# BENEFITS OF THE CLEAN DEVELOPMENT MECHANISM 2011

**United Nations**
Framework Convention on
Climate Change

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# EXECUTIVE SUMMARY

As the Kyoto Protocol's five-year first commitment period (2008–2012) draws to a close, it is time to assess the overall use and effectiveness of the clean development mechanism (CDM). This is the first in a series of reports, which provides an overview of the contribution of CDM project activities to sustainable development, technology transfer and investment.

The CDM was designed to meet a dual objective: to help developed countries meet a part of their emission reduction targets under the Kyoto Protocol and to assist developing countries in achieving sustainable development. While CDM projects provide tradable saleable certified emission reduction (CER) credits for participants in these projects, they can also provide benefits such as new investment in developing countries, transfer of climate-friendly technologies, the improvement of livelihoods and skills, job creation and increased economic activity.

This study analyzes the claims made by project participants in the project design documents (PDDs) of 3,276 CDM projects that were registered by the CDM Executive Board on or before 31 July 2011. It focuses specifically on three issues: sustainable development benefits associated with CDM projects, technology transfer prompted by CDM projects, and investment flows generated by CDM projects. The results have been compared with other studies to identify common trends and issues.

## CONTRIBUTION TO SUSTAINABLE DEVELOPMENT

Several attempts have been made to understand how a CDM project contributes to sustainable development or to assess how much a CDM project contributes to sustainable development. Most studies conclude that hydrofluorocarbon (HFC) and nitrous oxide $N_2O$ related projects yield the fewest sustainable development benefits, but the studies differ in their assessment of other project types. Other studies suggest a trade-off between the goals of the CDM in favour of producing low-cost emission reductions at the expense of achieving sustainable development benefits.

This study shows that most CDM projects claim several sustainable development benefits such as employment creation, the reduction of noise and pollution, and the protection of the natural resources. The type of benefit claimed has not changed significantly over time, but the mix of benefits claimed is somewhat different by host country and project type. There is also evidence to suggest that CDM projects are indeed making a contribution to sustainable development over and above the mitigation of greenhouse gas (GHG) emissions in the host country.

## CONTRIBUTION TO TECHNOLOGY TRANSFER

The need for technology transfer has been shown, in this and other studies, to fall over time as local sources of knowledge and equipment become more available and expertise on available technologies grows. This reflects a contribution made by the CDM to a developing country and the increasing maturity in the countries use of the CDM as the need for the further inflow of technology is reduced. However, the vast majority of developing countries involved in the CDM currently remain at the stage at which substantial levels of technology transfer still need to be, and are being, received.

The technological capacity of a country tends to be higher if a country has a larger population, more official development assistance (ODA) per capita, a higher ranking for the ease of doing business and a higher score on the democracy index. For those host countries technology transfer via the CDM is less likely to occur. However, technology transfer via the CDM typically responds quickly (in a year or two) to changes to these country characteristics.

## CONTRIBUTION TO FINANCIAL FLOWS

Annual investment in registered CDM projects rose from USD 40 million in 2004 to USD 47 billion in 2010 and now totals over USD 140 billion to mid 2011. The average investment per project is approximately USD 45 million. Over 75 per cent of projects in the Asia-Pacific region, have a 15 per cent higher average investment than all other projects. In all other regions, the average investment is generally less than half of the global average.

The average abatement cost for all types of CDM projects with a renewable crediting period is USD 2/tonne of carbon dioxide equivalent (t $CO_2$ eq) and USD 10/t $CO_2$ eq for projects with a fixed crediting period, except solar projects, which tend to be much more expensive. Projects have a greater potential to be profitable the longer they operate, which indicates a healthy market condition conducive to attracting more projects into the CDM pipeline. The average cost, however, varies considerably by project type and even more so by crediting period. The fact that some market participants choose a shorter crediting period, which may also result in lower expected returns as compared to a longer crediting period, indicates that the motivation for implementation of these projects may also be due to other reasons such as to assist research in renewable technologies that potentially have a lower abatement cost in the long run.

It is also apparent from other studies that investors focus on projects with low abatement cost so the CDM market is operating efficiently. Other studies also suggest that there is significant untapped potential for CDM projects in many countries that already make use of the CDM and its benefits.

# I. INTRODUCTION

As set out in Article 12, paragraph 2, of the Kyoto Protocol, the purpose of the CDM is to assist developing countries in achieving sustainable development and in contributing to the ultimate objective of the Convention (i.e. to achieve a stabilization of atmospheric GHG concentrations at a level that will prevent dangerous human induced climate system interference) and to assist developed countries in complying with their emission limitation and reduction commitments.

Climate change mitigation projects in developing countries can yield numerous benefits, such as the transfer of technology, rural energy provision, reduction of pollutants, contributions to livelihood improvement, employment creation and increased economic activity. This study presents evidence relating to the benefits of the CDM to developing countries. Specifically the CDM's contribution to sustainable development and to technology transfer is examined as well as emerging patterns in project investment and costs.

The evidence comes from five sources:

- Data captured from the project design documents (PDDs) of CDM projects and programmes of activities[1] (PoAs) registered and ruled[2] as such by 31 July 2011 (3,266 projects and 10 PoAs)[3];
- Responses to an ongoing survey[4] of project participants concerning the sustainable development and technology transfer impacts of their projects and PoAs (409 responses[5]);
- Published research on and analyses of the CDM and its impacts;
- The United Nations Environment Programme (UNEP) Risø Centre CDM Pipeline[6]. These data were used to classify projects by UNEP type and subtype;
- The Institute for Global Environmental Strategies (IGES) CDM Project Database[7]. These data were used for establishing the start of the CDM projects.

This study is structured as follows. Section 2 summarizes the claimed contributions of CDM projects[8] to sustainable development in their host countries. Section 3 highlights the transfer of technology via CDM projects. Section 4 sets out estimates of the investment triggered by CDM projects and abatement costs for various types of CDM projects. Finally, section 5 discusses opportunities for improvement and further work.

[1] UNFCCC, 2009, p. 23

[2] Projects for which the registration date and the decision to register by the CDM Executive Board was on or before 31 July 2011. A project can be registered after 31 July with a registration date before 31 July so long as it was submitted (as complete) to the secretariat before 31 July (see the Procedure for requests for registration of proposed CDM project activities, available at <https://cdm.unfccc.int/Reference/Procedures/index.html>).

[3] These data represent approximately 95 per cent of all registered projects before 31 July 2010. Technology transfer data are available for 3,232 projects, sustainable development data for 2,250 projects, capital investment for 1,676 projects and operating expenditures for 1,148 projects. All other data are based on the 3,276 projects.

[4] <https://www.research.net/s/unfccc>

[5] As at 1 September 2011.

[6] The UNEP Risø Centre CDM Pipeline provides monthly updated data for most CDM projects. Available at: <http://www.cdmpipeline.org/>.

[7] The IGES Market Mechanism Group provides monthly updated data for most CDM projects. Available at: <http://www.iges.or.jp/en/cdm/index.html>.

[8] Unless otherwise stated, for ease of exposition "projects" should be interpreted to include "PoAs".

# II. CONTRIBUTION TO SUSTAINABLE DEVELOPMENT

## 2.1. DEFINITION OF SUSTAINABLE DEVELOPMENT

The Brundtland Report, Our Common Future, defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".[9] It spawned an extensive body of literature on the concept of sustainable development as well as numerous attempts to measure whether specific actions contribute to sustainable development.

Despite these efforts, there is still no universally accepted definition of sustainable development or an agreed basis for determining whether a specific action, such as a proposed CDM project, would contribute to sustainable development. However, it is widely agreed that sustainable development comprises of three mutually reinforcing dimensions, namely economic development, social development, and environmental protection.[10]

Owing in part to the absence of an accepted international definition of sustainable development, the responsibility for determining whether a CDM project contributes to national sustainable development as defined by the host country currently resides with its designated national authority (DNA). The DNA therefore states in its letter of approval of the CDM project that, in its judgment, the proposed CDM project will contribute to the country's sustainable development.[11] A designated operational entity (DOE) must ensure confirmation by the DNA of the host country that the project activity assists in achieving sustainable development in the host country.[12]

## 2.2. ASSESSING SUSTAINABLE DEVELOPMENT

Assessing the contribution of the CDM in assisting host countries in achieving sustainable development is challenging for the same reason – the lack of an agreed operational definition. Two types of assessment of the contribution of the CDM to sustainable development are possible on a project-by-project basis:

- How a CDM project contributes to sustainable development; and
- How much a CDM project contributes to sustainable development.[13]

To determine how a CDM project contributes to sustainable development requires only a list of sustainable development indicators against which a project is assessed to show the nature of its contribution.[14]

How much a CDM project contributes to sustainable development requires a list of indicators, a quantitative or qualitative measure for each indicator that can be used to score the project, and weights that allow the scores for the different indicators to be aggregated into an overall measure of the extent of the contribution to sustainable development. Only two studies – by Sutter and Parreño (2007) and Alexeew et al. (2010) – attempt such an assessment. They are summarized in section 2.9 below.

[9] World Commission on Environment and Development, 1987, p. 8.

[10] Adams, 2006; Olsen, 2007; and Alexeew, et al., 2010.

[11] Olsen and Fenhann, 2008, table 1, p. 2821, summarizes the approaches used by seven countries. Sterk et al., 2009, summarizes the sustainable development requirements of 15 DNAs using the Gold Standard as a basis.

[12] Decision 3/CMP.6, paragraph 40

[13] Olsen and Fenhann, 2008, p. 2820.

[14] Olsen and Fenhann, 2008, uses this approach.

Table II-1. **Sustainable development dimensions and indicators for clean development mechanism projects**

| Dimension | Indicator | Description |
|---|---|---|
| Economic | Direct/indirect financial benefit for the local and/or regional economy | Economic improvements for the population through: domestic or community cost savings; poverty reduction and support for entrepreneurial activity in the local economy; financial benefits of the project for the national economy of the host country; enhancement of the local investment and tourism; improvement of trade balance for the country; reinvestment of clean development mechanism proceeds into the community; creation of tax revenue for the community |
| | Local/regional jobs generated directly/indirectly | Economic improvements through direct or indirect job creation or retention of jobs, during the operation and construction phases. Poverty alleviation is often cited as an indirect benefit of this |
| | Development/diffusion of local/imported technology | Development, use, improvement and/or diffusion of a new local or international technology, international technology transfer or an in-house innovative technology development has taken place serving as an example for others to emulate |
| | Investment in the local/ regional infrastructure | Creation of infrastructure (e.g. roads and bridges) and improved service availability (e.g. health centers and water availability) |
| Environment | Efficient utilization of natural resources | Promoting comprehensive utilization of the local natural resources (i.e. avoiding biomass decay and utilizing biomass for energy, utilizing water and solar resources); promoting efficiency (e.g. compact fluorescent lamps rather than incandescent lamps); recycling; creating positive by-products |
| | Reduction in noise, odours, dust or pollutants | Reducing: gaseous emissions other than greenhouse gases; effluents; and odour and noise pollution; and enhancing indoor air quality |
| | Improvement and/ or protection of natural resources | Improvement and/or protection of natural resources, including, inter alia, the security of non-renewable resources such as fossil fuels, or of renewable resources such as: soil and soil fertility; biodiversity (e.g. genetic diversity, species, alteration or preservation of habitats existing within the project's impact boundaries and depletion level of renewable stocks like water, forests and fisheries); water, availability of water and water quality |
| | Available utilities | Supplying more or making less use of energy; stabilizing energy for the promotion of local enterprises; diversifying the sources of electricity generation |
| | Promotion of renewable energy | Converting or adding to the country's energy capacity that is generated from renewable sources; reducing the dependence on fossil fuels; helping to stimulate the growth of the renewable power industries |
| Social | Labour conditions and/or human rights | Project will improve working and/or living conditions |
| | Promotion of education | Improved accessibility of educational resources (reducing time and energy spent by children in collecting firewood for cooking, having access to electricity to study during the night, and supplementing other educational opportunities); donating resources for local education |
| | Health and safety | Improvements to health, safety and welfare of local people through a reduction in exposure to factors impacting health and safety, and/or changes that improve their lifestyles, especially for the poorest and most vulnerable members of society |
| | Poverty alleviation | Emphasis on the respective country's core development priorities (i.e. poverty alleviation) |
| | Engagement of local population | Community or local/regional involvement in decision-making; respect and consideration of the rights of local/indigenous people; promotion of social harmony; education and awareness of local environmental issues; professional training of unskilled workers; reduction of urban migration |
| | Empowerment of women, care of children and frail | Provision of and improvements in access to education and training for youth and women; enhancement of the position of women and children in society |

## 2.3. INDICATORS OF SUSTAINABLE DEVELOPMENT

A list of sustainable development indicators is a requirement for both types of assessment. As yet there is no agreed list of indicators suitable for CDM projects. In this study a set of 15 indicators was empirically derived from a representative sample of 350 CDM projects. These indicators, presented in table II-1, cover the economic development, environmental protection and social development dimensions of sustainable development. They encompass most of the criteria used by other studies.[15] The descriptions attempt to clearly distinguish the different indicators so that claimed benefits can be assessed consistently.

The sustainable development claims in the PDDs of 2,250 of the projects registered as at 31 July 2011 were tabulated using the indicators in table II-1.[16] Up to four indicators were assigned to each project. This was sufficient to cover all of the sustainable development claims for most, but not all, projects.[17] Thus, a small number of indicators[18] are not captured for projects to which more than four could apply.

Assessing the statements from various sections of the PDDs[19] involves some subjectivity. Different analysts and assessment procedures may assign different indicators to a given project.[20] This is confirmed by the survey responses of multiple participants for the same project: for some projects the sustainable development indicators assigned differ slightly. With a large number of projects it is expected that there is no systematic bias due to such potential assessment differences.

Many projects claim reduction of GHG emissions as a contribution to sustainable development. A reduction in GHG emissions is excluded from the sustainable development indicators since this is a prerequisite for a CDM project.

The indicators in table II-1 were also used in the survey of project participants in which respondents were asked which of the indicators – up to four – apply to their project.

## 2.4. HOW CLEAN DEVELOPMENT MECHANISM PROJECTS CONTRIBUTE TO SUSTAINABLE DEVELOPMENT

The indicators for the 2,250 projects are used to describe how CDM projects claim to contribute to sustainable development.[21] The indicators are based on information in the PDDs, which reflects the expected contributions at the time the project is being validated. The actual contributions may differ, an issue that is explored in section 2.8 below.

Figure II-1 shows the number of projects that mentioned each of the 15 indicators. The sustainable development benefits claimed most frequently are employment creation (23 per cent of the projects) and reduction in noise, odours, dust or pollution (17 per cent of projects). Although the percentages are very different, Olsen and Fenhann found a similar pattern: employment generation was the most likely impact, followed by contribution to economic growth and improved air quality.[22]

As shown in figure II-1, claims of environmental (51 per cent of projects) and economic (43 per cent of projects) benefits far exceed those of social benefits (6 per cent of projects). In contrast, Olsen and Fenhann found the distribution of claimed benefits among the three dimensions to be fairly even, with the most claimed benefits in the social dimension, followed by the economic and environmental dimensions.[23]

[15] Input from Luz Fernandez; Charlotte Unger; Alexeew, et al., 2010; Huq, 2002; Nussbaumer, 2009; Olsen and Fenhann, 2007; Sutter and Parreño 2007; and Sterk et al., 2009.

[16] Constraints dictated that only 2,250 of the projects could be coded. The 2,250 projects provide good coverage of all host countries and project types. No verification of the claims made in the PDDs was undertaken.

[17] 50 per cent of the projects have four indicators, 30 per cent have three indicators, 15 per cent have two indicators, 5 per cent have one indicator

[18] Less than 10 per cent

[19] Most information on sustainable development contributions is found in section A.2. Description of the project activity, where the view of the project participants on the contribution of the project activity to sustainable development is requested (maximum one page).

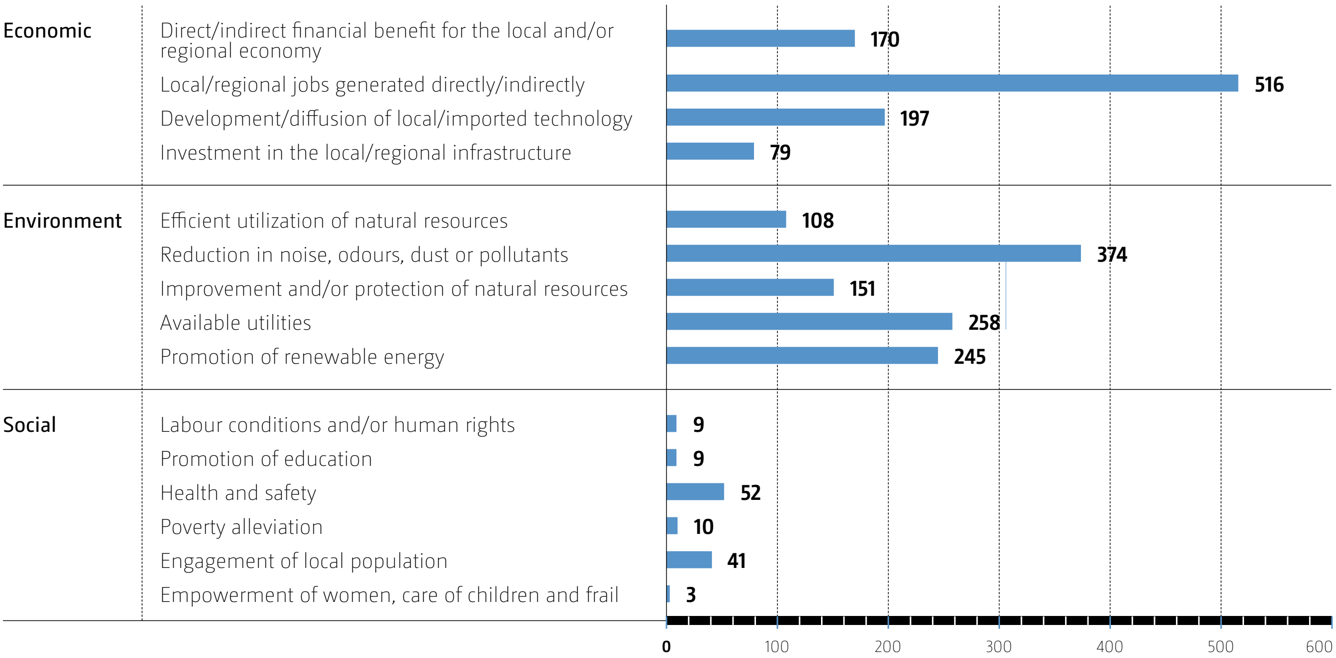
[20] Olsen and Fenhann, 2008, p. 2823.

[21] So that the contribution of each project has the same weight, the indicators for each project have a total weight of 4 – if there are four indicators they each have a weight of 1, if there are three indicators they each have a weight of 1.333, if there are two indicators each has a weight of 2 and a single code is given a weight of 4.

[22] Olsen and Fenhann, 2008, p. 2825, based on analysis of 296 projects in the pipeline as at 3 May 2006.

[23] Olsen and Fenhann, 2008, p. 2825. In some cases the distribution of claimed benefits among the three dimensions is not directly comparable. For instance, Olsen and Fenhann categorized employment as a social benefit, whereas in this study it is categorized as an economic benefit.

Figure II-1. **Number of sustainable development claims by indicator**



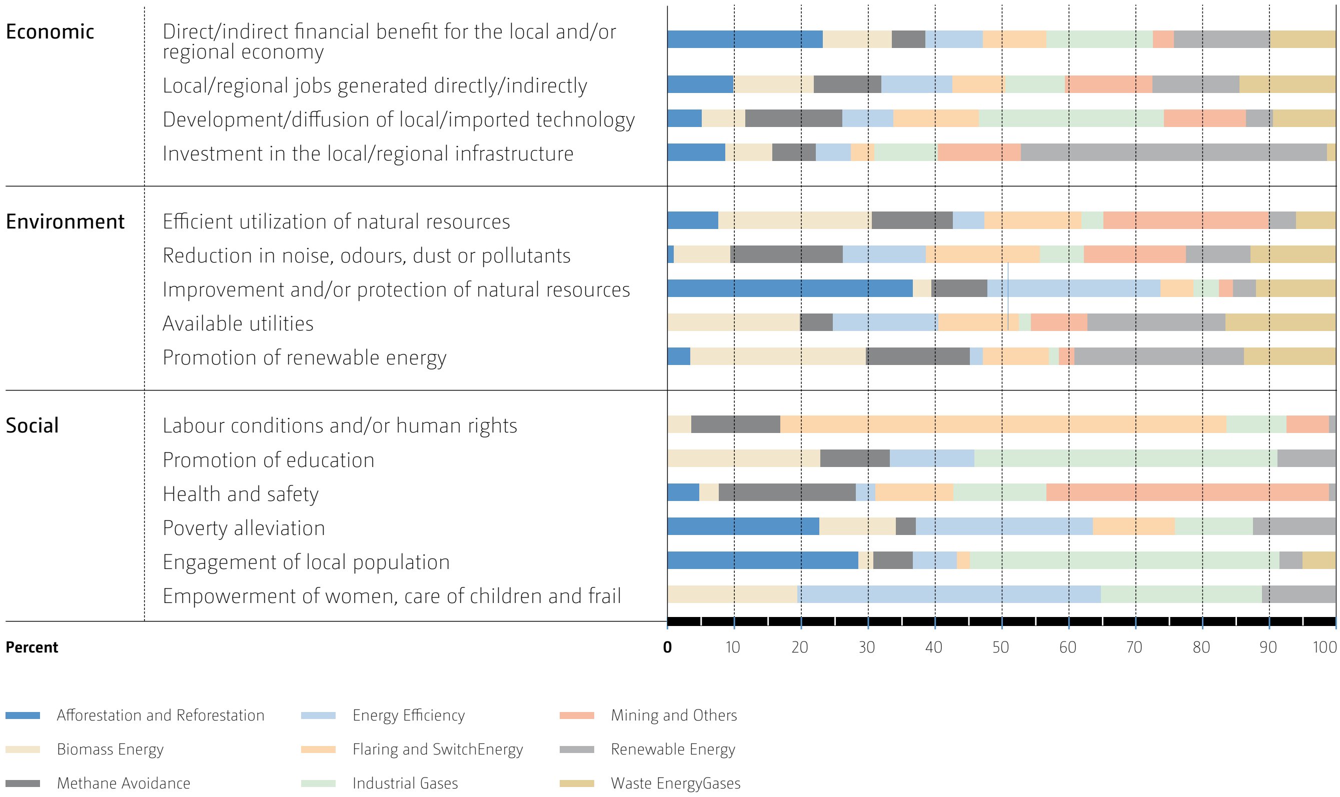

## 2.5. SUSTAINABLE DEVELOPMENT CONTRIBUTIONS BY UNFCCC PROJECT CATEGORY AND UNEP PROJECT TYPE

The sustainable development claims by UNFCCC project category are shown in figures II-2. The project categories and their definitions are presented in table VII-8 in the annex to this document. In every project category one or more projects claim at least nine of the 15 sustainable development indicators; waste energy projects mention the fewest (nine), while industrial gas projects mention the most (14). Projects in each category mention so many indicators; it is not surprising that there is no category of projects that has one or only a few indicators. With one exception, no indicator is mentioned by more than 25 per cent of the projects in a category. The exception is "improvement and/or protection of natural resources" which is mentioned by 36 per cent of the afforestation and reforestation projects. The largest social contributions are claimed by industrial gas projects, mainly through the engagement of the local population and promotion of education.

The sustainable development claims by UNEP project type are shown in figure II-3 and their definitions are presented in table VII-9 in the annex to this document. Projects of each project type claim between three and 13 of the 15 sustainable development indicators, with an average of almost nine. Carbon dioxide ($CO_2$) usage projects claim the fewest categories of benefits (three), while energy efficiency supply-side projects mention the most (13). For project types that mention only a few indicators, some are claimed by a large percentage of the projects: efficient utilization of natural resources by 50 per cent of the $CO_2$ usage projects and both local/regional jobs generated directly/indirectly and improvement and/or protection of natural resources by 42 per cent of the afforestation projects.

Although the UNEP project types were revised in 2009, so the project types in figure II-3 are not identical to those used by Olsen and Fenhann. They found that HFC and $N_2O$ projects claim the least sustainable development benefits, while energy distribution projects have the most, although this is only based on two projects.[24]

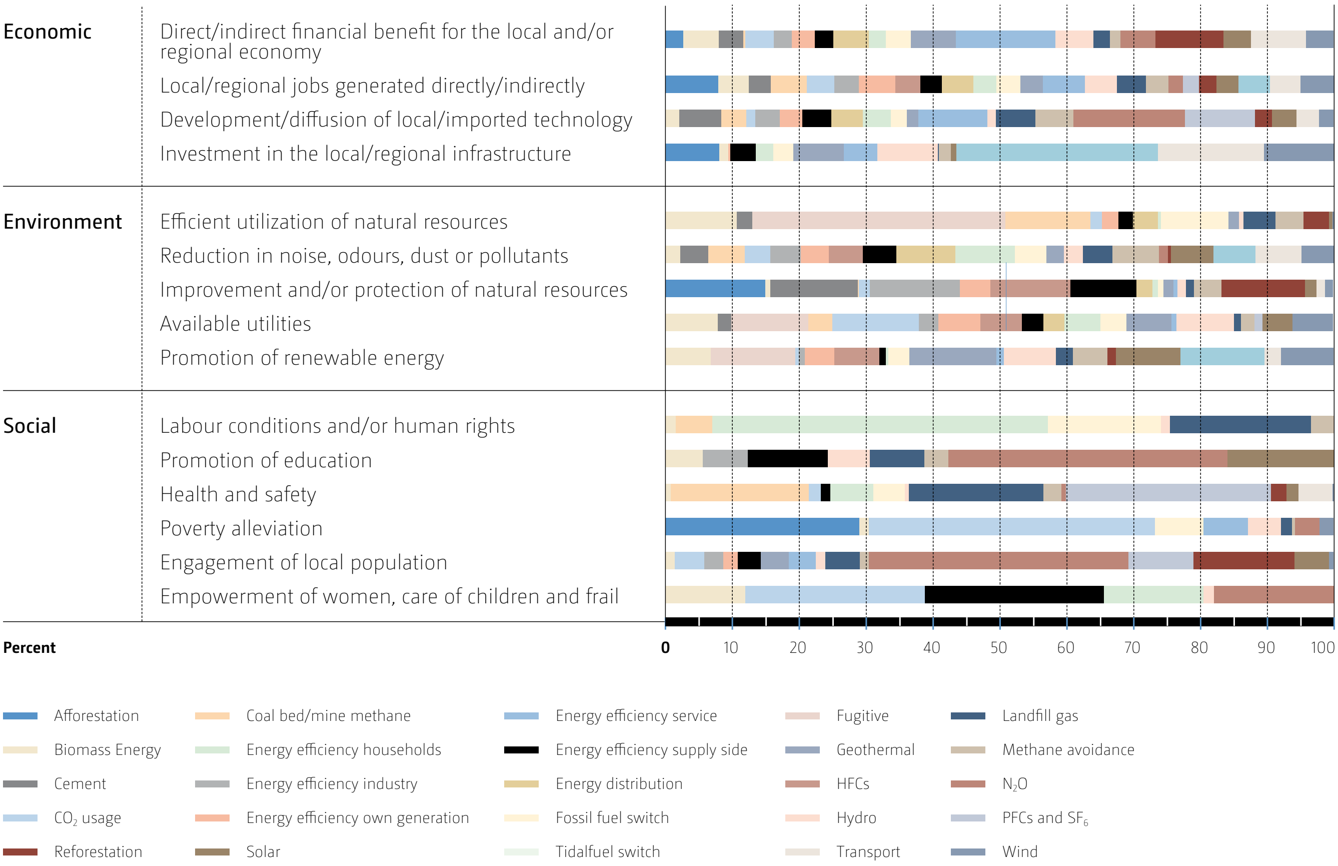
**Figure II-2.** **Sustainable development claims by UNFCCC project category as a percentage of the total claims for each criterion**




Furthermore a project could promise to provide benefits in one or two areas and do so really well, while another project could promise to provide many more benefits, but provide none of them properly. This analysis is limited to the PDD claims of how each project would benefit the host country only. To assess how well (or how much) a project contributes it would be necessary to score the project on each indicator. Such scores should probably not be based alone on the number or type of claims made in the PDDs.

[24] Olsen and Fenhann, 2008, figure 3, p. 2827.

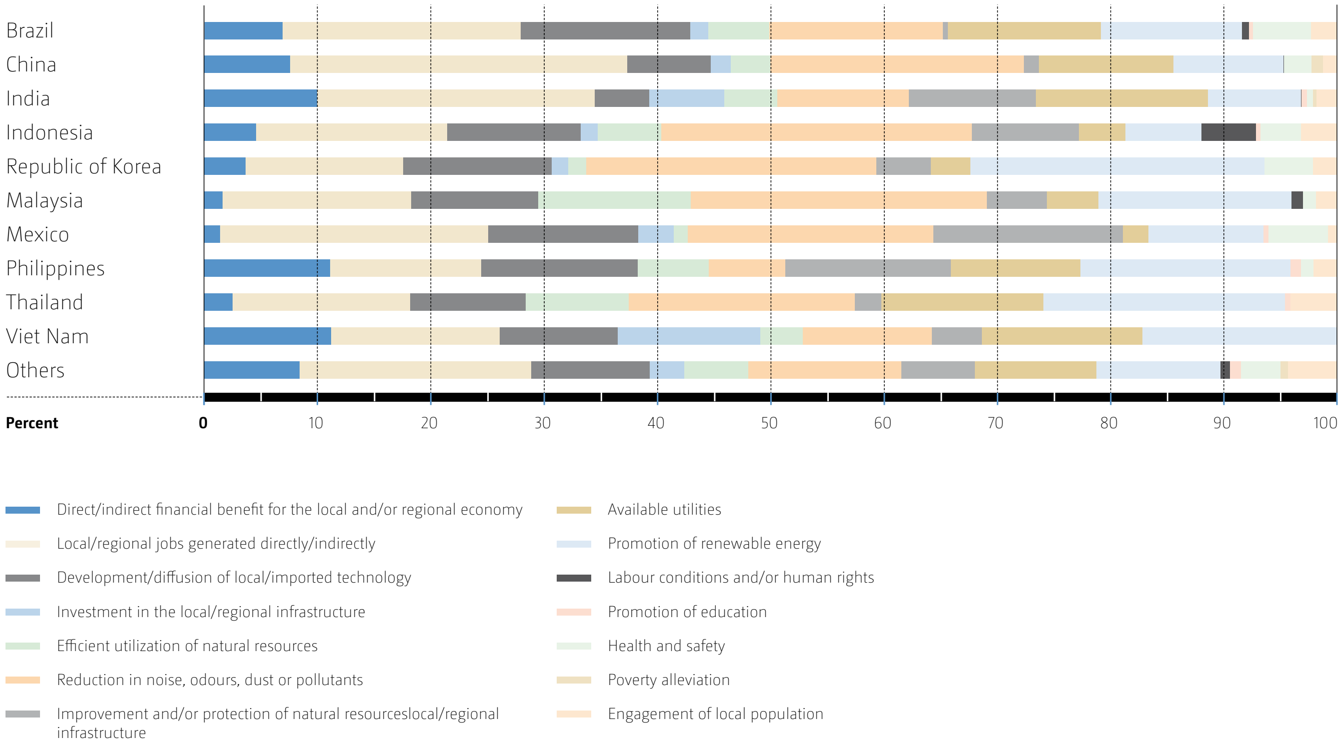
**Figure II-3.** **Sustainable development claims by UNEP project type as a percentage of the total claims for each criterion**




## 2.6. SUSTAINABLE DEVELOPMENT CONTRIBUTIONS BY HOST COUNTRY

The distribution of sustainable development claims by host country is shown in figure II-4 for the ten countries with the most registered projects and for all other host countries combined. Since these are countries with a relatively large number of projects and also of a mix of project types, it is not surprising that the projects they host claim many sustainable development benefits. Projects in each of the host countries, except Thailand and Vietnam, together cite 11 or 12 of the 15 sustainable development indicators. For Thailand and Vietnam the number is nine of 15. Many indicators are mentioned many times. With this diversity of claimed benefits, in only a few cases is an indicator mentioned for more than 25 per cent of the projects in a country[25]: local/regional jobs generated directly/indirectly for 30 per cent of the projects in China and reduction in noise, odours, dust or pollutants for 27 per cent of the projects in Indonesia and 26 per cent of the projects in Malaysia. No indicator is prominent in the ten largest CDM project host countries.

Figure II-4. **Sustainable development claims as a percentage of the total claims by host country**




## 2.7. TRENDS IN SUSTAINABLE DEVELOPMENT CONTRIBUTIONS

Figure II-5 shows the distribution of sustainable development claims for projects by year of registration. The only apparent trends are an increase in the percentage of projects that claim "reduction in noise, odours, dust or pollutants" and a reduction in the claims of efficient utilization of natural resources. The percentage of projects that claim to reduce noise, odours, dust or pollutants rises from 12 per cent of the projects registered in 2005 to 21 per cent of the projects registered during the first six months of 2011. The number of projects that claim efficient utilization of natural resources declines from 7 per cent of the projects registered in 2007 to 1 per cent of the projects registered during the first half of 2011. Reflecting the number and diversity of projects registered each year, the number of indicators mentioned varies between 11 and 14 per year after 2004.

[25] All claims are weighted such that total claims for a project equals four. Therefore 25 per cent of claims means the same as 25 per cent of projects.

Figure II-5. **Sustainable development claims as a percentage of the total claims by year of registration**


## 2.8. COMPARISON OF CLAIMS IN PRODUCT DESIGN DOCUMENTS AND SURVEY RESPONSES

The contributions to sustainable development are expectations at the time the project is being validated. The actual sustainable development contributions may therefore change over time. Project participants were asked to respond to the survey after the project had been registered, so the survey responses may better reflect each project's actual contributions to sustainable development. The survey attracted responses relating to the sustainable development contributions of 392 projects of which 336 overlapped with the projects for which data were recorded from PDDs.[26] The survey responses were compared with the indicators compiled from the PDDs.

Table II-2 shows the percentage of the survey response indicators that match the indicators obtained from the PDD for the same projects.[27] For 19 per cent of the projects none of the indicators from the PDD and the survey responses match, which means 80 per cent have at least one indicator in common. More over for 34 per cent of the projects, half the indicators from the two sources match each other and approximately 10 per cent of projects match for more than half of the indicators. The survey responses and the indicators from the PDD's are identical for two of the 336 projects.

The lack of perfect agreement may be due to differences in judgment or interpretation concerning the applicable indicator or changes to the project's stated sustainable development contributions. It was found that during the collection of data from the PDDs, that on many occasions statements were made that could have fallen into one or another indicator category.

Table II-2. **Comparison of sustainable development indicators from project design documents and survey responses**

| Type of match between survey and project design documents (PDD) indicators | Percentage match | Number of projects | Percentage of projects |
|---|---|---|---|
| No match between survey and PDD indicators | 0 | 65 | 19 |
| 1 in 4 matches between survey and PDD indicators | 25 | 99 | 29 |
| 1 in 3 matches between survey and PDD indicators | 33 | 28 | 8 |
| 1 in 2 or 2 in 4 matches between survey and PDD indicators | 50 | 113 | 34 |
| 2 in 3 matches between survey and PDD indicators | 67 | 12 | 4 |
| 3 in 4 matches between survey and PDD indicators | 75 | 17 | 5 |
| Perfect match between survey and PDD indicators | 100 | 2 | 1 |
| **Total** | | **336** | **100** |

The developer of a Gold Standard[28] project is required to submit a sustainability monitoring plan in addition to the sustainable development assessment in the PDD. The monitoring plan is used to verify if the CDM project has indeed contributed to sustainable development as anticipated in the PDD. This may cause the project developer to consider the impacts of the project carefully.[29] It may also create an incentive to keep the PDD analysis brief to minimize the monitoring requirements. The survey responses in table II-2 include responses in relation to 19 Gold Standard projects. The Gold Standard projects have approximately the same number of sustainable development indicators as regular CDM projects and the match between the survey and PDD indicators is the same as for regular CDM projects.[30]

## 2.9. OTHER STUDIES ON SUSTAINABLE DEVELOPMENT AND THE CLEAN DEVELOPMENT MECHANISM

Since the Kyoto Protocol entered into force in early 2005, the CDM has been the subject of extensive commentary and research in the academic literature.

Olsen (2007) reviews 19 studies that focus on sustainable development aspects of the CDM available as at June 2005. None of the studies assessed registered CDM projects, although some analysed projects similar to CDM projects. Olsen concludes that, at the time, a consensus was emerging that the CDM produces low-cost emission reductions at the expense of achieving sustainable development benefits.

[26] Approximately 7 per cent of the projects (29) were assessed by up to four different respondents, who provided slightly different assessments of the contribution of the same project to sustainable development.

[27] For the 29 projects with multiple survey responses, an average response was calculated and used for the comparison.

[28] See <http://www.cdmgoldstandard.org/>

[29] Sterk et al., 2009, p. 16.

[30] The data for Gold Standard projects are not reported separately here.

Sutter and Parreño (2007) apply multi-attribute utility theory[31] to assess the sustainable development contribution of the first 16 registered CDM projects.[32] Each project is scored on three equally weighted criteria – employment generation, distribution of returns from the sale of CERs, and improved local air quality – to get an overall score for its contribution to sustainable development. Also the additionality of each project is measured by the effect of the revenue from the sale of CERs on the project's profitability; the larger the increase the greater the additionality of the project.

Projects are then categorized as making a large or small contribution to sustainable development and having low or high additionality. Sutter and Parreño find no projects that make a large contribution to sustainable development and are highly additional.[33] Most of the emission reductions (over 95 per cent) come from HFC and landfill gas projects that are highly additional but make a small contribution to sustainable development. They conclude that the first 16 registered CDM projects may be far from delivering their claims to promote sustainable development although this conclusion could change with different indicators and weights.[34]

In response to concerns about the sustainable development contribution of CDM projects, several initiatives, including the Gold Standard and the Community Development Carbon Fund (CDCF)[35] were launched to support projects that meet specific sustainable development criteria. The Gold Standard label rewards best-practice CDM projects while the CDCF focuses on promoting CDM activities in underprivileged communities. Nussbaumer (2009) uses multi-criteria analysis to compare the sustainable development contributions of Gold Standard, CDCF and regular CDM projects. He applies 12 sustainable development criteria to 39 projects in 10 categories located in 12 countries.[36]

Nussbaumer finds that the sustainable development profiles of Gold Standard and CDCF projects tend to be comparable with or slightly more ample than similar regular projects.[37] The Gold Standard and CDCF projects perform better with respect to social criteria while regular CDM projects perform better on economic criteria. Overall Nussbaumer states that "labeled projects do not drastically outperform non-labeled ones", however the differences in the sustainable development performance of comparable categories of projects might be within the range of uncertainty intrinsic to such assessments.

Alexeew et al. (2010) apply a methodology similar to that used by Sutter and Parreño (2007) to assess the contribution to sustainable development and the additionality of 40 registered projects in India.[38] Contribution to sustainable development is assessed using 11 criteria – four social, four economic and three environmental. A project received a score between −1 and +1 for each criterion. The scores are summed – the criteria are weighted equally – to get an overall score for each project. Additionality is measured by the impact of the revenue from the sale of CERs on the project's profitability.

The sustainable development scores for individual projects range between 2 and 5.6 out of a possible range of −11 to +11. The values for each dimension of sustainability differ significantly across project types. Wind, hydro and biomass projects provide a relatively high number of sustainable development benefits. Energy efficiency and particularly HFC-23 projects are not as sustainable as the other kinds of projects.[39] Projects are categorized as making a large or small contribution to sustainable development and having low or high additionality. None of the projects both make a large contribution to sustainable development and have high additionality.[40]

In a recent detailed study of 10 CDM projects Boyd et. al. (2009) found that it can be misleading to assess project's sustainable development outcomes only through the project the documentation as local conditions change or are not declared due owing to either a lack of understanding of possible contributions or by intentional omission of critical views and opinions.[41]

In summary, it should be noted that, despite the lack of precision in the definition and understanding of sustainable development, the occurrence of certain claims, in the PDD's and survey responses, that include environmental and social considerations (such as efficient utilization of natural resources, the reduction in noise, odours, dust or pollutants, the improvement and/or protection of natural resources, clean and available utilities, the promotion of renewable energy, health and safety) are almost always solely attributed by the participants to the CDM project and would not have occurred in its absence. This indicates that the CDM may indeed contribute to assisting developing countries in sustainable development.

This study shows that most CDM projects claim several sustainable development benefits, the most prominent being employment creation. The host country may have an effect on the mix of benefits claimed however the diversity of claims makes this difficult to ascertain. Similarly different types of projects claim high numbers of benefits. Apart from reduction of noise and pollution the type of claim has not changed significantly since the first CDM project was registered. The multitude of claims and relative accuracy of claims made, as verified by a survey, provides evidence to suggest that CDM projects may be making some contribution to sustainable development in the host country. However, there is much room for improvement in the approaches used for both the declaration and the assessment of sustainable development of CDM projects.

[31] CDM projects are assessed with respect to multiple attributes (indicators), and the scores are weighted and aggregated to arrive at an overall assessment.

[32] The 16 projects cover seven project types – six hydro projects, three landfill gas projects, two biomass projects, two HFC-23 destruction projects and 1 project each for residential energy efficiency, fossil fuel switch and wind – in nine host countries.

[33] The paper includes conflicting information on this conclusion. Figure 3 and the text (p. 87) indicate there are no projects with a high rating for both additionality and sustainable development. But Table 17 reports that 2 projects accounting for 0.1 per cent of the projected emission reductions for the 16 projects have both high additionality and a high contribution to sustainable development.

[34] Sutter and Parreño, 2007, p. 89.

[35] See < http://wbcarbonfinance.org/>

[36] The 12 sustainable development criteria consist of four each for the social, economic and environmental dimensions. The criteria are not aggregated or weighted. The project categories are: biogas (thermal): (four projects); industrial energy efficiency: (six); landfill gas: (three); biomass: (three); biogas (electricity generation): (three); building energy efficiency: (three); hydro (run of river): (six); hydro (new dam): (three); wind: (six) and solar cooking: (two). Ten of the projects are CDCF, six are Gold Standard and 23 are regular CDM projects. Seventeen projects are located in India, eight in China, two each in Argentina, Honduras, Republic of Moldova and Nepal, and one each in Chile, Indonesia, Mexico, Panama, Peru and South Africa.

[37] Nussbaumer, 2009, p. 99.

[38] The 40 projects are a sample of the 379 that had been registered by 31 December 2008. They include 15 biomass, 12 wind, seven hydro, four energy efficiency and two HFC-23 destruction projects. Nine are regular CDM projects and 31 are small scale-projects.

[39] Alexeew et al., 2010, p. 12.

[40] Alexeew et al., 2010, figure 4, p. 11. This is consistent with Sutter and Parreño (2007). Unlike Sutter and Parreño, Alexeew et al. find that most projects make a large sustainable development contribution. That may be due to the project mix. Alexeew et al. (2010) assess 15 biomass and seven hydro projects (out of 40); project types that Sutter and Parreño also find to make a large contribution to sustainable development.

[41] This is consistent with the comparison of sustainable development indicators compiled from PDDs and those from survey responses for the same project discussed in section 2.9 above.


TASOL
Solar Energy Solutions

# III. TECHNOLOGY TRANSFER VIA CLEAN DEVELOPMENT MECHANISM PROJECTS

The transfer of technology is considered an important benefit to assist developing countries in achieving sustainable development. Some host countries specifically detail it as a requirement for approval of a project. As most GHG mitigation technologies are researched and designed in developed countries,[42] to reduce emissions in developing countries the technologies need to be transferred to those countries.[43] The CDM is one mechanism by which they could be transferred. Other mechanisms for transfer of technology include licensing, foreign direct investment, trade and, more recently, establishment of global research and development networks, acquisition of firms in developed countries, and recruitment by firms in developing countries of experts from developed countries.

## 3.1. DEFINITION OF TECHNOLOGY TRANSFER

Similar to the broader concept of sustainable development, there is no universally accepted definition of technology transfer.[44] The Intergovernmental Panel on Climate Change (IPCC) defines technology transfer as "a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private-sector entities, financial institutions, non-governmental organizations (NGOs) and research/education institutions".[45]

This definition covers every relevant flow of hardware, software, information and knowledge between and within countries, from developed to developing countries and vice versa whether on purely commercial terms or on a preferential basis. The IPCC acknowledges that "the treatment of technology transfer in this report is much broader than that in the UNFCCC or of any particular Article of that Convention".[46] In particular, the Convention and the CDM, as an international mechanism, focus on international transfers of technology.

In the literature the relative importance of the transfer of technological knowledge and equipment is an important issue. The United Nations Conference on Trade and Development (UNCTAD) excludes the mere sale or lease of goods from technology transfer.[47] Equipment that embodies a technology new to a country must be accompanied by transfer of sufficient knowledge to successfully install, operate and maintain the equipment.

Given possible differences in the interpretation of the meaning of technology transfer, the survey asked respondents for their view on when an organization can state it 'has' a technology.[48] Overwhelmingly, 68 per cent of respondents responded that it is when an organization uses and has knowledge of the technology. Simply using a technology (20 per cent) or having knowledge of a technology (10 per cent) is not sufficient. Thus, the views of the respondents are consistent with the literature.[49]

Whether technology transfer also requires that the recipient country to be able to adapt the technology to local conditions, to produce similar equipment domestically, or to further develop the technology is debated in the literature. Even technologies that are widely used often rely on equipment manufactured in a relatively small number of countries and technology development in even fewer countries.[50] Expecting every country to be a producer or innovator for every technology is unrealistic.

[42] Johnstone, et al., 2010., and Sterk et al., 2009

[43] The technologies may need to be adapted to developing countries' conditions, and technologies may need to be developed to mitigate emissions from sources found predominantly in developing countries.

[44] Popp, 2011, p. 136.

[45] IPCC, 2000, p. 3.

[46] IPCC, 2000, p. 3.

[47] UNCTAD, 1985, chapter 1, paragraph 1.2.

[48] To assist respondents the survey defines the terms as follows: technology – could include equipment, machinery, tools, techniques, crafts, systems or methods of organization; use – could include owning and/or operating equipment or processes that use the technology; and knowledge – could include shared or exclusive participation in patents, licences, training programmes, academic papers, etc. relating to the technology.

[49] Foray, 2009; Lall, 1993; and Popp, 2011.

[50] Virtually every country has the capacity to operate and maintain electricity generating equipment, but electricity generating equipment of any given type – coal, oil, natural gas, nuclear, hydro, wind, solar, geothermal, etc. – is manufactured by a relatively small number of countries and the development of the generating technology occurs in even fewer countries.

[51] Johnstone, et al., 2010.

At any time, international transfer of technology is unlikely if the technology is already available in the recipient country. Thus technology transfer via CDM projects is likely to be at a relatively low level for mature technologies already widely available in developing countries, such as hydroelectric generation and cement production. Technology development and transfer can happen quite quickly,[51] so technology transfer via CDM projects may change over time.

## 3.2. TECHNOLOGY TRANSFER CLAIMS OF CLEAN DEVELOPMENT MECHANISM PROJECTS

Claims of technology transfer made by project participants in the PDDs for 3232 projects registered as at 31 July 2011 have been tabulated and analysed.[52] CDM project participants are specifically requested in section A.4.3 of the PDD to "include a description of how environmentally safe and sound technology and know-how to be used is transferred to the host Party(ies)."[53] The CDM glossary of terms does not define 'technology transfer'.[54]

Each PDD is searched using a number of keywords to ensure that all statements relating to technology transfer are identified. The statements are tabulated under the following claim categories of claims:

- The project is expected to use imported equipment;
- The project is expected to use imported knowledge;
- The project is expected to use imported equipment and knowledge;
- It is stated that the project will not involve technology transfer;
- There are no statements with respect to technology transfer;
- Other statements relating to technology transfer.

It can be inferred from the statements in the PDDs that project participants overwhelmingly interpret technology transfer to mean the use of equipment and/or knowledge not previously available in the host country by the CDM project.[55]

Technology transfer related statements in the PDD reflect expectations at the time the project is being validated. The actual nature and frequency of technology transfer may differ as discussed in section 3.6 below.

## 3.3. TECHNOLOGY TRANSFER BY PROJECT TYPE

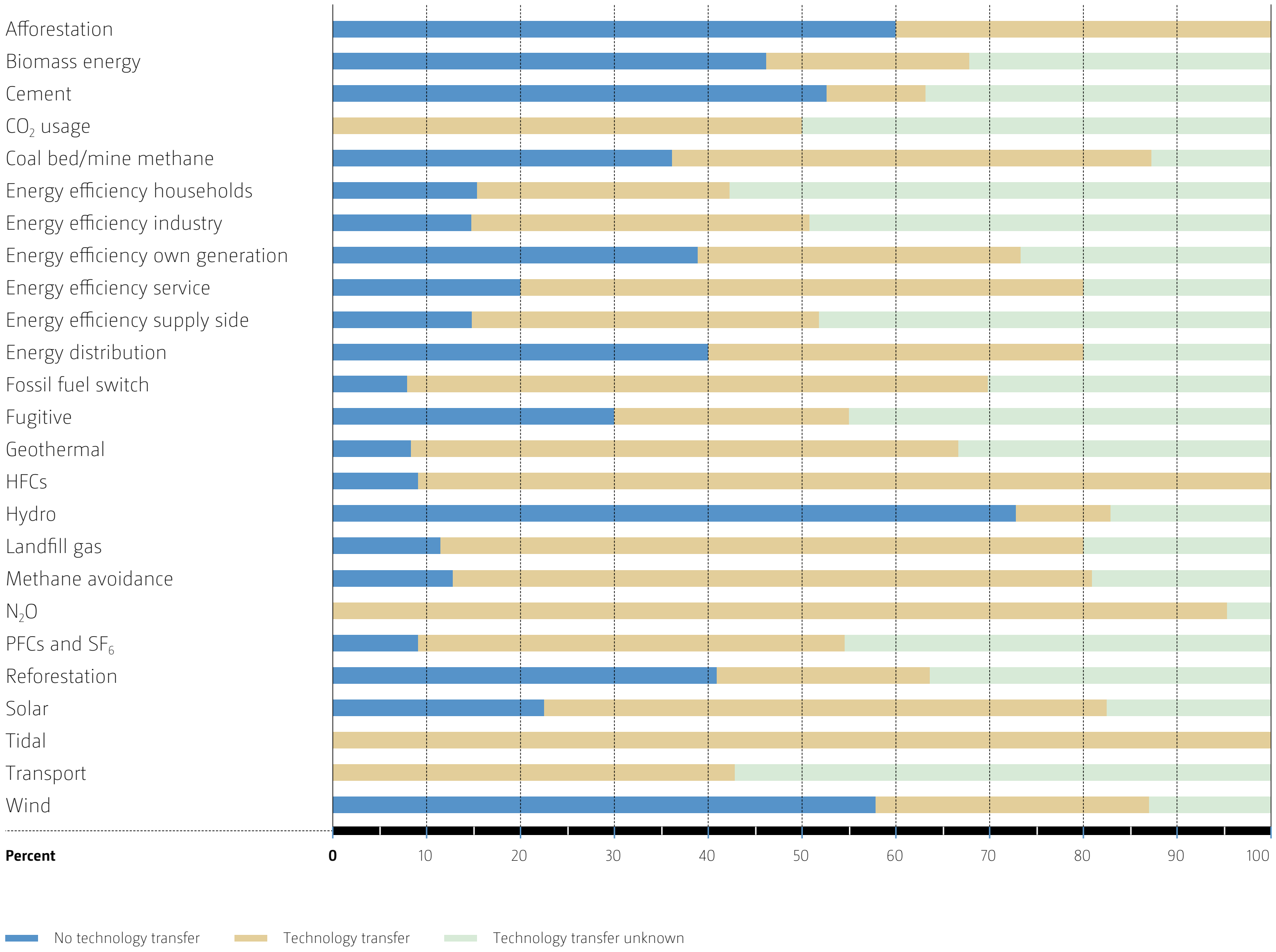
Project characteristics and the frequency of technology transfer – by number of projects and share of expected annual emission reductions – are shown in figure III-6 and table VII-10 in the annex to this document for UNEP project types and in figure III-7 and table VII-11 in the annex to this document for UNFCCC project categories.[56] The PDDs of 21 per cent of the projects made no explicit statement concerning technology transfer. Of the projects that claim, or explicitly state that they do not involve, technology transfer, 42 per cent of all projects representing 64 per cent of the total estimated annual emission reductions claim technology transfer.[57]

Not surprisingly, the distribution of technology transfer claims by UNEP project type is similar to that in the study conducted in 2010.[58] The largest difference versus the 2010 study is for the energy efficiency (households) project type where the percentages of projects claiming technology transfer (64 per cent) and estimated associated emission reductions (86 per cent) are substantially higher than the corresponding figures in the 2010 study – 38 per cent and 58 per cent, respectively. This may be due to the smaller number of projects (26) in this study versus a slightly higher number (32) in the 2010 study (see table IV-6).

As expected, the rate of technology transfer is lowest for hydro and cement type projects, which are mature technologies that are widely available in developing countries.

For the UNFCCC project categories (see table VII-11 in the annex to this document and figure III-7), the highest rates of technology transfer are claimed for industrial gases (over 90 per cent) and methane avoidance (about 85 per cent) projects. The lowest rates of technology transfer are claimed for biomass energy (about 35 per cent) and renewable energy (just over 20 per cent) projects.

**Figure III-6.** **Technology transfer by UNEP project type as a percentage of total registered projects**




[51] Johnstone, et al., 2010.

[52] In total, 44 of the 3,276 projects registered as at 31 July, 2011 could not be assessed with respect to technology transfer.

[53] UNFCCC, 2008, p. 8.

[54] UNFCCC, 2009

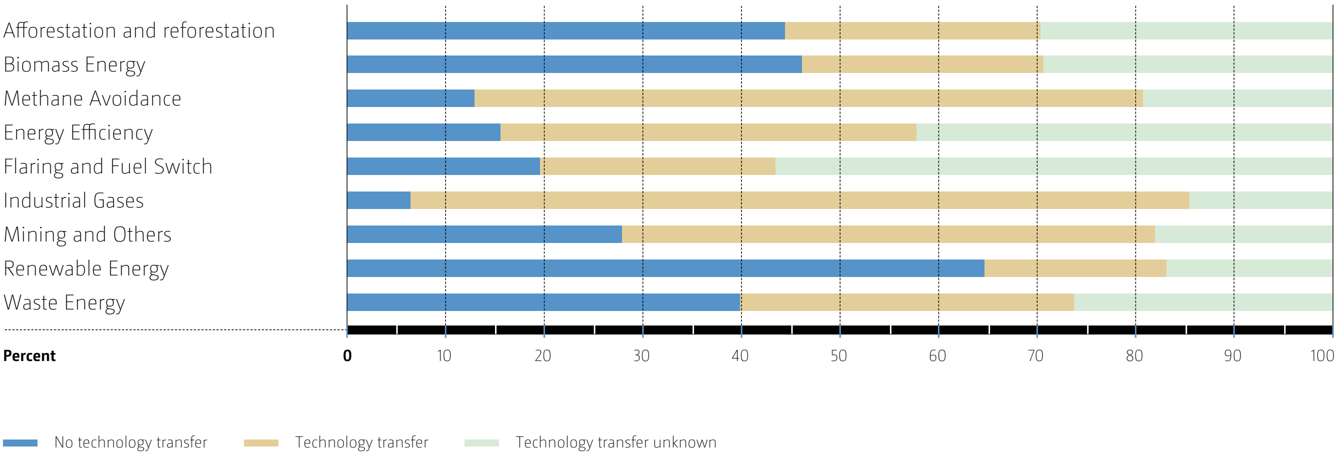
[55] A small number of projects claim transfer of technology within the host country. These projects are assessed as not involving (international) technology transfer.

[56] The project characteristics are based on the 3,276 registered projects, while the technology transfer percentages cover the 3,232 projects for which technology transfer information was tabulated.

[57] UNFCCC, 2010, table IV-6, p. 32 shows corresponding figures of 40 per cent and 59 per cent respectively for 4,984 projects in the pipeline (registered or under validation) as of 30 June 2010. Virtually all of the 3,276 projects covered in the table VII-11 in the annex to this document are covered by the 2010 study.

[58] UNFCCC, 2010, table IV-6, p. 32.

**Figure III-7.** **Technology transfer by UNFCCC project categories as a percentage of total registered projects**




## 3.4. TECHNOLOGY TRANSFER BY HOST COUNTRY

The rate of technology transfer by host country is presented in table III-3 for the 10 host countries with the most projects. The results are similar to those reported in the 2010 study.[59] This is not surprising since virtually all of the 3,232 projects covered in table III-3 are covered by the 2010 study together with other projects not registered by 31 July 2011. The Philippines is one of the ten largest host countries covered in table III-3, but when projects being validated were included in the 2010 study it was replaced by Chile.

**Table III-3.** **Technology transfer for registered projects in selected host countries**

| Country | Number of projects | Estimated emission reductions ($CO_2$ eq/year) | Average project size ($CO_2$ eq/year) | Technology transfer claims | | Percentage of projects where technology transfer could not be determined |
|---|---|---|---|---|---|---|
| | | | | Number of projects | Annual emission reductions | |
| Brazil | 195 | 23,081,763 | 118,368 | 35 % | 64 % | 26 % |
| China | 1,468 | 311,566,074 | 212,238 | 20 % | 52 % | 9 % |
| India | 694 | 52,996,395 | 76,364 | 16 % | 42 % | 37 % |
| Indonesia | 70 | 7,532,212 | 107,603 | 62 % | 49 % | 35 % |
| Republic of Korea | 61 | 18,724,386 | 306,957 | 53 % | 77 % | 37 % |
| Malaysia | 93 | 5,419,865 | 58,278 | 59 % | 67 % | 34 % |
| Mexico | 129 | 10,556,788 | 81,836 | 91 % | 90 % | 9 % |
| Philippines | 54 | 2,104,988 | 38,981 | 59 % | 68 % | 17 % |
| Thailand | 53 | 3,104,655 | 58,578 | 83 % | 86 % | 17 % |
| Viet Nam | 64 | 3,385,143 | 52,893 | 74 % | 46 % | 21 % |
| All other countries | 395 | 54,475,399 | 137,912 | 62 % | 66 % | 31 % |
| **Total** | **3,276** | **492,947,668** | **150,472** | **33 %** | **55 %** | **21 %** |

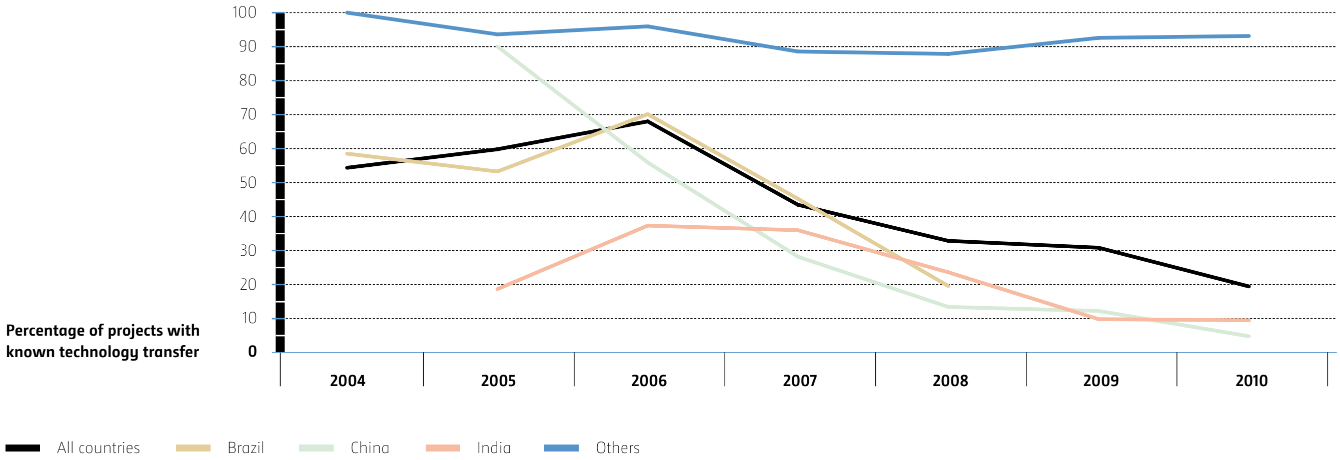
## 3.5. TREND IN TECHNOLOGY TRANSFER

The rate of technology transfer has declined over the life of the CDM as shown in figure III-8.[60] The decline has been steeper than the overall average in Brazil, China and India.[61] Initially, China had a rate of technology transfer higher than the average for all countries, but the rate is now substantially lower. India has consistently had a rate of technology transfer lower than the average for all countries. The rate of technology transfer for other host countries has been much higher than the overall average and has declined only slightly.

Several factors contribute to these results. First, as more projects of a given type are implemented in a country, the rate of new technology transfer declines, since local technology access has been created through previous projects. Second, the transfer of technologies used by CDM projects appears to have been happening through other channels as well, for example via licensing, foreign direct investment, R&D networks, merges, acquisitions and the recruitment of foreign experts.[62] Finally, changes in the mix of registered projects may affect the rate of technology transfer since each project type has a different frequency of technology transfer.

Over time, the need for technology transfer falls as local sources of knowledge and equipment become more available and expertise in the technologies grows. This reflects the contribution made by the CDM to a developing country and the increasing maturity in the countries use of the CDM as the need for the further inflow of technology is reduced. Nevertheless, the vast majority of developing countries involved in the CDM currently remain at the stage at which substantial levels of technology transfer still need to be, and are being, received.

**Figure III-8.** **Trends in technology transfer claims by host country**




[59] UNFCCC, 2010, table IV-4, p. 22.

[60] The data in figure III-8 are by number of projects and by the year in which a project is registered. The decline is larger when measured in terms of estimated annual emission reductions.

[61] The number of projects where technology transfer is known, but are too few for Brazil in 2009 and 2010, and for China and India in 2004, are not shown in figure III-8.

[62] Haščič and Johnstone, 2009; Lema and Lema, 2010.

## 3.6. COMPARISON OF CLAIMS IN PROJECT DESIGN DOCUMENTS AND SURVEY RESPONSES

The technology transfer claims from the PDDs are compared with the survey responses for the same projects in table III-4.

The survey responses indicate that 57 per cent of the 110 projects that stated that they do not expect technology transfer did not involve technology transfer.[63] Of the 89 projects that made no statement about technology transfer, 75 per cent involved some form of technology transfer. Of the 175 projects whose PDD stated that some form of technology transfer was anticipated, 152 (87 per cent) actually involved technology transfer.[64] Transfer of both equipment and knowledge was more common than anticipated in the PDDs.[65]

These results are quite similar to those reported from an earlier survey reported in the 2010 study.[66] That survey found that a claim of "no technology transfer" claim in a project's PDD was correct 88 per cent of the time (57 per cent in table III-4). Projects that expected some form of technology transfer actually involved technology transfer 89 per cent of the time (87 per cent in table III-4) and transfer of both knowledge and equipment was more frequent than expected. A total of 58 per cent of the projects that did not mention technology transfer in their PDD involved technology transfer (75 per cent in table III-4). The two surveys confirm the basic accuracy of the technology transfer claims made in the PDDs.

Table III-4. **Comparison of technology transfer (TT) claims in the project design documents versus survey responses**

| PDD claims | Specifically states no transfer | Unknown | Transfer of equipment only | Transfer of knowledge only | Transfer of equipment and knowledge | Total |
|---|---|---|---|---|---|---|
| Specifically states no transfer | 57% | 5% | 9% | 7% | 21% | 110 |
| Unknown | 21% | 3% | 24% | 11% | 40% | 89 |
| Transfer of equipment only | 7% | 2% | 24% | 7% | 60% | 45 |
| Transfer of knowledge only | 11% | 0% | 11% | 15% | 63% | 27 |
| Transfer of equipment and knowledge | 13% | 3% | 13% | 2% | 70% | 103 |

## 3.7. OTHER STUDIES ON TECHNOLOGY TRANSFER AND THE CLEAN DEVELOPMENT MECHANISM

Several papers have analysed technology transfer by CDM projects for registered projects (de Coninck et al. 2007; Dechezleprêtre et al. 2008; and Das 2011) or projects in the pipeline (Haites et al. 2006; Seres et al., 2009; UNFCCC, 2007, 2008 and 2010; and Haites et al. 2012) using information from PDDs.[67] All of these papers find that a substantial share of the CDM projects claim technology transfer. The frequency of technology transfer varies with the project characteristics, including project type, and the host country.

Results from the most recent and most comprehensive analysis (Haites et al., 2012) indicate that:

- The frequency of technology transfer differs significantly by project type;
- Larger projects are more likely to involve technology transfer;
- Small-scale projects are less likely to involve technology transfer;
- The host country has a significant influence on the rate of technology transfer;
- Technology transfer falls as the number of projects of the same type in a host country increases; and
- Technology transfer was more common during the early years of the CDM and has become less frequent since 2008.

A host country with a larger population, higher tariffs, more ODA per capita, a higher percentage of renewable energy generation, a higher ranking for the ease of doing business, a higher score on the democracy index and a greater technological capacity (as measured by discounted stock of patent applications) is likely to have a lower rate of technology transfer for CDM projects. Changes in these country characteristics affect the rate of technology transfer in CDM projects with different time lags. Most of the host country variables have a lag of only one or two years, which suggests that their effect on the rate of technology transfer is relatively quick.

Haščič and Johnstone (2009) study international transfer of wind technology from 1988 through 2007 and conclude that the CDM has had an influence on the extent of transfer between developed and developing countries, but that this effect is relatively small compared with other factors. Das (2011) concludes that the contribution of the CDM to technology transfer can at best be regarded as minimal. This is apparently based on an expectation that every project should involve technology transfer.[68] In almost all projects that involve technology transfer, she finds that the technological learning and capability-building are restricted to the level of operation and maintenance of an imported technology.

This study has shown there to be little overall difference in the levels of claimed technology transfer for registered projects for both types of projects and host countries. The claims in the PDD’s are also as accurate as have been shown in the past. Industrial gas projects tend to claim the highest and biomass and renewable energy projects the lowest levels of technology transfer. As indicated in other studies too, the rates of technology transfer over time show that the need for technology transfer falls as local sources of knowledge and equipment become more available, and expertise in available technologies grows. However there are many developing countries, also involved in the CDM, who could still benefit from technology transfer through the CDM or other channels.

[63] 24 per cent + 11 per cent + 40 per cent = 75 per cent

[64] Transfer of equipment only (45), transfer of knowledge only (27) and transfer of equipment and knowledge (103).

[65] 60 per cent for transfer of equipment only and 63 % for transfer of knowledge only. The total number that involved both knowledge and equipment transfer was 116, compared with the 103 based on the PDD information.

[66] UNFCCC, 2010, Table A-8, p. 37.

[67] A statistical test indicates that registered projects and projects in the pipeline that have not yet been registered are similar in terms of technology transfer and can be grouped together for analysis. (UNFCCC, 2010, Annex B).

[68] The conclusion is supported by the statement that “out of 1000 projects studied, only 265 involve technology transfer.”

# IV. INVESTMENTS IN AND COSTS OF CLEAN DEVELOPMENT MECHANISM PROJECTS

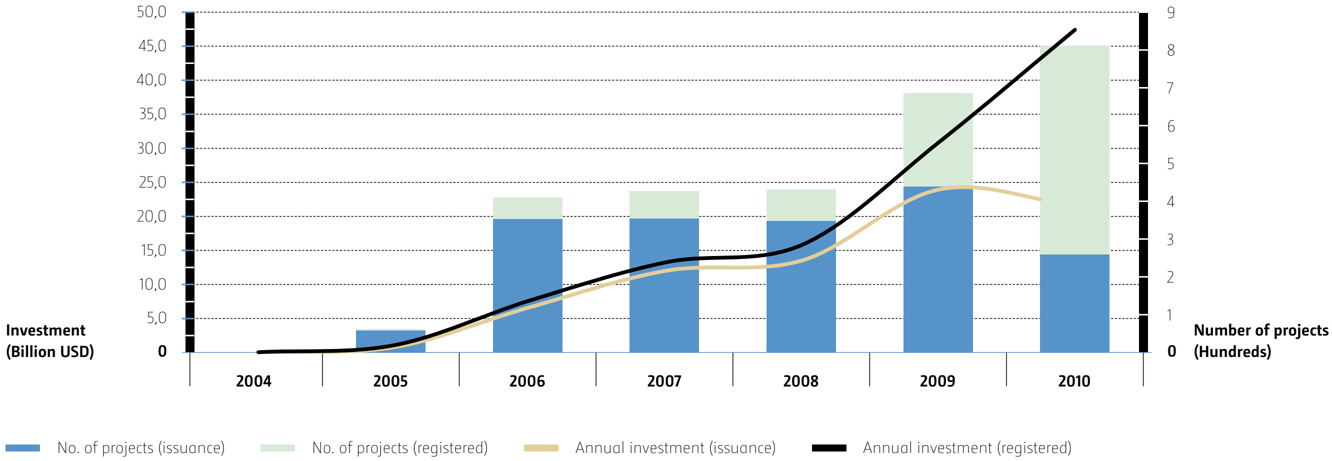
## 4.1. INVESTMENT TRIGGERED BY CLEAN DEVELOPMENT MECHANISM PROJECTS

Many CDM projects declare financial information relating to the proposed project activity using a set of tools offered by the CDM Executive Board as a way to demonstrate additionality.[69] The PDDs, support documents and appendices for 1,407 projects were analysed to gather data on the financials of CDM projects registered as at 31 July 2011. The information gathered per project included:

- Capital investment;
- Average annual operational costs;
- Average annual income (non-CER sources);
- Sources of income (description);
- Expected operating lifetime;
- Discount rate;
- Financial benchmark.

The cost information collected was used to calculate the cost per tonne of GHG gas emissions reduced by project type, which varied widely by project type.[70] The appropriate cost per tonne was then used to estimate the cost of projects that did not provide this information in the PDD.

**Figure IV-9.** **Investment in clean development mechanism projects by year (USD billion)**




[69] See <https://cdm.unfccc.int/Reference/tools/index.html>.

[70] UNEP project types and subtypes are used to provide as many different project types as possible and so capture the diversity in the cost by project type.

Figure IV-9 shows the estimated capital investment for all registered projects in each year of registration to the end of 2010. For projects registered late in the year, much of the investment likely occurs during the following year. Since the investment rises over time, the amount for a given year probably overstates the investment actually made during the year. As some projects may be delayed or never be implemented, figure IV-9 also shows the estimated investment by year for projects, which have either requested issuance or have been issued CERs (collectively shown as issuance) – projects that are certain to have been implemented. Since it is not absolutely certain that a registered CDM project is eventually implemented and as issuance projects are conservative proxies for implemented projects, the true investment per year lies somewhere between the two curves shown in figure IV-9.

The estimated investment in registered projects rose from USD 40 million in 2004 to USD 47 billion in 2010, totalling over USD 140 billion to mid 2011 (see table VII-12 in the annex to this document). The estimated investment in registered projects, which have requested issuance or have CERs issued (issuance) rose from USD 40 million in 2004 to almost USD 24 billion in 2009, totalling over USD 81 billion to mid 2011.

The apparent decline in investment and in the number of projects that have requested issuance or have been issued CERs (issuance) in 2010 is due mainly to the time lag between registration of the project and the first request for issuance of CERs. Typically several months are required before issuance can take place after a project is registered, implemented and has operated for some time. Emission reductions need to be independently verified by a DOE which takes time, and projects request issuance based on the economic or contractual need and not at predefined intervals. Therefore, it is likely that more projects have been implemented and more investment has taken place in 2010, than is shown in figure IV-9.

The cumulative estimated investment by region up to mid 2011 as presented in table IV-5, shows that the average investment is approximately USD 45 million per project. Over 75 per cent of all projects in the Asia-Pacific region have an average investment about 15 per cent higher than the global average. The higher average in this region could be due to a larger average project size or a combination of larger and more capital intensive projects. In all other regions, the average investment is generally less than half of the global average.

The estimated investment by host country is provided in table VII-12 in the annex to this document. About one quarter of the host countries, including countries in each region, have projects with an average investment higher than the global average. The differences in the average investment are due, at least in part, to differences in the mix of projects implemented in host countries, both in terms of the type of project such as a capital intensive hydro projects and or the overall project size.

Table IV-5. **Estimated investment in clean development mechanism projects by region (USD million)**

| | Number of projects | | Total investment | | Average investment | |
|---|---|---|---|---|---|---|
| | Registered | Issuance | Registered | Issuance | Registered | Issuance |
| Africa | 69 | 31 | 2,369 | 1,031 | 34 | 33 |
| Asia and the Pacific | 2,653 | 1,453 | 127,763 | 74,466 | 48 | 51 |
| Economies in transition | 13 | 5 | 144 | 74 | 11 | 15 |
| Latin America and the Caribbean | 541 | 344 | 11,458 | 5,957 | 21 | 17 |
| **Total** | 3,276 | 1,833 | 141,734 | 81,529 | 43 | 44 |

## 4.2. COST OF EMISSION REDUCTIONS

From information contained in PDDs, it is possible to estimate the mitigation cost by category or type of project. Essentially, this is the total cost of the project including initial outlay of capital and the annual net operational expenditures per CER expected for each type. From a project developer's standpoint, this mitigation cost should be below the expected CER price in order to make the project viable. As shown in the equation below, a project's mitigation cost is defined as the net present value[71] of its annual operations costs less its non-CDM related revenues (e.g. income from electricity sales for wind projects), plus the capital expenditures, all divided by the amount of GHG emission reductions it expects to achieve over its crediting period.[72]

$$C(CDM)_i = \frac{\sum_{t=1}^{cp} \frac{(C_t - R_t)}{(1+r)^t} + I_0}{\sum_{t=1}^{cp} A_t}$$

Where:

- $C(CDM)^i$ is the abatement cost of project i (in USD/t $CO_2$ eq);
- t is the time period (in years);
- cp is the length of its crediting period(s) (10 or 21 years);
- $C^t$ is the operation costs in year t (in USD);
- $R^t$ is the non-carbon revenues in year t (in USD);
- $I^0$ is the initial investment (in USD);
- $A^t$ is the abatement achieved by the project in year t (in t $CO_2$ eq);
- r is the discount rate.

All costs are expressed in USD, calculated using the current interbank exchange rate at the date the project started operations or was submitted for validation. The discount rate was the rate used to demonstrate additionality and is typically expressed as a discount rate, benchmark rate or hurdle rate. Where a rate was not disclosed, a country average was applied. Castro (2010) uses a median discount rate by country to normalize abatement costs, as the rate can vary significantly from one project to another within a single host country and this, in turn, could lead to less reliable abatement cost estimates. However, this study did not find that to be the case.[73]

In terms of the time period the crediting period was chosen over the operational lifetime of the project. For many projects, project developers tend to consider a lifetime equal to its crediting period, even if the project has a longer life. More than 60 per cent of all CDM projects choose a renewable seven-year crediting period for a maximum of 21 years and the remainder choose a single crediting period, usually 10 years. Some projects used shorter crediting periods, while others, especially hydro projects, typically have a much longer operational lifetime. For the calculation of costs, the time period that most likely informed the investment decision by the project developer was chosen – the CDM crediting period. Abatement costs were calculated for all projects that included data for capital and operational expenditures, and non-carbon revenues. For some projects either the revenue or the operational costs were not available. This reduced the number of projects to 1,014. Out of these 640 have a 21-year crediting period and 374 projects have a 10-year crediting period. Owing to the significant differences between these two periods, the abatement costs by UNFCCC project category and UNEP project type are provided in tables IV-6 and IV-7 by crediting period.

[71] As interest rates are generally positive, the net present value is the standard method used in order to discount future costs and benefits to current values.

[72] Castro, 2010, p. 12.

[73] Abatement costs were calculated using both a country standard discount rate and the discount rates from individual PDDs and no significant differences were found.

Table IV-6. **Abatement costs by UNFCCC project category (USD/t $CO_2$ eq)**

| | 21-year crediting period | | | 10-year crediting period | | | Total |
|---|---|---|---|---|---|---|---|
| UNFCCC project categories | Number of projects | Average (USD/t $CO_2$ eq) | Standard deviation (USD/t $CO_2$ eq) | Number of projects | Average (USD/t $CO_2$ eq) | Standard deviation (USD/t $CO_2$ eq) | Number of projects |
| Afforestation and Reforestation | 2 | | 3 | | | | 2 |
| Biomass Energy | 49 | - 1 | 8 | 20 | - 3 | 23 | 69 |
| Methane Avoidance | 115 | 2 | 3 | 101 | 4 | 5 | 216 |
| Energy Efficiency | 11 | 1 | 3 | 10 | 23 | 23 | 21 |
| Flaring and Fuel Switch | 2 | 5 | 7 | 10 | - 2 | 42 | 12 |
| Industrial Gases | 13 | | 1 | 8 | 4 | 12 | 21 |
| Mining and Others | 20 | 4 | 15 | 26 | 1 | 2 | 46 |
| Renewable Energy | 423 | 7 | 49 | 163 | 49 | 133 | 586 |
| Waste Energy | 5 | - 1 | 2 | 36 | 7 | 19 | 41 |
| **Total** | **640** | **5** | **40** | **374** | **24** | **91** | **1,014** |

Table IV-7. **Abatement costs by UNEP project type (USD/t $CO_2$ eq)**

| | 21-year crediting period | | | 10-year crediting period | | | Total |
|---|---|---|---|---|---|---|---|
| UNEP project types | Number of projects | Average (USD/t $CO_2$ eq) | Standard deviation (USD/t $CO_2$ eq) | Number of projects | Average (USD/t $CO_2$ eq) | Standard deviation (USD/t $CO_2$ eq) | Number of projects |
| Biomass energy | 65 | - 3 | 11 | 39 | - 12 | 23 | 104 |
| Cement | 1 | 5 | | 3 | 3 | 2 | 4 |
| Coal bed/mine methane | 18 | | 1 | 25 | 1 | 2 | 43 |
| Energy efficiency industry | | | | 4 | 10 | 10 | 4 |
| Energy efficiency own generation | 5 | - 1 | 2 | 33 | 7 | 20 | 38 |
| Energy efficiency supply side | 3 | 4 | 4 | 4 | 28 | 25 | 7 |
| Energy distribution | 1 | - 3 | | 1 | 3 | | 2 |
| Fossil fuel switch | 8 | | 2 | 7 | 8 | 58 | 15 |
| Fugitive | 1 | | | 4 | 5 | 5 | 5 |
| Geothermal | 4 | - 2 | 5 | | | | 4 |
| Hydro | 230 | 2 | 8 | 48 | 15 | 41 | 278 |
| Landfill gas | 50 | 2 | 3 | 40 | 4 | 4 | 90 |
| Methane avoidance | 60 | 2 | 3 | 58 | 4 | 6 | 118 |
| $N_2O$ | 12 | 1 | | | | | 12 |
| PFCs and $SF_6$ | | | | 7 | | 8 | 7 |
| Reforestation | 2 | | 3 | | | | 2 |
| Tidal | 1 | 5 | | | | | 1 |
| Transport | 1 | 67 | | | | | 1 |
| Wind | 170 | 3 | 7 | 91 | 29 | 14 | 261 |
| Total (excluding Solar) | 632 | 2 | 8 | 364 | 10 | 24 | 996 |
| Solar | 8 | 280 | 227 | 10 | 509 | 229 | 18 |
| **Total** | **640** | **5** | **40** | **374** | **24** | **91** | **1,014** |

The average abatement cost for all registered projects with a 21-year crediting period is USD 5/t $CO_2$ eq. Excluding solar projects, as they are substantially more costly than other types of project, the average project abatement cost falls to USD 2/t $CO_2$ eq. This is consistent with the findings of Castro (2010) who calculates the mitigation cost for 29 technologies using data from 252 registered projects in eight countries.[74] Twenty-two of the project types have a mitigation cost of USD 5/t $CO_2$ eq or less.[75] The average abatement cost for all registered projects with a 10-year crediting period is USD 24/t $CO_2$ eq, and USD 10/t $CO_2$ eq without solar projects.

There is substantially more variance in the abatement costs for projects with a 10-year crediting period relative to those with a 21-year crediting period as shown by the higher standard deviations for 10-year crediting period projects. Excluding solar projects, the standard deviation is USD 8/t $CO_2$ eq for projects with a 21-year crediting period. This means that most projects have an abatement cost of USD 2/t $CO_2$ eq plus or minus USD 8/t $CO_2$ eq, or in other words, abatement costs are between USD –6 and USD 10/t $CO_2$ eq.

Similarly, for projects with a 10-year crediting period, the standard deviation is USD 24/t $CO_2$ eq such that abatement costs are between USD –14 and USD 34/t $CO_2$ eq. This is due mainly to a smaller denominator in the abatement cost equation for this group. That is, project costs which would presumably be the same as for their 21-year crediting period counterparts are normalized by a much lower amount of emission reductions (over 10 rather than 21-years). This leads to a higher abatement cost and more volatility in its estimation.

This is also shown in figures IV-10 and IV-11 where the boxes illustrate the average abatement cost, give or take one standard deviation, and the horizontal lines provide the highest and lowest abatement costs.[76]

How can an abatement cost be negative? If the non-carbon revenue over the life of a project is greater than the capital and operational expenditures, its abatement cost will be below zero. It is evident from figures IV-10 and IV-11 that there are a number of projects that are profitable without CDM revenue. However, the profits may be below a benchmark that accounts for the risks involved or there may be other barriers impeding the project. Therefore, a negative abatement cost does not automatically imply that the project is not meeting criteria for additionality.

It should be noted that there could be a negative abatement cost bias for all biomass energy projects. Biomass energy projects typically involve converting biomass residues to energy for own use or for resale. For these projects, it was not always evident in the documentation if the biomass residues were purchased or if they were the residues of another process. If the project developer purchases the biomass, it is not always clear if this cost has been included as part of the operational costs of the project. It is likely that some of these costs have not been recorded, which would cause biomass projects to appear to be more profitable than they actually are. This is shown in figures IV-10 and IV-11, where the bulk of abatement costs for biomass energy projects are negative. This issue is not likely for other types of projects shown in this study.

In summary, the fact that some participants choose a shorter crediting period that can result in costs that are higher per expected emission reduction than the price of a CER, and the presence of very costly solar projects, especially those using photovoltaic technology, suggests that the primary motivation for the implementation of these projects is not the CDM. This is not to say that they would have been implemented without revenues from CERs, it is simply that, while some CDM projects with very low abatement costs have obvious financial benefits, which is enough incentive for the projects to take place, others seem less obvious. Implementation of these projects may be motivated by other reasons such as to help fund research into renewable technologies that potentially have a lower abatement cost in the long run.

[74] Castro, 2010. The categories used were UNEP project types and sub-types. The eight countries are Argentina, China, Israel, Malaysia, Mexico, Republic of Korea, South Africa and Thailand. The mitigation cost for HFC-23 destruction projects was estimated from published sources, as none of these projects included sufficient financial information to calculate their costs.

[75] Castro, 2010, figure II-2, p. 13.

[76] The data for UNEP project types Afforestation, $CO_2$ usage, Energy efficiency household, Energy efficiency service, and HFCs was insufficient for the calculation of abatement cost and so were excluded from figures IV-10 and IV-11, and table IV-7.

Figure IV-10. **Abatement costs of UNEP project types with a 21-year crediting period**

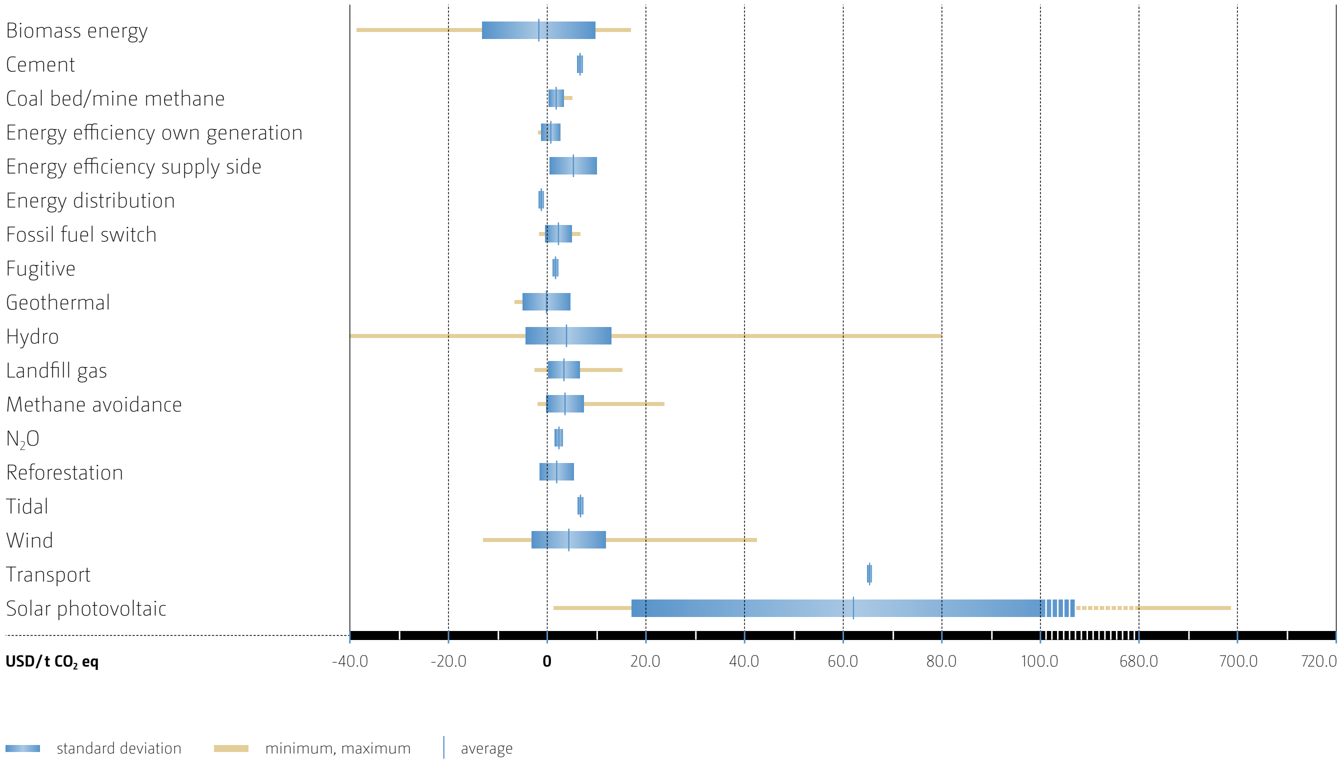
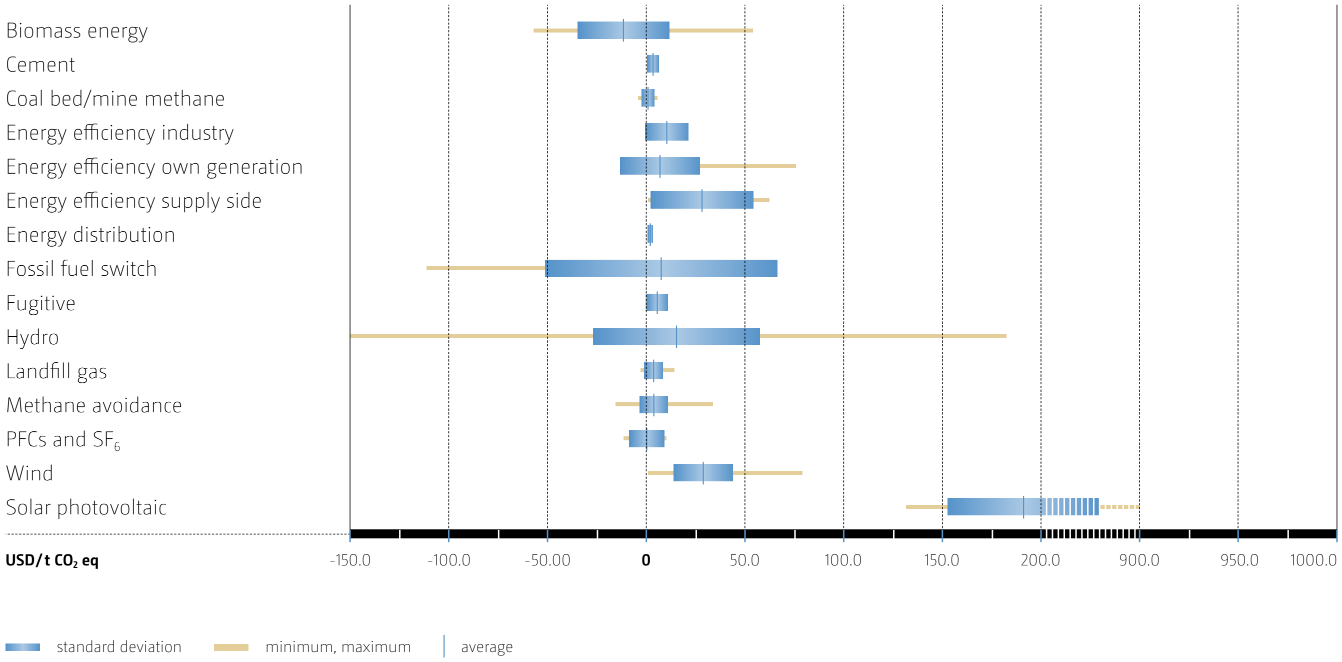



Figure IV-11. **Abatement costs of UNEP project types with a 10-year crediting period**



## 4.3. OTHER STUDIES ON COSTS OF THE CLEAN DEVELOPMENT MECHANISM

Financial data from the PDDs for 840 projects submitted for validation during 2003-2008 are used by Rahman et al. (2009) to estimate mitigation costs for 10 project types – biogas; biomass; hydro; wind; geothermal; hydrofluorocarbon, perfluorocarbon and nitrous oxide reduction; methane reduction, coal bed/mine and cement; supply-side energy efficiency; demand-side energy efficiency; and fossil fuel switch. The estimated marginal cost curves suggest economies of scale in emission abatement and cost differences by project type.[77] In particular, nitrogen and methane gas reduction projects are characterized by much lower marginal costs relative to wind or biomass projects.[78] The authors conclude that investors focus on projects with low mitigation costs, so the CDM market is operating efficiently and sending the right signals to the investors.[79]

Castro (2010) uses the mitigation costs to analyse whether CDM projects are capturing most of the low-cost emission reductions – the 'low-hanging fruit' – in the host countries. That might raise the cost to those countries of meeting possible future mitigation targets.[80] She uses the mitigation costs and the projected annual emission reductions for all CDM projects proposed as at October 2009 to develop a marginal abatement cost (MAC) curve for nine countries (Argentina, China, Indonesia, Israel, Malaysia, Mexico, Thailand, South Africa and South Korea). The MAC curve ranks the project types in order of increasing cost and shows the estimated annual emission reductions for each type. With the lowest (often negative) cost option at the origin, the MAC curve rises step-wise as one moves to the right and adds progressively more costly project types. The MAC curves show the potential emission reduction that could be achieved for less than a specified cost per t $CO_2$ eq.

Castro compares her MAC curves for CDM projects with MAC curves of all emission reduction options for the year 2010 for six of the nine countries above (excl. Indonesia, Israel and Malaysia). She finds that the percentage of abatement potential captured by the CDM projects ranges from 1.8 per cent in South Africa to 30.9 per cent in China.[81] On the basis of these results Castro concludes that there are still plenty of low-cost opportunities available – the low-hanging fruit argument is weak. In other words the CDM is not capturing all of the identified abatement potential in these countries.[82]

[77] The marginal costs did not decrease over time. (Rahman et al., 2009, pp. 16 and 17).

[78] Rahman, et al., 2009, p. 16.

[79] Rahman, et al., 2009, p. 16.

[80] Such an impact depends on the evolution of carbon credit prices, the way in which future abatement commitments for developing countries are set, whether CDM projects are developed unilaterally or bilaterally, the market power of the countries, and on the ability to bank credits from one commitment period to the next (Castro, 2010, pp. 8-9).

[81] Castro, 2010, table 1, p. 22. The figures for the other countries are: Mexico 2.1 per cent; Thailand 8.8 per cent; Argentina 17.6 per cent and Republic of Korea 17.7 per cent.

[82] Castro, 2010, p. 24.

# V. OPPORTUNITIES FOR IMPROVEMENT

This study has shown it is possible to make an initial estimate of the claimed contribution of the CDM to benefits for the host countries. These include a myriad of possible sustainable development criteria that are apparently being achieved at a project level, as well significant levels of international transfer of technology and know-how. It has also shown that it is possible to ascertain the overall investment due to the CDM and provide a basic cost estimate of CDM specific mitigation technologies and actions. It does however pose new questions and several areas for improvement.

Assessment of the sustainable development contribution of CDM projects requires, as a starting point, a set of indicators that can capture all of the benefits claimed in a consistent fashion. The indicators used in this and earlier studies do not fully meet this requirement. Further analysis of the PDD claims and survey responses can help identify indicators whose descriptions appear to be unclear. A revised set of indicators could be developed, subjected to expert review and public comment, and tested through a survey. In addition, some ex post verification of PDD claims and survey responses would likely need to be conducted.

Technology transfer via the CDM has been extensively analysed and been found to be a complex, dynamic process. While surveys show that the PDD claims are reasonably accurate, more ex-post data could improve the analyses. More research on the relative contributions of the CDM and other mechanisms to technology transfer would also be useful.

The additionality of the emission reductions achieved by CDM projects is critical for environmental integrity. A CDM project can reduce GHG emissions in several ways:

(1) Project reductions during its crediting period;
(2) Project reductions after the end of the crediting period;
(3) Increased adoption of the project's climate friendly technology in the host country due to increased awareness and/or technology transfer; and
(4) Less emissions leakage from Parties included in Annex B to the Kyoto Protocol, owing to reduced compliance costs.

The CDM additionality tests focus only on the first category of GHG emission reductions. The emission reductions in the second category can be calculated from available data. While some research is available on the emission reductions in the latter two categories, more research is needed for each category. There is not yet sufficient evidence to conclude that the emission reductions, in the first category, or overall, exceed the CERs issued for CDM projects.

One of the objectives of the CDM is to assist Annex I Parties in complying with their emission limitation and reduction commitments under the Kyoto Protocol. The contribution of the CDM to this objective can be assessed in terms of the projected use of CERs for compliance by Annex I Parties and cost savings due to the use of CERs relative to domestic emission reductions by Annex I Parties. Some research on both of these topics is available, but more would be useful to evaluate the performance of the CDM with respect to this objective.

Some of the above improvements and further work will be covered in future reports.

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# VII. ANNEXES/TABLES

Table VII-8. **Definitions of UNFCCC project categories and their associated methodologies or combinations thereof, applicable for the projects analysed in this study.**

| Category | Definition | Clean development mechanism methodologies |
|---|---|---|
| Afforestation and Reforestation | Afforestation and reforestation $CO_2$ sink activities | AR-AMS0001; AR-AM0001; AR-AM0002; AR-AM0003; AR-AM0004; AR-AM0005; AR-AM0010; AR-ACM0001 |
| Biomass energy | Heat and or power generation from biomass residues of both renewable and non-renewable biomass | AM0004; AM0015; AM0027; AM0036; ACM0002; ACM0006; ACM0018; AMS-I.A.; AMS-I.C.; AMS-I.D.; AMS-I.E.; AMS-I.F.; AMS-III.D.; AMS-III.H.; AMS-III.Q. |
| Methane avoidance | Methane avoidance/recovery, including heat and/or power generation, excluding coal mine/ bed methane | AM0002; AM0003; AM0006; AM0010; AM0011; AM0013; AM0016; AM0022; AM0025; AM0039; ACM0010; ACM0014; AM0083; ACM0002; AMS-III.Y.; ACM0001; AMS-I.A.; AMS-I.C.; AMS-I.D.; AMS-III.I.; AMS-III.D.; AMS-III.E.; AMS-III.F.; AMS-III.G.; AMS-III.H.; AMS-III.K.; AMS-III.O.; AMS-III.R. |
| Energy efficiency | Energy efficiency in all sectors and industries | AM0014; AM0033; AM0029; AM0038; AM0046; ACM0002; ACM0005; ACM0007; ACM0013; AMS-I.C; AMS-I.D.; AMS-II.A.; AMS-II.B.; AMS-II.C.; AMS-II.D., AMS-II.E.; AMS-II.G.; AMS-II.H.; AMS-II.J.; AMS-III.B.; AMS-III.J. |
| Flaring and fuel switch | Gas flaring and feed or fuel switch | AM0009; ACM0003; ACM0009; ACM0011 AMS-III.B. |
| Industrial gases | Industrial gases in all sectors and industries | AM0001; AM0008; AM0018; AM0021; AM0023; AM0028; AM0030; AM0034; AM0035; AM0041; AM0045; AM0058; AM0059; AM0069; AM0078; AM0079; ACM0004; AMS-III.AD; AMS-III.N. |
| Mining and others | Mining and others such as transport, construction etc. | AM0014; AM0031; AM0065; ACM0002; ACM0008; AMS-III.C.; AMS-III.T.; AMS-III.U. |
| Renewable energy | Renewable energy in all sectors and industries | AM0005; AM0026; ACM0002; AMS-I.D.; AMS-I.F. |
| Waste energy | Heat and/or power from waste energy such as gas, heat and pressure | AM0024; AM0032; AM0037; AM0055; AM0066; ACM0002; ACM0004; ACM0012 AMS-III.P.; AMS-III.Q. |

Table VII-9. **Definitions of UNEP project types applicable for the projects analyzed in this study.**

| Project type | Definition |
|---|---|
| Afforestation and reforestation | According to land use, land-use change and forestry rules |
| Agriculture | Irrigation, alternative fertilizers and rice crop methane avoidance |
| Methane avoidance | Biogas from manure, waste water, industrial solid waste and palm oil solid waste, or methane avoidance by composting or aerobic treatment |
| Biomass energy | New plant using biomass or existing ones changing from fossil fuels to biomass; also biofuels |
| Cement | Projects where lime in the cement is replaced by other materials, or neutralization with lime is avoided |
| $CO_2$ capture | Recovered $CO_2$ from tail gas substituting fossil fuels for production of $CO_2$ |
| Coal bed/mine methane | $CH_4$ is collected from coal mines or coal beds.  This includes ventilation air methane (VAM) |
| Energy distribution | Reduction in losses in transmission/distribution of electricity/district heat; country interconnection |
| Energy efficiency (EE) households | Energy efficiency improvements in domestic houses and appliances |
| EE industry | End-use energy efficiency improvements in industry |
| EE own generation | Waste heat or waste gas used for electricity production in industry |
| EE service | Energy efficiency improvements in buildings and appliances in public & private service |
| EE supply side | More efficient power plants producing electricity and district heat, coal field fire extinguishing |
| Fossil fuel switch | Switch from one fossil fuel to another fossil fuel (including new natural gas power plants) |
| Fugitive | Recovery instead of flaring of $CH_4$ from oil wells, gas pipeline leaks, charcoal production and fires in coal piles |
| Geothermal | Geothermal energy |
| HFCs | HFC-23 destruction |
| Hydro | New hydro power plants |
| Landfill gas | Collection of landfill gas, composting of municipal solid waste, or incinerating of the waste instead of landfilling |
| $N_2O$ | Reduction of $N_2O$ from production of nitric acid, adipic acid and caprolactam |
| PFCs and $SF_6$ | Reduction of emissions of PFCs and $SF_6$ |
| Solar | Solar photovoltaic, solar water heating and solar cooking |
| Tidal | Tidal power |
| Transport | More efficient transport |

**Table VII-10.** **Technology transfer by UNEP project type**

| Project type | Number of projects | Average project size ($CO_2$ eq/year) | Technology transfer claims | | Percentage of projects where technology transfer could not be determined |
|---|---|---|---|---|---|
| | | | Number of projects | Annual emission reductions | |
| Afforestation | 5 | 24,412 | 40% | 52% | 0% |
| Biomass energy | 373 | 64,399 | 32% | 44% | 32% |
| Cement | 19 | 169,134 | 17% | 16% | 37% |
| $CO_2$ usage | 2 | 11,844 | 100% | 100% | 50% |
| Coal bed/mine methane | 47 | 463,085 | 59% | 76% | 13% |
| Energy efficiency households | 26 | 63,828 | 64% | 86% | 58% |
| Energy efficiency industry | 62 | 26,343 | 71% | 75% | 49% |
| Energy efficiency own generation | 181 | 165,611 | 47% | 71% | 27% |
| Energy efficiency service | 5 | 11,756 | 75% | 94% | 20% |
| Energy efficiency supply side | 27 | 337,861 | 71% | 89% | 48% |
| Energy distribution | 5 | 454,421 | 50% | 11% | 20% |
| Fossil fuel switch | 64 | 503,507 | 89% | 99% | 30% |
| Fugitive | 20 | 643,325 | 45% | 70% | 45% |
| Geothermal | 12 | 265,165 | 88% | 97% | 33% |
| HFCs | 22 | 3696,307 | 91% | 97% | 0% |
| Hydro | 986 | 97,704 | 12% | 8% | 17% |
| Landfill gas | 200 | 168,764 | 86% | 88% | 20% |
| Methane avoidance | 388 | 38,735 | 84% | 86% | 19% |
| $N_2O$ | 65 | 742,516 | 100% | 100% | 5% |
| PFCs and $SF_6$ | 14 | 352,765 | 83% | 93% | 45% |
| Reforestation | 23 | 43,279 | 36% | 39% | 36% |
| Solar | 40 | 26,360 | 73% | 66% | 18% |
| Tidal | 1 | 315,440 | 100% | 100% | 0% |
| Transport | 7 | 80,470 | 100% | 100% | 57% |
| Wind | 682 | 100,059 | 34% | 33% | 13% |
| **Total** | **3,276** | **150,472** | **42%** | **64%** | **21%** |

**Table VII-11.** **Technology transfer by UNFCCC project category**

| Project category | Number of projects | Average project size ($CO_2$ eq/year) | Technology transfer claims | | Percentage of projects where technology transfer could not be determined |
|---|---|---|---|---|---|
| | | | Number of projects | Annual emission reductions | |
| Afforestation and reforestation | 28 | 39,910 | 37% | 42% | 30% |
| Biomass Energy | 251 | 62,288 | 35% | 36% | 29% |
| Methane Avoidance | 608 | 85,921 | 84% | 87% | 19% |
| Energy Efficiency | 156 | 283,315 | 73% | 92% | 42% |
| Flaring and Switch | 47 | 272,528 | 55% | 54% | 57% |
| Industrial Gases | 128 | 1105,125 | 92% | 97% | 15% |
| Mining and Others | 61 | 378,313 | 66% | 77% | 18% |
| Renewable Energy | 1,814 | 94,998 | 22% | 20% | 17% |
| Waste Energy | 183 | 164,433 | 46% | 70% | 26% |
| **Total** | **3,276** | **150,472** | **42 %** | **64 %** | **21 %** |

**Table VII-12.** **Investment in clean development mechanism projects by host country (USD million)**

| Country | Number of projects | | Total investment | | Average investment | |
|---|---|---|---|---|---|---|
| | Registered | Issuance | Registered | Issuance | Registered | Issuance |
| Albania | 1 | | 3 | | 3 | |
| Argentina | 23 | 12 | 311 | 174 | 14 | 14 |
| Armenia | 5 | 2 | 25 | 13 | 5 | 6 |
| Bangladesh | 2 | 1 | 10 | 5 | 5 | 5 |
| Bhutan | 2 | 1 | 184 | | 92 | |
| Bolivia | 4 | 1 | 381 | 74 | 95 | 74 |
| Brazil | 195 | 143 | 3,080 | 2,257 | 16 | 16 |
| Cambodia | 5 | 1 | 22 | 4 | 4 | 4 |
| Cameroon | 2 | | 8 | | 4 | |
| Chile | 50 | 29 | 1,327 | 691 | 27 | 24 |
| China | 1,468 | 830 | 96,311 | 63,156 | 66 | 76 |
| Colombia | 31 | 13 | 253 | 147 | 8 | 11 |
| Congo | 2 | | 5 | | 2 | |
| Costa Rica | 7 | 6 | 144 | 48 | 21 | 8 |
| Côte d`Ivoire | 3 | | 21 | | 7 | |
| Cuba | 2 | 2 | 312 | 312 | 156 | 156 |
| Cyprus | 6 | 3 | 73 | 3 | 12 | 1 |
| Dominican Republic | 2 | 1 | 91 | 4 | 45 | 4 |
| Ecuador | 16 | 11 | 305 | 152 | 19 | 14 |
| Egypt | 10 | 5 | 488 | 179 | 49 | 36 |
| El Salvador | 6 | 5 | 292 | 129 | 49 | 26 |
| Ethiopia | 1 | | 4 | | 4 | |
| Fiji | 2 | 1 | 15 | 13 | 7 | 13 |
| Georgia | 2 | 1 | 38 | 33 | 19 | 33 |
| Guatemala | 11 | 9 | 356 | 186 | 32 | 21 |
| Guyana | 1 | | 32 | | 32 | |
| Honduras | 19 | 15 | 131 | 109 | 7 | 7 |
| India | 694 | 419 | 21,144 | 7,531 | 30 | 18 |
| Indonesia | 70 | 30 | 1,512 | 856 | 22 | 29 |
| Iran | 5 | | 43 | | 9 | |
| Israel | 22 | 13 | 1,415 | 61 | 64 | 5 |
| Jamaica | 1 | 1 | 37 | 37 | 37 | 37 |
| Jordan | 2 | 1 | 24 | 22 | 12 | 22 |
| Kenya | 5 | | 759 | | 152 | |
| Republic of Korea | 61 | 30 | 1,991 | 859 | 33 | 29 |
| Laos People's Democratic Republic | 1 | 1 | 1 | 1 | 1 | 1 |
| Liberia | 1 | | 1 | | 1 | |
| Macedonia | 1 | | 22 | | 22 | |
| Madagascar | 1 | 1 | 6 | 6 | 6 | 6 |
| Malaysia | 93 | 36 | 544 | 359 | 6 | 10 |
| Mali | 1 | | 99 | | 99 | |
| Mexico | 129 | 71 | 2,575 | 998 | 20 | 14 |
| Mongolia | 3 | 2 | 66 | 65 | 22 | 33 |
| Morocco | 5 | 3 | 249 | 239 | 50 | 80 |
| Nepal | 4 | 2 | 27 | 6 | 7 | 3 |
| Nicaragua | 5 | 4 | 216 | 215 | 43 | 54 |

**Table VII-12.** **Investment in clean development mechanism projects by host country (USD million) (continued)**

| | Number of projects | | Total investment | | Average investment | |
|---|---|---|---|---|---|---|
| **Country** | **Registered** | **Issuance** | **Registered** | **Issuance** | **Registered** | **Issuance** |
| Nigeria | 5 | 3 | 498 | 451 | 100 | 150 |
| Pakistan | 12 | 4 | 370 | 167 | 31 | 42 |
| Panama | 7 | 4 | 276 | 51 | 39 | 13 |
| Papua New Guinea | 1 | 1 | 108 | 108 | 108 | 108 |
| Paraguay | 2 | | 2 | | 1 | |
| Peru | 25 | 15 | 1,328 | 363 | 53 | 24 |
| Philippines | 54 | 18 | 715 | 199 | 13 | 11 |
| Qatar | 1 | 1 | 260 | 260 | 260 | 260 |
| Republic of Moldova | 4 | 2 | 54 | 28 | 14 | 14 |
| Rwanda | 2 | | 2 | | 1 | |
| Senegal | 1 | | 9 | | 9 | |
| Singapore | 2 | 2 | 24 | 24 | 12 | 12 |
| South Africa | 20 | 14 | 127 | 91 | 6 | 6 |
| Sri Lanka | 7 | 7 | 79 | 79 | 11 | 11 |
| Syria | 3 | | 9 | | 3 | |
| Tanzania | 1 | 1 | 12 | 12 | 12 | 12 |
| Thailand | 53 | 31 | 461 | 336 | 9 | 11 |
| Tunisia | 3 | 2 | 30 | 29 | 10 | 14 |
| Uganda | 5 | 1 | 48 | 19 | 10 | 19 |
| United Arab Emirates | 4 | 2 | 425 | 108 | 106 | 54 |
| Uruguay | 6 | 2 | 40 | 11 | 7 | 6 |
| Uzbekistan | 11 | 6 | 339 | 12 | 31 | 2 |
| Viet Nam | 64 | 10 | 1,559 | 229 | 24 | 23 |
| Zambia | 1 | 1 | 6 | 6 | 6 | 6 |
| **Total** | **3,276** | **1,833** | **141,734** | **81,529** | **43** | **44** |

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