Impact of the Clean Development Mechanism

Quantifying the current and pre-2020 climate change mitigation impact of the CDM

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This paper is prepared under the remit of the research project "Concepts and country-specific strategies for the carbon markets post-2012" (FKZ UM 13 41 173) tendered by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), and executed in cooperation with Ecofys.

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Executive summary

This focus study is an offshoot of the research project “Concepts and Country-Specific Strategies for the Carbon Market Post 2012” (FKZ UM 13 41 173) and presents evidence on the impacts of the Clean Development Mechanism (CDM). This includes a **quantitative assessment of the mitigation impact of the CDM that occurs as a side effect of the current depressed market conditions**. This mitigation impact is unintended and undesirable, possible because under the current market conditions mitigation activities originally designed for generating emission reduction credits under the CDM continue to operate their mitigation equipment but discontinue issuing offsets. Using the data generated by the extensive survey of 1,310 CDM projects in the parent study (addressed as the ‘*Status Report*’ in text), this study mainly attempts to quantify the current unintended global mitigation impact of the CDM and attempts to quantify **effects for the actual supply and demand balance of offset units on the international market under current conditions**.

The survey conducted in the underlying research project generated quantitative data which includes, for example, the share of dismantled projects, projects that are operational but irreversibly left the CDM and projects continuing after their initial crediting period. This is new information, representative for the CDM, which offers opportunities to either quantify effects that have not been quantified before or update information on previous trends. A quantitative assessment approach based on predefined hypotheses is taken for investigating the research questions and conducting the quantification exercises.

The results presented in this focus study provide broad evidence that a large share of projected emission reductions in the CDM up to 2020 are generated by projects that do neither at present nor in the future engage in verification and issuance cycles under the current market conditions and that due to this effect the actual difference between the supply and demand of offset units on the international market is considerably smaller than widely assumed. The quantitative assessment of annual project data as given in the CDM project design documents combined with the statistically representative survey responses resulted in the following findings:

- Over 73% of the theoretical maximum emission reduction capacity of all registered CDM projects in the year 2014 is estimated to have occurred.
- The total actual projected emission reductions of the CDM, adjusted by performance losses, in 2014 would be in the order of 750 MtCO2e and a marginal downward trend of emission reductions for currently registered CDM projects is projected up to 2020 under current market conditions.
- With the approach in this focus study the credit supply from CDM emission reductions in 2014 is estimated to be in the order of 270 million CERs, and thus considerably lower than widely acknowledged maximum supply potentials of an average 640 million CERs per year.

Combining these results leads to the conclusion that **the annual net mitigation impact of the CDM in 2014 is in the order of 480 MtCO2e and thus might have reduced global emissions by approximately 1% in 2014**. Although unintended and undesirable, this effect is enormous given that the mechanism is designed to be a ‘zero sum’ instrument. The survey responses moreover allowed to draw conclusions on the price elasticity projected for potential market recovery scenarios. The study results show that **a EUR 2 market recovery will only lead to a modest increase in supply** and thus could be initiated by a modest increase in demand. In contrast, **a CER price of EUR 5 would already reduce the unintended net mitigation impact by more than 50%** as compared to the EUR 2 scenario but requires substantial increases in demand, or non-market interventions. A CER price in excess of EUR 5 could restore market confidence by significantly reducing the gap between the volume of emission reductions taking place and the feasible volume of credit issuance.

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Abbreviations

BAU	'Current Market Conditions Scenario' used in this focus study
BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
CER	Certified Emission Reduction credits (generated from CDM Projects)
CCER	Chinese Certified Emission Reduction credits (generated from the Chinse programme)
CDM	Clean Development Mechanism
ETS	Emission Trading Scheme
GHG	Greenhouse Gas
HFC	Hydrofluorocarbon
PDD	Project Design Document
PoA	Programme of Activities projects under CDM
V&I	Verification and Issuance (of CDM projects)

1. Introduction

This focus study presents evidence on the impacts of the Clean Development Mechanism (CDM), through the analysis of data obtained under the research project “Concepts and Country-Specific Strategies for the Carbon Market Post 2012” (FKZ UM 13 41 173) tendered by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). Main analysis results and details about the underlying database is provided through the publication issued in May 2015 titled “*Analysing the status quo of CDM projects – status and prospects”* (Warnecke et al. 2015), hereon referred to as the *Status Report*. This focus study builds on the *Status Report* and refers wherever required to sections, figures, or data sets in this publication. The *Status Report* comprehensively investigated the current situation of the CDM through an extensive survey of 1,310 CDM projects in order to analyse the implementation status of registered CDM projects, and to show to what extent registered projects have been affected by adverse CER market conditions. The circumstances under which registered projects are discontinued, and hence potentially fall back to their initial pre-CDM situation and resume baseline GHG emissions, were documented, and current barriers for CDM project initiation and continuation were explored. In addition to the quantitative data obtained through this process, a wealth of qualitative information was obtained through interviews with a wide range of CDM stakeholders.

1.1 Background

The CDM was introduced by the Kyoto Protocol as a flexibility mechanism and has developed into one of the most important carbon market instruments. While the first CDM project was registered in 2004, the CDM represents today the largest GHG emission offsetting scheme in the world. As of 01 September 2015 7,947 projects, including 283 Programme of Activities projects (PoA), have been registered in more than 110 host countries.

The CDM is designed as a pure offsetting mechanism without the objective to generate a net reduction of greenhouse gas (GHG) emissions. In order to increase flexibility with respect to the location of the emission reduction activity within compliance schemes, the CDM allows to convert 100% of the achieved GHG reduction into tradable units (certified emission reductions, CER) which are normally used to emit the same amount of GHG elsewhere. In this way, the CDM theoretically functions as a zero sum instrument with no net impact on the global emissions, although the increased level of flexibility achieved through CDM allows most cost-effective emission reductions and consequently should lead to more ambitious targets in mandatory schemes.

A global net reduction of GHG emissions might still occur for example when projects continue to operate their emission reduction activity also even after the end of the crediting period or when the CER issuance rate is below the actually reduced amount of emissions, for example to account for measurement uncertainties (Erickson et al. 2014; Warnecke et al. 2014). While the latter net reduction is difficult to quantify and might be rather small, an assessment and the quantification of the operational mitigation capacity after the end of the crediting period is potentially limited to the projects that have achieved this stage which was rather small in the past. Although occurring outside the CDM, further net mitigation can be achieved when reduction units are issued but retired and not used as allowances to compensate for emissions elsewhere, for example when using results-based financing approaches (Warnecke et al. 2015b).

The CDM might also result in an opposite effect, leading to increased net emissions. This can, for example, occur when non-additional projects are erroneously accepted and result in issuance of reduction units. This effect was addressed in various publications in recent years (e.g. Haya 2010; Michaelowa & Purohit 2007;

Schneider 2007). Erickson et al. (2014) have additionally analysed further potential for over- or under-crediting under the CDM for example relating from determining the emissions baseline for project activities. All effects, which potentially either lead to increased or decreased global net emissions, might compensate each other to a certain extent although not fully since many of them cannot co-exist according to Erickson et al. (2014) who developed one of the first approaches to estimate the range of aggregate effects of the CDM. However, assessment of the net impact with certainty remains problematic.

Against this background it is assumed that the recent decline in the carbon market conditions potentially leads to a new net reduction additional to the previously discussed effects. Current market conditions have led to a situation where projects continue the operation of their mitigation activities which were installed as part of their CDM project activities but do not intend anymore to issue offsets. This can lead to an unintended global mitigation impact under the CDM, since some emission reductions are not offset, as they were intended to be.

1.2 Objective and report structure

The survey data obtained in the underlying research project cannot deliver further insights on the additionality aspect and other methodological effects leading to over- or under-crediting since these were not questioned and were thus out of the analysis scope. Moreover, it is neither the purpose of this report to contribute to previous analyses nor to contribute to the discussion whether the CDM should be reformed in a way to generate a regular net mitigation impact in the future. Instead, the objective of this report is to analyse and quantify - to the extent possible - the current mitigation impact of the CDM that occurs as a side effect of the current market conditions. This potentially temporary effect is unintended and has not been quantified so far. The survey conducted in the underlying research project generated quantitative data which includes, for example, the share of dismantled projects, projects that are operational but irreversibly left the CDM and projects continuing after their initial crediting period. This is new information, representative for the CDM, which offers opportunities to either quantify effects that have not been quantified before or update information on previous trends.

Here it is explicitly noted that this climate change mitigation impact is an unintended and undesirable effect of the current market conditions. This net climate change mitigation is not interpreted as a positive impact due to the enormous yet incalculable cost incurred in terms of the loss of potential future participation in similar investments from disenfranchised private investors around the world, and the loss of trust and capacity that plays a role to facilitate such investments. This cost, albeit not possible to meaningfully quantify, is judged to be far above the untapped abatement costs from most sources of mitigation potential and is as such an economically undesirable outcome with negative implications for future investment potential.

The structure of this focus study is as follows. While ***section 1*** presents the background, the approach and some important definitions for the understanding of this study, in ***section 2***, key quantitative findings from the previous publication of this research project "*Analysing the status quo of CDM projects – status and prospects"* (Warnecke et al. 2015) are re-analysed and presented in terms of the volume of expected emission reductions, in order to fill a key information gap on the status and prospects of CDM projects relative to their potential mitigation impact and to provide the required background for subsequent sections.

In ***section 3*** quantitative analysis is conducted to respond to two major research questions which will be addressed in order to test assumptions and respective research hypotheses which have been the starting point for this report. The listed hypotheses are intended to guide the structure and the conclusions of this focus study. These will be assessed against the data of the quantitative analysis conducted for this focus study, and as such should not be interpreted as hypotheses defined in statistical analysis.

Hypothesis 1:

> *A large share of projected emission reductions in the CDM up to 2020 are generated by projects that do neither at present nor in the future engage in verification and issuance cycles under the current market conditions.*

Assuming the additionality of all registered projects and excluding other methodological effects with potential to lead to over- or under-crediting, the current unintended annual *net climate change mitigation* achieved by the CDM due to the market conditions may be significant and larger than initially assumed. A significant share of projects continue to operate their mitigation equipment but have irreversibly left the CDM and do not issue credits. In order to test the hypothesis we developed a quantification approach which aims to answer the following major research question:

> *What is the actual annual net climate change mitigation effect from the CDM due to the current market conditions?*

Hypothesis 2:

> *Due to the amount of emission reduction activity from CDM projects that does not lead to verification and issuance of credits (cf. hypothesis 1), the actual difference between the supply and demand of offset units on the international market may be considerably smaller than widely assumed.*

A substantial number of registered projects are considered as a source of CER supply, whilst the survey results disclosed that a large share of these projects are already dismantled, not operated or unable to convert achieved GHG reductions into tradable units (Warnecke et al. 2015). A continuation of the quantification approach for the first research question leads to estimates which answer the second major research question:

> *What is the actual different between supply and demand of offset units on the international market under current conditions?*

In ***section 4***, the study results are summarised and compared to the above hypotheses. Conclusions are drawn to the extent possible.

1.3 Approach and definitions

This study builds upon the main analysis which was published in May 2015 in the *Status Report* titled *Analysing the status quo of CDM projects – status and prospects* (Warnecke et al. 2015).

With regards to the reference to the existing dataset, the following group definitions, which are used throughout this document, are critical for the comprehension of results:

Sample	As per the *Status Report*, the sample includes the 1,310 projects which were randomly sampled from the study population for evaluation.
Study population	As per the *Status Report*, the study population is the total volume of CDM projects from which a sample was taken, including all project strata selected for study under the overarching research report, including 22 countries and 26 project types (see Warnecke et al. (2015, chap.2)). The study population includes 5,656 projects.
Entire CDM population	At times in section 3 and 4 of this focus study, results from the study population are up-scaled to give an indicative insight into the order of magnitude of the

respective result for the entire CDM population as a whole. Where such statements are made in this focus study, the entire CDM population refers to all existing CDM and PoA projects with a successful registration date on or before 01 September 2015; this is in total 7,947 projects, including 283 PoAs.

This is a deviation from the definition of the *entire CDM population* from the *Status Report*, which included only projects with a registration date in 2012 or earlier, including a total of 7,388 projects. For this focus study, the *entire CDM population* was updated to include projects with a registration up to 01 September 2015, in order to present the most complete picture regarding the potential impacts of the CDM.

As such, the results presented in this document are primarily related to the study population, whilst assumptions are made on the entire CDM population where appropriate.

Table 1: Comparison of the study population with the entire CDM population

	Number of projects (including PoAs)	Potential annual emission reductions (according to PDD)
Entire CDM population	7,947	1,016 $MtCO_2e$
Study population	5,656	589 $MtCO_2e$
Study population as % of entire CDM population	71%	58%

Table 1 shows that the study population represents 71% of the projects of the entire CDM population, as defined for this focus study (77% of all projects with a registration by 2012, the entire CDM population as defined in the *Status Report*). The table also shows that the study population represents 58% of the potential annual emission reductions according to the average annual values stated in the most recent project design documents. The differences between the composition of the study population and the entire CDM population should be noted: Projects with a registration after 2012 enter the market in a very different situation due to their ineligibility of their CERs for the EU Emission Trading Scheme (ETS); some of these projects will be delayed registrations, but others have not aimed for registration in 2012 and their business models should be adjusted accordingly. Therefore, some of the projects in this group are likely to behave differently to those evaluated, and to demonstrate a different reaction to various market scenarios. Furthermore, project types excluded from the study population were omitted for various reasons. A reason which was applied to some project types, such as large hydro (above 20MW capacity), was that the situation of these projects was not under particular doubt since scale of the investment made the implementation effectively irreversible. It is also reasonable to assume that the situation and behaviour of these project types could deviate from the study population. However, several project types were excluded rather because they were not of immediate individual interest at the point of research design, or because of anticipated challenges for the evaluation of those projects. Moreover, another large volume of projects were excluded because they were not hosted in the selected study countries. For these projects, there is no specific reason to assume that the situation would deviate far from the study population. In sum, the difference between the study population and the entire CDM population includes projects that could deviate from the study population situation, but also a large number of projects for which there is no specific reason for such an assumption. Therefore, it is possible to scale up results from the study population to the entire CDM population only for indicative purposes. Such figures are therefore presented as orders of magnitude to allow for inaccuracies due to the potential deviation of the projects not included in the evaluated study population. Specific methodologies for the calculations of projected impacts of the CDM are elaborated in detail in section 3.1.

2. Status and prospects of CDM emission reduction activity

Based on data collected through the individual project evaluation exercise, this section presents insights on the status and prospects of emission reduction activity under the CDM. Data for key questions of the evaluation exercise is presented relative to the volume of CER reductions. Projects reporting a larger volume of expected annual emission reductions occupy a proportionally larger share of the results than projects with a lower expected emission reduction volume, so that the status and prospects of the emission reductions, rather than the projects per se, is indicated. The expected annual emission reductions are taken from the average annual emission reductions reported in the most recent project design documents, as compiled in the UNEP DTU CDM project pipeline (UNEP DTU 2015). The results presented in this focus study are additional to the initial presentation of results in the *Status Report* (Warnecke et al. 2015), which were given relative to the quantity of projects. For example, the *Status Report* indicated what proportion of projects are in regular operation, whilst the results in this focus study for the corresponding evaluation question present the proportion of potential emission reductions which account to projects that are in regular operation.

In the *Status Report*, it was found that a relatively high proportion of projects were in continued operation, despite the unconducive present market conditions; between 64% and 79% of registered CDM projects were deemed to be in continued regular operation of the CDM component of their emission reduction activity, whilst the upper end of the range given was found to be most likely (Warnecke et al. 2015, chap.6). However, only approximately 26% of projects had received a positive return on their investment, and 56% of projects would consider a cancellation of their CDM registration in order to pursue other mechanisms. It was also discussed, that there is a high risk of the substantial loss of emission reduction activity and the irreversible loss of institutions and knowledge due to potential project closures under current market conditions.

For most analysis points, at the population level, only minor variations exist between the results presented relative to project quantity (see Warnecke et al. 2015 chapter 4) and the results relative to emissions reduction potential, presented here. This indicates only limited deviation between the conditions, status and prospects of CDM projects according to their size. More detailed investigation into the minor variations reveal some significant differences for specific project types, as discussed in the sections below. As per the approach in the Status Report, all results given in this section are representative of the study population (see definitions section 1.3), including a total of 5,656 projects.

Table 2 presents a summary of the status of the major project types studied according to the shares of potential annual emission reductions as predicted in the Project Design Documents (PDD). For the interpretation of the table it needs to be noted that project types in the study population deviate in some cases from the project type classification used in UNEP DTU CDM pipeline or IGES CDM Project Database. Changes occur, for example, where subtypes are excluded from the study population or where subtypes are allocated to different project types in order to allow reasonable conclusions. A major change occurred to the hydro project type since all projects above 20 MW where excluded (Warnecke et al. 2015, chap.2.3). Furthermore, it should be noted that the figures in the second column of Table 2 do not demonstrate already issued CERs, where industrial gases would be expected to occupy a much larger share, but rather potential annual emission reductions in the PDDs.

In general, the table indicates that the sources of the greatest emission reduction potential are relatively healthy, or may be under reasonably recovered market conditions; some of the largest project types in terms of expected emission reductions report high rates of regular project operation, a high rate of ability to continue verification and issuance activities with CER prices less than EUR 5, and a high rate of receipt of alternative contributions. Each individual parameter from the table is discussed in greater detail in the subsections 2.1 and 2.2, below.

Table 2: Summary of status and prospects of project types in the study population according to share of expected annual emission reductions

Project type	Share of emission reductions from the study population under projects with the stated condition				
	Fully implemented	In regular operation	Planning conversion to an alternative programme	Able to continue verification & issuance with a CER price of less than EUR 5	Receiving alternative revenues or cost savings
Total	**86%**	**80%**	**22%**	**56%**	**77%**
Wind	91%	90%	23%	75%	82%
HFCs	78%	78%	-*	-*	-*
N_2O	84%	79%	15%	82%	4%
Adipic acid	*100%*	*100%*	-*	-*	-*
Nitric acid	*61%*	*49%*	-*	-*	-*
EE own generation	97%	92%	24%	39%	61%
Small hydro (<20 MW)	83%	82%	46%	48%	90%
Biomass energy	83%	72%	40%	21%	78%
Landfill gas	67%	57%	28%	33%	54%
Fossil fuel switch	100%	78%	0%	1%	88%
Coal bed/mine methane	86%	71%	14%	14%	75%
Methane avoidance	78%	49%	32%	34%	67%
Solar	75%	68%	40%	62%	78%
EE households	54%	50%	15%	13%	28%
Cement	75%	63%	44%	19%	100%
EE industry	80%	68%	28%	60%	94%

*Some data points are omitted from the table due to low data availability on these project types.

2.1 Implementation and operational status

Figure 1 and Figure 2 indicate that 86% and 80% of emission reduction potential from responding projects is accounted for by projects that report full implementation, and regular operation, respectively. As defined in the *Status Report*, implementation is considered as the implementation of the specific mitigation component of the activity included in the CDM project design document. For project types where the CDM mitigation component is only a part of the overall constructed facility or implemented alongside other emission reduction measures, only the implementation of the specific CDM component is assessed. Assessments of regular project operation assess the operational status of the CDM component of the GHG emission reduction activity for projects that are fully implemented. This relatively high rates of implementation and operation are largely due to the particularly high implementation and operational status of wind projects, which represent 35.5% of the emission reduction activity in the study population; in terms of expected emission reductions, only three of fourteen studied project types (own generation energy efficiency, wind and hydro) report above average rates of project operation.

The implementation and operational status of emission reduction activity as shown in Figure 1 and Figure 2 represents a 1.5 percentage point increase on the statistics presented relative simply to the quantity of projects (Warnecke et al. 2015, fig.6; fig.10), indicating that some larger projects, in terms of potential emission reductions, might be marginally more likely to have reached implementation and regular operation. In particular, the high rates of implementation of adipic acid projects, and some HFC projects, which on average are substantially larger than other CDM projects in terms of emission reductions, influence these results: adipic acid projects worldwide and HFC projects in China account for 0.2% of CDM projects in the study population, but 16% of potential emission reductions. Biomass energy projects in China also cause an upward trend: Chinese biomass projects are on average approximately three times larger than biomass projects elsewhere, even including India, and these projects have been significantly more successful than biomass energy projects in other countries. This upwards effect is mitigated in particular by below average rates of implementation and operation of new natural gas plants in India, and solar PV projects in Chile and South Africa, all of which are significantly larger on average in terms of expected emission reductions than similar projects in other countries.

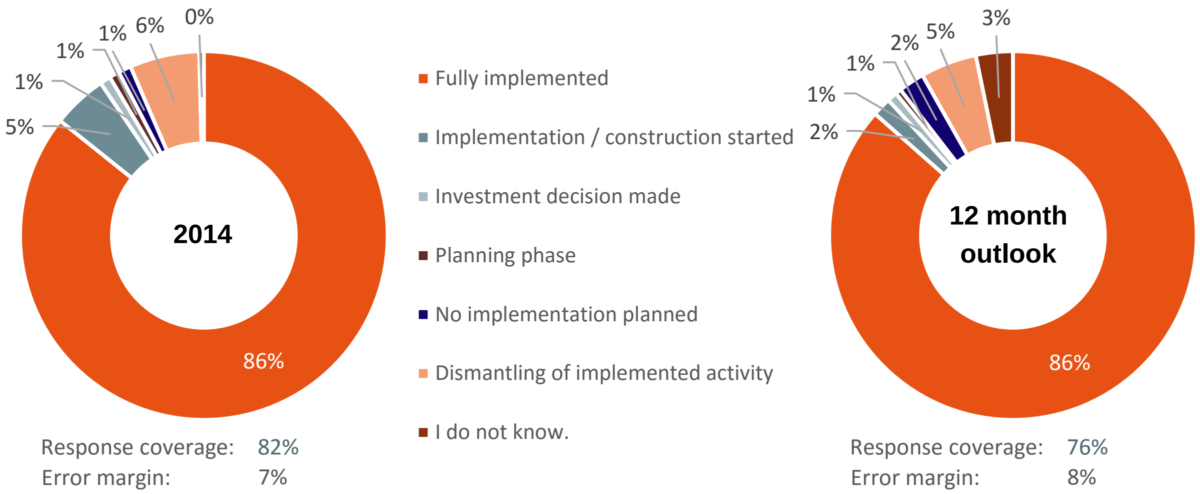

Figure 1: Implementation status of emission reduction activity under the CDM

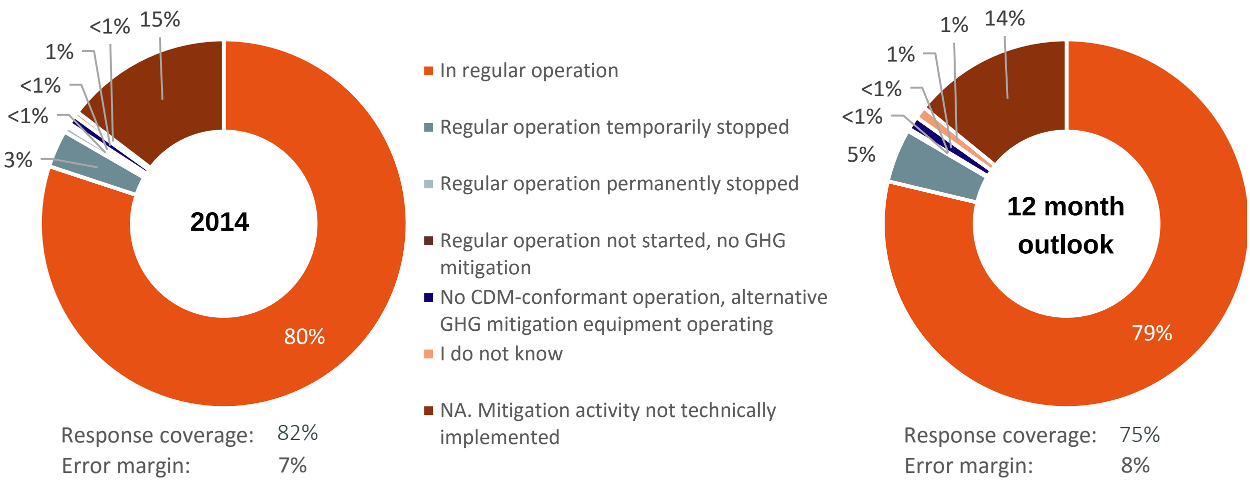

Figure 2: Operational status of emission reduction activity under the CDM

In the project evaluation conducted for the *Status Report*, not all projects in the sample were able to be evaluated: allowing for the 18% of emission reduction potential accounted for by projects for which no data could be obtained, it can be concluded that between 67% and 80% of the emission reduction potential under the CDM is accounted for by projects that report full implementation and regular operation. Analysis of non-evaluated projects in the *Status Report* indicates that the upper end of this range is more likely (Warnecke et al. 2015, chap.3.2.3).

The total potential for emission reductions of projects in the study population in 2014, according to the information from the most recent project design documents, was 589 MtCO_2e. At a first glance, the survey results would suggest that projects from the study population accounting for emission reductions of up to 474 MtCO_2e were in regular operation in 2014. In reality, the total volume of emission reductions that actually took place will be lower than this, since many projects which are considered to be operating their mitigation equipment will have generated lesser emission reductions than the anticipated potential indicated in the PDD due to operational issues. Further analysis into the quantification of the impact of CDM projects for emission reductions is given in section 3.

Figure 1 and Figure 2 also indicate that the 12 month outlook for the continuation of emission reduction activity is relatively stable: 86% of the emission reduction potential was expected to be still accounted for by implemented projects, whilst the proportion of emission reductions under projects in regular operation falls by just one percentage point, to 79%. This decrease is particularly small compared to the results relative to project numbers, which forecasts a four percentage point decrease in regular project operation, and indicates that many of those projects expecting to cease regular operation status are smaller projects that make only a marginal different on the results weighted to emission reduction volume.

It is noteworthy that the 12 month outlook varied considerably by region: the outlook for many Asian countries is a reduction in the rate of regular operation whilst the status quo is balanced by forecast increases in activity in other regions. In the main report we speculate that the forecasts in many non-Asian countries with less CDM experience may be unrealistic (Warnecke et al. 2015, chap.4.1); it is therefore reasonable to assume that the implementation and operational status of emission reduction activity under the CDM demonstrates at least a slight downward trend in the near future.

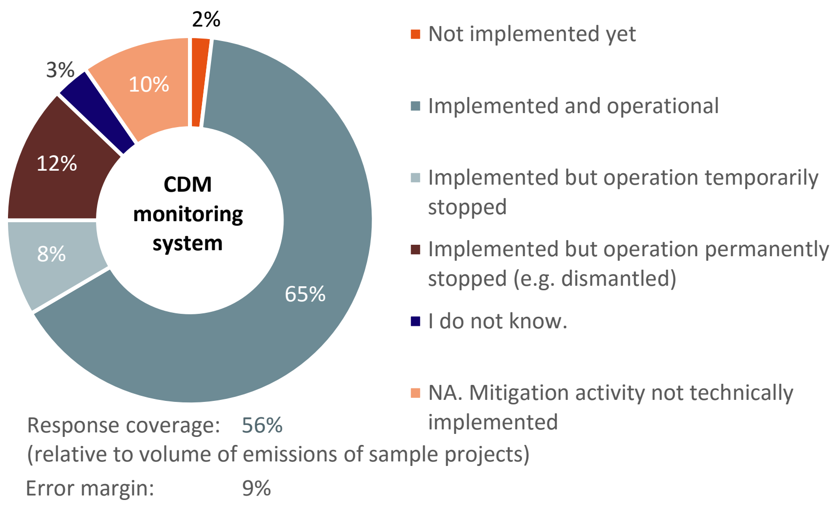

Figure 3: Status of the monitoring system of emission reduction activity under the CDM

Figure 3 shows that 65% of the potential emission reduction activity, according to project PDDs, under the CDM is accounted for by projects for which the CDM monitoring system remains implemented and operational. This is two percentage points lower than the results related to project numbers (Warnecke et al. 2015, fig.14), despite the fact that the emission reduction weighted results show a marginally higher rate of implementation and operation. This is an indication that larger projects might be less likely to be running their CDM monitoring systems despite being marginally more likely to continue operation.

2.2 Outlook indications

The following charts present indications for the outlook for emission reduction activity under the CDM in terms of the CER price level requirements for continuation of verification and issuance activities, receipt of alternative revenues or cost savings, plans for projects to convert to programmes outside of the CDM, and plans to cancel the CDM registration.

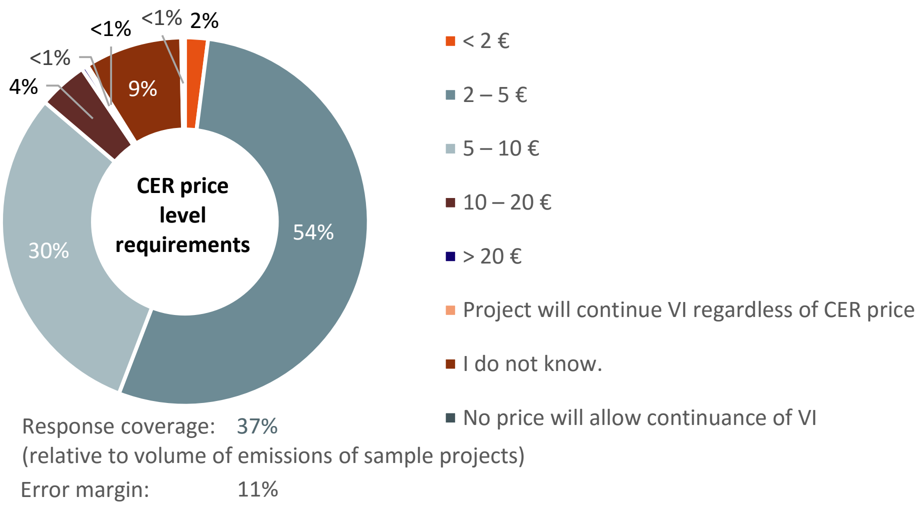

Figure 4: CER price level requirements for continuation of verification and issuance relative to volume of emission reductions

Figure 4 shows that approximately 56% of potential emission reduction activity would continue, or resume, verification and issuance activities at a CER price level of less than EUR 5. Furthermore, an additional 30% of potential emission reduction activity can be attributed to projects that would continue or resume verification and issuance activities with a CER price of under EUR 10. This result is slightly higher than the results relative to the number of projects presented in the main report: 53% under EUR 5 and 82% under EUR 10 (Warnecke et al. 2015, fig.28), indicating that larger projects with regards to emission reduction potential are more likely to report lower CER price requirements. Notably, the three most significant project types with regards to the volume of expected annual emission reductions – wind, HFCs and N_2O – are the three project types most likely to continue or resume verification and issuance activities with a CER price below EUR 5. As such, it can be conservatively estimated that an annual investment volume of less than EUR 1.6 billion would be required to reactivate an annual volume of 310 $MtCO_2e$ emission reductions to be verified and issued from these three project types in the study population. That the three largest project types are the most likely to continue with a CER price below EUR 5 represents a logical outcome since verification and issuance activities result in larger amounts of fixed costs, unrelated to the number of CERs, which have a smaller impact on CER price requirements when large CER volumes are verified. Monitoring and verification costs furthermore vary per technology. In contrast, some large potential emission reduction sources with very low proportions of projects able to continue below EUR 5 are fossil fuel switch, biomass energy, methane avoidance and landfill gas.

Price level requirements that projects have for continuation of V&I are also influenced by the potential receipt of alternative revenues or cost savings. Figure 5 shows that 77% of expected emission reductions are attributed to projects that report some level of contribution through revenues or cost savings, whilst for 18% the contributions are sufficient for continuous operation. The results differ from the results relative to the number of projects presented in the main report where only 50% of the projects report to benefit from insufficient additional revenues and an increased amount of 27% benefit from sufficient alternative revenues (Warnecke et al. 2015, fig.33), indicating that larger projects with regards to emission reduction potential are more likely to benefit from insufficient amounts of alternative revenues only. Wind projects, which account for 36% of emission reduction potential amongst the CDM population under study and likely have power purchase agreements signed, are amongst the project types that indicate to most likely benefit from alternative contributions. In contrast, industrial gas reduction projects (N_2O and HFCs), representing 22.1% of the total study population’s emission reductions, report only in very limited cases to benefit from alternative sources, which is in line with the study expectations.

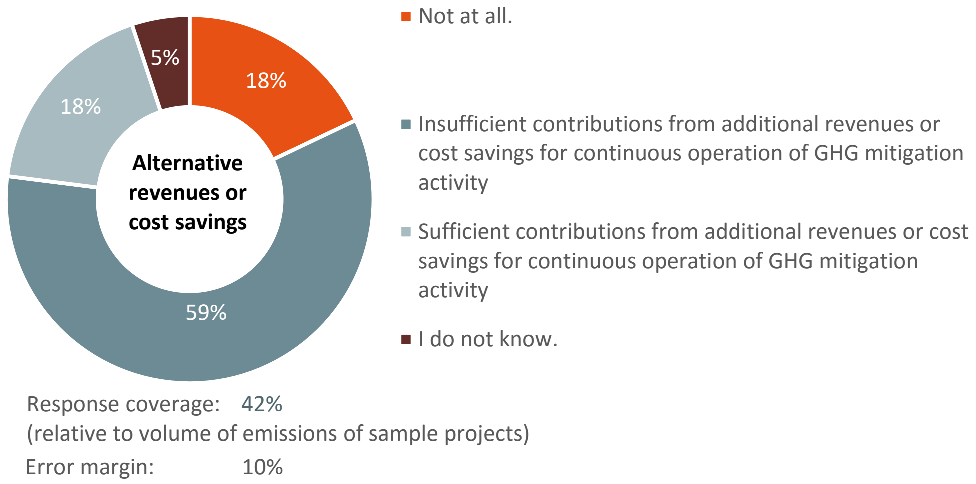

Figure 5: Receipt of alternative revenues or cost savings, relative to volume of emission reductions

Figure 6 gives an overview of the status of the CER marketing approach, based on the volume of potential emission reductions. Overall, 34% of potential emission reductions are covered by projects with ERPAs in place, although in the majority of cases the conditions of the ERPA are not sufficient for continuation of the project activity. 44% of potential emission reductions are accounted for by projects that indicate that attempts to market CERs have stopped, either temporarily or permanently. This overview provides a slightly more pessimistic outlook than the results relative to project number volumes (Warnecke et al. 2015 fig.19), where 36% of projects have valid ERPAs and 34% of projects have stopped attempts to market CERs. This variation is an indication that larger projects, relative to emission reduction potential, are less likely to have a valid ERPA in place, and more likely to have ceased attempts to marketing CERs.

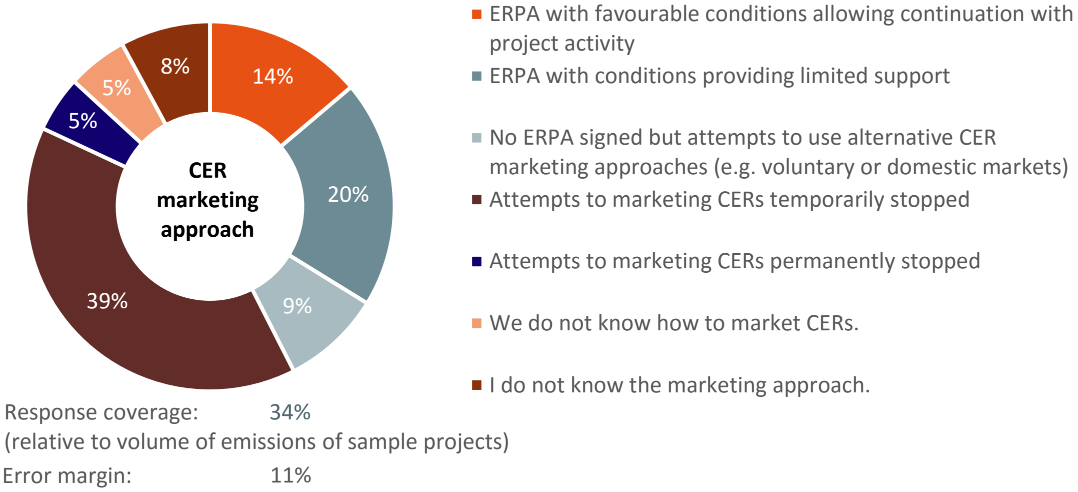

Figure 6: CER marketing approach of emission reduction activity under the CDM

Figure 7 shows that 22% of potential emission reduction activity under the CDM is accounted for by projects which plan to convert to alternative standards or mechanisms outside of the CDM. A large proportion of this volume is accounted for by projects in China that consider conversion to domestic schemes, namely China's Certified Emission Reduction (CCER) programme, attached to China's sub-national ETS. The proportion of emission activity accounted for by projects considering project conversion (22%) is considerably lower than the simple proportion of projects considering project conversion (31%) (Warnecke et al. 2015, fig.20), indicating that projects with a larger volume of emission reduction potential are less likely to seek project conversion.

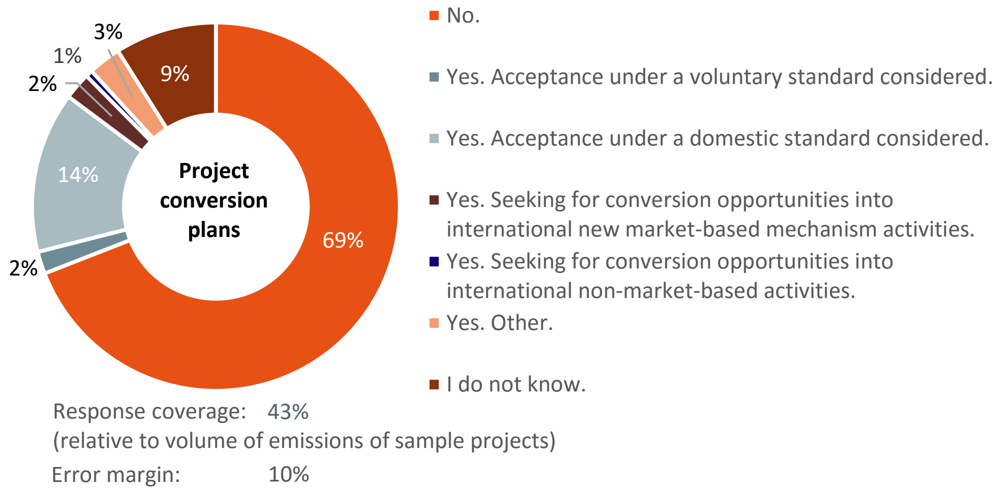

Figure 7: Project conversion plans relative to volume of emission reductions

In Warnecke et al (2015, fig.34), it was found that 26% of projects had already received a positive return on their investment, whilst 19% still expected to do so. Figure 8 shows these results relative to the volume of expected emission reductions, and indicates that larger projects were more likely to have fared well economically, since 35% of potential annual emission reductions are accounted for by projects which have already received a positive return on their initial investment and 17% still expect to do so.

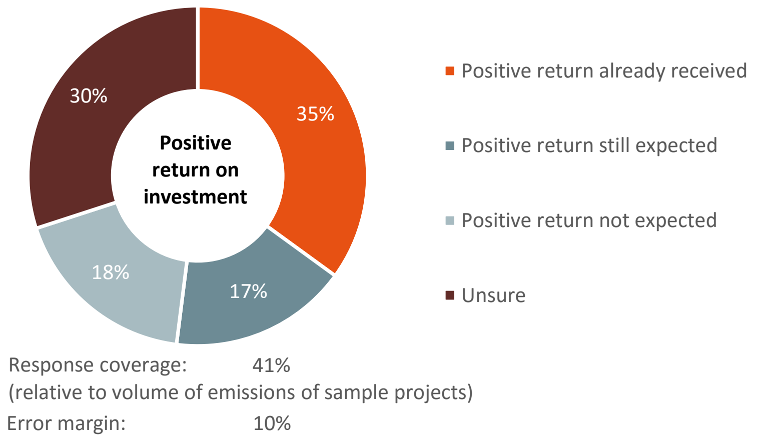

Figure 8: Return on investment status for emission reduction activity under the CDM

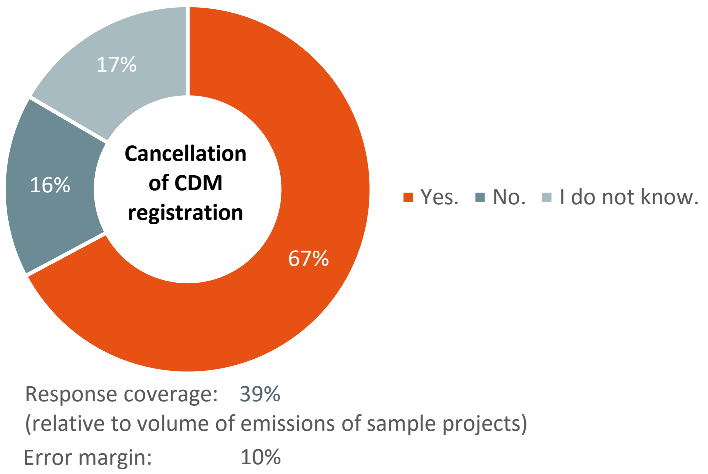

Figure 9: Projects considering cancellation of CDM registration, relative to volume of emission reductions

Figure 9 indicates that more than two thirds of emission reduction activity under the CDM can be attributed to projects that indicate they would consider a cancellation of their CDM registration if required to receive support or to convert to alternative programmes. That this proportion is significantly higher than the 56% of projects based on project numbers (Warnecke et al. 2015, fig.39), indicates that larger projects have a higher tendency to consider a cancellation of the CDM registration if this results in financial or other benefits. This may be a reflection that larger projects are more likely to have invested expensive assets and may be more business orientated. This interpretation is consistent with the insight that smaller projects reported more uncertainty about alternative options outside of the CDM, and were also more likely to report a support requirement for the identification of programmes and direct CER marketing opportunities.

3. Impacts of CDM projects

To date the absence of broad information on the status of individual CDM projects has resulted in difficulties to assess the ongoing impacts of CDM projects, as well as the specific conditions of the CER market. As a result, the best literature estimates for credit supply and credit demand are found as broad ranges (CDM EB 2015; World Bank 2014; Point Carbon 2012; UNFCCC 2015; Spalding-Fecher et al. 2012), with little certainty, whilst there is very little information available in the literature that distinguishes credit supply from actual emission reductions achieved.

Using the information obtained from the project level evaluation conducted under this research activity, this section will explore the impacts of CDM, with regards to three key indicators for which the calculation methodologies are explained in section 3.1:

- **Projected emission reductions:** this is an estimation of the actual emission reductions that will be achieved by CDM projects in the given year.
- **Projected credit supply:** this is the volume of emission reductions that take place in the given year which is considered likely to result in credit issuance either during the year or in subsequent years. Note that this is not equal to the credit issuance in the given year: credit issuance in a given year may include credits issued for emission reductions that took place in previous years, and some emission reductions achieved in 2014 may lead to credit issuance in subsequent years.
- **Projected net mitigation effect:** this is the difference between the projected emission reductions and the projected credit supply.

The analysis results presented in this section focus on the same CDM project study population addressed in section 2 and Warnecke et al. (2015). In some cases, the results are up-scaled to show an indication of the potential impact at the level of the CDM population (see section 1.3 for definitions). For each analysis point, scenarios are provided to show the results for 2014 and up to 2020 under different CER market price conditions. 2014 is taken as the starting point of the projections as this was the year in which the evaluation of projects' status and prospects took place.

3.1 Calculation methodology

Calculations are performed based on the data obtained in the extensive project survey conducted in the previous research activity combined with information from the UNEP DTU CDM Pipeline (UNEP DTU 2015) and the IGES CDM Project Database (IGES 2015). Figure 10 provides an overview of the major calculation steps, which are explained in detail below the figure.

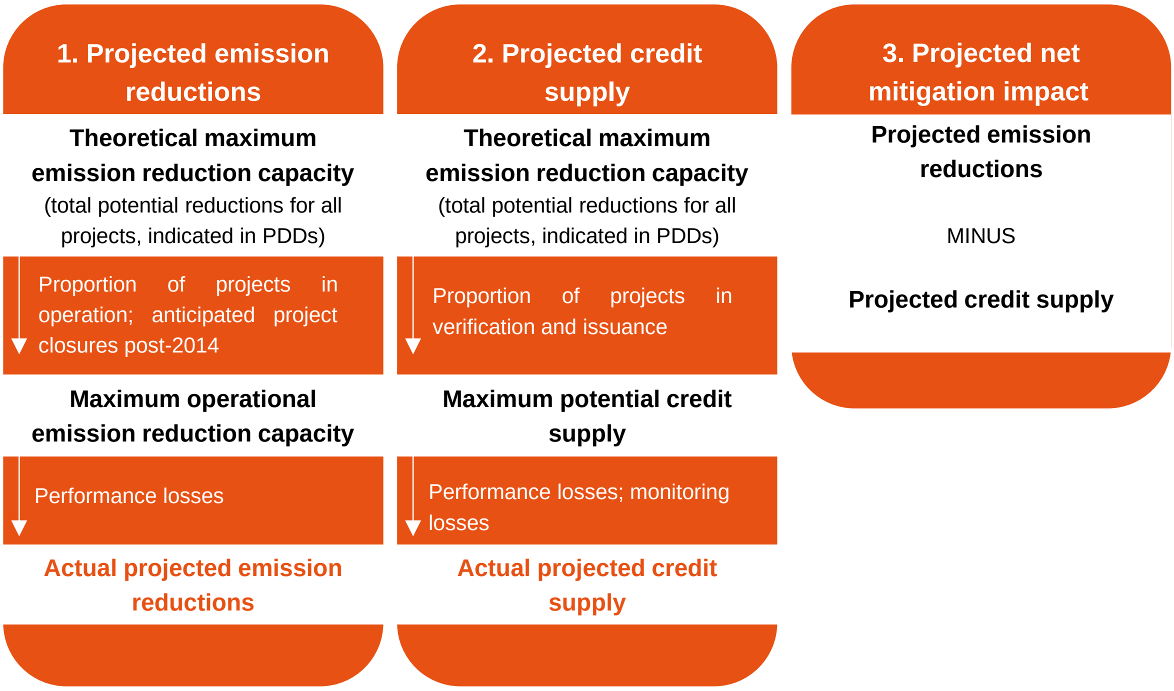

Figure 10: Overview of calculation steps for the key impact indicators

<u>Indicator 1: Projected emission reductions</u>

Projected emission reductions for the year 2014 and up to 2020 are calculated with the following steps:

1. The ***theoretical maximum emission reduction capacity*** is calculated based upon a summation of the expected annual emission reductions for each year given in PDDs, for all projects in the study population, regardless of their operational status. It is assumed for the theoretical maximum capacity that all projects renew their crediting periods as far as technically allowed, whilst the annual emission reductions remain the same as the average annual emission reductions posted in the most recent edit to the project design document. Updated information on the average annual emission reductions from the most recent crediting period was extracted from the September 2015 UNEP DTU CDM Pipeline (UNEP DTU 2015).

2. The ***maximum operating emission reduction capacity*** is calculated by adjusting the theoretical maximum emission reduction capacity according to the proportion of potential emission reductions accounted for by projects believed to be operating their GHG mitigation equipment (see calculation steps for *proportion of projects projected to be operating their GHG mitigation equipment* below). This is done based on the projected operation rates for each individual project type, and then scaled up to the population level. For years beyond 2014, the maximum operating emission reduction potential was adjusted according to the anticipated closure of project operation before or at the end of the current crediting period, based on project survey information. Where projects indicated that they would stop operating their GHG mitigation equipment before the end of the current crediting period, a linear decrease in operation activity, from the expected emission reductions in the project design document to zero, between 2014 and the date of the end of the crediting period, was assumed. This linear decrease is assumed in the absence of more clear information regarding the actual date when projects would be likely to cease operation. For projects where no data was obtained regarding plans for continuation of GHG mitigation after the end of the current credit period, the average outlook of responding projects for the specific project type was assumed.

3. The ***actual projected emission reductions*** is calculated by adjusting the maximum operating emission reduction capacity according to an assumed technical performance loss. This loss relates to project credit issuance success: data from the IGES database indicates that projects with issuance achieved on average 21% fewer credits than anticipated. This rate is understood to be attributable to both technical performance losses, where fewer emission reductions take place, and also losses caused by monitoring issues. In lieu of more guided information, a simplistic assumption is made that half of these losses are attributed to the former factor, and half to the latter. The adjustment in this step refers to the former factor. Data is adjusted on the level of project types based on the average technical performance losses of each individual project type, according to the IGES database (IGES 2015).

The ***proportion of projects projected to be operating their GHG mitigation equipment*** (required for the second step for calculating projected emission reductions, as described above) is calculated through the following criteria:

- The project operation status reported by projects directly during the evaluation conducted for the *Status Report* is taken directly. For projects reporting that the project is not in operation, this status is considered inaccurate and overruled in the case that either of the following two criteria are met.
- If the project is projected to be in regular verification and issuance (V&I), regular operation of the GHG mitigation equipment is assumed (see calculation steps for projects in V&I under indicator 2 below).
- If issuance took place since 2013, and the project does not report the dismantling of the project activity or the temporary or permanent cease of project operation, regular operation of the GHG mitigation equipment is assumed.

<u>Indicator 2: Projected credit supply</u>

The projected credit supply - the volume of emission reductions that take place in the given year which is considered likely to result in credit issuance either during the year or in subsequent years – is calculated through the following steps:

1. The ***theoretical maximum emission reduction capacity*** is calculated based upon a summation of the expected annual emission reductions for each year given in PDDs, for all projects in the study population, regardless of their operational status, as defined for indicator 1.
2. The ***theoretical maximum credit supply*** is calculated by adjusting the ***theoretical maximum emission reduction capacity,*** for the proportion of this capacity which is accounted for by ***projects projected to be in regular verification and issuance,*** (see calculation steps for *proportion of projects projected to be in regular verification and issuance* below).
3. The ***projected credit supply*** is calculated by adjusting the ***theoretical maximum credit supply*** for assumed performance and monitoring losses, based on the average issuance success rate for specific project types according to the IGES database (IGES 2015).

The ***proportion of projects projected to be in regular verification and issuance*** (required for the second step for calculating the proportion of operational projects, as described above) is calculated through the following criteria:

- If issuance took place since 2013, and the project does not report the dismantling of the project activity, the temporary or permanent cease of project operation, or the temporary or permanent dismantling of the monitoring equipment, regular verification and issuance is assumed. 2013 is taken as the year considered in this parameter, since it is considered that that this is a reasonable window for the last verification and issuance to have occurred for projects which are actively within this cycle.

- Negative outcomes from the first criteria, based upon the responses to the evaluation which took place in 2014, are overruled, if issuance took place in 2015 (the latest available indication of the project's issuance status) and the project indicated, in the evaluation conducted for the *Status Report*, a required CER price for continuation or resumption of V&I activities which is within the range of the scenario under study, regular verification and issuance is assumed. For projects where no required CER price was reported, the average price reported from the specific project type is applied.
- For projects with no issuance since 2013, if the project indicated a required CER price within the range of the scenario and the project does not report the dismantling of the project activity, the permanent cease of project operation, or the permanent dismantling of the monitoring equipment, regular verification and issuance is assumed.

Indicator 3: Projected net mitigation impact

The projected net mitigation impact is calculated as the difference between the projected emission reductions and the projected credit supply. The difference therefore relates to emission reductions which take place but are not credited and therefore not used to offset other emissions, generating an unintended net mitigation impact.

3.2 Projected emission reductions of CDM projects

This section presents the calculated projections for the first key indicator: *projected emission reductions* (see section 3.1 for definition and calculation methodology). There is little information available in the literature which assesses projected emission reductions which actually take place, since without a statistical overview of the proportion of projects in regular operation of the GHG emission reduction equipment, it is difficult to separate projections on the actual achieved emission reductions occurring at registered projects with the theoretical maximum emission reduction potential, which according to the data available from project design documents was approximately 1,016 $MtCO_2e$ in 2014. However, given the unconducive market conditions, some observers might have speculated that the actual emission reductions taking place at CDM projects may be much lower than the theoretical potential, due to the closure or adjustment of projects.

In terms of the *theoretical maximum emission reduction capacity*, defined in section 3.1, the study population represent 58% of the emission reduction potential of the entire CDM (see section 1.3 for group definitions). This is considerably less compared to the coverage of the CDM through the study population in terms of number of projects, which is >71% (Warnecke et al. 2015, chap.2.1). The difference indicates that our study population has covered an above average proportion of smaller projects, primarily due to the exclusion of large hydro projects above 20MW, which account for nearly 20% of potential annual emission reductions in the entire CDM.

1. Projected emission reductions	2014	
	Study population	Entire CDM (indicative)
Theoretical maximum emission reduction capacity (total potential reductions for all projects, indicated in PDDs)	**589 MtCO2e**	**1,016 MtCO2e**
↓ Proportion of projects in operation; anticipated project closures post-2014	Proportion in operation: 81.5%	Proportion in operation: 81.5%
Maximum operational emission reduction capacity	**480 MtCO2e**	**~ 830 MtCO2e**
↓ Performance losses	Performance losses (variable per project type)	Performance losses (variable per project type)
Actual projected emission reductions	**432 MtCO2e**	**~ 750 MtCO2e**

Figure 11: Overview of calculation steps for projected emission reductions

Figure 11 presents the calculation steps for *projected emission reductions* in 2014, both for the study population, and indicatively for the entire CDM. In greater detail, Table 3 presents projections for the *projected actual emission reductions* of registered projects from the study population up to 2020 under current market conditions.

Table 3: Projected emission reductions of the CDM project study population: current market conditions

Units: $MtCO_2e$ Data relative to the study population	2014	2015	2016	2017	2018	2019	2020	2015-2020	
								Total	Average
Projected emission reductions	**432**	**423**	**419**	**413**	**404**	**394**	**384**	**2,438**	**406**
Theoretical max capacity	589	582	579	572	561	547	533	3,375	562
% of max capacity achieved	73.4%							72.2%	

Table 3 shows that in 2014, *projected emission reductions* that actually took place are estimated at 73.4% of the *theoretical maximum emission reduction capacity* for the study population, reducing emissions at the project sites by a combined total of approximately 432 $MtCO_2e$. If the same rate of *projected emission reductions* would be assumed for project types outside of the study population, the total emission reductions of the entire CDM in 2014 (all registered projects) would have been in the order of 750 $MtCO_2e$.

It is apparent from Table 3 that the *projected emission reductions* from existing projects will decline in a relatively linear fashion up to 2020 under current market conditions. This decline is due to two factors: Most prominently, the *theoretical maximum emission reduction capacity* will decrease as a result of some projects reaching the end of their maximum crediting period durations. The gradient of the decline is conservative, since for the calculation of the *theoretical maximum capacity* it is assumed that all projects continue to renew their crediting periods up to the maximum allowable duration, which for the majority of projects was 21 years (3 times 7 years). The second factor for the decline in actual emission reductions is expectations for the temporary cease or permanent dismantling of project operation. The effect of this second factor in the projected decline is relatively marginal despite the very small proportion of projects that indicate they are able to sustain a working business model in current market conditions. Section 2 showed that less than 2% of the emissions reduction potential is accounted for by projects for which a CER price of less than EUR 2 is sufficient (current market conditions), although under current conditions 81% are still operating their emission reduction equipment. This insight provides an indication of the volume of CDM activity which continues purely as a result of irreversible sunk costs. Warnecke et al. (2015) found that a significant proportion of projects continue to operate not because they achieve a positive return on investment, but rather because to do otherwise would not incur any cost savings compared to the current situation. On average, over the period 2015-2020, the *projected actual emission reductions* of existing projects in the study population fall to just 72.2% of the theoretical maximum capacity, with average annual emission reductions in the order of 406 $MtCO_2e$, reaching a low of 384 $MtCO_2e$ in 2020. Assuming the same trend for project types outside of the study population, the total emission reductions of the CDM in 2020 would be in the order of 660 $MtCO_2e$. It should be noted that these calculations include only emission reductions from currently registered projects, and that new projects registered between 2015 and 2020 may increase the total emission reductions taking place.

In Table 4, the average annual *projected emission reductions* for the period from 2015 to 2020 are projected under five different market price scenarios. Market price scenarios are constructed through adjustments to the calculation variables explained in section 3.1, based upon the ways that projects are expected to react to different market situations according to the information collected from individual projects during the project evaluation conducted for the *Status Report*. The scenarios listed in the table assume that market conditions stabilise at the given CER price for the entire period between 2015 and 2020, and reports the average annual data across this period. Despite the decline in theoretical maximum emission reduction capacity, which is unaffected by the scenarios, all scenarios with a CER price of EUR 5 or higher show a projected increase in emission reductions from existing projects, compared to 2014. Notably, a modest recovery of the market CER price to EUR 2, does not result in a significant increase in projected emission reductions compared to the current market conditions scenario (BAU).

Table 4: Projected emission reductions of the CDM project study population: various scenarios

Units: $MtCO_2e$ Data relative to the study population	2014	2015-2020 (Average annual)				
		BAU	EUR 2	EUR 5	EUR 10	EUR 20
Projected emission reductions	**432**	**406**	**407**	**433**	**459**	**462**
Theoretical max capacity	589	562				
% of max capacity achieved	73.4%	69.8%	70.3%	75.6%	81.8%	84.5%

The rate at which projects meet their emission reduction potential varies considerably across project types. Table 5 shows that the rate of achievement of the theoretical max emission reduction capacity ranges from 37% for methane avoidance projects to 83% for wind and own generation energy efficiency projects.

Particularly low levels of emission reductions are projected from methane avoidance and household energy efficiency projects. These project types typically experience low levels of operation of the GHG mitigation equipment in the current situation, as discussed in Warnecke et al. (2015 Table 17).

The vast majority of projected emission reductions from the study population in 2014 comes from wind, HFC and N2O projects, which together account for more than half of all projected emission reductions.

Renewable energy projects in general report good performance in terms of the continuation of operation of the GHG mitigation activities, in line with the analysis from the main report that highlighted the positive prospects of project types with some degree of alternative revenues or cost savings (Warnecke et al. 2015, section 4.3 and Table 38). Particularly low levels of emission reductions are projected from methane avoidance and household energy efficiency projects. These particular project types typically experience low levels of operation of the GHG mitigation equipment in the current situation, as discussed in Warnecke et al. (2015, section 4.1). Although hydro projects represent only a modest volume of emission reductions in Table 5, this is due to only small hydro projects with a genarting capacity of below 20 MW being included in the study population. This is a notable difference from the entire CDM population, under which large hydro projects above 20 MW would likely be a major source of emission reductions.

Table 5: Projected emission reductions from project types: various scenarios

Units: $MtCO_2e$	Projected emission reductions 2014		Projected emission reductions 2015-2020 (Average annual)				
Project type	Emission reductions	% of theoretical max	BAU	EUR 2	EUR 5	EUR 10	EUR 20
Total study population	432	73%	406	407	433	459	462
Biomass energy	26	71%	24	23	24	28	28
Cement*	1	51%	1	1	1	1	1
Coal bed/mine methane	15	56%	15	15	15	20	20
EE households	2	40%	1	1	1	2	2
EE industry	2	61%	1	1	1	1	1
EE own generation	32	83%	28	28	29	29	29
Fossil fuel switch	19	67%	17	17	17	21	21
Small hydro (<20 MW)	30	76%	29	29	34	35	35
Landfill gas	17	50%	13	13	16	19	19
Methane avoidance	9	37%	8	8	8	11	12
N_2O	39	77%	40	40	41	41	41
HFCs*	62	78%	56	56	56	56	56
Solar	6	65%	6	7	8	9	9
Wind	174	83%	172	172	185	188	189

* Projections for HFCs and cement are omitted from the table due to low data availability on these project types.

3.3 Projected credit supply

This section presents the calculated projections for the second key indicator: *projected credit supply* (see section 3.1 for definition and calculation methodology). The indicator is not a projection of the actual issuance taking place in a given year, but rather the volume of emission reductions that take place in the given year which is considered likely to result in credit issuance either during the year or in subsequent years.

According to data presented in the public *CDM insights* statistics of the UNFCCC, updated August 2015, the maximum potential supply of credits from existing projects between 2015 and 2020, for emission reductions taking place during this period, is 3.24 billion CERs, or 648 million per year, excluding PoAs. Including potential issuance from emission reductions in previous years that were not yet issued, the potential supply is estimated to be as high as 1.28 billion CERs per year (UNFCCC 2015); an equivalent calculation for the maximum supply of potential credits including potential issuance from emission reductions in previous years that were not yet issued is not included in this focus study. Responses from the sampled projects in this research activity indicate that a large proportion of this estimated potential is unattainable, since only 65% of potential emission reductions are covered by projects which are operating their monitoring systems (cf. Figure 3). Furthermore, the analysis of this focus study for *projected credit supply* indicates that the likely supply of issued credits is far below the maximum potential, as indicated in the overview of calculation steps for this indicator in Figure 12 (see section 3.1 for full calculation methodology).

2. Projected credit supply	**2014**	
	Study population	**Entire CDM (indicative)**
Theoretical maximum emission reduction capacity (total potential reductions for all projects, indicated in PDDs)	**589 MtCO2e**	**1,016 MtCO2e**
Proportion of projects in verification and issuance	Proportion in V&I: 33.3%	Proportion in V&I: 33.3%
Maximum potential credit supply	**196 MtCO2e**	**~ 340 MtCO2e**
Performance losses; monitoring losses	Performance & monitoring losses (variable per type)	Performance & monitoring losses (variable per type)
Actual projected credit supply	**157 MtCO2e**	**~ 270 MtCO2e**

Figure 12: Overview of calculation steps for projected credit supply

Table 6 presents the results for the calculation of the *projected credit supply* indicator in greater detail, showing that that the average *projected credit supply* per year between 2015 and 2020 is 148 million CERs. If the same rate of issuance is assumed for the entire CDM then the average annual credit supply can be expected to be in the order of 270 million CERs. As per the *projected emission reductions* in section 3.2, it should be noted that these calculations include only *projected credit supply* from currently registered projects, and that new projects registered between 2015 and 2020 may increase the total. For comparison, the indicative figure given for annual credit supply for the entire CDM in 2014 – in the order of 270 million CERs – is in the same order of magnitude as many estimates for credit demand, although the estimates vary considerably from 77 million CERs per year (CDM EB 2015), to 205 million CERs per year (World Bank 2014), and 270 million CERs per year (Point Carbon 2012).

Table 6: Projected credit supply of the study population: current market conditions

Units: million CERs Data relative to the study population	2014	2015	2016	2017	2018	2019	2020	2015-2020	
								Total	Average
Projected credit issuance	**157**	**154**	**153**	**151**	**148**	**144**	**141**	**889**	**148**
Theoretical max capacity	589	582	579	572	561	547	533	3,375	562
% of max capacity issued	26.7%							26.4%	

The *projected credit supply* for the project types and countries included in the study population demonstrates a similar trend as the *projected emission reductions* up to 2020, under current market conditions. Table 6 shows that a linear decline is estimated at a rate only slightly greater than the decline of the *theoretical maximum capacity*. It is projected that 26.7% of the *theoretical max capacity* for 2014 will result in *credit supply* for 2014, with this rate falling to an average of 26.4% over the period from 2015 to 2020. As with the *projected emission reductions*, this is an indication that under current market conditions very few projects which are not currently in regular V&I will restart or begin these cycles, whilst only a moderate proportion of those currently in V&I cycles will stop doing so. The majority of this credit issuance is accounted for by projects for which, as discussed in section 3.2, there are no cost savings to achieve through a cease of operation, and for which the costs of V&I are sufficiently low to continue issuance at the current market price.

Table 7: Projected credit supply of the CDM project study population: various scenarios

Units: million CERs Data relative to the study population	2014	2015-2020 (Average annual)				
		BAU	EUR 2	EUR 5	EUR 10	EUR 20
Projected credit issuance	**157**	**148**	**150**	**327**	**405**	**411**
Theoretical max capacity	589	562				
% of max capacity issued	26.7%	26.4%	26.7%	58.1%	72.0%	73.2%

Table 7 presents the projection of credit issuance under the five scenarios for each major project type in the study population. The difference between project types is considerable; some project types, including household energy efficiency and solar report close to zero credit issuance, whilst N_2O and HFC projects are far above the population average, with projected issuance in 2014 of 66% and 78% of the theoretical maximum capacity, respectively.

For the outlook up to 2020, many project types follow the trend of reactivating V&I cycles at a credit price of EUR 5. However, significant increases in V&I activities at enhanced CER prices levels are not forecasted for HFCs and N_2O projects, which currently demonstrate a high level of credit issuance and appear to be near a maximum point. Existing projects for cement, industrial energy efficiency and household energy efficiency, which also show very low rates of issuance, are unlikely to see significant reactivation of V&I cycles at any credit price up to EUR 20. In contrast, wind projects show a major reactivation of issuance from the EUR 5 price level: wind projects are projected to account for 8% of credits under a continuation of current conditions, but 46% under a EUR 5 CER price scenario.

The projected credit issuance per project type is analysed in greater detail, and in comparison to the projected emission reductions, in section 3.4 which discusses the net climate change mitigation impacts.

Table 8: Projected credit issuance from project types: various scenarios

Units: million CERs	Projected credit supply 2014		Projected credit supply 2015-2020 (Average annual)				
Project type	Credit issuance	% of theoretical max	BAU	EUR 2	EUR 5	EUR 10	EUR 20
Total study population	157	27%	148	150	327	405	411
Biomass energy	8	23%	8	8	9	24	25
Cement*	1	30%	0	0	0	0	0
Coal bed/mine methane	5	20%	5	5	7	14	14
EE households	0	0%	0	0	0	1	1
EE industry	1	25%	1	1	1	1	1
EE own generation	13	32%	11	11	21	25	26
Fossil fuel switch	11	38%	10	10	10	18	18
Hydro	9	23%	9	9	27	31	32
Landfill gas	8	23%	6	6	9	13	14
Methane avoidance	1	6%	1	1	3	6	7
N_2O	33	66%	34	34	38	38	38
HFCs*	62	78%	56	56	56	56	56
Solar	0	0%	0	1	8	9	9
Wind	13	6%	12	12	152	171	172

* Projections for HFCs and cement are omitted from the table due to low data availability on these project types.

3.4 Net climate change mitigation impact

This section presents the calculated projections for the third key indicator: *projected net mitigation impact*, based on comparatively analyses the results presented in sections 3.2 and 0 to discuss the key research question regarding the net mitigation impact of the CDM. A comparative analysis of the results presented can estimate **what is the annual net mitigation achieved by the CDM** in the current situation, and **what the annual net mitigation impact could be up to 2020** under the various price scenarios.

The hypothesis mooted in section1.2, was that the actual annual net mitigation impact from the CDM in the current situation may be significant and larger than initially assumed, due to the high share of projects that continue to operate their mitigation equipment but have irreversibly left the CDM.

3. Projected net mitigation impact	2014	
	Study population	Entire CDM (indicative)
Projected emission reductions	**432 MtCO2e**	**750 MtCO2e**
MINUS	MINUS	MINUS
Projected credit supply	**157 MtCO2e**	**270 MtCO2e**
	275 MtCO2e	**480 MtCO2e**

Figure 13: Overview of calculation steps for net mitigation impact

Table 9 shows the projected net mitigation impact of registered CDM projects in the study population. The net mitigation effect for these purposes is defined as the *projected emission reductions* for which no credit issuance takes place. As Table 9 indicates, 63.7% of *projected emission reductions* from the study population in 2014 is estimated to be non-credited and therefore a *net mitigation impact*. This is a very large proportion, considering that the CDM was not designed to be an instrument for achieving net mitigation. If this rate is also assumed for project types not included in the study population, **the annual net mitigation impact of the entire CDM in 2014 could have been in the order of 480 MtCO$_2$e, and might have reduced global emissions by approximately 1% in 2014**.

Table 9: Projected net mitigation impact of the CDM project study population: current market conditions

Units: MtCO$_2$e Data relative to the study population	2014	2015	2016	2017	2018	2019	2020	2015-2020	
								Total	Average
Projected net mitigation impact	**275**	**269**	**267**	**262**	**257**	**250**	**244**	**1,549**	**258**
% of projected emission reductions	63.7%							63.5%	

Table 9 also shows that the net mitigation impact of existing CDM projects is projected to decline up to 2020 under current market conditions. This decline is proportional to the decline in the theoretical maximum emissions reduction potential and the projected actual emission reductions as discussed in section 3.2, as well as the decline of projected credit issuance discussed in section 3.3. As such, the proportion of emission reductions that can be considered a net mitigation impact does not change significantly up to 2020 under a scenario that assumes the continuation of current market conditions. As for the previous indicators, the calculations do not include projects that may be registered between 2015 and 2020, and which will add to the *projected emission reductions* and *projected credit supply*.

Table 10: Projected net mitigation impact of the CDM project study population: various scenarios

Units: MtCO$_2$e Data relative to the study population	2014	2015-2020 (Average annual)				
		BAU	EUR 2	EUR 5	EUR 10	EUR 20
Projected net mitigation impact	**275**	**258**	**257**	**106**	**54**	**51**
% of projected emission reductions	63.7%	63.5%	63.2%	24.5%	11.7%	11.1%

Table 10 shows how the *projected net mitigation impact* up to 2020 is affected by CER market price scenarios. No significant difference in the net mitigation impact is projected for scenarios with low CER market prices. The projections for a price of EUR 2 deviate by less than one percentage point from the scenario with the continuation of current market conditions. This is a reflection of both the limited change in projected credit issuance and the actual emission reductions between these scenarios. However, a major decrease in the net mitigation impact is projected for scenarios with moderate and higher CER prices. At a price level of EUR 5, the net mitigation impact decreases from approximately 63% of total projected emission reductions to approximately 25%, decreasing further to 11% under scenarios with higher prices. This considerable decrease in the net mitigation impact is due to the large rate of reactivation of V&I cycles at these price points (Table 7), despite only a very slight increase in projected emission reductions (Table 3).

In Table 11, the net mitigation impact is examined at the project type level. Whilst most project types follow the general trend, there are some notable exceptions. In particular, the net mitigation impact from wind projects is very large at 93% of emission reductions, but is also particularly responsive to price changes, reducing to 9% under a CER price of EUR 20. Solar projects also report a similar responsive trend at higher CER prices.

Table 11: Projected net mitigation impact from project types: various scenarios

Units: $MtCO_2e$ Project type	2014	2015-2020 (Average annual)				
		BAU	EUR 2	EUR 5	EUR 10	EUR 20
Total study population	275 (64%)	258 (64%)	257 (63%)	106 (25%)	54 (12%)	51 (11%)
Biomass energy	18 (68%)	16 (68%)	15 (67%)	14 (61%)	4 (13%)	4 (13%)
Cement	-	-	-	-	-	-
Coal bed/mine methane	10 (64%)	10 64%)	10 64%)	9 (57%)	6 (29%)	6 (29%)
EE households	2 (100%)	1 (100%)	1 (100%)	1 (93%)	0 (28%)	0 (24%)
EE industry	1 (59%)	1 (59%)	1 (58%)	0 (18%)	0 (18%)	0 (18%)
EE own generation	20 (61%)	17 (61%)	17 (60%)	8 (27%)	4 (14%)	4 (12%)
Fossil fuel switch	8 (43%)	7 (43%)	7 (43%)	7 (42%)	4 (18%)	4 (18%)
Hydro	21 (69%)	20 (69%)	20 (68%)	7 (22%)	4 (11%)	3 (9%)
Landfill gas	9 (54%)	7 (54%)	7 (55%)	8 (47%)	5 (29%)	5 (28%)
Methane avoidance	8 (84%)	7 (84%)	7 (83%)	5 (62%)	5 (47%)	5 (43%)
N_2O	6 (15%)	6 (15%)	6 (14%)	3 (8%)	2 (6%)	2 (6%)
HFCs	-	-	-	-	-	-
Solar	6 (100%)	6 (100%)	6 (83%)	1 (8%)	0 (4%)	0 (2%)
Wind	161 (93%)	160 (93%)	160 (93%)	33 (18%)	17 (9%)	17 (9%)

Cement and HFCs are omitted from the table due to insufficient response data.

4. Summary and conclusions

The findings presented in this focus study offer new insights into the current and projected impacts of the CDM up to 2020, with regards to the amount of climate change mitigation activity in regular operation under the CDM, the projected supply of CERs under various market scenarios, and the extent of the emergence of an unintended net-mitigation impact, caused by projects in regular operation of their mitigation equipment who do not issue credits.

In ***section 1.2***, two hypotheses were presented for quantitative assessment:

Hypothesis 1: *A large share of projected emission reductions in the CDM up to 2020 are generated by projects that do neither at present nor in the future engage in verification and issuance cycles under the current market conditions.*

This hypothesis was presented to investigate what proportion of CDM projects continue to operate their mitigation equipment, and what proportion of this activity can be counted as a net mitigation impact.

Hypothesis 2: *Due to the amount of emission reduction activity from CDM projects that does not lead to verification and issuance of credits (cf. hypothesis 1), the actual difference between the supply and demand of offset units on the international market may be considerably smaller than widely assumed.*

This hypothesis allows to investigate the trends for credit supply and demand projections, with implications for potential market recovery scenarios.

According to the results presented in ***section 2*** and ***section 3***, it is judged that both are these hypotheses can be accepted as an accurate portrayal of the present situation. The supporting arguments are summarised in the following conclusions:

Over 73% of the theoretical maximum emission reduction capacity in 2014 is estimated to have occurred. We find that between 67% and 80% of potential emission reductions from the sampled population occur at projects that report continued regular operation of the GHG emission abatement equipment, with the upper end of the range more likely. Assuming the top end of this range, a seven percentage point decrease in actual emission reductions is estimated through bottom-up adjustments from the project type level, according to average technical performance losses included in issuance success rates. If the same trend would hold for project types outside of the sampled population, **the total emission reductions of the CDM in 2014 would be in the order of 750 MtCO_2e**.

A marginal downward trend of emission reductions for currently registered CDM projects is projected up to 2020 under current market conditions. Survey data shows that the outlook for emission reduction volumes in the 12 months following the evaluation period appeared relatively stable. However, this is judged to be slightly over-optimistic due to considerable regional variations and especially optimistic outlooks in regions with less CDM experience. This judgement is consistent with our bottom-up calculations that project the changes in actual emission reductions according to the ending of crediting periods and information on project outlooks provided by project participants directly. Actual emission reductions are expected to decrease by a rate of slightly less than 2% per year up to 2020, although this will still represent 72% of the theoretical maximum emission reductions in 2020. If the same trend would hold for project types outside of the sampled population, **the total emission reductions of currently registered projects in the CDM in 2020 would be in the order of 640 MtCO_2e**. Including new projects potentially registered from 2015 onwards, which are excluded in this focus study, would lead to higher projections.

An estimated 27% of theoretical maximum emission reductions in 2014 may lead to credit issuance, either in 2014 or in subsequent years. If this trend would hold for project types outside of the sampled population**, credit supply from CDM emission reductions in 2014 could be in the order of 270 million CERs.** This deviates from the actual issuance in 2014, of 102 million CERs, which includes issuance for emission reductions taking place in previous years and also does not include emission reductions taking place in 2014 which are likely to be credit in subsequent years (UNFCCC 2015). The projected credit supply is considerably lower than widely acknowledged maximum supply potentials of an average 640 million CERs per year (UNFCCC 2015). Furthermore, under current market conditions, credit issuance is projected to decrease marginally up to 2020, at a rate of approximately 1.7% per year.

The annual net mitigation impact of the CDM in 2014 could be in the order of 480 MtCO_2e, and might have reduced global emissions by approximately 1% in 2014. Since the rate of estimated issuance is far lower than the rate of projected achieved emission reductions, a substantial net mitigation impact is observed in 2014. Approximately 64% of achieved emission reductions under the CDM are estimated to generate a net mitigation effect. This is an enormous proportion for a 'net zero' mechanism, and represents a significant proportion of global GHG emissions. This effect is mostly attributed to projects where operation continues since the sunk costs are irreversible and ceasing the activity does not result in cost savings, whilst the CER price is not sufficient to cover costs associated with verification and issuance. This impact in unintended and undesirable, as stated in ***section 1***, largely due to the major opportunity cost it represents in the alienation of disenfranchised private investors. Under a continuation of current market conditions the net mitigation impact is projected to decrease marginally in absolute terms, at a rate of approximately 1.9% per year, but will remain relatively stable as a share of total CDM project emission reduction activity.

Modest demand increases may drive a market recovery to a CER price of EUR 2. The very little proportion of projects that would be reactivated to continue V&I cycles in the case of a market price of EUR 2 according to our survey data is a clear indication that a price recovery to this level may be realistically achievable with only modest increases in demand. The supply of credits in this scenario within the project types included in this study population increase by just 1.4% from 148 million CERs to 150 million CERs. The direct tangible mitigation impacts projected for this scenario are limited, if not insignificant: projected emissions reductions increase by just 0.2% compared to the current conditions scenario, and the net mitigation impact remains also relatively constant. However, although the impact of a small market price recovery would have limited consequences for the impacts of existing projects, achieving a recovery to a market price of EUR 2 would be a small development for recovery of trust in market mechanisms and carbon pricing signals, amongst policy makers as well as potential private sector investors[1].

A CER price of EUR 5 would require substantial increases in demand, or non-market interventions. This price level would only marginally increase projected emission reductions from currently registered projects, although emission reductions could be increased by potentially newly registered projects. Compared to the little variation between a continuation of current conditions and the EUR 2 scenario, there is an extreme elasticity of supply between the EUR 2 and EUR 5 scenarios. Between these two scenarios, the potential annual supply of credits increases by more than double, to 327 million CERs for the study population, or 545 million CERs for the CDM as a whole if the same rate of issuance is assumed for project types not included in the study. The large elasticity of supply observed between these two scenarios indicates that efforts to recover to a market price of EUR 5 would require very substantial increases in demand, or non-market interventions. A recovery of the CER price to EUR 5 is projected to have only limited

[1] It should be noted that the EUR 2 CER price scenario may be the scenario most prone to potential reliability issues. Survey respondents might have felt less inclined to indicate that EUR 2 was a sufficient price to recommence or continue V&I cycles; Figure 4 showed that just 2% of emission reductions were accounted to projects that indicated an ability to recommence V&I operations at a price level of EUR 2, although it is expected that this might be slightly larger in reality.

consequences for increasing emission reductions of currently registered projects, which are projected to increase by 6% compared to the EUR 2 scenario. This is only a very small increase compared to the 108% increase in credit issuance, and this has the effect to reduce the unintended net mitigation impact by more than one half compared to the EUR 2 scenario. However, Warnecke et al (2013) indicates a number of potential new projects could be likely to develop and/or re-enter the market at this price, significantly increasing the total emission reductions including these new projects.

CER prices in excess of EUR 5 could restore market confidence by significantly reducing the gap between the volume emission reductions taking place and the volume of credit issuance that is viable. At price levels above EUR 5, projected credit issuance continues to increase significantly, whilst the increase in the projected emission reductions is only very slight. As such, the net mitigation drops off to 11% of emissions for a EUR 20 price scenario. At this price level, emission reductions under existing CDM projects would increase to up to 84% of the theoretical maximum emissions reduction capacity. The reduction in the net mitigation impact would also generate a significantly positive impact in terms of restoring trust from private investors for investments in climate change mitigation activities.

Using previously unavailable information on the directly reported status and prospects of a study population that includes the majority of the CDM, this focus study has provided more insight into a gap of understanding for the CDM, regarding the actual emission reductions that take place, the proportion of which is not credited and subsequently a net-mitigation impact, and the prospects for these indicators for currently registered projects up to 2020 under various CER price level scenarios. The quantification is subject to a number of limitations due to the manifold assumptions required, as discussed in the methodology in section 3.1. Further study could deepen the insights provided here by analysing in finer detail the projections for these indicators at various price levels between EUR 1 and EUR 5; the differences that occur between this range are substantial and the limited price points analysed by this focus study within this range is a limitation, allowing for general insights on potential trends, but not allowing to directly inform policy implications with detailed and accurate information under more refined scenarios. Furthermore, the analysis here could be further supplemented by establishing a more coherent picture on the likely volume of new projects to develop and enter the market under various price scenarios. Such an analysis would have key implications for both domestic policy planning and for the potential role that market mechanisms can play in the frameworks constructed around future international climate change agreements.

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