CDM. A problem with the methods applying approach (d) is that they are unfocused and that the links to the approaches (a) or (b) are unclear.

(e) Determine that the project is different from the baseline scenario

In the methodologies examined, some methods involve a comparison of the project and baseline scenario, others do not. As more detailed information about the methods is offered above, the empirical findings are only briefly summarized here. A comparison of the project and baseline scenario forms part of some methods applying the analytical approach (a) or (b). Hence, neither analytical approach (a) nor (b) guarantees or precludes a comparison. In contrast, none of the methods examined which apply analytical approach (c) or (d) entails that the project be compared with the baseline scenario.

The following key criteria for additionality are applied (alone or in combination) in the methodologies examined:

The Identified Key Criteria for Additionality

(a)	The project faces prohibitive barriers
(b)	The project is not economically viable (without CERs)
(c)	The project is different from the baseline scenario (*c.f.* Eq. 1)

The primary methods for evaluating additionality apply either criterion (a) or (b). Criterion (c) is embedded in the sense that some methods which applied (a) or (b) compared the project with the baseline scenario. When criterion (c) was applied, this was done to show that the project was a less viable investment compared with the baseline scenario due to either lower profitability (*i.e.* essentially economic barriers) or to the existence of some other prohibitive barrier(s) which does not hinder the baseline scenario.

The methodologies examined were approved by the EB after the guidance and clarification offered by the EB in 2003, apparently irrespective of whether or not they were in accordance with Eq. 1. The question is whether Eq. 1 improves the credibility of the credits or not? Additionality is an inherently relative concept – it is not possible to be additional (in any sense) relative to nothing. A comparative method is equally essential when calculating emissions reductions - most would not accept an assessment of emissions reduction based on a description of project emissions. By clarifying what a project is to be compared with improves transparency and could also promote that a project does not apply different scenarios for the *ex ante* evaluations of investment additionality and emissions reductions (which is unacceptable). When Eq. 1 was applied among the methodologies examined there appeared to be a more obvious consistency between baseline scenario and baseline emissions. This is important for the validity of the credits, because the baseline emissions are supposedly the emissions

related to the baseline scenario. This implies that Eq. 1 is important for the validity of the credits.

5.4 Emissions Reductions

5.4.1 Definition of Emissions Reductions

Emissions reductions are defined as the difference between baseline emissions and CDM project activity emissions (hereafter referred to as project emissions) (UNFCCC, 2002a: Appendix B, Calculations). The formula for emissions reductions (ER) that can be derived from the Marrakesh Accords is as follows:

Eq. 3 $$ER = BE - PE,$$

where: BE=emissions within the project boundary + L_p
PE=emissions within the project boundary + L_p

ER: Emissions reductions
BE: Baseline emissions
PE: Project emissions
L_p: Leakage attributable to the CDM project

Project emissions are defined as the sum of (a) anthropogenic emissions by sources of GHGs from the CDM project activity within the project boundaries and (b) leakage. *Project boundaries* must encompass all anthropogenic emissions by sources of GHGs under the control of the project participants that are significant and reasonably attributable to the CDM project activity. *Leakage* is defined as the net change in anthropogenic emissions by sources of GHGs which occur outside the CDM project boundaries and that is measurable and attributable to the CDM project activity. *Baseline emissions* are defined as the sum of (a) anthropogenic emissions by sources of GHGs of the baseline and (b) leakage. The *baseline* is required to cover "emissions from all gases, sectors and source categories listed in Annex A within the project boundary" (UNFCCC, 2002a: Appendix B, Calculations; also see §44, 51 and 52).

There are two issues with the definitions and requirements provided by the Marrakesh Accords. (1) Both BE and PE are to be encompassed by the *project boundaries*. This implies that BE and PE are not differentiated (*i.e.* $BE - PE = 0$). (2) *Leakage* attributable to the CDM project (L_p) is to be accounted for both in the estimation of BE and PE. This implies that leakage will be cancelled out ($L_p - L_p = 0$). Under these conditions, ER will be zero. This was most likely not intentional.

Nevertheless, it means that to find out how *ER* is defined and calculated it is necessary to examine the AMs.

5.4.2 Definition of Emissions Reductions in Electricity Generation

The empirical findings imply that ER (in tCO_2e) can be expressed as in Eq. 4. This formula reflects how ER was calculated in the AMs as a group, but none of the AMs applied it fully.

Eq. 4 $$ER = (BE + L_{b\ indirect}) - (PE + L_{p\ indirect} + L_{p\ market})$$

ER *Emissions reductions*
BE *Baseline emissions*
PE *Project emissions*
$L_{b\ indirect}$: *Leakage in the form of indirect emissions associated with the baseline scenario*
$L_{p\ indirect}$: *Leakage in the form of indirect emissions associated with the project*
$L_{p\ market}$: *Leakage due to market effects caused by the project*

The AMs apply different formulae for calculating the *ER* (see below).[37] These tend to be specific for the AM rather than general for grid-connected electricity generation. *L* is considered by all AMs, but this is not always expressed in the formulae supplied. Furthermore, it tends to be conceptualized as primarily arising due to either market effects or indirect emissions. *Market effects* tend to be conceptualized as arising due to increased fossil fuel use caused by the project diverting biomass from other users (AM0004:5, 9; AM0007:2-3; AM0015:10). However, AM0010 conceptualizes market effects as possibly arising due to increased electricity consumption caused by the project affecting the electricity tariffs through increased supply of electricity, but this methodology is not to be used if *L* is expected (AM0010:3). Hence, AM0010 does not account for any *L*. *Indirect emissions* are considered by AM0005, AM0007, and AM0015, but only AM0005 accounts for it. It conceptualizes leakage as possibly arising to due to indirect emissions caused by activities such as power plant construction and fuel handling (extraction, processing, and transport) and land inundation (for hydroelectric projects) (AM0005:5).

[37] In this dissertation only electricity generation is addressed. Differences are thus not explained by formulae accounting for methane destruction or heat generation.

AM	Formulae for Calculating Emissions Reductions
AM0004, AM0007, AM0015	$ER = BE - PE - L_{p\ market}$
AM0010	$ER = BE$
AM0005	$ER = (BE + L_{p\ indirect}) - (PE + L_{p\ indirect})$ [a]

[a] *L is only accounted for if $L_p > L_b$ (i.e. when L_p is greater than L_b)*

Source: Respective AM

Considering that all AMs apply to renewable grid-connected electricity generation projects, it is difficult to explain why AM0004 accounts for emissions from combustion of biomass (in *PE*), while others do not. Similarly, it cannot be explained why some account for $L_{indirect}$, while others account for L_{market}; or why the latter is conceptualized differently among AMs. This indicates that *ER* is determined rather *ad hoc*. This introduces uncertainty regarding the validity and reliability of the calculations.

5.4.3 Direct & Indirect Environmental Criteria

Under the CDM, there is no explicit criterion for environmental additionality. However, there is a criterion embedded in the calculation of emissions reductions. Eq. 4 implies that the *ex ante* and *ex post* criterion can be expressed as follows:

Environmental Criterion

Eq. 5 $$BE + L_{b\ indirect} > PE + L_{p\ indirect} + L_{p\ market}$$

This criterion represents a comparison of emissions; and Eq. 5 simply states that $(BE + L_{b\ indirect})$ must be greater than $(PE + L_{p\ indirect} + L_{p\ market})$. However, in practice, the criterion that is indirectly applied by AM0005 (when $L_{p\ indirect} < L_{b\ indirect}$) and AM0010 (which equates *PE* and *L* with zero) is essentially that of Eq. 6. Furthermore, AMs are not always transparent regarding whether *L* would be assessed *ex ante*. If leakage is not accounted for, the *ex ante* criterion is *de facto* as follows:

Eq. 6 $$BE > PE$$

As will be shown below, both *BE* and *PE* depend on Q_p. Hence, Eq. 6 can be modified to clarify the key elements. The following general formula for *BE* (for electricity generation) is largely derived from the empirical findings:

Eq. 7 $BE = EF_b \cdot Q_p$

BE: Baseline emissions (in tCO_2e)
EF_b: Baseline emission factor (in tCO_2e/MWh)
Q_p: Total output (in MWh) of the project

PE can in turn be expressed using a similar formula:

Eq. 8 $PE = EF_p \cdot Q_p$

PE: Project emissions (in tCO_2e)
EF_p: Project emission factor (in tCO_2e/MWh)
Q_p: Total output (in MWh) of the project

This is not a formula for calculating *PE*. EF_p can be estimated by dividing *PE* by Q_p (*i.e.* electricity delivered to the grid). Replacing *PE* and *BE* in Eq. 6 with Eq. 7 and Eq. 8 gives the following criterion:

Ex Ante Environmental Additionality Criterion: Single-Source Baseline Scenario

Eq. 9 $EF_b > EF_p$

In contrast to Eq. 6, which appears to compare emissions, the above operation and derived expression (Eq. 9) clarify that the criterion represents a comparison of emissions intensities. In addition to serving as an environmental criterion, it can thus also serve as a technological criterion.

Assuming that the baseline scenario consists of a single source (*e.g.* EF_{Ex} and EF_{LCF}) (seeTable 5.2), Eq. 9 is compatible with the additionality criterion Eq. 1. This is because Eq. 9 expresses that the project is different from the baseline scenario by being less emission-intensive. Hence, in principle, Eq. 9 is a criterion for *environmental additionality* and *technological additionality*.

The equivalent criterion for a multiple-source baseline scenario (*i.e.* $X_b = \{x_{b_1}, x_{b_2}, \dots x_n\}$) can be derived using the following (*c.f.* Eq. 2):

Eq. 10 $EF_p \notin \{EF_{b_1}, EF_{b_2}, \dots EF_n\}$

This formula states that the emission factor of the project (EF_p) should be different from those of the baseline sources. More specifically, to reduce emissions the project must be less emission-intensive. Hence, if the baseline emission factors (EF_{b_i}) range

between some lower value a and higher value b, *i.e.* ($a \leq EF_{b_i} \leq b$), then the criterion for *environmental additionality* and *technological additionality* for multiple-source baseline scenarios can be expressed as follows:

General *Ex Ante* Criterion for Environmental Additionality

Eq. 11	$a > EF_p$	where $a \leq EF_{b_i} \leq b$

This formula states that the project must be less emission-intensive compared with the least emission-intensive baseline source. Eq. 11 can be applied when a single-source baseline scenario is used and achieves the same results as Eq. 9. Furthermore, Eq. 11 is in agreement with the additionality criterion for multiple-source baseline scenarios (Eq. 2). This implies that Eq. 11 is a *general criterion* or expression for environmental additionality.

Eq. 11 was indirectly applied by the AMs examined that required the use of a single-source baseline scenario, but a different criterion was applied by those requiring the use of a multiple-source baseline scenario, namely:

Ex Ante Environmental Criterion Applied in AMs: Multiple-Source Baseline Scenario

Eq. 12	$\overline{EF}_b > EF_p$

This formula states that the project must be less emission-intensive than the emissions intensity of the generation-weighted average plant in the baseline scenario ($\overline{EF}_b$). Examples of $\overline{EF}_b$ found in the AMs include: EF_{CM}, EF_{BM}, EF_{OM} and EF_{SAv} (see Table 5.2). The value of $\overline{EF}_b$ will always be some value between a and b (*c.f.* Eq. 11). This means that, it is not shown that the project is different from the normal range of BAU emissions intensity. This means that it is not obvious how emissions are conceptualized as being reduced. This issue is further addressed in Ch. 6 and 7.

5.4.4 Discussion: Operationalizing Eq. 11

Although Eq. 11 is already indirectly applied in some of the AMs, there are a couple of key issues which affect its effective operationalization. One possible issue is that *BE* and *PE* in the AMs tend to only account for emissions related to the process of electricity generation. As a general rule, to allow for a more correct environmental comparison, *BE* and *PE* must also encompass what is considered as $L_{indirect}$ under the CDM. The exception is if this type of emissions (*e.g.* emissions from fuel transports) is accountable to the baseline scenario and the project is comparable (*i.e.* $L_{b\ indirect} - L_p$

$_{indirect} = 0$), then they can be neglected (Tillman *et al.*, 1994). This leaves the issue of L_{market}, as these are only associated with the project.

In the CDM literature, there are different perspectives on L_{market}. While some perceive that the CDM is associated with L_{market}, which needs to be neutralized, others view the CDM as a potential means to significantly reduce L_{market} (Chomitz, 2002; Kallbekken *et al.*, 2007). The former is considered below as it is the perception reflected in the AMs examined. Carbon crediting in general, due to its project-based nature, will inherently be associated with L_{market}. The alternative is global action, but this is restricted by the political reality of climate politics. A problem is that the more effective carbon crediting is, *i.e.* the more projects there are that actually reduce emissions and thus dependency on fossil fuels, the greater the probability that L_{market} will increase. A central argument is that L_{market} needs to be dealt with in the broader context of addressing climate change to promote environmental effectiveness (impact effectiveness). However, it seems counterproductive to penalize initiatives (such as carbon crediting) which take place largely due to political inability to achieve an agreement that caps global GHG emissions, at least when accounting for L_{market} implies that an project is penalized for actions taken by other actors (who increase their emissions). In this case, it would appear to be more rational to address the sources of increased emissions. In principle, a possible alternative is to require that the baseline scenario reflects international best practices rather than national or local practices. This could most likely reduce carbon leakage due to shifts in production sites as described by Schneider *et al.* (2010). Then again, in the CDM context, the issue of setting international baselines is ultimately a political question. L_{market} needs to be examined further, but a more detailed examination is beyond the scope of this chapter.

The second issue relates to the system boundaries, *i.e.* the timeframe and geographical and technological boundaries, of the baseline scenario and the project. The system boundaries are important in an environmental comparative analysis and ensure the comparability of BE and PE (and thus EF_b and EF_p).

The relevant timeframe (time horizon) needs to be known to operationalize Eq. 11 and it needs to allow for an accurate comparison of emissions. The problem with the AMs examined is that ER is expressed on an annual basis. This is necessary for the purpose of earning credits on an annual basis *ex post*; but it is in principle not sufficient to operationalize the environmental *ex ante* criterion of Eq. 11, because BE, PE and/or L may vary for different years. The PDDs examined specify the crediting period (either 10 or 21 (7*3) years); and they also provide an *ex ante* estimation of emissions reductions for 7 (2), 8(1), 10 (1) or 21(1) years (numbers in brackets indicate the number of PDDs). The expected operational lifetime was reported as 25 years in the majority of the PDDs examined (one reported 15 years and one reported

a minimum of 25 years). For an environmental comparative analysis, the product lifetime must be considered when deciding the relevant timeframe (Tillman *et al.*, 1994). However, in the context of grid-connected electricity generation CDM projects, what are compared are the emissions caused by a specific project and emissions caused by the baseline scenario (reflecting other power plants). In addition, in an economic investment analysis (*e.g.* NPV analysis), the relevant timeframe depends on the expected cashflow related to the investment - it is equally reasonable to do the equivalent when performing an environmental analysis, *i.e.* account for the timeframe during which the project is expected to cause emissions. This implies that the relevant timeframe for the *ex ante* assessment of a project is the expected project lifetime. This will also facilitate consistency between the timeframe considered in the *ex ante* assessments of additionality and emissions reductions.

Geographical boundaries are not sufficiently addressed in the methodologies examined. AM0007 does not specify the geographical boundaries for selecting plausible alternatives which could be the baseline scenario (see Ch. 5.2.4). The other AMs mention 'the electricity grid' but most do not explain what this implied. It is thus unclear whether it refers to a regional, national, or international grid. Regional grids can be interconnected and make up a national grid. These can in turn be interconnected and make up an international grid.

Technological boundaries vary and are not comparable across the AMs examined. For estimating *PE*, AM0004 includes emissions from combustion of biomass to generate electricity, fossil fuel used as start-up and auxiliary fuel, and transports of biomass. In contrast, AM0005 and AM0010 account for no *PE*; and AM0007 and AM0015 only accounts for combustion of fossil fuel due to electricity generation. While fuel transports are conceptualized as a source of *PE* in AM0004, these are viewed as a potential source of $L_{p\ indirect}$ in AM0005, AM0007, and AM0015. However, only the former accounts for $L_{p\ indirect}$ when determining *ER*. For estimating *BE* for grid electricity generation, AM0004 and AM0010 account for emissions from all plants connected to the grid, but the former also includes emissions from the alternative use of fuel (continued open air burning of biomass). In contrast, AM0005 and AM0015 only account for emissions from fossil fuel-fired power plants connected to the grid, as reflected by the CM, but also account for electricity imports and exports. Furthermore, the AMs vary in terms of the GHGs accounted for. These inconsistencies in the system boundaries not only hinder an effective operationalization of Eq. 11, but they also imply that the calculations of the *ER* among the AMs are not comparable. By extension, the ensuing credits are not equivalent.

5.5 Conclusions of the Critical Examination of the CDM Methodologies

As part of addressing the research question 'Are CDM methodologies valid and reliable?' this chapter critically examines how Certified Emissions reductions (CERs) are created through CDM methodologies. This mechanism dominates the credit market and methodologies for creating carbon credits developed largely under the CDM. *Validity* (logical correctness) and *reliability* (reproducibility) are important for the *credibility* of the credits.

The creation of CERs relies upon the key concepts of *additionality* and *emissions reductions.* Both are relative concepts which are related to the *baseline scenario,* describing 'what would have taken place otherwise' (in the absence of a CDM project). A CDM project must be *additional*, and an additional project is not the *baseline scenario*. *Emissions reductions* are the difference between the emissions of the baseline scenario *(baseline emissions)* and those of the project *(project emissions)*.

Several issues which affect the credibility of the credits were identified through examination of the Additionality Tool (AT) and Approved Methodologies (AMs) applicable to grid-connected electricity generation projects. The primary issues identified were:

- The baseline scenario tended to be defined by the AMs (only two provide guidelines for identifying it); and while the AMs are applicable to similar projects, the baseline scenario differs widely across the AMs. This appears to be due to differences between AMs and not necessarily because the projects to which they refer are different. This suggests that reliability is an issue, as relatively similar projects may end up applying quite different baseline scenarios for no apparent reason. This also creates uncertainty regarding the validity of the baseline scenario.

- The guidelines for identifying the baseline scenario were not clear about the sampling criteria. In other words, the criteria for selecting the plausible alternatives (*i.e.* potential baseline scenarios) were not very specific. For example, the level of approach and the geographical boundaries were not addressed. This suggests that the identification of the baseline scenario can be arbitrary, which creates issues with the validity and reliability of the results of the assessment of additionality and emissions reductions.

- Not all methodologies appear to ensure that the baseline scenario is consistent with the baseline emissions. This creates a validity issue, because baseline emissions are supposedly the emissions of the baseline scenario. This suggests

that the conceptual link between investment additional projects (outputs) and emissions reductions (outcomes) is weak.

- Additionality is an inherently relative concept, and the counterfactual or null hypothesis is central for establishing additionality (see Ch. 4). When operationalizing a relative concept, a comparative method is essential for the validity of the results. In the CDM context, (investment) additionality is conceptualized as different from the baseline scenario. However, such a comparison is not necessarily required among the assessments of investment additionality examined here. Clarifying what a project should be compared with improves transparency and could also ensure that a project does not apply different scenarios for the *ex ante* (pre-registration) assessments of investment additionality and emissions reductions, which would be unacceptable (see above).

- A general *ex ante* criterion for *environmental additionality* was identified (in the context of electricity generation CDM projects), namely that the emissions intensity of the project must be below that of the baseline source(s). It is general in the sense that it can be applied irrespective of whether a single-source or a multiple-source baseline scenario is used (a *source* is a plant, facility, *etc.*). This criterion was indirectly applied through the calculation of emissions reductions by the AMs examined requiring the use of a single-source baseline scenario. However, it was not adhered to when the baseline scenario reflected multiple sources (*i.e.* when *e.g.* EF_{CM} was applied). Instead, the indirectly applied criterion was that the project must be less emission-intensive that the generation-weighted average source included in the baseline scenario. This implies that it is not demonstrated that the project is less emission-intensive than the normal range of BAU emissions intensity. This implies that it is not obvious how emissions are envisioned (or conceptualized) as being reduced. Hence, it is unclear how environmental additionality is pursued.

- Although the general criterion for environmental additionality (which also reflects technological additionality) is already indirectly applied in some of the AMs, there are some issues which affect its effective operationalization.

  - Firstly, as a general rule, indirect emissions (leakage) need to be accounted for in the notions of baseline emissions *(BE)* and project emissions *(PE).* Whether or not leakage due to market effects should be accounted for in *PE* could benefit from more research. It is possible that such leakage is better addressed through other means. International baselines could most likely

reduce carbon leakage due to shifts in production sites, but the introduction of such baselines is ultimately a political question.

- Secondly, the system boundaries of the baseline scenario and the project are not adequately addressed and also tend to diverge across methodologies. To ensure comparability between *BE* and *PE*, experiences from LCAs show that system boundaries need to be defined at several dimensions (timeframe, and geographical and technological boundaries). Inconsistent system boundaries when comparing *BE* and *PE* will hinder effective comparison of a project's emissions intensity and that of the baseline sources. It also implies that the estimated emissions reductions are not valid. Inconsistent system boundaries across AMs imply that the environmental criteria of the different AMs are not comparable and that the credits created through different methodologies are not equivalent.

6

CREDIT CREATION

ENVIRONMENTAL CRITERIA & BASELINE SCENARIOS IN CDM METHODOLOGIES – IS THERE A PLAUSIBLE THEORY OF EMISSIONS REDUCTIONS IN THE METHODOLOGIES?

6.1 Introduction

In this chapter, two of the key issues identified in the previous chapter are examined. Both are important for the validity of the environmental additionality claim and comprise the following:

(a) *Ex ante* environmental criterion, and
(b) Conceptual link (or lack thereof) between the *ex ante* evaluations.

Two environmental criteria were identified and depending on the criterion applied, it was found that it was not always clear how emissions were conceptualized as being reduced. More specifically, when a multiple-source baseline scenario was applied, the environmental criterion did not establish that the project was different from the baseline sources in terms of emissions intensity - the project could be within the normal range of BAU emissions intensity and still fulfill requirements for approval as a CDM project. Questions that can be put forward are whether this a recurring feature and whether it is a significant problem. Although an issue for validity, it is less significant if few CDM methodologies and projects apply multiple-source baseline scenarios. There is reason to believe that this type of baseline scenario is commonly applied. In the literature on calculating emissions reductions in GHG mitigation projects, *standardized baselines methodologies*, also known as *multi-project baselines (MPBs)* for their applicability to multiple projects, have been highly recommended (Kartha *et al.*, 2004; Murtishaw *et al.*, 2006; Steenhof, 2009). In particular, Kartha *et al.* (2004) recommend the use of the combined margin (CM) scenario. This scenario is included in one of the first approved consolidated methodologies (ACM0002) for

large-scale electricity generation projects under the CDM. The CM scenario and MPBs in general are multiple-source baseline scenarios.

The conceptual link between the *ex ante* evaluations of investment additionality and emissions reductions is important for linking outputs with outcomes. Without this link, the argument that investment additionality ensures environmentally credible CERs appears to rest on weak ground. The conceptual link is examined by comparing the scenario(s) reflected in the *ex ante* evaluations. The concepts of *investment additionality* and *emissions reductions* are both relative concepts related to the baseline scenario; the latter acts as a link between the former two concepts. Therefore, in this dissertation the baseline scenario is described as a *logic link* between the *ex ante* evaluations.

The 'Theory of Emissions Reductions' & the Baseline Scenario

If a project 'is not different from the baseline scenario ('what would have happened otherwise'), then it cannot truly reduce emissions. To ensure this a project must be investment additional. Such a project is not the *baseline scenario*, which is determined through an assessment of investment additionality. The difference between the emissions of the *baseline scenario* (baseline emissions) and those of the project (project emissions) are the emissions reductions.

This idea or 'theory' is broadly acknowledged, but the question is whether it is reflected in the CDM methodologies. The findings presented in Ch. 5 suggest that this is not necessarily the case.

This chapter critically examines: (a) the *ex ante* environmental criterion (or criteria); and (b) the (baseline) scenario(s) applied in the CDM *ex ante* evaluations. This is pursued through case studies of 'CDM methodologies' and the following were selected: all CDM methodologies found in Sectoral Scope 1 that were applicable to large-scale grid-connected electricity generation projects with one output (electricity) and methodological tools (available by 21 Aug. 2006). In addition, 30 registered CDM projects were selected and the methodologies applied in the PDDs for these projects were examined. These projects were all large-scale grid-connected electricity generation projects, and the intention was to select the 10 most recently registered (by 2 Dec. 2009), in China, India, and Brazil. These three were the largest CDM host countries in terms of registered projects at that time. Of the 1916 CDM projects registered by 2 Dec. 2009, 35% were to be found in China, 25% in India and 9% in Brazil (CDM 'Project Search' database, 2 Dec. 2009).

- 3 Approved Methodologies (AMs)
- 4 Approved Consolidated Methodologies (ACMs)
- 1 tool for the demonstration and assessment of additionality (Additionality Tool (AT)
- Methodologies applied in the PDDs for 30 registered CDM projects found in China, India and Brazil

Detailed lists of methodologies and projects are available in Appendix 1: Table A.1 and A.2, respectively.

In this chapter, to help put an otherwise relatively abstract analysis into context, a *theory-of-change* approach is applied. The approach can be seen as a means to clarify the significance of the analysis in relation to the program (CDM) and the target (emissions reductions). The *theory of change* in this context can be understood as 'the idea of emissions reductions'. More generally, the *theory of change* is an approach to program evaluation. The theory of change is not tested. Rather the theory (or theories) of change (emissions reductions) embedded in the CDM methodologies is critically examined. The question is whether there is a *plausible* theory (or theories) of change in the CDM *ex ante* evaluation (in principle, there can be more than one). Here, 'plausible' means a theory (or idea) in the CDM context where there is a clear link between the key concepts of *additionality* and *emissions reduction* that explains how emissions are conceptualized as reduced. Furthermore, the 'change' of interest in this dissertation is emissions reductions.

The outline of the remainder of this chapter is as follows. In section 6.1, the theory-of-change approach to evaluation is introduced. This is followed by a description of how it was applied for the purposes of this chapter. In section 6.2, the key factors (investment additionality and emissions reductions) are examined. In section 6.3, the logic gaps between these factors are analyzed. In section 6.4, the findings from examining the selected CDM methodologies are discussed. The conclusions are presented in section 6.5.

6.1.1 Theory of Change

The origin of the theory-of-change approach to evaluation, or theory-oriented evaluation, can be traced to the 1930s, but it became more widely known with Huey-Tsyh Chen's seminal book *"Theory Driven Evaluations"* from 1990 (Stame, 2004; Coryn *et al.*, 2011).[38] This approach opened the black box of programs and emerged

[38] Also referred to as program-theory evaluation, theory-based evaluation, theory-guided evaluation, theory-of-action, theory-of-change evaluation, program logic, logical frameworks, outcomes hierarchies, realist or realistic evaluation and program theory-driven evaluation science, among many others (Coryn *et al.*, 2011).

as a reaction to method-oriented evaluations. It has been described as a 'new wave' where there was a change in attitude toward methods. "All methods can have merit when one puts the theories that can explain a programme at the centre of the evaluation design" (Stame, 2004). Theory-driven forms of evaluation have been embraced as the preferred method for evaluation practice by numerous scholars and theorists, practitioners, and other entities, but a common vocabulary, definition, and shared conceptual and operational understanding have yet to be developed. As also noted by Coryn *et al.* (2011), it is difficult to define the core principle because theory-driven evaluation has no obvious ideological basis, which numerous other forms of evaluation clearly do. Furthermore, a wide variety of practitioners (from those who favor a systems approach to logic models) claim to be theory-driven in some capacity.

Theory-driven evaluations can investigate the entire program theory or only one aspect, element, or chain of the program theory (Weiss, 2000). In this dissertation, a simple linear representation of the program theory is shown in Fig. 3.1 (Ch. 3). "A crucial aspect of program theory, no matter how it is developed or articulated, is how various components relate to one another… Most importantly, a program theory should be *plausible* (*i.e.*, having the outward appearance of truth, reason, or credibility) and stipulate the cause-and-effect sequence…" (Coryn *et al.*, 2011).

Weiss describes the *theory of change* of the program as including the implementation theory and the program theory (Weiss, 2000). The *implementation theory* of the program describes the expected steps in the implementation of the program, *i.e.* the *implementation process*. The *program theory* describes the mechanisms as "the things that will largely determine whether the implementation theory succeeds in moving through the steps" (Weiss, 2000:36); and there can in turn be one or more 'theories of action'. While some programs are designed on an explicit theoretical basis, many are rather the product of experience, intuition, and professional rules of thumb. In the former case, it can be investigated whether the assumptions of the theory hold in practice. In the latter, it is necessary to uncover the implicit assumptions underlying the program and there are often multiple views on what will make the program successful (Weiss, 2000).

6.1.2 Theory-of-Change Approach to Examining the Credibility of CERs

Credible credits, reflecting real emissions reductions, are commonly conceptualized as depending on the project being 'additional' and reducing GHG emissions relative to a project-specific baseline scenario. As part of the implementation process of the CDM, projects apply CDM methodologies to determine that they are (a) investment additional and (b) will reduce emissions relative to the baseline scenario. Once validated by Designated Operational Entity (DOE), projects can be registered as

CDM projects (the project cycle is further explained in Ch. 2). The methodologies and the DOEs can be seen as important *inputs* to the implementation process. Projects are in turn outputs of the CDM (here referred to as Output I), and these projects can earn credits for the emissions reductions achieved. CERs are also outputs (here referred to as Output II), and these have a price and can be bought and sold in the carbon market. CERs offer an additional source of income for the CDM projects and create an incentive for emissions reductions. Emissions reductions can be described as an (expected) outcome, which is necessary to achieve the (expected) impact, *i.e.* climate change mitigation. However, the CDM is part of the KP and the credits can be used by Parties to achieve their emissions targets. The aggregated emissions reductions are thus determined by the KP. This is why the CDM is often described as a zero-sum game. In this broader context, the *impact* (or *environmental effectiveness*) is determined by the emissions target of the KP, and it cannot be improved by the CDM. However, if the credits are not *credible* (*i.e.* reflecting 'real' emissions reductions) then the expected outcome and impact will be reduced. Furthermore, the KP cannot achieve the same outcomes without the CDM. Although one could argue that emissions reductions are the same wherever they are achieved, the CDM promotes emissions reductions in countries and by actors which have no targets under the KP. The engagement of these (developing) countries and (private sector) actors is in turn generally accepted as important in relation to the aim of addressing climate change. This implies that the CDM has an important role to play, but the credibility of the credits is crucial.

Logic Model

For the purpose of critically examining the credibility of credits, a *logic model* influenced by Millar *et al.* (2001) was applied. This model, instead of starting from the inputs of CDM, working through the process, and ending with the desired target (or outcome), begins from the desired target and works its way backwards. It could perhaps be referred to as an inverted logic model. As explained by Millar *et al.*, "logic models that start with the inputs and work their way to the desired outcomes sometimes reflect a natural tendency to limit one's thinking to existing activities, programs, and research questions. We found that starting with the inputs tended to foster a defense of the status quo. One is less likely to challenge the status quo when one starts with the status quo" (Millar *et al.*, 2001:76).

The logic model process included the following steps:

1. Identify the target to be achieved
2. Identify factors that are known to influence the target
3. For each factor, identify activities needed to change the factor in such a way that it can make the desired end-state happen.
4. Gaps will become clear. Identify what new actions are needed to fill these gaps.

This process is largely comparable to the process described in Millar *et al.* (2001), but was altered for the purposes of this chapter. For example, they included a step for identifying (federal, state, local and private sector) programs for each activity (after step 3), whereas in this chapter, the CDM is the program of interest and others are not addressed. Furthermore, this study is limited to addressing the implementation process ('activities') in the sense that what are addressed are the *ex ante* criteria of additionality and emissions reductions. This also means that step 4 is focused on a key aspect, the *ex ante* evaluation of proposed CDM projects, within the element of implementation process of a single program, rather than focusing on multiple programs as was the case in Millar *et al.* The inverse approach means that the analysis in this chapter examines the environmental criterion (or criteria) before investment additionality.

6.2 Target & Key Factors

The target of interest in this chapter is emissions reductions. To achieve this target, the CDM seeks to ensure both *Output I* (*i.e.* projects which are investment additional and reduce emissions) and *Output II* (*i.e.* credible credits, reflecting real or additional emissions reductions). Ensuring Output I requires an *ex ante* evaluation that is valid, reliable, and practicable. Furthermore, this output is a necessary prerequisite for ensuring Output II. However, ensuring the latter also requires an *ex post* evaluation that determines the amount of credits to be issued to a registered project. This evaluation needs to include methods for calculating, monitoring and verifying the emissions reductions claimed. Others have already addressed the calculation of emissions reductions in electricity generation projects (*e.g.* Kartha *et al.*, 2004; Murtishaw *et al.*, 2006; Steenhof, 2009) and the CDM supervisory system (Lund, 2010). The primary focus in this chapter is the CDM methodologies applied in the *ex ante* evaluation necessary for ensuring Output I. Practicality is only addressed to a lesser extent.

The key factors in the *ex ante* evaluation are identified as environmental and investment additionality. In the PDDs, the former is addressed in section 'B.6.3. Ex-ante calculation of emission reductions' (hereafter referred to as '*ex ante* evaluation of

emissions reductions'); and the latter in 'B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality)' (hereafter referred to as '*ex ante* evaluation of investment additionality') (EB, 2006). *Investment additionality* is commonly considered as the primary prerequisite to ensure the environmental credibility of the credits and it has been addressed in several studies (see Ch. 4). What appear to have received less attention both in the CDM literature and in practice are:

- The *environmental (additionality) criterion* necessary for promoting emissions reducing projects (Output I); and
- The *logic link* (or lack thereof) between the *ex ante* evaluations of investment additionality and emissions reductions.

It is commonly accepted that to reduce emissions, a project must be investment additional, *i.e.* it is not the baseline scenario, and reduce emissions compared with the baseline scenario. This suggests that, conceptually, the baseline scenario represents what is referred to in this dissertation as the *logic link* between the *ex ante* criteria of investment additionality and emissions reductions. However, as was shown in Ch. 5, the baseline scenario is not always applied in the CDM methodologies for assessing investment additionality. To examine the possible implicit logic link, or the lack of it, the following were compared:

(a) The scenario reflected by the baseline emission factor (EF_b) and
(b) The scenario reflected in the (investment) additionality assessment.

'Additionality' and 'emissions reductions' are inherently relative concepts. A project cannot be additional or reduce emission (in any sense) compared with nothing. This suggests that the assessments of emissions reductions and investment additionality will necessarily be made relative to something. The scenario (*i.e.* the 'something') is identified through the following parameters (or dimensions):

(i) *Level of approach: e.g.* actor, sector, country
(ii) *Timeframe:* years and/or historical, contemporary, future (relative to the project)
(iii) *Geographical boundaries: e.g.* local/regional, national, international
(iv) *Sampling frame: e.g.* fossil fuel-fired power plants
(v) *Plant age:* historical, contemporary, future (relative to the project)

The key question is whether there is a plausible theory of change (or emissions reductions). In this chapter this question is approached through an examination of the *environmental criterion* (or criteria) and a comparison of scenario (a) and (b) along the selected parameters. The latter were identified as relevant through the work presented in Ch. 5.

6.2.1 Study of the CDM *Ex Ante* Evaluation of Emissions Reductions

In the calculation of emissions reductions, the key elements compared are the baseline emission factor (EF_b) and the project emission factor (EF_p). Two (indirect) criteria for emissions reductions were identified here (*c.f.* Ch. 5).

Environmental Criteria for Emissions Reductions

Eq. 1 $a > EF_p$ where ($a \leq EF_{b_i} \leq b$)

This formula states that the project must be less emission-intensive than the emissions sources included in the baseline scenario. a *and* b *denote the lowest and highest emission factor values, respectively, among the baseline emissions sources.*

Eq. 2 $\overline{EF}_b > EF_p$

This formula states that the project must be less emission-intensive than the (generation-weighted) average emission factor of the emissions sources included in the baseline scenario.

These criteria are not equivalent (see Ch. 5). An issue with Eq. 2 is that it does not ensure that the project is different from the BAU *emissions sources* (*i.e.* plants, facilities, units, *etc.*). This challenges the idea of a project introducing change (and thus emissions reductions), because the project can have an emission factor that is within the normal range of BAU emissions intensity and still be registered as a CDM project.

Eq. 2 was the most commonly applied criterion among the CDM methodologies and projects examined. Both Eq. 1 and 2 were indirectly applied depending on the baseline scenario applied. Eq. 1 was applied when a project applied a *single-source baseline scenario* (*i.e.* a baseline scenario comprising a single emissions source), and Eq. 2 when a project applied a *multiple-source baseline scenario* (*i.e.* a baseline scenario comprising multiple emissions source). These criteria were indirectly applied in the sense that they are not explicit criteria, but they were embedded in the calculations of emissions reductions (*c.f.* Ch. 5).

The majority of the methodologies examined required or allowed the use of a multiple-source baseline scenario; and it was applied by all the projects examined. As shown in Table 6.1, the most common EF_b alternative among the methodologies examined was the combined margin emission factor (EF_{CM}). Other EF_b alternatives included *e.g.* the generation-weighted system average emission factor (EF_{SAv}) and the build margin emission factor (EF_{BM}). The various emission factors are briefly described below. All the projects examined applied the EF_{CM}.

Table 6.1
Baseline Emission factors in the Methodologies

Methodology	Project Type	Baseline Emission Factor (EF_b) (see notation below)
AM0019 [a]	Greenfield	EF_{Ex} (reflecting a single identified plant)
	Brownfield	-
AM0026	Greenfield	EF_{CM}
	Brownfield	EF_{Ex} (existing facility before modification or retrofitting) and EF_{CM} (for electricity generation above baseline level, i.e. pre-modification and pre-retrofit level)
AM0029	Greenfield	The emission factor with the lowest value: EF_{BM}, EF_{CM} , or EF_T
	Brownfield	-
ACM0002	Greenfield	EF_{CM}
	Brownfield	EF_{Ex} (existing facility before modification or retrofitting) and EF_{CM} (for electricity generation above baseline levels, i.e. pre-modification and pre-retrofit)
ACM0004	Greenfield	EF_{CM}
	Brownfield	-
ACM0006 [a]	Greenfield	EF_{CM} if project > 15MW, or alternatively EF_{SAv} if project < 15MW
	Brownfield	EF_{Ex} (existing plant before fuel-switch)
ACM0007	Greenfield	-
	Brownfield	Combination of EF_{Ex} (estimated on existing power plant to be converted from single to combined cycle power generation) and EF_{CM} (reflecting the increased generation of electricity relative to the pre-conversion)

[a] *ACM0006: see scenarios 1-4, 9-14, and 16 (p. 21); and scenario 15 on p 23. The following are not addressed here: scenarios 5-8 (see notations below).*

Acronyms: Approved Methodology (AM), Approved Consolidated Methodology (ACM)

EF_{BM}	*Emission factor of the build margin (BM)*	*(multiple-source)*
EF_{CM}	*Emission factor of the combined margin (CM)*	*(multiple-source)*
EF_{Ex}	*Emission factor of the existing facility*	*(single-source)*
EF_{SAv}	*System average emission factor*	*(multiple-source)*
EF_T	*Emission factor of the technology identified as the baseline scenario*	*(single-source)*

Note: (1) the above EF abbreviations may diverge from those applied in the methodologies (e.g. AM0019 uses 'EF_{bl}'). The above abbreviations are applied here for a more consistent terminology in this dissertation. (2) EF_b reflecting electricity generation is addressed here. However, captive power and cogeneration is not addressed. Some of the methodologies apply to various types of projects and can include a range of different types of baseline scenarios addressing e.g. heat generation and uncontrolled burning of biomass (see ACM0006) (see section 1.4.3, 'Case Selection & Limitations').

Source: Respective methodology (see Appendix 1, Table A.1)

The EF_{CM} was recommended by Kartha *et al.* (2004) as appropriate for most electricity generation projects, and for greenfield projects in particular. This is because in practice it is very difficult to know what electricity will actually be replaced (*i.e.* generation of capacity additions/plants on the operating margin). This is particularly so when a project does not obviously replace, modify or retrofit an existing project, *i.e.* when it is not a brownfield project. In general, Kartha *et al.* (2004) found that it is important to consider the effects of a project on the operation of existing power plants (the operating margin) and on the construction of new generation facilities (the build margin). They also recommended that the EF_{CM} be estimated based on grid-specific data (Kartha *et al.*, 2004). In principle, the EF_{Ex} could be valid for brownfield projects, but any increase in electricity generation due to a change at the existing plant should be accounted for by applying the EF_{CM} (Kartha *et al.*, 2004). Kartha *et al.* (2004) have been influential in the CDM context (this paper is *e.g.* mentioned in several of the PDDs examined and several ideas are clearly reflected in the methods for deriving the EF_{CM}).

Kartha *et al.* (2004) examined various methods for calculating emissions reductions. They and others agree that 'multiproject baselines' are less costly and require less effort (see *e.g.* Murtishaw *et al.*, 2006; Steenhof, 2009). In the literature on calculating emissions reductions for the power sector, *multiproject baselines* and *standardized baseline methodologies* are commonly used terms. These denote that the methodologies/baselines are applicable to multiple projects, and in contrast to a project-by-project approach. It is not a coincidence that the term *multiple-source baseline scenarios* was chosen for use in this dissertation. In contrast to *e.g.* Kartha *et al.* (2004), the focus here is not on calculation of the emissions reductions and the applicability of the baseline scenario. A multiple-source baseline scenario does not describe applicability, but that a baseline scenario comprises multiple emissions sources. In principle, a multiple-source baseline scenario can be tailored to a specific project or applicable to multiple projects. In contrast, *multi-project baselines* are specifically designed to be applicable to multiple projects. The relationship between the multi-project baselines and multiple-source baseline scenarios is further discussed in section 6.4.

Table 6.2 provides an overview of the findings from examining the individual emission factors. These results are discussed below.

Table 6.2
Overview of Findings from Examining Individual Emission factors (section 6.2.1)

EF	Level of Approach		Timeframe		Geographical Boundaries		Sampling Fame		Plant(s) Age [b]	
	Meth.	Proj.	Meth.	Proj.	Meth.	Proj.	Meth.	Proj.	Meth.	Proj.
EF_{Ex}	Actor	-	Existing plant/ Crediting period	-	-	-	(FF)	-	-	-
EF_{BM}	Sub.	-	Annual/ Crediting period	-	Reg.	-		-	Possibly Con.	-
EF_{CM}	Sub.	Sub.		Crediting period [a]	Reg.	Local/ Reg.		(FF)	Hist.-Con.	Hist.-Con.
EF_{Sav}	Sector	-		-	Reg.	-		-	Hist.-Con.	-
EF_{T}	Sub.	-	Crediting period	-	Reg.	-	-	-	Likely Con.	-

[a] *7 or 10 years*

[b] *Relative to project starting date*

Abbreviations: Contemporary (Con.), Fossil fuel-fired power plants (FF), Historical (Hist.), Methodology (Meth.), Project (Proj.) Regional (Reg.), Sub-sector (Sub.)

Source: Methodologies and PDDs for projects listed in Appendix 1, Table A.1 and A.2, respectively.

Level of Approach

The EF_{Ex} can be described as reflecting an actor (or project-specific) approach (AM0019, ACM0006, and ACM0007). EF_{CM}, EF_{BM} and EF_{T} are described in this chapter as reflecting a *sub-sector* (project-type specific/technology-specific) approach (AM0026, AM0029, ACM0002, ACM0004, and ACM0007); and the EF_{Sav} is described as reflecting a *sector* approach, because it reflects all electricity sources connected to a grid (ACM0006). All the CDM projects examined applied the EF_{CM} and all are categorized in this chapter as reflecting a sub-sector approach. This is explained by the sampling frames primarily including only fossil-fuel electricity generation (see below).

Timeframe

In the methodologies, emissions reductions (and thus also the EF_b) tended to be accounted for on an annual basis or was fixed for the crediting period. This largely depended on whether *ex ante* or *ex post* data would be applied in the real-life context. If EF_b is determined based on *ex ante* data (which is necessary in determining EF_{Ex}, but it was also included as an option when determining e.g. EF_{OM} in ACM0002) it

will be fixed. If *ex post* data is to be used, EF_b would be estimated on an annual basis. However, the timeframe of EF_{Ex} tended to depend on the pre-existing plant (see AM0019:2; AM0026:2; ACM0002:4; and ACM006:23). Nevertheless, project participants can only choose either a renewable 7-year or fixed 10-year crediting period (hence this will limit the maximum timeframe). In practice, the timeframe considered among the projects examined when they estimate the emissions reductions *ex ante* corresponds to the 7- or 10-year crediting period. For example, project 1844 estimates emissions reductions *ex ante* for the first 7 years (of the operational lifetime) in the PDD, but the expected operational lifetime of the project is 35 years, preceded by another 3.5 years of construction. For the *ex post* calculation of emissions reductions, it is perhaps preferable to use shorter timeframes (as reflected by *e.g.* the crediting periods) to allow for more accurate calculations. However, in the example provided, the *ex ante* environmental evaluation only accounts for approximately 18% of the time during which the project is expected to cause emissions. In general, this does not allow for an accurate *ex ante* environmental comparison (*c.f.* Ch. 5), largely because it is highly unlikely that the EF_b (particularly when reflecting multiple emissions sources) will be constant for as long as 20-40 years.

Geographical Boundaries

All but one of the methodologies examined describe the geographical boundaries as depending on the regional electricity grid (to which the project is to be connected). AM0019 does not describe the geographical boundaries. This methodology applied EF_{Ex}. Generally, the geographical boundaries of EF_{Ex} will be determined by the location of the existing plant reflected by the emission factor. All the projects examined apply the EF_{CM} and use either local isolated or regional interconnected grids. As a result, the EF_{CM} values in the same country vary significantly, but the Chinese and Indian values vary less than the Brazilian (see Table 6.3). Difference in variability was confirmed by comparing standard deviation values. According to the PDDs, China and India centrally publish regional EF_{BM} and EF_{OM} values. This did not appear to the case in Brazil (according to the PDDs reviewed). This possibly explains the greater variability in the Brazilin data, but it could also be that there are greater regional differences in the country.

Table 6.3
Baseline Emission Factor Values

China	tCO_2/MWh	$\bar{x}$	σ
EF_{BM}	0.574-0.940	0.761	0.136
EF_{OM}	0.942-1.291	1.178	0.114
EF_{CM}	0.850-1.078	0.985	0.072

India	tCO_2/MWh	$\bar{x}$	σ
EF_{BM}	0.590-0.710	0.655	0.056
EF_{OM}	0.986-1.004	1.000	0.005
EF_{CM}	0.793-0.930	0.862	0.052

Brazil	tCO_2/MWh	$\bar{x}$	σ
EF_{BM}	0.049-1.016	0.192	0.291
EF_{OM}	0.104-0.958	0.497	0.244
EF_{CM}	0.077-0.942	0.344	0.241

$\bar{x}$: Average; σ: Standard deviation

Source: Information was gathered and values computed based on information provided in the PDDs for the projects listed in Appendix 1, Table A.2.

Sampling Frame (for sources included in the EF_b)

Most methodologies and all projects examined indicated that they are limited to including only fossil fuel-fired power plants in the estimation of the EF_b. This implies that the level of approach can be described as sub-sector. Methodologies tended to states that "[f]or the baseline determination, project participants shall only account CO_2 emissions from electricity generation in fossil fuel fired power that is displaced due to the project activity" (see AM0019:6; AM0026:3; AM0029:4; and ACM0002:3; ACM0004:1; ACM0006:15). Furthermore, in AM0019 the title indicated its applicability is limited to projects replacing a fossil fuel-fired plant (see Appendix 1, Table A.1) and the applicability of ACM0004 was restricted to electricity generation projects "that displace electricity generation with fossil fuels in the electricity grid or displace captive electricity generation from fossil fuels..." (ACM0004:1). According to ACM0002 "[t]he project activity mainly reduces carbon dioxide through substitution of grid electricity generation with fossil fuel fired power plants by renewable electricity" (ACM0002:12). ACM0006 includes a similar statement (ACM0006:17). According to ACM0007, "[f]or the purpose of determining the **baseline**, project participants shall include the following emission sources: CO_2 emissions from fossil fuel fired power plants connected to the electricity system and in the operating and build margin…" (ACM0007:3). These findings indicated that the sampling frame is limited to fossil fuel-fired plants among most of the examined methodologies. AM0029 (when applying EF_T) appear to be the only

exception. However, an examination of the calculative methods for estimating the EF_{CM} suggests that this is not necessarily the case. Whether only fossil fuel-fired power plants are actually included in the estimation of the EF_b depends on the calculative method applied (see below). The sampling frame is thus somewhat unclear.

The majority of the methodologies examined refer to ACM0002 for calculating the EF_{CM} (AM0029, ACM0004, ACM0006, and ACM0007). ACM0007, which is the only methodology examined allowing the use of EF_{Sav}, requires that ACM0002 be applied to estimate it using the 'Average OM' method. Despite its name, the latter is a method for estimating the generation-weighted system average. The EF_{CM} is a weighted average of the EF_{BM} and EF_{OM} and the respective weights are by default 0.5. EF_{BM} excludes 'low-cost and must-run' (LCMR) power sources. These typically include hydro, geothermal, wind, low-cost biomass, and nuclear. Hence, its sampling frame is limited to fossil fuel-fired power sources. In contrast, EF_{OM} may include non-fossil fuel power sources (*i.e.* LCMR power sources) depending on the method applied to estimate it. For estimating EF_{OM}, ACM0002 includes four methods (see below). The inclusion of LCMR power sources implies that non-fossil fuel-fired power sources may be included. The only methodology examined that allows the use of EF_{BM} requires that ACM0002 be applied to estimate it (AM0029). As mentioned earlier, the EF_{BM} described in ACM0002 excludes LCMR power sources.

EF_{OM} Method	LCMR Sources
'Average OM'	Included
'Simple OM'	Excluded
'Simple Adjusted OM'	Included
'Dispatch Data Analysis'	Excluded

Acronyms: Emission factor of the operating margin (EF_{OM}), 'Low-cost and must-run' (LCMR)

Source: ACM0002 (see Appendix 1, Table A.2)

The projects examined all applied EF_{CM} values derived through the application of ACM0002; and they varied in terms of including or excluding fossil fuel-fired power sources. The Chinese values were estimated based on excluding non-fossil fuel-fired power sources. In contrast, the Indian EF_{BM} values included non-fossil fuel-fired power sources. In the majority of the Brazilian projects examined, the EF_{OM} included non-fossil fuel power sources; and the type of power source included in the EF_{BM} could not be determined. However, as far as it was possible to determine, no project applied EF_{BM} and EF_{OM} values which both included non-fossil fuel power sources. Despite some uncertainties, EF_{CM} applied by the projects are categorized here as reflecting a sub-sector approach.

Plant Age

The explicit or implicit age of the power plants included in the estimation of the EF_b will depend on the type of emission factor and methodology applied and the real-life context. Findings are summarized below.

EF_b	Plant Age (relative to the project)
EF_{Ex}	Depends on the identified/existing plant
EF_{BM} [a]	Possibly contemporary
EF_{CM}	Historical – contemporary (ranges)
EF_{Sav}	Historical – contemporary (ranges)
EF_T	Likely contemporary

[a] *AM0029*

Note: The various EF_b are described under Table 6.1.

Source: Methodologies and PDDs for projects listed in Appendix 1, Table A.1 and A.2, respectively.

Only one methodology examined (AM0029) allows the application of EF_{BM} and it applies ACM0002 to estimate it. ACM0002 includes two options for the sample group, and the group that comprises the larger annual generation is to be used. The sample group may consist of either (a) the five most recently built plants, or (b) capacity additions that comprise 20% of the system generation (in MWh) and that have been built most recently. The latter group was applied by all the projects examined in China and India. In half of the Brazilian projects (PDDs for projects 809, 891, 1317, 1829 and 1999), the sample group could not be determined based on the information available in the PDDs. In the remaining half, the following was found: three reflected the 'five most recently built plants' (PDDs for projects 1232, 1342, and 1843); and two reflected the 'capacity additions that represent 20% of the system generation' (PDDs for projects 1279 and 1626).

In general, information about the age of the plants used to estimate the EF_b was not available in the PDDs examined. Project 1844 is an exception (found in India). In its PDD, the EF_{OM} and EF_{BM} included plants with operational starting dates of 1967-2006 and 2001-2007, respectively. The project expected to start operations in 2009. In China and India, emission factor data are published centrally. However, in China, the relevant information is only published in Chinese and is difficult to interpret. However, it appears that only aggregated regional data are published. The oldest plants in the Indian database have operational starting dates dating back to the 1920s (CEA, 2008). According to project 2736, depending on the region, the EF_{BM} covers units commissioned in the last five to ten years (PDD for project 2736). Furthermore, plants more than 10 years old are allowed for calculating the EF_{BM} according to the

'Tool to calculate the emission factor for an electricity system, Version 02' (available on the CDM website).[39] These findings show that the age of the power plants included in the EF_{CM} can range significantly. The findings also indicate that the age of the plants included in the estimation of EF_{Sav} will likely range significantly due to the extended operational lifetimes of electricity power plants in general. The EF_{BM} is the only emission factor that is likely to exclude very old plants, but as plants older than 10 years are not excluded, it is not certain that it can be considered as ensuring the inclusion of only contemporary plants. There is no age limit for EF_{EX} and the age of the plant will depend on the identified or existing plant. Similarly, there is no age limit for EF_T, but it is to be ensured "all relevant power plant technologies that have recently been constructed or are under construction or are being planned (e.g. documented in official power expansion plans) are included as plausible [baseline] alternatives" as part of identifying the baseline scenario (AM0029: 2). This suggests that it seems likely that contemporary investments (relative to the project) will be considered. Assuming that it reflects a contemporary investment, EF_T can be described as a BM scenario reflecting a single source.

6.2.2 Study of the CDM *Ex Ante* Evaluation of Additionality

Additionality can be assessed using different criteria which aim to weed out viable investments. This aim is primarily pursued by determining that a project (a) faces prohibitive barriers, (b) is not economically viable and/or (c) is different from the baseline scenario (*c.f.* Ch. 5).

Methodologies

To address additionality, all the methodologies examined require that the AT be applied. According to the AT examined, a project participant can choose to apply either the Investment Analysis (Step 2) or the Barrier Analysis (Step 3), or both. The former includes three options (see below).

Investment Analysis (Step 2), Options:

(I)	Simple cost analysis
(II)	Investment comparison analysis
(III)	Benchmark analysis

Source: 'Tool for the demonstration and assessment of additionality' (see Appendix 1, Table A.1).

[39] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v2.2.1.pdf/history_view (last accessed 30 Dec. 2011)

While most of the methodologies examined require that the AT be applied as it stands, there are two exceptions. AM0029 require that project participants apply Step 2, Option III. Furthermore, AM0026 allows those pursuing Step 2 to apply an alternative method of analysis (not included in the AT). This method incorporates the use of the optimization model used by the electricity regulating authority to identify the capacity expansion plan. The findings are summarized in Table 6.4.

Data were largely inferred from the information available in the methodologies examined (AT and AM0026). As indicated, actual application of the methodologies will often determine the actual outcome. For example, according to the AT, as an alternative (to the project), 'continuation of current situation' can be included if applicable. This cannot be classified on its own, context specific information is needed.

Table 6.4
Overview of Findings from Examining the CDM *Ex Ante* Evaluation of Additionality: Methodologies

	Additionality Tool (AT)				AM0026
	Step 2: Investment Analysis (Options)			Step 3: Barrier Analysis	Alternative available if Step 2 of the AT is pursued
	I	II	III		
Comparison of the project and the *alternative(s)* is explicitly required (a)	No	Yes	No	Yes	Yes
Level of approach	-	Actor / Sub./ ? (c)	Actor/ Sub./ Sec./ Country (f)	Actor / Sub./ ? (c)	Sector
Timeframe	-	Con. (d)	Con.– Fut. (g)	Con. (d)	Con.– Fut.
Geographical boundaries	-	-	Local/ Reg./ Nat.	-	Local/Reg./Nat.
Sampling frame	-	(a)	Similar project type and decision context	(a)	Capacity addition plan
Age of plant(s)	-	Con./ ? (d)	Con.– Y. (h)	Con./ ? (d)	Con.– Y.
Notes:	(b)	(e)		(e)	

Abbreviations: Contemporary (Con.), Future (Fut.), National (Nat.), Regional (Reg.), Sector (Sec.), Sub-sector. (Sub.), Y. (Young.), International (Int:l); Unknown (?)

(a) The alternative(s) are described as realistic and credible alternative(s) available to the project developer or similar project developer that provide outputs or services comparable to the proposed project. Furthermore, 'current situation' was described as a possible alternative if applicable.
(b) Only the project is addressed.
(c) Other levels ('?') may possibly apply depending on what the 'current situation' is (if included).
(d) Project developers will reasonably be expected to consider contemporary alternatives (to the proposed project). 'Current situation' cannot be understood without context.
(e) The age of contemporary alternative(s) will be contemporary compared with the proposed project. 'Current situation' cannot be understood without context.
(f) Depends on the type of benchmark used (e.g. company internal benchmark, benchmarks relevant for similar projects, government bonds, etc.)
(g) Financial indicator (benchmark) values will reasonably be contemporary or possibly forward looking. Historical values are less likely to be applied.
(h) Contemporary financial values suggest that the implicit 'age of plants' will be contemporary, and younger (relative to the project) if the value is forward looking.

Source: Relevant information was derived or inferred from the respective methodology (see Appendix 1, Table A.1).

Projects

The projects examined applied the AT to assess additionality and the majority applied the Investment Analysis (Step 2). Of the 30 CDM projects examined, 25 applied the Investment Analysis by itself or in combination with the Barrier Analysis (Step 3).[40] Of these, 24 applied the Benchmark Analysis (Step 2: Option III). The only exception applied the Investment Comparison Analysis (Step 2: Option II). The Barrier Analysis (Step 3) was applied by 14 of the projects examined.[41] Findings from the case study are presented below.

Investment Analysis: Investment Comparison Analysis (Step 2, Option II)

Level of approach	Actor
Timeframe	30 years
Geographical boundaries	Local
Sampling frame	Alternatives to be developed by the project developer
Age of plant(s)	Contemporary (relative to the project)

Source: PDD for project 1844 (see Appendix1, Table A.2).

The investment comparison analysis was applied by project 1844. In the analysis, actor-specific alternatives to the proposed CDM project (hydro power plant) were compared (using equity IRR). The timeframe of the investment analysis is largely comparable to the expected operation lifetime of the project, which is 35 years. The sampling frame included alternatives to be developed by the project developer in question. The alternatives included the project (as a non-CDM project), coal-fired power plants (50-300 MW) and natural gas-fired power plants (50-119.8 MW). The cost estimates were based on the assumption that the coal and natural gas-fired power plants would be located in Chandigarh and connected to the northern regional grid (of India) (same as the proposed CDM project).

[40] China: 9 of 10 projects; India: 9 of 10 projects; Brazil: 7 of 10 projects

[41] China: 1 of 10 projects; India: 5 of 10 projects; Brazil: 8 of 10 projects

Investment Analysis: Benchmark Analysis (Step 2, Option III)

Level of approach	Actor, sub-sector, sector, country or international
Timeframe	Generally corresponded to the project's operational lifetime (20-35 years)
Geographical boundaries	Local, national or international
Sampling frame	Investment(s) available to the project participant, small hydropower plants, electricity generating power plants, alternative investments in the country, alternative international investments (alternative investment are not necessarily investments in electricity generation)
Age of plant(s)	Contemporary – younger (relative to the project investment decision)

Source: PDDs for projects: 2744, 1854, 2756, 2745, 2118, 2590, 2450, 2693, 1855 (found in China); 2736, 2605, 2474, 1687, 2347, 2112, 1905, 2025 (found in India); and 1829, 1999, 1843, 1626, 1232, 1279, 1342 (found in Brazil) (see Appendix1, Table A.2).

In the benchmark analyses of the projects examined, no reference was made to the baseline scenario. The findings summarized above were largely inferred from the applied benchmarks and their values as described below.

The level of approach varied among the projects. The Chinese projects applied either a sector approach (electric power sector benchmark, 8%) or a sub-sector approach (project-type/technology-specific benchmark for small hydropower projects, 10%). In contrast, the Indian and Brazilian projects applied a wider variety of benchmarks; and the level of approach varied more. Examples of actor-level approaches include the use of *e.g.* local lending rate applicable to the proposed project (project 1687) and investor-specific required rate of return plus a country risk premium (project 1232 and 1342). Examples of country-level approaches are the use of *e.g.* the Prime Lending Rate published by the Reserve Bank of India (project 2025) and government bond rates (project 1828). As also suggested by these examples the geographical boundaries varied, generally from local to national. However, some projects applied a country risk premium when deriving the benchmark (see above). This implies that the level of approach and geographical boundary can be described as international.

The timeframe of the investment analysis generally corresponded explicitly to the operational lifetime of the projects examined, ranging between 20 and 35 years. However, some also included time for *e.g.*, financing, logistics planning, and/or construction.

The age of the plants was inferred from the fact that benchmark values tended to be relevant around the time when the investment analysis was carried out. Such benchmark values are relevant for contemporary investments. Project 1999 is an

exception in that it applied a 21-year government bond rate (issued 2007). This benchmark can be described as reflecting contemporary and future investments and thus contemporary and younger plants relative to the project (investment decision).

Barrier Analysis (Step III)

Level of approach	Sub-sector
Timeframe	Contemporary – future
Geographical boundaries	National
Sampling frame	Thermoelectric units
Age of plant(s)	Contemporary – younger (relative to the project investment decision)

Source: PDDs for projects 1279 and 1999 (see Appendix 1, Table A.2).

As part of the barrier analysis, projects have to show that at least one of the alternatives (to the project) is not prevented by the barriers (AT) (under section B.3, Step 3, Sub-step 3b, in the PDDs). The projects examined generally described several barriers facing the project, at length (under section B.3, Step 3, Sub-step 3a, in the PDDs). While the description of the barriers generally was several pages long in the PDDs examined, the part showing that at least one of the alternatives (to the project) is not prevented by the barriers was seldom more than a few sentences. Only two of the 14 projects examined applying barrier analysis offered some type of analysis regarding the effect of the barriers on what can be considered comparable to the baseline scenario relevant for electricity generation (PDDs for projects 1279 and 1999). The analyses offered by these two were examined and the results are given above. Both projects considered the construction of new thermoelectric units in Brazil (PDDs for projects 1279 and 1999).

In the remaining cases, there was no comparative analysis or the alternative(s) (mentioned in the analysis) were clearly different from the scenario reflected by the EF_{CM}. For example, project 2561 (the only project in China applying a barrier analysis) simply states that "the supply of equivalent power generation by the Northeast China Grid...is not prevented by the barriers listed" (PDDs for project 2561:20). This is not so much an analysis as a conclusion, and it is unclear how the project participants arrived at it (this is further discussed in section 6.4). The projects in India either simply stated that the barriers are not applicable to the baseline scenario, did not compare the project with any alternative(s), or did not address the baseline scenario/alternative(s) relevant for electricity generation (see PDDs for projects 2605, 1687, 2347, 2378, 1905). Similarly, the Brazilian projects described the alternative(s) as 'financial market investments', 'other distribution facility', 'investments abroad', or 'current situation at the landfill' (PDDs for projects 809,

891, 1232, 1317, 1342, and 1626). These are clearly different from the scenario reflected by the EF_{CM}. Hence, no further analysis was pursued.

6.3 Gaps: Comparison of Scenarios

The key question pursued in the present chapter is whether there is a plausible theory of change reflected in the CDM methodologies and projects analyzed here. To examine this, the following are compared below:

(a) Scenario reflected by the baseline emission factor (EF_b), and
(b) Scenario reflected in the assessment of investment additionality.

6.3.1 CDM Methodologies

Do the methodologies examined require or ensure that the scenario reflected by the EF_b is compared with the proposed CDM project in the additionality assessment? In one case this was explicitly ensured, namely in AM0029 when EF_T was to be applied. This scenario can be described as a BM scenario reflecting a single source, assuming that it reflects a contemporary investment, which appears reasonable (see section 6.2.1). In methodologies applying an EF_{Ex} it seems likely that the scenario reflected by the emission factor will be compared with the proposed CDM project in the additionality assessment, but this was less clearly specified in ACM0007 compared with AM0019 and AM0006. In the remaining cases, to examine this question, the relevant findings from section 6.2 are summarized in Table 6.5.

In contrast to the AMs and the ACMs, the AT is a general framework. Due to this, the application (and the real-life context) will largely determine the explicit or implicit scenario. Hence, some parameters could not be anticipated (*e.g.* geographical boundaries). Other parameters could vary depending on how the AT is applied (*e.g.* level of approach). However, the parameter of concern is the age of plant(s). The long operational lifetimes of electricity generation plants mean that the scenario reflected by the EF_{CM} and EF_{Sav} can consist of plants with widely varying ages. In contrast, the scenario reflected in the additionality assessment through the AT will most likely reflect contemporary investments in power/emissions sources. From an investment perspective, it is reasonable to consider the current context relative to the investment (*i.e.* proposed CDM project). This suggests that the scenario applied to assess investement additionality may be very different to that reflected by the EF_{CM} or EF_{SAv}. The EF_{CM} was in turn the most common EF_b alternative among the methodologies examined, and it was either required or allowed to be applied by 6 of the 7 AMs and

ACMs examined (see Table 6.1). In addition, all AMs and ACMs examined required the AT to be applied to assess additionality.

Table 6.5
Comparing Scenarios in the Methodologies

			Level of Approach	Timeframe [a]	Geographical Boundaries	Sampling Frame (plant type(s))	Age of the Plant(s) [b]
EF_b	EF_{Ex}		Actor	Existing plant/ Crediting period	-	(Fossil fuel)	-
	EF_{BM}		Sub.	Annual/ Crediting period	Reg.		Possibly Con.
	EF_{CM}		Sub.				Hist.-Con.
	EF_{Sav}		Sector				Hist.-Con
	EF_T		Sub.	Crediting period		-	Likely Con.
Additionality Assessment	AM0026		Sector	Con.-Fut.	Local/ Reg./ Nat. (grid)	Capacity addition plan	Con.-Young.
	Step 2: Investment Analysis [c]	Option I	-	-	-	-	-
		Option II	Actor / Sub./ ?	Con.	-	Alt. available to the project developer or similar project developers + 'current situation' if applicable	Con./?
		Option III	Actor/ Sub./ Sector/ Country	Con.-Fut.	Local/ Reg./ Nat.	Similar project type and decision context	Con.-Young.
	Step 3: Barrier Analysis		Actor / Sub./ ?	Con.	-	Alt. available to the project developer or similar project developers + 'current situation' if applicable	Con./ ?

[a] *Additionality assessment: relative to the project*
[b] *Relative to the project start date/ investment decision*
[c] *Step 2 options: (I) Simple cost, (II) Investment comparison, and (III) Benchmark*

Abbreviations: Alternatives (Alt.), Contemporary (Con.), Future (Fut.), National (Nat.), Regional (Reg.), Sub-sector. (Sub.), Younger (Young.), International (Int:l)

Note: The various EF_b are described under Table 6.1.

Source: See section 6.2

6.3.2 CDM Projects

All the projects examined applied the EF_{CM}. So the question is whether the CDM projects compared the scenario reflected by the EF_{CM} and the proposed CDM project in the additionality assessment prior to registration. To examine this question, the relevant findings from section 6.2 are summarized in Table 6.6. Among those projects applying a benchmark or investment comparison analysis, there was significant divergence along the various parameters (see Table 6.6). This implies that the scenario reflected by the EF_{CM} and the scenario applied to assess additionality are not the same. Furthermore, in the majority of cases when barrier analysis was applied, there was no comparative analysis or the scenario reflected in the barrier analysis was clearly different from that reflected by the EF_{CM} (see section 6.2.2). Hence, in the projects examined, irrespective of how additionality was assessed, the scenario reflected by the EF_{CM} was not applied. Either a different scenario was applied or there was no comparative analysis.

Table 6.6
Comparing Scenarios in the Projects

Scenario(s) reflected in:		Level of Approach	Timeframe [a]	Geographical Boundaries	Sampling Frame (plant type(s))	Age of the Plants [b]
EF_{CM}		Sub.	Crediting period (7 or 10 yrs.)	Local Reg.	Fossil fuel	Hist.-Con.
Additionality assessment	Benchmark Analysis	Actor Sub. Nat. Int:l	Operational lifetime (20-35 yrs.)	Local Reg. Nat. Int:l	Investment(s) available to the project participant, small hydropower plants, electricity generating power plants, alternative investments in the country, alternative international investments	Con.-Young.[c]
	Investment Comparison Analysis	Actor	30 yrs. (comparable to operational lifetime)	Local	Alt. to be developed by the project developer	Con.
	Barrier Analysis	Sub.	Con.-Fut.	Nat.	Thermoelectric units	Con.-Young.

[a] *EF_{CM}: years; Additionality assessment: Relative to the project*
[b] *Relative to the project start date/investment decision*
[c] *Benchmark values tended to be contemporary relative to the time when investment was considered.*

Abbreviations: Alternatives (Alt.), Contemporary (Con.), Future (Fut.), Historical (Hist.), International (Int:l), National (Nat.), Relative (Rel.), Younger (Young.)

Source: See section 6.2

6.4 Discussion: *Ex Ante* Evaluation in Context

6.4.1 Validity: Baseline Scenarios & Single and Multiple Case Comparisons

The fundamental problems addressed in this chapter are quite simple. Basically what is addressed is the need for an adequate environmental criterion and valid comparisons that measure what is claimed. However, this is not necessarily easy to determine largely due to the complexity of the CDM methodologies. In addition, the counterfactual nature of baseline scenario perhaps also creates unnecessary distraction. Real-life complexities need to be considered, but it is also valuable to appreciate the basics. Below, two analogies are used in an attempt to clarify what may appear as rather complex issues and to illustrate an otherwise relatively abstract discussion.

A: Single-Case Comparison

If I were to claim that my apple is bigger than Anna's apple (*c.f.* single-source baseline scenario), I would prove this by comparing my apple with Anna's apple, for example by comparing their weights. If 'bigger' is interpreted as meaning both heavier (*c.f.* investment additional) and greater circumference (*c.f.* reduce emissions). I would prove that my apple both weighs more and has a greater circumference than Anna's apple. My claim is not valid if I compare my apple's weight with that of Anna's apple and my apple's circumference with that of Eric's apple (some other scenario). Only half of my claim has been substantiated.

This analogy points to the importance of measuring what is claimed to ensure validity. Going back to the CDM, if projects are required to be both investment additional and reduce emissions, to ensure valid results the respective *ex ante* assessment must generally apply the same baseline scenario. Possible exceptions to the general recommendation are examined in Ch. 7.

B: Multiple-Case Comparison

If I were to claim that my apple is *bigger than apples in general*, I could attempt to compare it with all apples in the world, but a more pragmatic (and generally accepted) approach is to use a basket containing apples that are representative of apples in general (*c.f.* multiple-source baseline scenario). A basket of many apples is preferable to *e.g.* Eric's apple, because apples tend to come in various sizes and shapes. Hence, comparing my apple with Eric's apple is less certain to yield valid results. The problem of determining whether my claim is true or no can be understood as involving three issues.

Problem 1: Selection of apples representative of 'apples in general'
The first problem is selecting the most representative apples of 'apples in general' for the basket (*i.e.* the baseline scenario) (Basket A). Once this is done, can I compare my apple's weight with that of those in Basket A and my apple's circumference with that of only some apples found in Basket A (in principle, Basket B) or completely different apples (*i.e.* Basket C)? No, because Basket A specifically includes the 'most representative apples of apples in general'. Logically, either Basket A is the most representative or it is not (conversely, either the baseline scenario is the most likely scenario of 'what would have happened otherwise' in the absence of the CDM project, or it is not). Using two baskets in this context implies that the entire analysis is invalid. Likewise, using different baseline scenarios for assessing investment additionality and emissions reductions is not a valid approach.

Problem 2: Define what is to be measured
The second problem is to define what 'bigger' means in this context. Assume that the apples in Basket A have the following characteristics:

Basket A: 'Apples in general' / 'normal apples'

- Weight: 70-180 grams, average 120 grams
- Circumference: 10-25 cm, average 20 cm

My apple weighs 130 grams and measures 23 cm. If the principle found in the CDM context (see Eq. 2) is applied to this hypothetical case, my apple would be considered bigger – it weighs more than the average apple and it has a greater circumference compared with the average apple.[42] In contrast, my view is that while my apple is slightly *bigger than the average apple* it is still within the normal range of apples in general – it is still *a normal apple compared with apples in general.*

Going back to the case of environmental additionality, if the emissions intensity of the baseline sources range between some value a and b, I would argue that an investment that falls within this range is not environmentally additional in terms of emissions intensity. In principle, it does not matter which level of approach is applied (actor, sector, country).

Actor-specific (or project-specific) baseline scenarios are likely to be less transparent and more easily manipulated compared with a sector-specific baseline. As has already been noted in the innovation policy literature on additionality, it is inherently difficult for policy-makers to know the original intentions of firms (see Ch. 4). In addition, an actor-specific approach is less relevant considering the type of

[42] In the CDM context, what is compared is the emissions intensity in the case of electricity generation.

baseline scenarios generally recommended and addressed in the literature on calculating emissions reductions in the electricity sector (see *e.g.* Kartha *et al.*, 2004; Murtishaw *et al.*, 2006; Sharma and Shrestha, 2006; Zhang *et al.*, 2006; Steenhof, 2009). These tend to address sector-specific or technology-specific baselines. For electricity generation projects, the generally recommended baseline scenario is the CM scenario according to Kartha *et al.* (2004) (they did not limit it to fossil fuel-fired plants as appears to be the case under the CDM). However, they mentioned brownfield projects as an exception, where the "operating characteristics of the preretrofit plant provides an appropriate baseline to the extent: (a) that generation does not exceed pre-retrofit levels and (b) that the plant is likely to continue operating as it has in the past" (Kartha *et al.*, 2004:559). Another exception was when larger projects can clearly demonstrate that a specific type of plant is the most likely alternative for the non-project case. "In these cases, minimum performance parameters (e.g. efficiency and load factors) should be developed for the baseline calculation to ensure that the baseline scenario facilities are based on reasonable assumptions" (*ibid.*). The suggestion was that the baseline was calculated based on minimum performance parameters, based on for example an average from the most recently built gas plants, rather than on the characteristics of a very inefficient gas plant. This essentially implies a technology-specific BM scenario.

Problem 3: Measurement

The third and final problem is the actual determination, which involves the methods applied to measure and weigh the apples. This is not addressed in this chapter. However, the application of Eq. 1 ($a > EF_p$, where $a \leq EF_{b_i} \leq b$) is not at odds with the recommendations in the literature on calculating emissions reductions concerning the use of multiproject baselines, and the EF_{CM} in particular. Eq. 1 is an *ex ante criterion*, not a method for calculating emissions reductions *ex post*. *Ex ante* criteria are necessary for promoting projects (Output I) that will encourage the envisioned change (*i.e.* outcome(s)); and the validity of the criteria is closely linked to their ability to facilitate this change. Methods for calculating emissions reductions are necessary for earning credits (Output II) *ex post*. Valid, reliable and practicable methods are crucial for ensuring that Output II both (a) provides incentives for realizing Output I and (b) safeguards the environmental integrity of the KP. This implies that criterion Eq. 1 and multiproject baselines are essentially complementary.

6.4.2 Sector-Specific Baseline Scenario & Investment Additionality

The appropriateness and value of a sector-specific baseline compared with actor-specific (or project-specific) baseline in the context of electricity generation has thus

far been discussed in the context of calculating emissions reductions. This leaves the assessment of investment additionality. What has been said about baseline scenarios and environmental additionality can largely be transferred to the case of investment additionality. As already suggested earlier, an actor-based approach (relying on actor-specific, or project-specific, baseline scenarios), is less recommendable compared with a sector-based approach (relying on sector-specific baseline scenarios). A possible exception is when brownfield projects apply the EF_{Ex}. Furthermore, because of the importance of ensuring validity and the value of linking outputs to outcomes through consistent use of a single baseline scenario, an actor-based approach in the additionality assessment appears to be largely inappropriate in the *ex ante* evaluation of greenfield electricity generation projects. These projects tend to apply the CM scenario (see Table 6.1). This scenario was recommended by Kartha *et al.* (2004) for new sources (i.e. greenfield projects) in particular, because it is very difficult to know what such a project would actually replace. The CM scenario is a multiple-source scenario. If a multiple-source baseline scenario (e.g. EF_{BM}, EF_{CM}, or EF_{Sav}) is applied in the *ex ante* evaluation of emissions reductions this baseline scenario should as a general rule also be applied in the *ex ante* evaluation of additionality (possible exceptions to this general recommendation are examined in Ch. 7). If the generally accepted profitability of investments of the baseline sources ranges between some value *a* and *b*, it can be argued that an investment that falls within this BAU range is not investment additional in terms of profitability.

Additionality is an inherently relative concept and the majority of the additionality assessments examined compare the project to something. However, when the baseline scenario reflected grid electricity generation, barrier analysis generally included no comparative analysis (see section 6.2.2). Barriers facing the project were on the other hand generally described at length. Schneider (2009) found that the application of the barrier analysis to be highly subjective and difficult to validate in an objective and transparent manner. To his findings, it can be added that it is logically impossible to show that any barriers:

(a) have hindered ongoing activities (such as grid electricity generation) or
(b) will hinder activities which will continue (such as grid electricity generation).

In addition, the projects examined refrained from attempting such an argument (apparently by avoiding a comparative analysis). This suggests that there is reason to reconsider the use of grid electricity generation as the baseline scenario. More specifically, the age of the investments needs more attention.

Logically, the only investments that can be prevented from being realized by contemporary barriers, economic or otherwise, are those that have not yet been realized. This is supported by the empirical findings. The two projects examined that

did provide a comparative analysis in their respective barrier analysis considered the construction of new thermoelectric units in Brazil (projects 1279 and 1999). Similarly, in the remaining types of additionality assessments (investment analysis) applied among the projects examined, the implicit/explicit ages of the plants (with which the project was compared) were either contemporary or younger relative to the investment decision (Table 6.6). This suggests that a multiple-source scenario reflecting historical investments is unsuitable for assessing investment additionality. In summary, while the methodologies and CDM projects examined largely favor EF_{CM}, the only multiple-source baseline scenario that could potentially facilitate a logic link between the environmental and investment additionality is EF_{BM}.

6.4.3 A Practical Concern: The Baseline Scenario & Zero Emissions Plants

A sector-based approach involving electricity generation implies that a wide range of plants with widely diverging emissions intensities can be included in the baseline scenario. What if the zero-emissions plants are included in the EF_b? This would in principle render all zero-emissions plants environmentally non-additional. However, if *e.g.* construction and transport are included in the *ex ante* environmental evaluation, EF_b is unlikely (in the current fossil fuel-dependent world) to include plants that are completely emissions free. Nevertheless, a pragmatic approach could be to deem all zero-emissions projects environmentally additional as long as all expected future plants to be built are not zero-emissions plants. In such a context, there can be no further change in terms of emissions reductions. From an environmental perspective, approving zero-emissions plants by default as environmentally additional is not a problem as they in principle cause no emissions.

6.5 Conclusions of the Critical Examination of Environmental Criteria & Baseline Scenarios

The aim of this chapter was to examine whether there is a plausible theory (or theories) of emissions reductions (change) in the selected methodologies applicable and applied to large-scale electricity generation CDM projects ('CDM methodologies', in brief). This was approached through an examination of the environmental criterion and the baseline scenario(s) applied in the *ex ante* evaluation of projects. The conclusion is that the theory of change embedded in the CDM methodologies examined is flawed and the key problems are summarized below.

In the CDM context, it is commonly acknowledged that if a project is not different from 'what would have happened otherwise' (*i.e.* the *baseline scenario*), then

it cannot truly reduce emissions. More to the point, emissions reductions cannot be promoted beyond BAU by promoting non-investment additional projects, *i.e.* the expected change (or outcome) in terms of emissions reductions cannot be achieved. It is also commonly acknowledged that an *additional* project is not the *baseline scenario*; and e*missions reductions* are the difference between the emissions of the baseline scenario (*baseline emissions*) and those of the project (*project emissions*). These ideas are clearly reflected in the CDM methodologies and the PDDs for registered CDM projects examined here. In addition, both investment additionality and emissions reduction must be, and are, evaluated *ex ante*. However, although the baseline scenario is what is referred to here as the *logic link* between the *ex ante* evaluations of investment additionality and emissions reductions, these are disconnected in practice. The critical examination of CDM methodologies and CDM projects found that the scenario reflected by the baseline emissions can be, and is, significantly different from the explicit or implicit scenario applied to assess investment additionality. This implies that investment additionality and emissions reductions are assessed relative to different scenarios – this is an invalid approach.

There are three key issues with the *ex ante* evaluation of emissions reductions performed by the CDM projects examined, which all applied the CM scenario (weighted average of the BM and OM scenario). The first two issues concern the timeframe and the age of the plants reflected by the baseline scenario. The timeframes only accounted for a fraction of the time period during which the project was expected to cause emissions. The timeframe was either 7 or 10 years, but the expected operational lifetime of the projects examined was commonly 20-35 years. The age of the plants could range from historical to contemporary relative to the start date of the proposed CDM project. In one *ex ante* evaluation of emissions reductions, the baseline scenario included 40-year old investments, and could potentially include even older.

In contrast to the *ex ante* evaluation of emissions reductions, when determining investment additionality the timeframe largely corresponded to the project's operational lifetime; and (the explicit or implicit) age of the investments that the project was compared with was generally contemporary relative to the investment decision of the project. The examined additionality assessments could reflect a BM scenario, but they never reflected a scenario reflecting historical investments (which are included in the CM scenario).

The third issue is the environmental criterion. The indirectly applied criterion for emissions reductions when multiple-source scenarios (*e.g.* CM scenario) are involved implies that a project's emissions intensity can be within the normal range of BAU emissions intensity and still be approved as a CDM project. It thus appears that the environmental additionality of the project is questionable. The EF_{CM} was applied by all the CDM projects examined and it was included in almost all methodologies

examined. This indicates that this is a significant issue. The idea (or theory) of emissions reductions appears to rely on the idea of replacement. However, the additionality assessment does not address whether anything is replaced, but whether the proposed CDM project is a viable investment. An example of a relevant question is whether or not the investment additionality assessment and the information available in the PDDs support the idea that the baseline scenario is replaced by the project (or its outputs). This suggests that an examination of the theory of emissions reductions underlying the creation of CERs requires more in-depth studies of CDM projects. This is pursued in Ch. 7.

7

CREDIT CREATION

THE ENVIRONMENTAL ADDITIONALITY ARGUMENT IN CDM PROJECTS

7.1 Introduction

The environmental additionality argument in the CDM project design document (PDD) is often complex and not very transparent. In other words, it is not a simple matter to evaluate the plausibility or validity of the claim that emissions are reduced. The PDDs generally include a description of the project, but this description is not focused on justifying how emissions reductions are envisioned. The justification is largely pursued implicitly through the *ex ante* evaluations of investment additionality and emissions reduction in the PDD. These *ex ante* evaluations are to ensure that the emissions reductions are 'real' or environmentally additional, but they are project-specific, technically detailed and not easy to penetrate without rather specific knowledge about *e.g.* the technology in question, CDM additionality assessments, environmental assessments and mathematics, host country and/or local conditions, and so forth. Furthermore, as described in the two previous chapters, the *ex ante* evaluations are separate and distinct analyses. Their relationship is not necessarily apparent. This means that the theory of emissions reductions underlying the creation of CERs is not obvious.

Under the CDM, it is not required that electricity generation projects are less emission-intensive than BAU plants included in the baseline scenario (see Ch. 6). It is sufficient that the project is less emission-intensive than the generation-weighted average BAU plant. This criterion is embedded in the calculative methods applied when multiple-source baseline scenarios are applied (see Eq. 2, Ch. 6). The calculative method, exemplified for example by the combined margin (CM) method which was prescribed by Kartha *et al.* (2004), is based on the assumption that the baseline scenario would be replaced by the project. The CM method was included in one of

the first Approved Consolidated Methodologies (ACM0002). To date, it is the most commonly applied methodology under the CDM (CDM/JI Pipeline Analysis and Database, 1 Nov. 2011). The findings presented in Ch. 6 appear to suggest that the environmental additionality argument based on an assumption of replacement begs the question (*i.e.* the conclusion that emissions are reduced is based on a premise that lacks support). Three reasons can be identified through rational reasoning and the empirical findings presented thus far. Firstly, being less emission-intensive does not imply that anything will be replaced. Secondly, the investment additionality assessment aims to evaluate project viability, but it does not determine that anything is replaced (see Ch. 5 and 6). Thirdly, an examination of the PDDs for registered large-scale electricity generation CDM projects applying the CM method show that investment additionality and emissions reductions are determined relative to different (baseline) scenarios (see Ch. 6). This further refutes the idea that the former can support the claim that the baseline scenario reflected in the calculation of emissions reductions would be replaced by the project. Hence, the embedded environmental additionality argument does not appear to be properly supported.

This chapter further examines the validity of the environmental additionality argument included in the PDDs for registered CDM projects. This can also be linked to the question of whether or not there is a *plausible theory of change* (see Ch. 6). Thus far, the empirical evidence indicates that the environmental additionality argument is weak, at best; but is it possible that the project-specific circumstances provide the necessary context (or missing information) which supports the idea that emissions are reduced? In contrast to the preceding more abstract analyses (Ch. 6), which focused on very specific issues, this chapter is broader and also sensitive to project-specific conditions which could affect the validity of the claim. The key difference compared with Ch. 6 is that the current chapter takes into account project characteristics and the narrative of how emissions are reduced by the project (as described in the PDD) in the analyses of the *ex ante* evaluations. The analytical approach is further described in the following sub-section. The research was pursued through analyses of the PDDs for three registered large-scale grid-connected electricity generation CDM projects which applied different types of baseline scenarios (see Table 7.1). One applied a single-source scenario (an existing plant). The other two applied different multiple-source scenarios, namely a build margin (BM) and a combined margin (CM) scenario. These two are examples of what is commonly referred to as 'standardized baselines' (or MPBs) in the CDM context (see *e.g.* Kartha *et al.*, 2004; Steenhof, 2009).

The outline of the remainder of this chapter is as follows. Section 7.1 includes a description of the analytical approach and the CDM projects examined. Section 7.2 describes the projects and the narratives of how emissions are reduced, as envisioned in the PDDs. Ch. 7.3 examines the environmental criterion applied in the PDD for the respective project. In section 7.4, the *ex ante* evaluations of emissions reductions

and investment additionality are compared, taking into consideration the project-specific contexts. This is largely pursued through a comparison of the logic(s) and scenario(s) applied in the *ex ante* evaluations. Finally, section 7.5 presents a concluding discussion on the 'gaps' in the environmental additionality argument.

7.1.1 Analytical Approach

As in the research presented in the preceding chapter, a theory-of-change approach was applied. Similarly, (1) a logic model starting with the target of emissions reductions was pursued; (2) a specific aspect of the implementation process was examined, namely the *ex ante* evaluation (more specifically the methodologies applied in this evaluation); and (3) key factors in the *ex ante* evaluation were examined, namely (a) environmental additionality and (b) investment additionality (*c.f.* Ch. 6).

Primary Units of Analysis

The present chapter brings together the following units in an integrated analysis.

- Project characteristics
- Project's narrative of emissions reductions
- *Ex ante* evaluation of emissions reductions
- *Ex ante* evaluation of investment additionality
- Scenario(s) applied in the *ex ante* evaluations

The analysis was sensitive to the 'project-specific context' in that it took into consideration the project characteristics and the project's narrative of how emissions are envisioned as reduced (as described in the PDD). The primary source of information was the PDD for the respective project. The following key characteristics of the project are considered: project type, size, dates and timeframes, grid and location. The examination of the *ex ante* evaluation of emissions reductions identifies the environmental criterion applied. The examination of the *ex ante* evaluation of investment additionality primarily deliberates on this evaluation's capacity to supplement the environmental criterion. The primary issue is whether these elements (*i.e.* primary units of analysis) can provide for a valid environmental additionality argument. The analysis is limited to the validity of the argument as such. Hence, the aim is not to examine *e.g.* the appropriateness or plausibility of the baseline scenario, the correctness or plausibility of the investment analysis, or the correctness of data and information in the PDD.

Although the *ex ante* evaluations of emissions reductions and investment additionality are two quite distinct analyses, they are conceptually linked through the

baseline scenario (*c.f.* Ch. 5 and 6). However, as was shown in the previous chapter, in practice the *ex ante* evaluations were disconnected due to the use of different scenarios. The theoretical link could not be established. This chapter takes another look at the scenarios applied in the *ex ante* evaluations (see below). The questions are if the *ex ante* evaluations of the CDM projects examined for this chapter are also disconnected; and if so, can there still be a valid environmental additionality argument?

In both the *ex ante* evaluation of emissions reductions and investment additionality, the project is compared with 'something'. In the projects examined, this 'something' is a *scenario* which reflects another source or other sources (than the CDM project). The following were examined:

Scenarios Examined

(a) The scenario reflected in the baseline emission factor (EF_b)
(b) The scenario reflected in the barrier/investment analysis
(c) The scenario reflected in the common practice analysis

The (a) scenario is applied in the *ex ante* evaluation of emissions reductions; and (b) and (c) in the *ex ante* evaluation of investment additionality. In the latter evaluation, the barrier and/or investment analysis represent(s) the primary investment additionality check, while common practice analysis is a credibility check, supplementing the barrier/investment analysis (*c.f.* Ch. 5). The scenarios are primarily identified through the following parameters (or dimensions):

Parameters/Dimensions for Identifying Scenarios

(i) *Level of approach: e.g.* actor, sector, country
(ii) *Timeframe:* years and/or historical, contemporary, future (relative to the project)
(iii) *Geographical boundaries: e.g.* local/regional, national, international
(iv) *Sampling frame for baseline source(s): e.g.* fossil fuel-fired power plants
(v) *Plant age:* historical, contemporary, future (relative to the project).

Logic underlying the Environmental Additionality Argument: Dissimilarity & Replacement

The research presented in this chapter examined the environmental additionality argument included in the PDDs. This research identified two distinct types of logic in the PDD narratives of emissions reductions and the *ex ante* evaluations. To describe these, the terms *dissimilarity logic* and *replacement logic* are used. These are not generally applied terms, to my knowledge. They are applied here as heuristic tools for indicating distinctly different rationales/reasoning. *Dissimilarity logic* describes a logic

based on dissimilarities or differences between what is compared, *i.e.* the project and the scenario. *Replacement logic* describes a logic based on the idea that the project physically replaces or displaces (in time) the electricity generation of the scenario or the scenario.

7.1.2 Cases & Case Selection

The CDM projects examined in this chapter are listed in Table 7.1. Each represents the most recently registered CDM project (by 5 Nov. 2010) using the ACM in question. All three were registered large-scale grid-connected electricity generation CDM projects with one output (electricity).

Table 7.1
The CDM Projects

	CDM Project		*ACM*	*Baseline-Scenario Type*		
				A: Scenario [d]	*B: Source(s)*	*C: Applicability*
A	1758 [a]	Fuel-switching of the Aqaba Thermal Power Station	ACM0011 version 1	Existing plant	Single	Project-specific
B	2716 [b]	Grid connected energy efficiency power generation	ACM0013 version 2	BM	Multiple	Standardized
C	3688 [c]	Inner Mongolia Zhuozi II Wind Power Project	ACM0002 version 10	CM	Multiple	Standardized

[a] *Registration date: 2008/09/30*
[b] *Registration date: 2009/12/16*
[c] *Registration date: 2010/11/05*
[d] *Scenario applied to calculate emissions reductions*

Note: The provided project numbers are the CDM reference numbers which all registered CDM projects receive.

Acronyms: Approved Consolidated Methodology (ACM), Build margin (BM), Combined margin (CM)

Source: CDM website, 5 Nov 2010; Respective project's PDD

The CDM projects examined were selected primarily to represent the application of different baseline scenarios in the calculation of emissions reductions (see Table 7.1: Baseline-scenario type, A), but also to represent different project types (fuel-switch, coal-fired power plant (energy efficiency), and zero-emissions power plant). In this dissertation, scenarios are differentiated by the number of sources included in the baseline scenario ('single-source'/ 'multiple-source') (see Table 7.1: Baseline-scenario type, B). In the CDM context, baseline scenarios are commonly described as 'project-

specific' or 'standardized', where applicability is the primary concern (see Table 7.1: Baseline-scenario type, C). A standardized baseline is more broadly applicable than a project-specific baseline.

While they all applied ACMs found in 'Sectoral Scope 1: Energy industries (renewable -/non-renewable)', each project applied a different methodology (see Table 7.1: ACM). When CDM projects were selected in late 2010 for the present study, 74% of all registered large-scale projects in Sectoral Scope 1 applied ACM0002 (CDM 'Project Search' database, 5 Nov. 2010). This was the reason for including a project applying ACM0002 for studying the use of the CM scenario. ACM0002 is only applicable to large-scale zero-emissions electricity generation projects. The remaining two projects were chosen to represent the application of other baseline scenarios, other project types and other methodologies. ACM0011 was the only methodology for grid-connected fuel-switch projects at existing plants and it was applied by 5 projects entering the validation stage by mid-2011. ACM0013 is only applicable to large-scale fossil fuel-fired power plants using less emission-intensive technology. It was the most commonly applied methodology for energy efficiency (supply side) among the projects to enter the CDM validation stage (41 in total) (CDM/JI Pipeline Analysis and Database, 1 Jul. 2011). By mid-2011, there were 1091 registered projects that applied ACM0002. One had registered using ACM0011 and five had registered using ACM0013 (CDM 'Project Search' database, 21 Jul. 2011).

7.2 Project-Specific Context

An overview of the project characteristics is provided in Table 7.2. This is followed by descriptions of the projects and their narratives of how emissions are reduced.

Table 7.2
Project Characteristics

Project		A	B	C
(CDM registration no.)		1758	2716	3688
Project Type	(i)	Grid-connected electricity generation, with one output (electricity)		
	(ii)	Brownfield project	Greenfield project	
	(iii)	Fossil fuel-fired power plant		Renewable power plant
	(iv)	NG-fired power plant	Coal-fired power-plant	Wind power
	(v)	Fuel-switch from HFO to NG	Super-critical coal-fired power plant	-
Size(in MW)		650 (5x130)	1320 (2x660)	48 (24x2)
Dates	Project starting date	2002/02/28 [a]	2007/09/06 [b]	2007/08/20 [c]
	Reg. date	2008/09/30	2009/12/16	2010/11/05
Timeframes	Operational lifetime	Units 1-2: 2004-2016 Units 3-5: 2003-2028	2011-2037 [d] (25years) [e]	2009-2029 (20 years) [f]
	Crediting period	2008-2017	2011-2021	2010-2017
Grid		Jordan	India	NCPG
Location	Country	Jordan	India	China
	Region	Aqaba Special Economic Zone Authority	Gujarat	Inner Mongolia Autonomous Region

[a] *Starting date was referred to as the "time of decision making" (PDD for A: Section C.1.1)*
[b] *When agreement with engineering, procurement, and construction contractors executed (PDD for B: Section C.1.1)*
[c] *Project construction launched (PDD for C: Section C.1.1)*
[d] *Validation report for B: 23*
[e] *PDD for B: Section C.1.1*
[f] *Full commissioning of all windturbines (expected), in 2009 (PDD for C:10)*

Acronyms: Heavy fuel oil (HFO); Megawatt (MW); Natural gas (NG); North China Power Grid (NCPG)

Source: Sections A-C in the PDDs for the respective projects, and the validation report for B

7.2.1 Project A: Project Description & Narrative of Emissions Reductions

This is a brownfield project (fuel-switch at existing plant) at the Aqaba Thermal Power Station (ATPS), in Jordan. The existing plant was a 650 MW power station, comprising five 130MW units. Units 1 and 2 started operation in 1986 and units 3-5 in 1998. The designed (or expected) lifetime is 30 years. The CDM project entailed a

fuel-switch from heavy fuel oil (HFO) to natural gas (NG) at each of the five units. According to the PDD, emissions reductions would be achieved by switching to a less carbon-intensive fuel. The plant's total capacity (in MW), electricity generation (Q_p) (in MWh), and operational lifetime would remain unchanged by the CDM project. The conversion to NG firing at the five units was executed 2003-2004 (PDD for A: Section A). The alternative envisioned is that HFO will continue to be consumed at ATPS. The baseline scenario is the existing plant. The rationale for envisioning emissions reductions is that the CDM project replaces the baseline scenario, *i.e.* emissions reductions are envisioned based on replacement logic.

7.2.2 Project B: Project Description & Narrative of Emissions Reductions

This is a greenfield project, by Adani Power Limited (APL), in India. B is a new super-critical coal-fired power plant (1320MW), comprising two 660 MW units. According to the PDD, emissions are reduced because the project has a higher generation efficiency (implying reduced coal consumption) compared with sub-critical coal-fired power plants presently operating in India (PDD for B: Section A). The alternative envisioned is that APL will invest in a sub-critical coal-fired power plant, *i.e.* the baseline scenario is a BM scenario reflecting sub-critical coal-fired power plants. The rationale for envisioning emissions reductions is that the CDM project replaces the baseline scenario, *i.e.* emissions reductions are envisioned based on replacement logic.

7.2.3 Project C: Project Description & Narrative of Emissions Reductions

This is a greenfield project, by Inner Mongolia Datang International Zhuozi Wind Power Co., Ltd, in China. C is a windpower project (48 MW), comprising 24 x 2MW turbines. Emissions reductions are envisioned as a result of replacing electricity generated from fossil fuel-fired power plants connected to the North China Power Grid (NCPG) (PDD for C: Section A). The alternative envisioned is the described electricity generation which existed prior to the start of the implementation of C, *i.e.* the baseline scenario is a CM scenario reflecting electricity generated from fossil fuel-fired power plants connected to the NCPG. However, in contrast to the other two projects, what is envisioned as replaced is not explicitly the baseline scenario but the electricity generation of the baseline scenario (and thus baseline emissions). Hence, the rationale for envisioning emissions reductions is that the CDM project's emissions replace the baseline emissions, *i.e.* emissions reductions are envisioned based on replacement logic.

7.3 Environmental Criterion in the *Ex Ante* Evaluation of Emissions Reductions

In principle, the *ex ante* evaluation of emissions reductions in the PDDs for all three projects examined can be described as a comparison of emissions (of the project and the baseline scenario) (see Section B 6.3 in the PDDs). However, as was revealed in Ch. 5, it is possible to show that the key environmental criteria are based on comparisons of emission factors. Furthermore, the implicitly or indirectly applied environmental criterion depends on the type of baseline scenario applied (single-source or multiple-source).

7.3.1 Project A: Single-Source Baseline Scenario

Project A applied a single-source baseline scenario and the indirectly applied environmental criterion is expressed by Eq. 1. An alternative would have been to describe the *ex ante* evaluation of emissions reductions as five separate comparisons. However, the five units were treated as a single project in the PDD (PDD for A: Section B.6). In Eq. 1, the project emission factor (EF_p) is all the emissions accountable to the project (in tCO_2e) divided by the project output (Q_p) (in MWh). Similarly, the baseline emission factor (EF_b) is all the emissions accountable to the baseline scenario divided by the baseline output (Q_b). The timeframe of the *ex ante* evaluation of emissions reductions was 10 years (PDD for A: Section B.6.3), which corresponds to the chosen crediting period (see Table 7.2). In this project, the environmental criterion determines environmental outcome additionality at project level. The level is determined by the project-specific baseline.

Eq. 1 $a > EF_p$ in project A, a is the emission factor of the baseline source (EF_b) (*c.f.* Ch. 5).

EF_p: *Emission factor of the project (in tCO_2e/MWh)*
EF_b: *Emission factor of a single-source baseline scenario (in tCO_2e/MWh)*

Eq. 1 determines that a project is different from the baseline source(s) in terms of emissions intensity and it can be described as reflecting dissimilarity logic. Furthermore, in principle, it is a *valid environmental additionality* criterion in its own right (see Ch. 5). Eq. 1 can be viewed as valuable for a *plausible theory of change*, largely because of how the baseline scenario is conceptualized in the carbon crediting context. The baseline scenario is commonly understood as synonymous with 'what would have happened otherwise' or BAU. To introduce any change, it is reasonable to

assume that something different from BAU will need to be introduced. The rationale here is that change cannot be achieved by introducing something that is BAU (*i.e.* not different from the baseline scenario).

7.3.2 Projects B & C: Multiple-Source Baseline Scenario

Project B

This project applied a multiple-source baseline scenario and the indirectly applied environmental criterion is expressed by Eq. 2. In the *ex ante* evaluation of emissions reductions, B was compared with an alternative BM scenario. The EF_{BM} reflected the 'top 15% performing power plants' identified among a specific sample group (further described in section 7.4.2) (PDD for B: Section B.6). The timeframe of the *ex ante* evaluation of emissions reductions was 10 years (PDD for B: Section B.6.3) and corresponded to the chosen crediting period (see Table 7.2).

Project C

This project also applied a multiple-source baseline scenario and the indirectly applied environmental criterion is expressed by Eq. 2. However, project C was compared with a CM scenario. The EF_{CM} reflected the fossil fuel-fired power plants connected to the NCPG (PDD for C: Section B.6). The timeframe of the *ex ante* evaluation of emissions reductions was 7 years (PDD for C: Section B.6.3) and corresponded to the chosen crediting period (see Table 7.2).

Eq. 2 $\overline{EF_b} > EF_p$ where the emission factor of the sources (*i*=1-n) can range between some lower value *a* and higher value *b*, (*i.e.* $a \leq EF_{b_i} \leq b$) (*c.f.* Ch. 5)

$\overline{EF_b}$: *Generation-weighted average emission factor of the multiple-source baseline sources (in tCO_2e/MWh)*

EF_p: *Emission factor of the project (in tCO_2e/MWh)*

This formula states that the project must be less emission-intensive than the generation-weighted average emission factor of the baseline sources. It can alternatively be described as the emission factor of the generation-weighted average source.

In principle, Eq. 2 is not a valid environmental additionality criterion (see Ch. 5). However, emissions reductions can be envisioned, assuming that $EF_p \cdot Q_p$ will replace

$\overline{EF_b} \cdot Q_p$. This is why Eq. 2 is described in this dissertation as based on replacement logic. For a *valid environmental additionality argument*, Eq. 2 needs to be supplemented by an analysis which establishes that it is reasonable to assume that the $\overline{EF_b} \cdot Q_p$will be replaced by $EF_p \cdot Q_p$. Important questions are if and how this is done in the PDD.

Another fundamental difference between Eq. 1 and Eq. 2 is that the former does not determine the amount of change that will be achieved *ex post, i.e.* emissions reductions (*ER*) (in tCO_2e). Under Eq. 2, the change is determined by what is replaced (the baseline scenario) and that which replaces it (the CDM project). In contrast, Eq. 1 only establishes that the item to be introduced (the CDM project) is different from 'what would have otherwise taken place' (the baseline scenario) (*c.f.* Eq. 1). In principle, the *ex post* evaluation of emissions reductions could be based on *e.g.* $ER = \left(\overline{EF_b} \cdot Q_p + L_b\right) - (EF_p \cdot Q_p + L_p)$, or perhaps even on the economic needs to realize the project, as suggested by Wara (2008). However, in the carbon crediting context, the latter may prove challenging to operationalize because credits must reflect equivalent quantities of *ER*. This dissertation primarily examines the *ex ante* evaluation, but more research on the *ex post* evaluation of emissions reductions in the context of applying a criterion reflecting dissimilarity logic could be valuable.

In Projects B and C, the environmental criterion determines environmental outcome additionality at a technology-specific level, assuming that it is shown that it is reasonable to assume that $EF_p \cdot Q_p$ will replace $\overline{EF_b} \cdot Q_p$. The level is determined by the technology-specific baseline. In B, the baseline scenario reflects sub-critical coal-fired power plants in India (see section 7.4.2). In C, the baseline scenario reflects fossil fuel-fired power plants connected to the NCPG (see section 7.4.3).

7.3.3 Comments Regarding the Explicit and Implicit Environmental Criteria

Among electricity generation CDM projects, the explicit (*ex ante* and *ex post*) environmental criterion can generally be expressed as in Eq. 3.

Eq. 3 $\quad BE + L_b > PE + L_p \qquad$ (*c.f.* Eq. 5 in Ch. 5)

The notions of baseline emissions *(BE)*, leakage accountable to the baseline scenario *(L_b)*, project emissions *(PE)*, and leakage accountable to the project *(L_p)* are clearly separated in all the CDM methodologies examined for this dissertation (Ch. 5-7). By extension EF_b is in the methodologies examined equated to BE/Q_b. However, a more correct environmental comparative analysis based on emission factors commonly requires that $EF_p = (PE + L_p)/Q_p$ is compared with $EF_{b_i} = (BE_i + L_{b_i})/Q_{b_i}$ (*c.f.* section 5.4.4).

EF_p was not specified in any of the projects examined (A-C). The project methodologies were aimed towards estimating PE per year, based on the annual fuel and energy consumption (if any). Q_p is, however, generally given in the PDDs for electricity generation projects to estimate baseline emissions, as ($BE = EF_b \cdot Q_p$). Hence, $EF_p = (PE + L_p)/Q_p$ can be derived from the information available in the PDDs. L_p was only accounted for by one of the projects examined in this chapter, namely project A, and it accounted for upstream fugitive methane (CH_4) emissions due to fuel extraction, processing, transportation, and distribution of the natural gas consumed by the CDM project (*c.f.* $L_{p\ indirect}$, section 5.4.2). In all three projects examined for this chapter, L_b was zero.

Neither Eq. 1 nor Eq. 2 was explicit in any of the three project PDDs. These criteria were indirectly applied through the *ex ante* evaluation of emissions reductions, where Eq. 3 was explicitly applied. Where a single-source baseline scenario is concerned, applying Eq. 1 or 3 does not make any difference. If emissions accountable to the project are smaller than those accountable to the baseline scenario (Eq. 3), it follows that the project is less emission-intensive than the baseline scenario (Eq. 1). In contrast, where multiple-source baseline scenarios are concerned, a comparison of emission factors (Eq. 1) has the ability to show that a project is less emission-intensive compared with the baseline sources ($EF_p \notin \{EF_{b_1}, EF_{b_2}, \dots EF_n\}$) (*c.f.* Ch. 5: Eq. 10 and 11). This is not possible through either Eq. 2 or 3. However, if EF_{b_i} did not vary, it would in practice not matter whether Eq. 1, 2 or 3 was applied as a criterion, but this is not the case in electricity generation. Renewable energy projects are commonly recognized as zero-emissions projects (*i.e.* 0 tCO_2/MWh). In contrast, both existing and more recently built fossil fuel-fired power plants can have emission factors in excess of 1 tCO_2/MWh (see Table 6.3: EF_{BM} and EF_{OM}). If EF_{b_i} did not vary, any of the criteria would suffice to ensure that a project is less emission-intensive than the baseline sources.

7.4 Environmental Additionality Argument

7.4.1 Project A

This project applied Eq. 1. As such, the *ex ante* evaluation of investment additionality is not necessary for the purpose of ensuring a valid environmental additionality argument. However investment additionality can promote that the CDM does not unnecessarily provide financial assistance to a project that does not need it to be realized. Nevertheless, the following analysis compares the various units of analysis to further examine the environmental additionality argument in the PDD. A reason for doing this is that the narrative reflected replacement logic. This indicates that the

explicit theory of emissions reductions was based on a reasoning built on the idea that emissions would be reduced because $EF_p \cdot Q_p$ would replace $EF_b \cdot Q_p$.

Unit of Analysis	Logic
Narrative of emissions reductions	Replacement
Ex ante evaluation of emissions reductions	Dissimilarity
Ex ante evaluation of investment additionality	
Investment analysis	Dissimilarity
Common practice analysis	Dissimilarity

As part of the *ex ante* evaluation of investment additionality, the HFO scenario (*i.e.* baseline scenario) and NG scenario (*i.e.* CDM project) were compared through an investment analysis, comparing net present values (PDD for A: Section B.5). The analysis in the PDD shows that the HFO scenario is more profitable than the NG scenario, *i.e.* they are different. This analysis can be described as reflecting dissimilarity logic. On its own, it cannot support the idea that the baseline scenario will be replaced.

In this particular case, the project-specific context explains why it is reasonable to assume that $EF_p \cdot Q_p$ would replace $EF_b \cdot Q_p$ if the project is investment additional. This is because the investment analysis shows that the NG scenario (EF_p) is less profitable than the HFO scenario EF_b, and due to this it is reasoned in the PDD that the latter is unlikely to be replaced (without the CDM). Furthermore, the NG scenario would physically replace the HFO scenario, implying that $EF_p \cdot Q_p$ would replace $EF_b \cdot Q_p$. Hence, it can be said that there is a valid environmental additionality argument based on replacement logic.

A common practice analysis was also included in the *ex ante* evaluation of investment additionality (PDD for A: Section B.5). While the *ex ante* evaluation of emissions reductions establishes environmental additionality at project level, the common practice analysis widens the scope to some extent. This is because this analysis addresses fuel-switch from HFO to NG in the host country. The aim of the common practice analysis was to determine if there were projects similar to the CDM project (*i.e.* fuel-switch from HFO to NG) in the host country; and *e.g.* it included a list of all power stations connected to the national grid in Jordan in 2002. According to the analysis in the PDD, there was no other HFO-fired power plant switching to NG in Jordan between 2002 and 2005. Although there were two NG-fired power plants in 2002, this was not further addressed in the PDD.

In this particular case, the common practice analysis indirectly examined whether there were existing activities similar to the baseline scenario (HFO-fired power plants).

Due to this, the analysis can be interpreted as reflecting both dissimilarity and replacement logic. This was not the case in the other two projects, which only addressed the existence of activities similar to the project (see below). Project A's common practice analysis can be described as reflecting dissimilarity logic, because it shows that there were no activities similar to the project. Hence, the analysis can be viewed as supporting the environmental additionality argument based on the dissimilarity logic. A possible weakness is that the existing use of NG by other plants was not analyzed. The common practice analysis can also be described as reflecting replacement logic, because it shows that the replacement of HFO (with NG) was not common practice at the time when the fuel-switch was executed. Therefore, this analysis can be viewed as supporting the environmental additionality argument based on replacement logic. A possible weakness is that the timeframe was relatively limited.

Dates

A potential issue with A is that the fuel-switch was carried out in 2003-2004, but it was registered as a CDM project in 2008 (see Table 7.2). Hence, the fuel-switch appears to have taken place without the CDM.

Diverging Timeframes

The same (baseline) scenario was reflected in the *ex ante* evaluations of environmental and investment additionality. Furthermore, a similar scenario to the baseline scenario (other plants using HFO) was reflected in the common practice analysis. Nevertheless, the timeframes diverged. The timeframe in the *ex ante* evaluation of emissions reductions largely converged with the crediting period. The CDM project applied a 10-year crediting period, 2008-2017, but for units 1-2 (of the total 5), credits were only to be claimed until 2016, when the designed lifetime of these units would expire. In contrast, the timeframe in the *ex ante* evaluation of investment additionality converged with the operational lifetime of the CDM project (which would not extend the lifetime of the existing plant). Hence, the timeframe for units 1-2 was 2003-2016, and that of units 3-5 was 2003-2027. Finally, the timeframe of the common practice analysis was 2002-2005.

Timeframe	
Ex ante evaluation of emissions reductions (converged with the project's crediting period)	
Units 1-2	2008-2016
Units 3-5	2008-2017
Ex ante evaluation of investment additionality (converged with the project's operational lifetime)	
Units 1-2	2003-2016
Units 3-5	2003-2027
Common practice analysis	2002-2005

Source: PDD for A

In all the projects examined (A-C), the timeframe of the *ex ante* evaluation of emissions reductions tended to reflect the crediting period (7 or 10 years). For an environmental comparative analysis, it is generally preferable that the operational lifetime is considered. However, if EF_b and EF_p can reasonably be expected to be constant over the entire operational lifetime, it does not matter what timeframe is applied in the *ex ante* evaluation of environmental additionality. This is addressed in Ch. 5 and is not further addressed here.

It could be potentially valuable to extend the timeframe of the common practice analysis to better match the operational lifetime of the CDM project. This would allow an analysis of the likelihood of activities similar to the project being introduced during the CDM project's lifetime. If, for example, it is shown that a fuel-switch from HFO to NG is likely to occur among most HFO plants within the next 5 years, a possible approach is to deem the project environmentally additional up until the point in time when the project is no longer different from BAU. This approach essentially operationalizes the idea that the CDM can promote an early introduction of less emission-intensive projects (*c.f.* behavioral additionality in Ch. 4).

In contrast, once A is registered as a CDM project it will continue to receive credits irrespective of external circumstances during the 10-year crediting period, based on what occurred at the pre-existing plant in 2002. This is because the EF_b is fixed (PDD for A: 33). The same is true for Projects B and C. In the former, the EF_b is fixed during the 10-year crediting period and it appears that the EF_b is determined by plants that are in the range of 4-9 years old relative to the start of the crediting period (estimation based on information given in Table 7.2 and the description of the sample criteria, see section 7.4.2). In the latter, the EF_b is fixed during the 7-year crediting period and it is largely determined by the emissions intensities of fossil fuel-fired power plants existing 2004-2006 (Table 7.2; and PDD for C: Section B.6). This

suggests that the youngest plants will be 4 years relative to the start of the crediting period (2010) and there is no upper age limit.

7.4.2 Project B

This project applied Eq. 2. For a valid environmental additionality argument, this criterion needs to be supplemented by an analysis which establishes that it is reasonable to assume that $\overline{EF}_b \cdot Q_p$will be replaced by $EF_p \cdot Q_p$. Furthermore, the narrative of emissions reductions in this project also clearly reflected the idea that emissions reductions would be achieved as a result of the project replacing the baseline scenario. The question is thus whether the assumption of replacement was supported.

Unit of Analysis	Logic
Narrative of emissions reductions	Replacement
Ex ante evaluation of emissions reductions	Replacement
Investment analysis	Dissimilarity
Common practice analysis	Dissimilarity

In this project's *ex ante* evaluation of investment additionality, a sub-critical (baseline scenario) and a super-critical coal-fired power plant (CDM project) were compared through an investment analysis, comparing the levelized cost of electricity generation.[43] The analysis in the PDD shows that the baseline scenario is more profitable than the CDM project, *i.e.* they are different. As in the previous case (Project A), this analysis cannot support the idea of replacement on its own (see above).

The narrative of project B provides a context that appears to explain why it is reasonable to assume that $EF_p \cdot Q_p$ would replace $\overline{EF}_b \cdot Q_p$ if the project is investment additional. This is because the investment analysis shows that the project (in theory EF_p) is less profitable than the baseline scenario (in theory $\overline{EF}_b$), and due to this it is reasoned that the latter is unlikely to be replaced (without the CDM). Furthermore, the project would hypothetically replace the baseline scenario, implying that $EF_p \cdot Q_p$ would replace $\overline{EF}_b \cdot Q_p$. Hence, there is a believable or plausible rationale.

A significant problem with B is that different scenarios are applied in the *ex ante* evaluations. Emissions reductions are determined relative to Scenario (a) ($\overline{EF}_b$).

[43] Project B applies Additionality tool, version 5.2. This document did not define *levelized cost* of energy. However, it is commonly understood as the present value of the constant unit cost of energy (per kWh or MWh) over the lifetime of the project.

However, the investment additionality of the project is determined relative to Scenario (b) (See *Different Scenarios*, below). Project B's common practice analysis shows that the project is different compared with Scenario (c) (further described below). Hence, it is not shown that Scenario (a) is likely to be replaced. Without this, there is no valid environmental additionality argument. Furthermore, the project's coal-consumption data applied in the investment analysis do not match data applied in the *ex ante* assessment of emissions reductions. This implies that EF_p in these two *ex ante* assessments are not the same, *i.e.* different project scenarios are applied. This creates the same validity problem as when different baseline scenarios are applied in the *ex ante* evaluations. In addition, the conservativeness of the *ex ante* evaluations is questionable due to the use of different data in these evaluations (design/operational SHR data) (see *Data Issues* below).

Ex Ante Evaluation	Scenarios
Ex ante evaluation of emissions reductions	(a) 'Top 15% performers', sub-critical power plants in India; data based on operational efficiency [a]
Investment analysis	(b) 56 thermal power plants in India, data based on design SHR [b]
Common practice analysis	(c) 1320 MW super-critical coal-fired power plants in India [c]

[a] *PDD for B: 35-37; 40-43; Table 10 (p. 42-43)*
[b] *PDD for B: 19; Table 3.1 (p. 56); CEA (2007)*
[c] *PDD for B: 33*

Acronym: Station heat rate (SHR)

A common practice analysis was also included in the *ex ante* evaluation of investment additionality (PDD for B: Section B.5). It determined that there are no activities similar to the project. Hence, the analysis reflects dissimilarity logic. There are three issues. Firstly, the timeframe of the common practice analysis does not match the project's lifetime. The information in the PDD only refers to historical events. The value of applying a timeframe corresponding to the project's operational lifetime is further addressed under 'Project A', 'Diverging Timeframes' (see above). Secondly, the definition of 'similar' is specific or narrow – the PDD's common practice analysis is limited to including grid-connected super-critical coal-fired power plants of the same size (1320 MW) in India. Due to the narrower delimitation, the conservativeness of the analysis can be questioned. The PDD states that super-critical coal-based power generation technology has been implemented in India (PDD for B: 33). A reasonable

question is whether project size is relevant for strengthening the environmental additionality argument. The relationship is not apparent. Thirdly, and perhaps more importantly in this particular project, an analysis reflecting dissimilarity logic does not in itself strengthen the claim that the project will replace the baseline scenario. What is needed is a context or narrative that explains why the lack of projects similar to the CDM project would imply that the BM baseline scenario, Scenario (a), would be likely to be replaced. This is lacking in the common practice analysis and the PDD.

Different Scenarios

The primary indicator that Scenario (a) differs from Scenario (b) is the age of the plants. The plants included in Scenario (a) are not specified in PDD for B, but they are described as the top '15% performers' in terms of operational efficiency. These were in turn described as selected from a sample group of 13 projects which are listed in the PDD. *Operational efficiency* is determined by the net electricity generation, fuel consumption, and net calorific value of the fuel (PDD for B: 36-37). These 13 plants were described as follows:

Scenario (a)

- Using same fuel, *i.e.* coal
- Sub-critical power plants
- Capacity between 330MW to 990MW
- Constructed in the last 5 years (2002-3 to 2006-7)
- Operating at base load
- Supply electricity to the grid before start of the proposed project activity
- Located in India

Source: PDD for B: 35-37; 40-43

The age of the plants in Scenario (a) could only be in the range 0-5 years, relative to the starting date of the project (see Table 7.2). In contrast, in the *ex ante* assessment of investment additionality, Scenario (b) reflected 56 thermal power plants of unknown age.

In Scenario (b) the level of approach can be described as actor-specific and the age of the baseline plant appears to be same as the project. However, the baseline cost of electricity generation is calculated based on the weighted average design *station heat rate (SHR)* of 56 thermal power plants in India, in 2006-07 (PDD for B: 19, 56; CEA, 2007).

The SHR is an important measure for assessing efficiency in thermal power plants (measured in kcal/kWh).[44] Furthermore, it was one of the key parameters in the investment analysis. The PDD for B and the CEA (2007) document referred to in the PDD suggest that the age of the plants used to derive the SHR could possibly range from historical to contemporary relative to the CDM project. There is no age limit mentioned. This indicates that while the project applies a BM scenario, it reflects not so much sub-critical power plants being built as thermal power plants that existed at a specific point in time. This shows that a BM scenario does not necessarily reflect contemporary investments in practice.

Further investigation found that none of the sample-group plants from which the top 15% performers were selected for Scenario (a) could be identified among the 56 plants used to estimate the weighted average design SHR (which was applied in the investment analysis) for Scenario (b).[45] This indicates that two distinct sets of plants were applied in Scenario (a) and (b). According to the PDD, Scenario (a) resulted in a lower emissions-factor value *vis-à-vis* that of Scenario (b). Hence, the rationale for selecting Scenario (a) seems reasonable, but it is not clear why this scenario was not applied in the *ex ante* evaluation of investment additionality. This scenario's sampling frame appears to be a better match for a BM scenario reflecting sub-critical power plants. The problem is that if Scenario (a) had been applied, it is possible that project would not have been deemed investment additional (analysis is provided below under 'Data Issues').

Project B applied different levels of fuel consumption (in megatons, Mt) for the project in the *ex ante* evaluations (see 'Data Issues' below). A lower coal consumption value was applied in the *ex ante* evaluation of emissions reductions than was applied in the *ex ante* evaluation of investment additionality. In principle, this means that the project scenario was not the same in the *ex ante* evaluations and they were not conservative.

Data Issues

While Scenario (a) relies on operational efficiencies, Scenario (b) relies on design SHR data (PDD for B). Neither the operating SHR values for the top 15% performers nor those for the sample-group plants are provided by the PDD for B or by its references.

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[44] "The heat rate of a power plant is the amount of chemical energy that must be supplied to produce one unit of electrical energy. If a power plant converted 100% of the chemical energy in the fuel into electricity, the plant would have a heat rate of 860 kcal/kWh. Alternatively, the required input divided by the actual output, is the reciprocal of the efficiency. Chemical energy is usually measured in kilocalories (kcal) (or sometimes kilojoules, kJ) and electrical energy is usually measured in kilowatt-hours (kWh), the unit of heat rate is normally kcal/kWh (or kJ/kWh)" (CEA, 2007:1).

[45] Comparison of information available in PDD for B: Table 10 (p. 42-43) with PDD for of B (p. 19 and 56) and CEA (2007: 13.6-13.9).

Nevertheless, operating SHR is generally higher than design SHR (higher values equal lower efficiency). Hence, if Scenario (a) had been applied in the *ex ante* evaluation of investment additionality, it is possible that the baseline (levelized) cost of electricity generation would have been significantly higher. If the weighted average operating SHR in India in 2006-07 had been used to assess the baseline cost of electricity generation, the baseline cost would have been 2.27 INR/kWh (see below). In contrast, the baseline cost offered by the PDD was based on the weighted average design SHR and was reported as 2.02 INR/kWh. The project's (levelized) cost for electricity generation, based on design SHR, was reportedly 2.14 INR/kWh.

Design/Operating Station Heat Rate (SHR)		Levelized Cost
Ex ante evaluation of investment additionality		
Scenario (b)	Design SHR (2398 kcal/kWh)	2.02 INR/kWh [a]
Project	Design SHR (2150 kcal/kWh)	2.14 INR/kWh [b]
Same comparison using operating SHR data		
Scenario (b)	Operating SHR (2861 kcal/kWh)	2.27 INR/kWh [c]
Project	Estimated operating SHR (design SHR*10%)	2.25 INR/kWh (maximum cost) [d]

[a] *PDD for B: 27, 29-30, and spreadsheet in Appendix 1.*

[b] *PDD for B: 27, 29-30, and spreadsheet in Appendix 1*

[c] *Weighted average operating SHR: 2861 kcal/kWh (CEA, 2007) = baseline cost 2.27 INR/kWh. This was calculated using the spreadsheet in Appendix 1 (PDD for B). This is a conservative estimation.*

[d] *Design SHR 2150 kcal/kWh * 1.1 = 2.25 INR/kWh. This was calculated using the spreadsheet in Appendix 1 (PDD for B).*

If the *ex ante* evaluation of investment additionality were based on operating SHR, the project's cost would have to be greater than 2.27 INR/kWh for the project to be investment additional. To reach 2.28 INR/kWh or higher, the project's operating SHR must deviate approximately 12.5% or more from the design SHR. This is not extraordinary in India, where at plant level, design and operating SHR deviated by 2.05-72.16% (data for 2006/07) and on average by 19.31% (CEA, 2007). However, according to CEA (2007), stations with operating SHR values deviating more than 10% compared with the design SHR values are considered as poorly operating. Assuming a maximum deviation of 10%, the CDM project's maximum cost would be 2.25 INR/kWh (due to increased fuel consumption). This suggests that the project would not have been deemed investment additional based on a conservative assessment using operating SHR. This analysis not only suggests that investment additionality is uncertain if Scenario (a) had been applied, but also that investment additionality is questionable based on a comparison applying Scenario (b).

Another issue with project B is that it reports different levels of fuel consumption for the project in the *ex ante* evaluations. According to the *ex ante* evaluation of emissions reductions, the project would consume 2.98 Mt of coal during the first year of operations, and thereafter 3.76 Mt/year. Yet, according to the *ex ante* evaluation of investment additionality, the project would consume 4.06 Mt/year (see below). Furthermore, operational SHR can be significantly higher than design SHR in India; assuming a conservative 10% deviation, coal consumption would be 4.47 Mt/year.[46] The project's annual net output of electricity in MWh was the same in both *ex ante* evaluations (PDD for B: Table 12, p. 43, and Appendix 1).

If the project's fuel consumption as reported in the *ex ante* evaluation of emissions reductions had been used in the *ex ante* evaluation of investment additionality, the project's cost for electricity generation would have been 2.03 INR/kWh instead of 2.14 INR/kWh (see below). This means that the project would be barely investment additional compared with the reported baseline cost of 2.02 INR/kWh (PDD for B: 27, 29-30, and Appendix 1). The analysis indicates that either the emissions reductions are exaggerated or the project is barely investment additional.

Project's Coal Consumption	Levelized Cost
Ex ante evaluation of emissions reductions	
Year 1: 2.98 Mt/year; thereafter: 3.76 Mt/year [a]	2.03 INR/kWh [b]
Ex ante evaluation of investment additionality	
4.06 Mt/year [c]	2.14 INR/kWh [d]

[a] *As reported in PDD for B, Table 12, p. 43.*

[b] *Estimated cost: 2.03 INR/kWh was calculated as follows: The fuel consumption data reported in the PDD for B, Table 12 (p.43), was inserted into the spreadsheet in Appendix 1 to the PDD for B. Furthermore, for year 11 and onwards the value 3.76 Gt/ year was applied.*

[c] *Value reported in spreadsheet in Appendix 1 of PDD for B.*

[d] *PDD for B: 27, 29-30, and Appendix 1*

7.4.3 Project C

As in the previous case, this project also applied Eq. 2. For a valid environmental additionality argument, this criterion needs to be supplemented by an analysis which establishes that it is reasonable to assume that $\overline{EF_b} \cdot Q_p$ will be replaced by $EF_p \cdot Q_p$. Furthermore, the narrative of emissions reductions in this project clearly reflected the idea that emissions reductions would be achieved as a result of the project replacing

[46] Project design SHR 2150 kcal/kWh * 1.1 = 4.47 Mt/year. This was calculated using the spreadsheet in Appendix 1 to PDD for B.

the electricity generation related to $\overline{EF_b}$. Hence, the question is whether the assumption of replacement was supported.

Unit of Analysis	Logic
Narrative of emissions reductions	Replacement
Ex ante evaluation of emissions reductions	Replacement
Ex ante evaluation of investment additionality	
Investment analysis	Dissimilarity
Common practice analysis	Dissimilarity

As in the previous two cases, the *ex ante* evaluation of investment additionality reflected dissimilarity logic. Project C applied a benchmark analysis showing that the project profitability is below a specific benchmark value (*i.e.* baseline benchmark). However, in contrast to the previous two cases, the project-specific context of project C does not explain why it is reasonable to assume that $EF_p \cdot Q_p$ would replace $\overline{EF_b} \cdot Q_p$ if the project is investment additional.

The plants included in the CM scenario (reflected in $\overline{EF_b}$) will not be replaced either physically (as in Project A) or hypothetically (as in project B) because the project is investment additional. The assumption that electricity generation of the baseline sources will be replaced or displaced in time by that of the project (in the amount of Q_p) hinges on the implicit assumption that demand for electricity in the system does not exceed the supply. No such discussion was included in the PDD for C (this was generally the case in the three projects examined and is further discussed in section 7.5). This indicates that there is no valid environmental additionality argument in the PDD.

As in project B, a problem with C is that different scenarios are applied in the *ex ante* evaluations. Emissions reductions are determined relative to Scenario (a). However, investment additionality is determined relative to Scenario (b) (see 'Different Scenarios' below). A telling description of the baseline benchmark is "the benchmark IRR of the project" (PDD for C: 13). Furthermore, the common practice analysis addresses Scenario (c) (see below). Hence, it is not shown that Scenario (a) is likely to be replaced. This means that even if the narrative had established that it is reasonable to assume that the baseline scenario in the *ex ante* investment additionality analysis would be replaced if the project is investment additional, there would still be no valid environmental additionality argument.

Ex Ante Evaluation	Scenario
Ex ante evaluation of emissions reductions	(a) CM; fossil fuel-fired power plants of varying age [a]
Ex ante evaluation of investment additionality	
Investment analysis	(b) BM; contemporary electricity sector investments [b]
Common practice analysis	(c) 50-100 MW windpower plants in Inner Mongolia Autonomous Region, with Chinese owners, that are not CDM projects, and that are not seeking registration or registered with other carbon programs [c]

[a] *PDD for C: Section B.6*
[b] *Derived from information available in PDD for C: Section B.5 and the validation report for C by TÜV Reinland (see "Different Scenarios", below).*
[c] *PDD for C: Section B.5*

A common practice analysis was also included in the *ex ante* evaluation of investment additionality (PDD for C: Section B.5). It showed that there are no activities similar to the project. Hence, the analysis reflects dissimilarity logic and it does not address Scenario (a). The issues are essentially the same as those described for project B. To begin with, the timeframe does not match that of the project's lifetime and only historical events (2002-2006) are considered (this issue is further discussed under 'A: Project 1758', 'Diverging Time Frames', above). Secondly, the definition of 'similar' is specific or narrow – the common practice analysis is limited to including 50-100 MW windpower plants in Inner Mongolia Autonomous Region, with Chinese owners, that are not CDM projects, and that are not seeking registration or registered with other carbon programs (PDD for C: 22-23). It is reasonable to question whether the nationality of the owner and the size of the project are relevant for strengthening the environmental additionality argument. The relationships are not apparent. Thirdly, an analysis reflecting dissimilarity logic does not on its own show that anything will be replaced (see section 7.4.2).

Different Scenarios

The primary indicator showing that two distinct scenarios were applied in the *ex ante* evaluations was the (explicit/implicit) age of the plants. In the *ex ante* evaluation of emissions reductions, the CM scenario was applied to estimate $\overline{EF}_b$. The CM scenario applied the following weights: $EF_{CM} = EF_{BM} \cdot 0.25 + EF_{OM} \cdot 0.75$. The most heavily weighted emission factor, EF_{OM}, was calculated based on total fossil fuel consumption of the NCPG and net electricity generation of all existing power plants

serving NCPG not including low-cost/must-run plants, in 2004-2006 (PDD for C: Section B.6). Hence, $\overline{EF_b}$ primarily reflected existing plants where the age of the plants could range from historical to contemporary relative to the starting date of the project activity (see Table 7.2).

In contrast, in the *ex ante* evaluation of investment additionality, the baseline benchmark IRR reflected contemporary investments in the electric power sector in China. The benchmark value was in accordance with *Interim Rules on Economic Assessment of Electrical Engineering Retrofit Projects*, issued by former State Power Corporation of China, in 2002 (PDD for C: 13). This document had not been revised since 2002 according to the validation report by TÜV Reinland (the DOE). Furthermore, this report mentioned that the source had been used by other newly registered CDM windfarm projects, in China, in their investment analyses (TÜV Reinland, 2010:24). This strongly indicates that a contemporary BM scenario was applied in the *ex ante* evaluation of investment additionality, and that this scenario was not limited to fossil fuel-fired plants. Most importantly, the implicit age of the plants in the scenario reflected by the applied benchmark was contemporary relative to the starting date of the project. This is highly unlikely to be consistent with the age of the plants reflected by EF_{OM}.

7.5 Concluding Discussion: Gaps in the Environmental Additionality Argument

In this chapter, the environmental additionality arguments in three CDM projects representing the application of different baseline scenarios were examined. For brevity, these projects are referred to as A, B and C. These applied different types of baseline scenarios. Depending on whether or not a single-source or multiple-source baseline scenario was applied, projects A-C indirectly applied different environmental criteria in the *ex ante* evaluation of emissions reductions (see below).

Project	Baseline Scenario	Environmental Criterion	
A	Existing plant	Eq. 1.	$a > EF_p$
B	Build margin (BM) scenario	Eq. 2.	$\overline{EF_b} > EF_p$
C	Combined margin (CM) scenario	Eq. 2.	$\overline{EF_b} > EF_p$

These criteria are further explained in section 7.3.

In principle, Eq. 1 is a valid environmental additionality criterion in its own right. This conclusion is based on the assumption that the baseline scenario reflects 'what would have happened' in the absence of the CDM project during a specified

timeframe (*e.g.* years 1-10). This implies that the total baseline electricity output and emissions intensities of the baseline plant(s) would be fixed (and therefore also the baseline emissions during years 1-10). In principle, the introduction of a CDM project implies that the generation of the baseline plant or some plants (if there is more than one) will necessarily be replaced or displaced during the timeframe considered. Furthermore, because the CDM project is less emission-intensive compared with each baseline plant (if there is more than one) according to Eq. 1, it follows that emissions reductions will be achieved. This shows that the idea that something will be replaced is embedded or implicit in Eq. 1. When Eq. 1 is applied in such a way, an *ex ante* evaluation of investment additionality can be viewed as a valuable supplementary analysis for supporting the claim that the project is not a baseline plant, but in principle, environmental additionality can be established without it. This, however, requires a forward looking baseline scenario which describes the plant, or plants, that will be part of the system (*i.e.* grid), during a specific timeframe.

This chapter did not examine baseline scenarios, and more research is required to operationalize Eq. 1 as described above. However, there are likely to be issues with the baseline scenarios and *ex ante* evaluations of all three projects. A and B can be described as applying forward looking baseline scenarios, but the PDD for A did not analyze the existing or future use of NG. The PDD for B did not analyze existing super-critical coal-fired power plants (only those of the same size) or future investments in such plants. The baseline scenario in C can be described as contemporary (it reflected the contemporary grid, relative to the project's starting date), but it was not forward looking. Furthermore, PDD for C did not analyze system development, *i.e.* the plants that would be part of the grid in the future. This chapter assumes that the baseline scenario is appropriate and a plausible representation of 'what would have happened' without the CDM.

Eq. 2 is not a valid environmental additionality criterion on its own. It needs to be supplemented by an analysis which establishes that it is reasonable to assume that $EF_p \cdot Q_p$ will replace $\overline{EF}_b \cdot Q_p$ during a specified timeframe (*e.g.* years 1-10). This is necessary for a valid environmental additionality argument. Neither B nor C was found to have a valid argument, because it was not established that it is reasonable to assume that $EF_p \cdot Q_p$ will replace $\overline{EF}_b \cdot Q_p$. What this means is that these projects do not reasonably show that emissions will be reduced. In other words there is no apparent plausible theory of change.

In the cases examined, the *ex ante* evaluation of investment additionality on its own did not determine that anything would be replaced. However, as shown by the examination of projects A and B, 'the project-specific context' can offer an explanation of why it is reasonable to assume that the project would replace the baseline scenario if the project is investment additional. For the analysis, the 'project-specific context' was

provided by the project characteristics and narrative of emissions reductions, as described in the PDD.

Project C represented the use of a CM scenario. It was in turn the only project that did not provide in the PDD a 'project-specific context' that offered an explanation of why it is reasonable to assume that $\overline{EF_b} \cdot Q_p$will be replaced by $EF_p \cdot Q_p$ if the project is investment additional. This implies that it remains to be shown that the CM scenario can be applied while achieving a valid environmental additionality argument. Project C is a zero-emissions project, and because of this it could perhaps be argued that an invalid environmental additionality argument is not a significant problem in this particular project. My personal opinion regarding zero-emissions projects, considering the current fossil-fuel dependent reality, is that the crediting of these projects is more an economic issue rather than an environmental one. However, in a fossil-fuel dependent reality, few if any projects give rise to zero emissions, for example due to emissions relating to the construction of the power plant. Nevertheless, perhaps the more significant problem is that the application of the CM scenario is not limited to renewable projects according to the findings in Ch. 6 (see AM0029, ACM0004, and ACM0007).

None of the projects examined analyzed or discussed the assumption that Q_p would replace or displace other electricity generation reflected by $\overline{EF_b}$ in the *ex ante* evaluation of emissions reductions. However, given the project-specific context, this assumption appears to be reasonable in projects A and B. In A, a less emission-intensive fuel would physically replace the more emission-intensive fuel used at a specific plant (currently connected to the grid). The existing plant's output and operational lifetime were described as unchanged by the CDM project. In B, a less emission-intensive investment would replace a more emission-intensive hypothetical alternative that would have been chosen by the project participants in the absence of CDM. Outputs and operational lifetimes were the same according to the PDD.

In C, however, it was less clear that the Q_p would replace or displace the electricity generation reflected by $\overline{EF_b}$. This assumption may be justifiable if there is adequate supply to meet the demand for electricity (during the timeframe considered). However, if demand exceeds supply (as described by B; PDD for B: 3-4), the introduction of more electricity through a CDM project will not necessarily replace or displace any electricity. Instead, it is quite possible that the introduction of a CDM project will shift the supply curve to the right (Fig. 7.1), making more electricity available (resulting in increased emissions). In this context, investment additionality is of little help. In principle, it will ensure that the investment would not have taken place without the CDM. If anything, this suggests that the supply curve will be shifted by the CDM project.

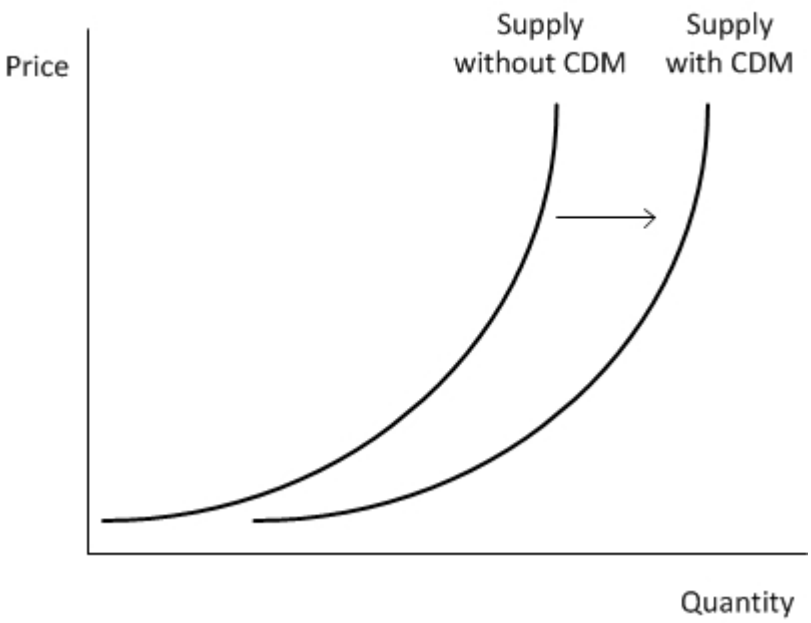

Fig. 7.1
Hypothetical Illustration of Supply of Electricity

The environmental additionality argument in the PDD for B was found to be invalid. This was because of an unjustified use of different scenarios in the *ex ante* evaluations. This project explicitly applied an environmentally more conservative emission factor ($\overline{EF_b}$) vis-à-vis the emission factor of the baseline scenario. Hence, there appears to be a reasonable explanation for applying different scenarios in the *ex ante* evaluations of emissions reductions and investment additionality, Scenario (a) and (b), respectively. However, it is not explained why Scenario (a) was not used in the *ex ante* evaluation of investment additionality. In fact, Scenario (a) seems to be a better match to what is claimed to be the scenario in the *ex ante* evaluation of investment additionality, namely sub-critical coal-fired power plants.

Scenario (a) is based on:	Operating SHR of the sub-critical coal-fired power plants
Scenario (b) is based on:	Design SHR of thermal power plants
	Most of these primarily consume coal, but plants consuming lignite are also included (CEA, 2007).

If Scenario (a) had been applied in the *ex ante* evaluation of investment additionality, the project is unlikely to have been deemed investment additional. Project B applied different types of station heat rate (SHR) data in the *ex ante* evaluations of emissions reductions and investment additionality. In the former, operational SHR is applied, but in the latter design SHR was applied. If operational SHR had been applied in the

ex ante evaluation of investment additionality, the project would most likely not have been deemed investment additional.

Project B applied different coal-consumption estimates for the project in the *ex ante* evaluations of emissions reductions and investment additionality. In principle, this means that different project scenarios were applied in the *ex ante* evaluations. This creates the same problem with validity as if different baseline scenarios had been applied in these evaluations. A higher estimate was applied in the *ex ante* evaluation of emissions reductions vis-à-vis that applied in the *ex ante* evaluation of investment additionality. This is clearly not conservative. If the annual coal consumption as specified in the *ex ante* evaluation of emissions reductions had been applied in the *ex ante* evaluation of investment additionality, B would still have been investment additional, but only barely. What the preceding examples show is that allowing the use of different project and baseline scenarios in the *ex ante* evaluations provides significant scope to apply lax scenarios, thus exaggerating emissions reductions and investment additionality.

Of the projects examined, A was the only one to apply the same baseline scenario in the *ex ante* evaluations of emissions reductions and investment additionality. Furthermore, A is the only project that can be described as demonstrating a valid environmental additionality argument. This chapter only addressed the validity of the argument as such. Hence, the appropriateness or plausibility of the baseline scenario, the correctness of data in the PDD, and the correctness or plausibility of the investment analysis were not examined.

8

DISCUSSION: LOOKING BACK & THINKING AHEAD

Environmental integrity is at the heart of the CDM and methodologies have a major role in ensuring this integrity. Methodologies are required to establish a project's emissions baseline, or expected emissions without the project, and to monitor the actual ongoing emissions once a project is implemented. The difference between the baseline and actual emissions determines what a project is eligible to earn in the form of credits. Methodologies are essential when quantifying emissions reductions in an uncapped environment on a project-by-project basis.

Christiana Figueres, Executive Secretary
United Nations Framework Convention on Climate Change

UNFCCC (2010b), p. 3

8.1 Case Study Findings in Brief: Back to Basics

8.1.1 Explicit Theory of Emissions Reductions

Essentially, the research conducted for this dissertation is largely about the theory (or idea) of emissions reductions in carbon crediting, how this or some other implicit theory (or theories) is followed through in practice, and whether the approach is appropriate or credible in relation to the expected outcome of emissions reductions. The broadly acknowledged theory in the CDM context is as follows:

I: The Generally Accepted Theory of Emissions Reductions in the CDM

To truly reduce emissions, a project cannot be the baseline scenario ('what would have happened otherwise'). To ensure this, a project must be investment additional. The difference between the baseline emissions and project emissions are the emissions reductions. If a project is investment additional and reduces emission, then emissions will be truly reduced.

See e.g. Kollmuss (2011) for a recent reference reflecting this idea.

This theory appears to be reflected in the CDM practices. Projects must show in their PDDs that they are both investment additional and reduce emissions to be eligible for registration, which is a condition for earning CERs. Methodologies approved by the EB are applied to assess investment additionality and calculate emissions reductions *ex ante*, while DOEs check that projects fulfill eligibility criteria as part of the validation process. However, the present in-depth studies of CDM methodologies and registered CDM projects found several inconsistencies and weaknesses (see below and Ch. 5-7). A conclusion that can be drawn is that the commonly acknowledged theory of emissions reductions is generally not supported by the empirical findings. A possible exception was one CDM project applying a single-source baseline scenario. However, in this particular case, investment additionality was not necessary to establish environmental additionality (Ch. 7).

Additionality is a relative concept (Ch. 4). Under the CDM an additional project is understood as different from the baseline scenario. However, this was not necessarily determined through the methods applied to assess investment additionality (Ch. 5). Furthermore, all 32 registered CDM projects examined here that applied a multiple-source baseline scenario in the *ex ante* evaluation of emissions reductions used a different baseline scenario in the investment additionality assessment (Ch. 6-7). The use of different baseline scenarios in the *ex ante* evaluations of investment additionality (outputs) and emissions reductions (outcomes) implies that (a) the validity of both types of *ex ante* assessments is questionable and (b) there is no conceptual link between the measured outputs (investment additional project) and outcomes (emissions reductions) (Ch. 6). This link is crucial for the argument that investment additionality ensures additional emissions reductions.

Two *ex ante* environmental criteria were identified (Eq. 1 and Eq. 2, see below). These were indirectly applied depending on the baseline scenario applied in the *ex ante* evaluation of emissions reductions. Eq. 1 was required to be, or was, applied when a project applied a single-source baseline scenario (Ch. 5-7). It determines that the project is different from the baseline scenario and can be described as an environmental additionality criterion in its own right (Ch. 5). In contrast, Eq. 2 was required to be, or was, applied when a project applied a multiple-source baseline scenario (Ch. 5-7). This criterion does not determine that the project is different from the baseline sources – it is not an environmental additionality criterion on its own (Ch. 5). Emissions reductions can be envisioned, but rely on the assumption that the project (or its output) (*e.g.* in MWh of electricity) will replace or displace in time the baseline scenario (or its output) (Ch. 6 and 7).

In-depth studies of three registered CDM projects found that both Eq. 1 and 2 could in principle support a valid environmental additionality argument (Ch. 7). However, neither of the two projects applying a multiple-source baseline scenario established that it is reasonable to assume that the project (or its output) would

replace or displace in time the baseline scenario (or its output). In other words, these did not have a valid environmental additionality argument. Hence, they did not establish that it is reasonable to assume that emission would be reduced or, equivalently, there was no apparent plausible theory of change.

The project applying a combined margin (CM) scenario was the only project unable to explain why it is reasonable to assume that the project's output would replace that of the baseline scenario if the project is investment additional (project C, Ch. 7). In the brownfield project examined, the baseline scenario was an existing plant. The realization of this project implied that the baseline scenario would be physically replaced (project A, Ch. 7). In one of the greenfield projects examined, an alternative build margin (BM) scenario was applied. The realization of this project implied that the baseline scenario would be hypothetically replaced (project B, Ch. 7). In both these examples, an investment additionality assessment supported the argument that the project was unlikely to be realized (and thus replace the baseline scenario) without the CDM. This was done by showing that the baseline scenario was more profitable.[47] In contrast, in the second greenfield project that applied a CM scenario, the realization of the project would not physically or hypothetically replace the baseline scenario (project C, Ch. 7). Instead, the notion of emissions reductions was based on the assumption that the electricity generation of the baseline sources would be replaced by that of the project (in the amount of the project output). In this context, it is not apparent how the investment additionality supports the claim that the baseline electricity generation would be affected. If demand exceeds supply of electricity, the introduction of more electricity through a CDM project will not necessarily replace (or displace in time) any electricity. In 2008, 22% of the world's population (1.5 billion people) was estimated to be without access to electricity (OECD/IEA, 2009). The average electrification rate in developing countries was 72%. However, electrification rates varied widely at country level, ranging from below 10% to close to 90% (*ibid.*). If demand exceeds supply, investment additionality suggests that the CDM project will make more electricity available compared with BAU. This implies that emission will be increased rather than reduced. This indicates that what needs to be examined to support the claim that electricity generation will be replaced or displaced in time is the demand and supply of electricity in the relevant system (to which the project is connected) during the relevant timeframe (during which the project supplies electricity). Such an analysis was generally lacking in the PDDs examined here (Ch. 7).

[47] The problem with project B was not the reasoning, but that different baseline scenarios were applied in the *ex-ante* evaluations of investment additionality and emissions reductions. Hence, it was not shown that the baseline scenario applied to calculate emissions reductions would be replaced. Several other problems were also identified (see Ch. 7)

8.1.2 Implicit or Embedded Theories of Emissions Reductions

The in-depth studies of CDM methodologies and CDM projects presented here identified two environmental criteria being applied, represented by Eq. 1 and Eq. 2 (see below). Furthermore, it was found that both could in principle support a valid environmental additionality argument. If operationalized appropriately, they can represent plausible theories of change (or theories of emissions reductions). How this can be done is discussed below primarily based on the following:

- Insights provided by the innovation policy literature on additionality and the policy-related literature on effectiveness (Ch. 3-4).
- Insights gained from the empirical studies of CDM methodologies applicable and/or applied to large-scale electricity generation CDM projects (Ch. 5-7).

An overview of the criteria identified and inputs on operationalizing them is summarized on one page (see below).

The theories based on Eq. 1 and Eq. 2 are hereafter referred to as II and III, respectively (see below). Both II and III take their starting point in establishing environmental outcome additionality and determine that the project reduces emissions compared with the baseline scenario. The baseline scenario determines the level of approach. The empirical findings show that the level of approach in registered CDM projects varies widely, from actor to sector (Ch. 6 and 7). In contrast to II and III, the current practice is to start from establishing investment additionality (Ch. 4-7). The baseline scenario determines the level of approach and the empirical findings show that the level of approach in registered CDM projects ranges from actor to international (Ch. 6 and 7). However, the aim of the CDM *ex ante* evaluation is not to promote unprofitable or non-viable projects (outputs) *per se*, but to promote expected outcomes, namely additional emissions reductions.

In terms of promoting expected outcomes, in the literature on additionality and effectiveness there appears to be little support for focusing on outputs or a 'project-based approach' (applying actor- or project-specific baseline scenarios). Both the innovation policy literature on additionality and the policy-related literature on effectiveness indicate that outputs do not necessarily translate to expected outcomes (Ch. 3 and 4). For example, an unprofitable project (*i.e.* 'additional project' in the CDM context) does not in itself imply that emissions will be reduced. Furthermore, it has been pointed out in the innovation policy literature on additionality that it is very difficult to assess a firm's original intentions (*i.e.* project-specific baseline is difficult to determine) (Ch. 4). In light of this it appears more appropriate to focus on environmental outcome additionality in the CDM *ex ante* evaluation, and to apply sector-specific baseline scenarios (*i.e.* pursue a 'sector-based approach'). The idea of

applying sector-specific baseline scenarios also tends to be supported by the literature on calculating emissions reductions in the electricity sector (Ch. 6). More recently, it has also won political acceptance as indicated by the official introduction of 'standardized baselines' and the EB's work on developing guidelines for 'sector-specific standardized baselines' (see section 8.3).

The insights provided by the innovation policy literature on additionality regarding input additionality and behavioral additionality could perhaps also be incorporated to promote environmental outcome additionality (Ch. 4). This dissertation suggests that input additionality can be a valuable second-order condition. In the CDM context, such a condition could potentially weed out investments that are profitable without the further financial support that the CERs provide. This could potentially promote cost effectiveness. However, this would require rethinking the additionality assessment, as input additionality is not currently required to be addressed (Ch. 4-7). In principle, an analysis of input additionality is not necessary to determine environmental outcome additionality, assuming that the baseline scenario reflects what 'would have happened otherwise'. However, due to the practical difficulties involved in accurately foreseeing this, an *ex ante* evaluation of input additionality may in practice be a valuable tool for promoting environmental outcome additionality. Possible drawbacks are that an assessment of input additionality entails transaction costs and that the empirical link between the concept *input additionality* and outputs appears to be weak (see section 4.2.2, 'Input Additionality').

Currently, under the CDM, additionality is approached in an either-or approach. Hence, either the project is additional or it is not during the operational lifetime (Ch. 5-7). However, it is conceivable that the CDM has more subtle effects, allowing for changes in the scope, scale and speed of the work (see 'Behavioral Additionality' in Ch. 4). In electricity generation projects the operational lifetime can entail several decades (Ch. 6). While it will be important that the environmental additionality of a project, over the project lifetime, is not negative (*i.e.* that emissions increase), it is conceivable that it may not be environmentally additional during the entire timeframe. For example it might be environmentally additional for the first 5 or 10 years, and subsequently be non-additional (without increasing emissions relative to the baseline). As suggested in Ch. 7, it may be reasonable to approve a project that promotes an early introduction of an emission-reducing activity (see section 7.4.1). Furthermore, interviews indicate that there is reason to believe that the practical approach of project developers to the development of CDM projects is poorly reflected the current CDM *ex ante* evaluation.[48] In this evaluation the CDM project is

[48] Based on interview with Natsuki Tsukuda and Sumie Nakayama, J-Power, on 8 Aug. 2007 (see Appendix 2), and informal discussions with project developers at various carbon conferences (Carbon Expo and Carbon Market Insights, 2005-2010).

treated as a single entity. However, developers tend to describe it in a compartmentalized manner, referring to the 'underlying project' and the 'CDM component'. This suggests that more empirical studies will likely benefit the development of more effective *ex ante* evaluations and behavioral additionality concepts may be useful.

Identified Environmental Criteria & Inputs on Operationalization

Theory II: Environmental Additionality based on Environmental Criterion $a > EF_p$ (Eq. 1)

where $a \leq EF_{b_i} \leq b$

Basic idea: The crediting project is strictly different from the baseline scenario ('what would have happened otherwise' in the absence of the crediting project) in terms of emissions intensity. Assuming an appropriate baseline scenario, the realization of the crediting project will replace 'what would have happened otherwise'; and emissions will be reduced.

Key factor: Baseline scenario (see below).

Theory III: Environmental Additionality based on Environmental Criterion $\overline{EF}_b > EF_p$ (Eq. 2)

where $a \leq EF_{b_i} \leq b$

Basic idea: The crediting project is less emission-intensive compared with the generation-weighted average BAU source, but not necessarily strictly different from the plants included in the baseline scenario in terms of emission-intensity. Assuming that the crediting project replaces (or displaced in time) the generation-weighted average BAU source (or outputs), emissions will be reduced.

Key factor: An analysis that determines that the 'the generation-weighted average BAU source' (or outputs) reflected by the baseline scenario is replaced (or displaced).

'Additionality Assessment'

Basic idea in relation to A: Input additionality could be a valuable second-order condition which promotes effectiveness by reducing the chance of unnecessarily supporting projects which are viable without further (financial) assistance. In principle, input additionality is not necessary for determining environmental outcome additionality, but may be a valuable in practice.

Basic idea in relation to B: Can be an essential analysis, assuming that it determines that the project will replace or displace the 'the generation-weighted average BAU project (or their output) reflected by the baseline scenario. The current investment additionality assessment may need to be fundamentally reconsidered (see discussion on CM scenario above).

Key factor: Application of the same baseline scenario as applied in the *ex ante* evaluation of emissions reductions.

Baseline Scenario for A and B (by dimensions)

Level of approach	Sector
Geographical boundaries	Needs to be relevant in relation to the sector. Boundaries at the international level could avoid some leakage problems.
Timeframe	Same as project lifetime
Age of the power plant(s)	Same as project and younger
Technological boundaries	Same as project

8.2 Looking into the Past: Credits & Environmental Additionality

In the context of crediting, focusing on environmental outcome additionality and pursuing a sector-based approach (sector-specific emissions baselines) is not an unconventional idea, rather the opposite. With a historical perspective, what is unproven is the idea of pursuing emissions reductions (outcomes) through an assessment of investment additionality (or project additionality) and a project-based approach (project-specific emissions baselines), as is currently the case in carbon crediting.

Although earlier credit-based systems preceding carbon crediting are commonly referred to as 'uncapped', this is to some degree misleading. There were no absolute emissions caps (as in the 'capped' permit-based systems), but there were rate-based pollution limits which were legally binding. Furthermore, whether credit or permit-based, emissions trading systems preceding carbon trading appear to have covered a (sub-)sector and/or were designed to target certain types of pollution (see Ch. 2). Earlier credit-based systems in general relied on predetermined rate-based standards (see *e.g.* Anderson, 2001; Stavins, 2001; Sterner, 2003). These tended to apply to sources whether they created credits or not. A more descriptive term thus appears to be *relative pollution ceilings* or *relative caps*. In contrast, carbon crediting can more fittingly be described as uncapped – baselines only apply to those engaged in credit creation and can vary from project to project. The use of relative caps implies that the earlier credit-based systems were more clearly linked to achieving pollution targets. Furthermore, if a pollution target is the baseline (*e.g.* under the lead phase-out program), then the creation of credits implies that sources voluntarily reduce emissions (or inputs as in the lead phase-out program) below legal requirements. In contrast, credit creation under the CDM is not designed to promote emissions below the Kyoto targets.

Under the US offset program, while creating credits was voluntary for existing sources, offsetting was mandatory for certain new sources (*c.f.* greenfield projects). According to the Clean Air Act (CAA) of 1970, firms that constructed new emissions sources or significantly modified existing sources had to meet stringent New Source Performance Standards (Solomon and Gorman, 2002). Firms wishing to construct new facilities in non-attainment areas could only do so by ensuring "the lowest achievable emission rate" and acquiring credits from existing facilities in that air shed (CAA §173/42 USC §7503, (a) (1)(B)(2), (c)(1)).[49] [50] New sources faced technology

[49] A 'non-attainment area' is a geographical area which does not meet air quality standards (Ch. 2).

[50] States may allow the owner or operator of a source to obtain such emissions reductions in another non-attainment area under certain conditions, see CAA §173/ USC §7503 (c) (1).

requirements and they were required to offset emissions by 120% (Oates, 2000; Tietenberg, 2006).

In the CDM context, credit creating and offsetting activities engage all sources through economic incentives. In contrast, under the US offset program the same was only true for existing sources (Ch. 2). In the context of carbon crediting (*i.e.* credit creation), credits offer an additional source of income to those that voluntarily reduce emissions. Those with emissions targets under *e.g.* the KP or the EU ETS can use credits to reduce the cost of reaching emissions targets and offset their emissions 1:1. Under the CDM, neither credit creation nor offsetting is mandatory. Another difference between the CDM and for example the US offset program is that under the latter, the ability to offset depended on the credit-creating source being located in the same air shed. In contrast, the CDM only engages credit-creating sources that are not located in geographical areas with emissions reduction commitments under the KP.

As described above, there are several noticeable differences between earlier credit-based systems and the CDM. Comparatively speaking, the CDM appears to be less concerned with emissions targets and reducing emissions, and more concerned with broadening the engagement of emissions sources (more specifically emissions sources in developing countries) in mitigation activities. Looking into the future of climate change mitigation, this is an important feature. However, one could also argue that for this broadened engagement to be meaningful, ensuring 'real' or additional emissions reductions is valuable. Furthermore, the importance of environmental integrity in the CDM context is generally acknowledged.

Investment additionality is a key issue in the CDM, but in earlier credit-based systems it does not seem to have attracted attention. In earlier credit-based systems, credits were created based on emissions reductions relative to emissions in existing sources (which are measurable) or rate-based pollution standards (which were defined by policy-makers and which tended to be below existing emissions) (Ch. 2). The main issue was thus environmental outcome additionality and environmental integrity was more an issue of setting appropriate targets and monitoring pollution and production outputs. In the early days of emissions trading, the difficulty involved in measuring, monitoring, and tracking emissions was identified as impeding the creation and trade of credits (Solomon and Gorman, 2002). However, 'additionality' was not mentioned in any of the literature describing earlier credit-trading systems reviewed for this dissertation (see Ch. 2).

Experiences with earlier credit-based systems and the findings presented in this dissertation indicate that it is possible to design environmentally credible crediting systems which promote environmental outcome additionality without relying on an assessment of project-level investment additionality and project-specific baseline scenarios. However, while Eq. 2 (*c.f.* theory III) may appear largely interchangeable with that applied in earlier credit-based systems (Eq. 3, *c.f.* theory IV, below), the

latter approach, which forgoes an additionality assessment, cannot simply be transferred to the CDM (or similar uncapped) context. The criterion applied in theory IV cannot be transferred to the context of carbon crediting in the absence of relative caps similar to those applied in the earlier systems. Furthermore, if the relative cap/rate-based standard reflects the BAU development, this approach will not achieve anything but 'what would have taken place otherwise'. Essentially, there will be no environmental additionality. To apply the environmental criterion of Eq. 2 without a determination of what is replaced requires relative caps or rate-based pollution standards which are below the baseline emissions. However, the introduction of relative caps is a political issue which most likely needs to be addressed through the UN climate negotiations.

Theory IV: Environmental Additionality based on Environmental Criterion $EF_{standard} > EF_p$ (Eq. 3)

Basic idea: The crediting project is less emission-intensive compared with the rate-based pollution standard. Emissions will be reduced assuming the application of a relative cap or rate-based standard which is below baseline emissions.

Key factor: A relative cap below BAU emissions.

8.3 Looking Ahead

8.3.1 Environmental Integrity & Up-Scaling

Significant challenges for the future of carbon crediting include the issues of environmental integrity and up-scaling of the CDM (or similar crediting mechanism) (OECD/IEA, 2009; Grubb *et al.*, 2011). The findings in this dissertation strongly suggest that the environmental integrity of the CDM can be improved through a sector-based approach. The idea of a mechanism based on a sectoral approach has been discussed in the climate policy literature since 2005 and at the climate negotiation since 2009 (Schneider and Cames, 2009). It is envisioned to improve environmental integrity and promote an up-scaling and as offering as possible way forward in light of the difficulties of reaching a climate agreement on a global cap of GHG emissions. Terminology has varied, but sectoral approaches have been envisioned as a potential route to engaging developing countries in global GHG mitigation (Meckling and Chung, 2009). Furthermore, they are proposed as bottom-up alternatives to the top-down approach of internationally agreed targets and timetables. However, "[e]conomic convention holds that sectoral approaches are second-best alternatives to economy-wide mechanisms with regard to cost-effectiveness" (*ibid:* 654). A comprehensive approach allows emissions to be reduced

in the least costly sector while avoiding leakage from regulated to unregulated sectors. Sectoral approaches miss these cost-saving options and create room for leakage.

While it is important to be aware of the shortcomings of a sectoral approach, it is also relevant to remember the political and practical reality. Firstly, a global cap appears unlikely to be introduced for some time to come. Secondly, developing countries are wary of sectoral approaches because they essentially introduce sectoral emissions reduction targets (Meckling and Chung, 2009). Introducing emissions targets for developing countries is a contentious issue which has been strongly opposed by developing countries at the climate negotiations. Finally, the approach in crediting thus far has been project-specific. In light of this, a sectoral approach in the CDM context would constitute a significant step for developing countries and a step towards a wider approach. Various types of sectoral approaches have been discussed, but one form is the so-called 'sector-CDM' or 'sectoral CDM'. This is described as a crediting mechanism based on 'established baselines in sectors', on 'BAU emissions level', and on 'sectoral no-lose targets' (where the baseline is set below the BAU emissions). Others, however, refer to 'sector-CDM' and 'sectoral no-lose mechanism' as separate mechanisms (Schneider and Cames, 2009; Coria *et al.*, 2010; Fujiwara *et al.*, 2010).

A concrete step towards addressing what has been acknowledged as important future challenges for the CDM is the agreement at the 2010 climate negotiations in Mexico to implement 'standardized baselines' (UNFCCC, 2011b, Decision 3/CMP.6). This subsequently led to the development of guidelines for the establishment of 'sector-specific standardized baselines' by the EB (EB, 2011). A 'standardized baseline' is calculated on a single, standard estimation of the GHGs that would have been emitted if certain types of CDM projects were not implemented (CDM Rulebook: What is a Baseline?).[51] The agreed definition is as follows:

> [A] baseline established for a Party or a group of Parties to facilitate the calculation of emission reduction and removal and/or the determination of additionality for [CDM] project activities, while providing assistance for assuring environmental integrity.
>
> *UNFCCC (2011b), Decision 3/CMP.6: §44*

The work related to the development and assessment of sector-specific standardized baselines covers not only baseline scenario identification and baseline emission determination, but also additionality demonstration (EB, 2011:§5). This work is still at an early stage, but the guidelines are discussed in the following sub-section.

[51] The CDM Rulebook is freely available to the public. It is an online database of the CDM rules, developed by Baker & McKenzie and funded by the following organizations: British Foreign & Commonwealth Office, Swedish Energy Agency, Australian Government Department of Climate Change and Energy Efficiency, New Zealand Ministry for the Environment, Asian Development Bank, The World Bank, UNDP, UNEP Risoe.

Expectations are that "the use of standardized baselines could reduce transaction costs, enhance transparency, objectivity and predictability, facilitate access to the [CDM], particularly with regard to underrepresented project types and regions, and scale up the abatement of greenhouse gas emissions, while ensuring environmental integrity…" (UNFCCC, 2011b, Decision 3/CMP.6: Preamble). The official acceptance and introduction of sector-specific baselines signifies a conscious move away from the project-by-project approach to evaluation. Furthermore, it indicates that future efforts to improve the effectiveness of the CDM will focus on developing an approach that promotes sector-level environmental additionality (*i.e.* outcome additionality at sector level).

8.3.2 Sector-Specific Standardized Baselines

As was noted at the climate negotiations in Mexico, standardization was already being applied in some approved baseline and monitoring methodologies under the CDM (UNFCCC, 2011b, Decision 3/CMP.6: Preamble). The research presented in this dissertation covered several CDM methodologies which include standardized baselines (*e.g.* the CM and BM scenario). Furthermore, countries such as China and India already offer centrally published CM and BM emission factor values for CDM projects (Ch. 6). The research findings can likely be extended to other types of stationary sources where it is meaningful to think about emissions in terms of emissions per output. The guidelines provided by the EB are specified as applicable to sectors where project activities are implemented for stationary sources (EB, 2011:§5). This suggests that it is possible to provide relevant inputs based on the research presented here.

The research on environmental outcome additionality presented here indicates that it is valuable to have a plausible theory of emissions reductions. This determines what an 'appropriate' environmental criterion and baseline scenario comprise, as well as the role of an additionality assessment. This dissertation identifies three plausible theories in the context of crediting (see theory II-IV, above), but it is possible that there are more. Within the identified theories, the research also shows that the role of an additionality assessment can vary; it can promote cost effectiveness (theory II), can be necessary for environmental additionality (theory III) or can be largely redundant (theory IV). The research findings show that the following issues are relevant to consider:

- Environmental criterion
- Baseline scenario
- Additionality assessment
- Supply and demand context

The theory of emissions reductions is not clear in the agreed text from the negotiations in Mexico or the guidelines provided by the EB (EB, 2011; UNFCCC, 2011b Decision 3/CMP.6). However, it seems rather clear that standardized baselines do not imply relative caps below BAU emissions, which are necessary for pursuing an approach consistent with theory IV. What continues to be considered is an uncapped system where baselines reflect BAU emissions and only apply to the crediting activities. Furthermore, a sector-based approach implies that multiple-source baselines are involved. This suggests that the relevant theory is III.

An examination of the EB guidelines showed that the environmental criterion (or criteria) to be applied is not specified. The baseline scenario dimensions are also unclear in terms of geographical boundaries, level of approach, timeframe, age of plants and technological boundaries. Supply and demand for the outputs in question are not mentioned. While the definition of *standardized baseline* refers to Party or Parties (*i.e.* country or countries) and *sector* is defined as a segment of a national economy which is characterized by its outputs (EB, 2011:§8(e)), it appears that the geographical coverage can possibly imply local coverage (*i.e.* region within a country) (EB, 2011:§16, 25, 35 and 41; UNFCCC, 2011b, Decision 3/CMP.6). In a more general context, local or national coverage suggests that it will be more important to consider the mobility of the sources and trade. For obvious reasons, mobility is rather limited in grid-connected electricity generation. An electricity generation facility cannot be located in China and supply electricity to Germany. The mobility of other types of production is not necessarily as limited and carbon leakage due to relocation or shifts in production sources may be relevant to consider (*c.f.* Kollmuss and Lazarus, 2010; Schneider *et al.*, 2010). Mobility and trade is not mentioned in the texts on baseline standardization examined here.

The EB guidelines refer to 'sector-specific standardized baselines', which suggests that the level of approach is sector. Furthermore, the guidelines indicate that the *sector* will be determined based on the output. However, when a sector as a whole is not homogeneous, it can be disaggregated into 'homogeneous sections' (EB, 2011:§47). While it is unclear what homogeneity implies, the guidelines indicate that standardized baselines can vary depending on *e.g.* fuel inputs and technology. This suggests technology-specific baselines rather sector-specific baselines. Economic insights suggest that disaggregation into 'homogeneous sections' negatively affects the scope for realizing cost-saving opportunities and creates room for leakage. The research findings suggest that it is valuable to keep in mind the target and that

without due deliberation, disaggregation into 'homogeneous sections' (using *e.g.* technology-specific baselines rather than sector-specific baselines) may weaken the link between the CDM outputs and the intended effects on the outcome level. From an environmental perspective, disaggregation implies that certain technologies are *de facto* acknowledged and promoted through the CDM. Taking the example of electricity generation, the long lifetime of the projects implies that it may be relevant to carefully consider what types of technologies are promoted. An example of a question that could be put forward in this context is whether the CDM (or similar mechanisms) should promote the introduction of coal-based technology. Coal is a cheap fuel. As shown by the examination of a super-critical coal-fired power plant in India (Ch. 7), advanced coal-based technology can be viable without further financial assistance in developing counties (*i.e.* investment additionality is doubtful). Without change in energy policies, fossil fuels are expected to continue to account for 80% the energy mix running the global economy 2025-2030 (IPCC, 2007). If the aim is to decarbonize the global economy and wean it from fossil-fuel dependency, it appears contradictory to promote the introduction of new fossil fuel-fired power plants which would otherwise not have been built.

According to the EB guidelines on sector-specific baselines, "Additionality is not to be demonstrated for each individual activity *ex post* (after its formulation) but rather for types of measures and *ex ante*" (EB, 2011:§14). Positive lists are mentioned as applicable. These are described as "a positive list of technologies using given energy sources" (EB, 2011:§11). Again, this indicates that standardized baselines can imply technology-specific baselines. In contrast to the current additionality assessment as examined here, positive lists are much more simple and straightforward to apply for project developers. It also moves away from the project-by-project approach to evaluation, which has been found to be cumbersome and limiting the scope of the CDM. At the same time, the role of the additionality assessment becomes more opaque. Assuming that theory III is applied, a key question is whether positive lists are able to show that the baseline scenario is replaced by the project.

8.4 Conclusions

This chapter briefly summarizes some of the more important research findings which largely relates to (a) the generally accepted and explicit idea or theory of emissions reductions in carbon crediting, (b) how this or some other implicit theory (or theories) is followed through in practice, and (c) the appropriateness or credibility of this approach in relation to the expected outcome of emissions reductions. These findings are in turn discussed in relation to historical experiences with crediting

preceding carbon crediting and what can currently be envisioned as the path ahead for carbon crediting which involves sector-specific standardized baselines.

The generally accepted idea or theory of emissions reductions in carbon crediting stipulates that to ensure 'real' or additional emissions reductions (*i.e.* outcome additionality) relative to a baseline scenario it is necessary to establish investment additionality relative to a baseline scenario (see theory I, above). However, the idea that investment additionality (effects at the output level) will ensure outcome additionality (effects at the outcome level) appears to lack support in the innovation policy literature on additionality and the policy related literature on effectiveness. In both sets of literature, it is recognized that outputs do not necessarily translate to outcomes. Furthermore, it is in stark contrast to how (additional) emissions reductions were pursued in credit-based systems preceding carbon crediting. In addition, the in-depth case studies of methodologies applicable and applied to CDM projects show that the generally accepted theory was not supported by the empirical findings. A central problem is that investment additionality and emissions reductions tended to be measured against different baseline scenarios. Furthermore, when the same baseline scenario was applied, it was found that investment additionality was not necessary to establish environmental outcome additionality. Hence, there are reasons to doubt the plausibility of the generally accepted theory of emissions reductions in carbon crediting and its representativeness in terms of how emissions reductions are being determined in practice.

The research identified three plausible theories of emissions reductions that could potentially be applied in the carbon crediting context (see theories II-IV, above), but it is possible that there are more. Two of the theories (II and III) were identified through case studies of approved CDM methodologies and registered CDM projects. The third (IV) was identified as applied in credit-based systems preceding carbon crediting. In other words, it was possible to identify several believable or plausible ideas of how emissions would be reduced through carbon crediting projects. However, to operationalize the identified theories in for example the CDM context the current practices would need to be reconsidered.

The overall conclusion is that it appears more attention could be given to the plausibility of the theory of emissions reductions, not only in the current CDM context, but also in the continued development of sector-specific standardized baselines. The latter are explicitly envisioned to address many of the recognized problems related to the CDM, including *e.g.* environmental integrity, scale, and transaction costs. While sectoral approaches are acknowledged as second-best alternatives to global emissions caps, they are envisioned to improve environmental integrity and promote an up-scaling of the CDM (or similar mechanism). In addition, sectoral approaches can be a potential route to engaging developing countries in global GHG mitigation and offer alternative bottom-up approaches compared with the top-

down approach entailing internationally agreed emissions targets and timetables. Compared to the current project-by-project approach pursued under the CDM, the research presented here suggests that sector-specific standardized baselines could potentially entail significant improvements. They can also be viewed as a significant political achievement considering the reluctance among developing countries towards emission targets. While the sector-specific standardized baselines currently considered under the CDM are not comparable to sectoral targets, the official acceptance of such baselines can be a first step which may facilitate sectoral targets in the long run. However, to realize the envisioned potentials, particularly in terms of improving environmental integrity, the research indicates that it is important to deliberate on the plausibility of the theory of emissions reductions underlying credit creation in the development and operationalization of sector-specific standardized baselines.

9

Concluding Remarks

The themes of this dissertation are effectiveness, additionality, and environmental additionality. *Effectiveness* is a relative concept and can be approached in different ways. More generally it relates to the degree of achieving of some end (Ch. 3). Additionality is essentially a measure of effects. In a policy-related context, effects can be measured at different levels: outputs, outcomes and impacts. These three make up the elements of the program impact theory; and the various additionality concepts introduced in the innovation policy literature can be linked to these elements (Ch. 4). The research presented in this dissertation is concerned with the emissions reductions claimed through crediting activities pursued under the CDM. As such it is largely concerned with environmental outcome additionality.

The aim of this dissertation was to critically examine the effectiveness and environmental credibility of carbon credits, and this was pursued through a study of additionality and the CDM. The primary research questions were 'What is an effective carbon credit?' and 'Do CERs represent additional emissions reductions?' As was shown, there is not one concept of *effectiveness*, but many. This was also reflected in the critique of the CDM in the climate policy literature. This critique can be linked to the concepts of *goal achievement* and *cost effectiveness*. However, few studies could be described as approaching effectiveness in a wider sense, and studies tended to be topic specific. Another way of describing the critique of the CDM is that it is linked to concerns about effectiveness related to the different elements of the program theory. The examination of the critique of the CDM in the climate policy literature, the implicit (market) critique of the CDM embedded in the existence of VER activities, and the political and public critique of VER suggest that *output effectiveness* can be a meaningful concept for describing the critique of carbon credits more generally. The outputs in question are projects and credits. While output quality in terms of environmental integrity is a generally acknowledged concern in carbon crediting due to questionable investment additionality, the quantity of the outputs have been

described as widely surpassing expectations. Nevertheless, it is also widely agreed that the CDM (or similar mechanisms) needs to be up-scaled if it is to fulfill its potentials in the future. In this context, additionality is acknowledged as one of the key challenges.

While the effectiveness of carbon credits and the CDM can be interpreted in various ways (and tends to be a politicized issue), environmental integrity or environmental additionality can be viewed as a generally important feature. The bottom line is that a carbon credit is proclaimed to represent a reduction of GHGs equivalent of 1 tCO_2e. From this it largely derives its existential legitimacy and a market value. Without environmental additionality it becomes difficult to argue that carbon crediting is a meaningful instrument for engaging developing countries in mitigation activities. Without environmental additionality, there is no mitigation. The credibility of crediting as a mechanism for promoting sustainable development in a climate change related context also becomes rather doubtful. Furthermore, without environmental additionality, the idea that crediting mechanisms transfer emission reducing technology and promotes global efforts to address climate change also seems largely unsubstantiated. Environmental additionality is certainly not the only concern affecting the effectiveness of carbon credits, but it is an important one.

The research presented in this dissertation is to some degree abstract and complex, largely due to the complexity of the CDM methodologies examined. However, the identified problems are rather basic and straightforward (Ch. 5-7). Essentially, what this dissertation says is that it is important to have a clear and plausible idea about how emissions can be reduced and methodologies that ensure that what is claimed to be measured is also actually measured. For example, currently under the CDM, emissions reductions are required to be measured relative to a baseline scenario describing 'what would have happened otherwise' and projects are required to be investment additional relative to 'what would have happened otherwise'. Despite this, the examination of the methodologies applicable and applied to registered CDM projects shows that this is rarely established in a credible manner. A key problem is that 'what would have happened otherwise' tends to depend on what is being measured. When the emissions reductions of a project are to be determined, one baseline scenario is applied, but another is applied when the investment additionality of the same project is to be determined. This is obviously not a valid approach. Another problem is that emissions reductions tended to be claimed based on the assumption that something (other project or outputs) would be replaced by the CDM project or its outputs, but it was generally not determined that anything would actually be replaced.

The findings presented in this dissertation can be useful for improving the environmental integrity of carbon crediting and for the of development sector-specific standardized baselines currently pursued under the CDM. This dissertation identifies

several plausible ideas or theories of emissions reductions based on a sector-level approach, and also provides inputs on how these can be operationalized (Ch. 8). Furthermore, this dissertation broadens the concept of *additionality* compared with how it is currently understood and approached under the CDM, and also clarifies its links to the concept of *effectiveness*. These insights can be valuable for improving the *ex ante* evaluation of crediting projects aimed to promote expected effects on the outcome level. While this dissertation only addresses emissions reductions, the insights could also be potentially valuable in relation to pursuing other types of outcomes (*e.g.* technology transfer and sustainability benefits). The credibility of CDM methodologies was also examined by considering their ability to promote valid and reliable results. As indicated by this examination, there is relevant experience in LCA that could be drawn upon to improve the credibility of the environmental comparison necessary to determine emissions reductions.

Carbon crediting mechanisms and sectoral approaches are envisioned as important for the continued efforts to address climate change. While a top-down approach with a global cap on GHG emissions is often acknowledged as more effective and preferable, the political reality is that a global cap is unlikely in the near future. Considering the current project-by-project approach pursued under the CDM and the reluctance among developing countries to commit to emissions targets, the official acceptance of sector-specific standardized baselines represents a potential improvement and potentially significant achievement. However, if the envisioned improvements in the environmental integrity of the CDM are to be realized, this dissertation strongly suggests that it will be important to give more attention to the plausibility of the theory of emissions reductions underlying the creation of credits.

APPENDIX 1

Table A.1
Overview of Selected CDM Methodologies

Methodology/Methodological tool	Approach
AM0019: Renewable energy projects replacing part of the electricity production of one single fossil-fuel-fired power plant that stands alone or supplies to a grid, excluding biomass projects (version 2.0) (valid: 2006/05/18 – onwards; (still valid by 2011/06/13)	B
AM0026: Methodology for zero-emissions grid-connected electricity generation from renewable sources in Chile or in countries with merit order based dispatch grid (version 2.0) (valid: 2006/05/18-2007/11/01)	B
AM0029: Baseline Methodology for Grid Connected Electricity Generation Plants using Natural Gas (version 1.0) (valid: 2006/05/18-2007/11/01)	B
ACM0002: Consolidated baseline methodology for grid-connected electricity generation from renewable sources (version 6.0) (valid: 2006/05/18-2007/11/13)	A or B
ACM0004: Consolidated baseline methodology for waste gas and/or heat and/or pressure for power generation (version 2.0) (valid: 2006/03/02-2007/07/05) (replaced by ACM0012)	n.a.
ACM0006: Consolidated baseline methodology for grid-connected electricity generation form biomass residues (version 3.0) (valid: 2006/05/18-2006/10/31)	A or B
ACM0007: Baseline methodology for conversion from single cycle to combined cycle power generation (version 1.0) (valid: 2005/05/27-2007/05/17)	A or B
Tool for the demonstration and assessment of additionality (version 2.0) (valid: 2005/11/25-2007/02/15)	-

A: Existing actual or historical emissions as applicable

B: Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment

C: The average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category

Acronyms: Approved methodology (AM); Approved consolidated methodology (ACM)

Source: UNFCCC (2002a), §48 a-c; and respective methodology/tool. These were tracked through the following CDM databases: (i) 'Approved Baseline and Monitoring Methodologies for Large Scale CDM Project Activities' (all but ACM0004 were available here), (accessed 13 Jun. 2011); (ii) 'Validation projects' (ACM0004 was tracked through this database), direct link: http://cdm.unfccc.int/methodologies/DB/3NL6ELY805NDZHF4YZRPK94MAPALUB/view.html *(accessed 13 Jun. 2011)*

Table A.2
Overview of the Selected CDM Projects

	CDM ref.	*Project name*	*Registration date*	*Methodology*
China	2744	Tadi 16 MW Hydropower Project in Zhejiang Province	2009/11/23	ACM0002 ver. 7
	1854	Hebei Shangyi Qijiashan Wind Farm Project	2009/11/23	ACM0002 ver. 8
	2756	Miyi Wantan Hydroelectric Project	2009/11/23	ACM0002 ver. 7
	2745	Longtoutan 25MW Hydropower Project in Jiangxi Province, China	2009/11/16	ACM0002 ver. 7
	2118	Hunan Taoyuan Huirenxi Hydropower Project	2009/11/05	ACM0002 ver. 7
	2590	Sichuan Xiaolongmen Hydropower Project	2009/11/02	ACM0002 ver. 7
	2450	Xilinguole Huitengliang Wind Power Project Guotai Phase I	2009/11/02	ACM0002 ver. 7
	2561	Heilongjiang Wangkui 50MW Level Biomass Cogeneration Project	2009/11/02	ACM0006 ver. 6
	2693	Gansu Luqu Duosongduo Hydropower Station Project	2009/10/29	ACM0002 ver. 7
	1855	CECIC Zhangbei Dayangzhuang Wind Farm Project	2008/10/27	ACM0002 ver. 7
India	2736	24 MW Shamburi Mini Hydel Project, Karnataka, India	2009/11/16	ACM0002 ver. 7
	2605	100 MW Wind Power Project by RS India Wind Energy Pvt. Ltd. at Matrewadi & Varekrwadi, Satara district in Maharashtra	2009/10/11	ACM0002 ver. 7
	2474	25.6 MW grid connected Wind Power based electricity generation project in Karnataka, India.	2009/07/27	ACM0002 ver. 7
	1687	24.8 MW Wind power project by Belgaum Wind Farms Private Ltd. in Gadag, Karnataka	2009/06/19	ACM0002 ver. 7
	2347	150 MW grid connected Wind Power based electricity generation project in Gujarat, India	2009/06/18	ACM0002 ver. 7
	2378	Integrated Municipal Waste Processing Complex at Ghazipur, Delhi	2009/05/23	AM0025 ver.10
	2112	24 MW Perla Mini Hydel Project, Karnataka, India	2009/05/12	ACM0002 ver. 6
	1844	Budhil Hydro Electric Project, India (BHEP)	2009/05/07	ACM0002 ver. 6
	1905	Generation of power from process waste heat at Hi-Tech Carbon, Tamil Nadu	2009/04/14	ACM0012 ver. 1
	2025	Chutak Hydroelectric Project	2009/04/01	ACM0002 ver. 6
Brazil	1829	Ceran's 14 de Julho Hydro Power Plant CDM Project Activity	2009/04/19	ACM0002 ver. 6
	1999	Piabanha River Hydroelectric Plants	2009/03/22	ACM0002 ver. 6
	1843	Primavera Small Hydroelectric Project	2008/10/20	ACM0002 ver. 6
	1626	Feira de Santana Landfill Gas Project	2008/07/20	ACM0001 ver. 6; ACM0002 ver. 6
	1232	UHE Mascarenhas power upgrading project	2008/05/26	ACM0002 ver. 6
	1279	Fundão-Santa Clara Energetic Complex Project (FSCECP)	2008/05/25	ACM0002 ver. 6
	1342	Sao Joao hydro power plant	2008/05/02	ACM0002 ver. 6
	1317	Paraíso Small Hydropower Plant – PDH Paraíso	2008/02/11	ACM0002 ver. 6
	891	Atiaia – Buriti Small Hydropower Plant.	2007/07/31	ACM0002 ver. 6
	809	Garganta da Jararaca Small Hydroelectric Power Plant (SHP)	2007/07/31	ACM0002 ver. 6

Project 1855: The project list was re-checked against the CDM database in mid-2011. It was found that this project should not have been included. It was incorrectly included as it was listed in the CDM Pipeline as registered on 27 Oct. 2009, during the spring of 2010. The correct project (CDM reference number 2501) was a hydropower project in China (registered 23 Oct. 2009). It also applied ACM0002 as the examined project (1855), but the former applied version 9. Due to time limitations and both projects applying ACM0002, the original case selection was not altered.

Source: CDM 'Project Search' database (last accessed 2 Dec. 2009); CDM/JI Pipeline Analysis and Database (accessed Dec. 2009-May 2010).

APPENDIX 2: INTERVIEW DETAILS

Sumie Nakayama
Senior Manager, Climate Change Group, Corporate Planning & Administration Dept., J-Power (e-mail: Sumie_nakayama@jpower.co.jp)

Natsuki Tsukada
Manager, Climate Change Group, Corporate Planning & Administration Dept., J-Power (e-mail: Natsuki_tsukada@jpower.co.jp)

Time and place:

8 August 2007, 15:00-17:00

Electric Power Development Co., Ltd (J-Power)
15-1, Ginza 6-Chome, Chuo-ku, Tokyo 104-8165, Japan
Tel. 81-3-3546-9375, Fax: 81-3-3546-9531
http://www.jpower.co.jp/english/

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(Databases are listed at the end)

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