Vulnerability of CDM Projects for Discontinuation of Mitigation Activities

Assessment of Project Vulnerability and Options to Support Continued Mitigation

Executive Summary

Umwelt Bundesamt

DEHSt
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Editorial information

For the full methodological details and analysis behind this work, please consult the full report, available from https://www.dehst.de/EN/carrying-out-climate-projects/project-mechanisms/clean-development-mechanism-cdm/clean-development-mechanism-cdm-node.html

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Introduction

Despite its previous successes and achievements, the global carbon market finds itself currently in a critical and uncertain period. The large number of mitigation activities initiated through the two most important project based carbon market mechanisms - the Clean Development Mechanism (CDM) and Joint Implementation (JI) - has led to an increasing supply of emission reduction credits, which in recent years has superseded the demand for such credits. Demand has tailed off considerably due to the global economic crisis, a stronger focus on domestic mitigation action, criticisms with regard to transaction costs and environmental integrity of the mechanisms, as well as the time lag in concluding a new major international climate change agreement with a clearly defined role for flexibility mechanisms not before 2012 as formerly planed but only in 2015. The discourse between supply and demand has had a dramatic effect on the price of CDM and JI credits, which has plummeted in recent years. This market price collapse, amongst other challenges, has consequences for market and investor confidence, current actors in the market mechanisms, and future potential uses for international market mechanisms.

Recent analysis from NewClimate Institute shows that the large majority of CDM projects continued to operate their mitigation activities in 2014, although the majority no longer had a financial incentive to invest in verification and issuance of credits (Warnecke et al. 2015). Therefore, most of these projects operate without the support of market mechanism finance, whereas there is a considerable risk of project discontinuation for specific project types.

Article 6 of the Paris Agreement establishes a new framework for international carbon market mechanisms. However, considerable uncertainty remains how many countries will use international project based credits both before and beyond 2020, and whether already implemented mitigation activities will be supported.

Research Objectives

This study forms part of a broader project, commissioned by the German Emissions Trading Authority (DEHSt) at the German Environment Agency (Umweltbundesamt, UBA), with the primary objective to analyse the current situation and development of the international carbon markets.

This report address three key research questions:

(1) To what extent are different types of existing CDM projects at risk of discontinuing GHG abatement?
(2) What is the potential GHG abatement impact, compared to the current status quo, of supporting the continuation of GHG abatement of these projects?
(3) What are options to ensure the short- and long-term continuation of existing CDM projects that are at risk of discontinuing GHG abatement?

The results of this research project have high relevance for policy makers aiming to close the pre-2020 mitigation gap by supporting existing CDM projects as well as for international negotiations on international market-based mechanisms under the Paris Agreement. This report offers new insight on what may be the implications of supporting existing CDM projects through national policies or international climate finance, Through the identification of which project types are vulnerable of discontinuing GHG abatement and the identification of suitable options for ensuring their continuation, this report is relevant for those interested in the status of existing CDM projects and in the design of support schemes for pre-2020 mitigation action.

Overview of Project Vulnerability

A methodology was developed for the assessment of the vulnerability of existing CDM projects for the discontinuation of GHG emission abatement. The methodology employs a systematic approach to assess the likelihood of project continuation, for any given project, based upon applicable laws and regulations, economic benefits and costs, barriers and other conditions. The assessment of vulnerability of project discontinuation takes as a starting point the assumption that the project owners do not have any CER revenues, which is a reality for many projects under current market conditions. The assessment of project discontinuation vulnerability considers only the situation of projects at the current point in time.

Whether the economic conditions favour continuation of the activity or not in the absence of CERs at the present time is not in any way a reflection or even an indication of the additionality of projects at the point of their inception. Furthermore, it needs to be considered that the additionality demonstration does not only contain financial analyses but also takes into account other barriers preventing the project implementation like investment or technological constraints.

The methodology is illustrated in the stepped decision chart in Figure 1.

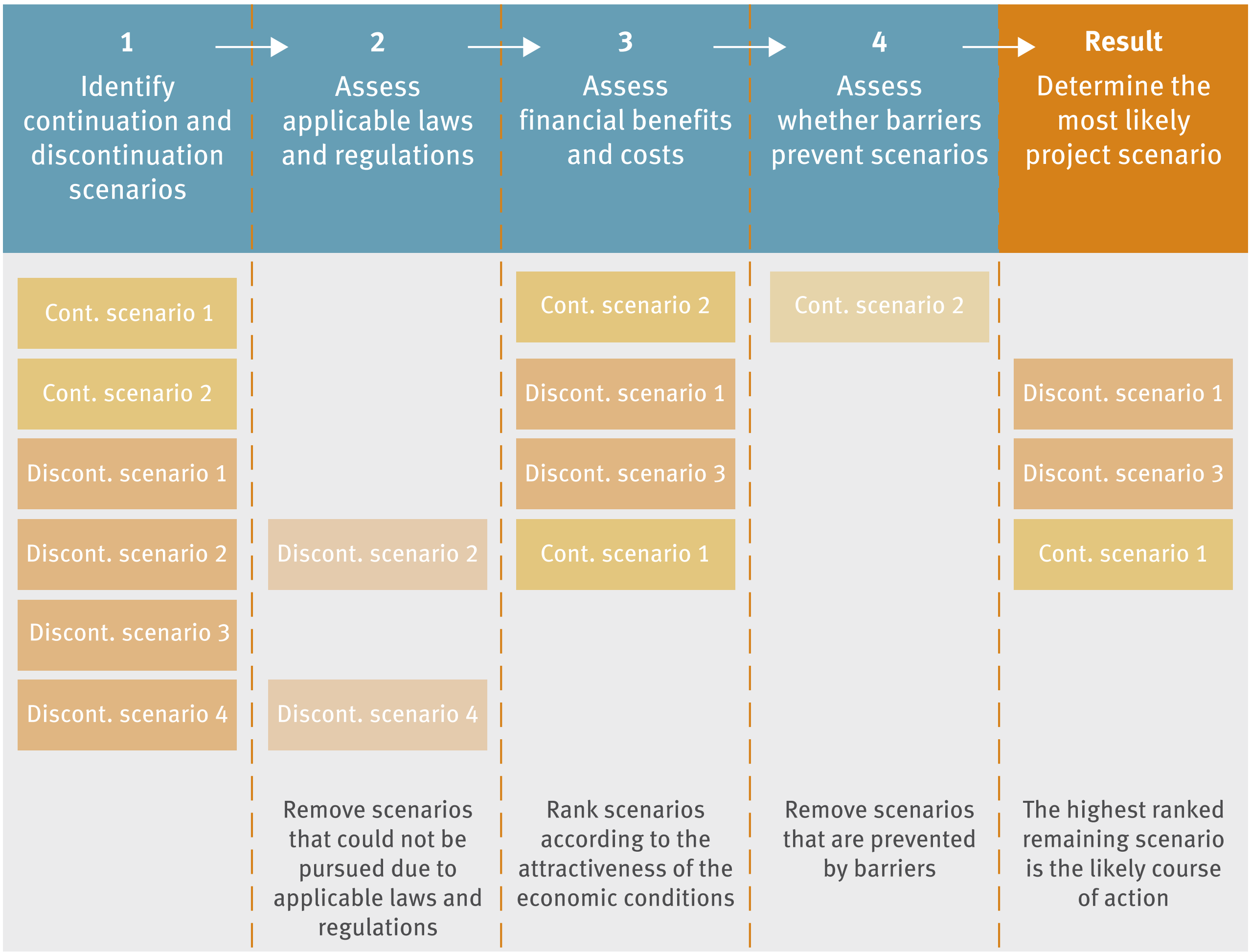

Figure 1: Decision chart used for the assessment of the risk that different CDM project types stop GHG abatement. Source: Author, based on Schneider & Cames (2014)

The methodology is applied to categories of project types and their typical conditions, rather than to individual projects. The findings are likely to hold for most of the projects in the categories, but individual projects may face different conditions and may hence have a different vulnerability for project discontinuation. This assessment methodology was broadly applied to all major project types, before specific project types within specific countries were selected for more detailed analysis. An overview of the results from the initial assessment is given in Table 1.

Based on the results of the initial assessment for all major project types, summarised in Table 1, three major project types with uncertain vulnerability and particular relevance for mitigation and sustainable development impacts – methane avoidance, biomass energy, household energy efficiency – were selected for further analysis. Focus countries were selected for their numbers of CDM projects, their importance for the specific project types analysed, the estimated information and data availability, and considerations on optimum geographic representation.

Table 1: Initial assessment of project discontinuation vulnerability for all major project types

Project type *Including a description of subproject types where appropriate (this does not include an exhaustive list of included subtypes)*	**Registered projects** (inc. PoA CPAs) **No.**	**%**	**Abatement potential 2013-2020 (CO_2e)*** **M t**	**%**	**Project vulnerability (initial assessment)**
Biomass energy Use of biomass-based fuels, such as agricultural and forestry residues, biogas and biodiesel, for energy generation	684	8.0 %	326	4.3 %	**Variable** according to subtype and local conditions
Coal mine / bed methane Treatment and/or utilisation of methane from coal mines, including ventilation air methane	86	1.0 %	295	3.9 %	**Low:** Financial benefits for power generation often exceed operational expenditures (OPEX)
EE households Lighting, stoves and appliances	417	4.9 %	122	1.6 %	**Variable** according to subtype and local conditions
EE industry Efficiency improvement in industrial plant processes	100	1.2 %	23	0.3 %	**Low:** Significant cost savings with no or low additional OPEX
EE own generation Use of process wastes for heat or energy generation	316	3.7 %	309	4.0 %	**Low:** Significant cost savings with no or low additional OPEX
EE supply side Efficiency improvements of existing energy generation facilities incl. fossil fuel plants, cogeneration and combined cycle projects	70	0.8 %	199	2.6 %	**Low:** Significant cost savings with no or low additional OPEX
Forests Afforestation, reforestation, mangroves and agroforestry	57	0.7 %	20	0.3 %	**Low-Medium** according to capacity of owner and local legislation
Fossil fuel switch New natural gas plants and switch from oil to natural gas	104	1.2 %	390	5.1 %	**Low-Medium** according to project subtype and global fuel markets
Fugitive Treatment of fugitive gases from oil and gas production	47	0.6 %	183	2.4 %	**Variable** according to project subtype
Geothermal	34	0.4 %	73	1.0 %	**Low:** Significant revenues and very low OPEX
HFCs Treatment of HFC23 waste gases	22	0.3 %	604	7.9 %	**High:** OPEX incurred yet no significant financial benefits
Hydro	2,152	25.2 %	1,974	25.8 %	**Low:** Significant revenues and very low OPEX
Landfill gas Treatment of landfill gas and municipal solid waste including flaring and power generation activities	382	4.5 %	405	5.3 %	**Variable** according to subtype and local conditions
Methane avoidance Avoidance, treatment and utilisation of methane from manure, wastewater, palm oil waste and composting	792	9.3 %	197	2.6 %	**Variable** according to subtype and utilisation of wastes and methane
N_2O Decomposition of N_2O from nitric and adipic acid production	104	1.2 %	467	6.1 %	**High:** Incurs OPEX but no or very low financial benefits

PFCs+SF$_6$ Avoidance, treatment or recycling PFC and SF$_6$ gases	15	0.2 %	38	0.5 %	**Low (AM78)-High (AM35/65):** No revenues but additio-nal OPEX for projects using methodologies AM35/AM65
Solar Solar PV, solar thermal and solar water heating	509	6.0 %	131	1.7 %	**Low:** Non-CER revenues usually greater than OPEX
Wind	2,480	29.1 %	1,775	23.2 %	**Low:** Significant revenues and very low operating expenditures
Total	**8,371**	**98.1 %**	**7,529**	**98.5 %**	

*Accumulated expected GHG emission reductions 2013-2020 according to PDD information (UNEP DTU 2016).

Methane Avoidance

Methane avoidance includes a variety of project types. Three major sub-types were assessed in detail: commercial livestock manure management; wastewater; and palm oil solid waste composting.

Commercial livestock manure management

Summary of activity	Management of manure produced by commercially reared livestock, resulting in production of biogas, with flaring and/or utilisation.
Countries analysed	Thailand, Mexico and Brazil

Risk of discontinuation of mitigation activity

Table 3 shows that in the absence of significant barriers, the continuation of the activity with utilisation of biogas for on-site energy generation, and potentially selling electricity to the grid, is the economically rational option: analysis of project conditions shows that the ability to sell electricity from biogas to the grid makes continuation highly lucrative. **In Thailand, where the capacity of farm owners to continue to operate equipment is usually sufficient, projects are generally at a low risk of discontinuation.** In contrast, **farms in Mexico and Brazil often have insufficient capacity to continue to operate the mitigation equipment**, which was originally operated by third party participants; many of these farms are known to have already ceased mitigation. The lack of ability to sell electricity to the grid in Mexico and Brazil also reduces the incentive to overcome barriers. As such, a discontinuation scenario under which methane emissions are released is most likely in Mexico and Brazil.

Table 2: Summary of assessed scenarios for manure management projects

Scenario *Scenarios in bold are deemed the most economically rational (see decision chart, Figure 1)*	Compatible with regulations MEX	BRA	THA	Financial conditions	Potential barriers
Scenarios resulting in continuation of the mitigation activity					
Activity continues with utilisation of the biogas primarily for on-site electricity and steam generation.	✓	✓	✓	Positive	None in Thailand
Activity continues with utilisation of biogas for on-site energy generation or selling electricity to the grid.	✓	✓	✓	Very positive	Major barriers in MEX/BRA
Activity continues and the captured biogas is primarily flared.	✓	✓	✓	Negative	
Scenarios resulting in discontinuation of the mitigation activity					
Manure and effluent is routinely removed from livestock facility and applied to cropland or pasture, or disposed into waterways or on land.	×	×	×	n.a	n.a
Manure continues to be disposed in existing lagoons, but methane emissions from decay are released rather than collected and utilised, while the remaining sludge is applied to the land.	✓	✓	✓	Neutral	None

Potential for supporting continuation of vulnerable projects in Brazil and Mexico

The mitigation impact of supporting the continuation of these projects in Mexico and Brazil is determined to be approximately 2 M t CO_2e per year in both countries. In addition to the direct mitigation impact for existing projects, some support options could offer a broader mitigation impact due to the large number of similar non-CDM activities which may have significant mitigation potential.

The potential impact of support through established international market based approaches, for example through restored or preferential CER demand, is probably limited, due to the inability of most projects to continue to issue CERs after their single ten-year crediting period, but also due to the inability to reactivate original third party CDM project owners and administrators, who have moved away from the business in the case of many commercial livestock manure projects in Brazil and Mexico. **Domestic policy measures may have the greatest potential** to remove the barriers for project continuation; in particular, programmes for awareness and training, microcredit programmes to address availability of capital for motor replacements, and streamlining bureaucratic procedures for grid connectivity. Such measures could be driven by international support channels, including supported NAMAs, with which several ministries in Mexico have significant experience, or potentially a pilot sector-level crediting mechanism. Sector-level crediting mechanism approaches are not at a highly-developed stage at the national or international level; only a pilot approach would be feasible before 2020, and the effectiveness of such approaches is uncertain. Approaches based on internationally supported domestic sector wide policy measures could potentially have a large impact due to the ability to affect both registered CDM projects and similar non-CDM activities in the sector.

Wastewater

Summary of activity	Effluent wastewater from industrial activities is treated an-aerobically, thereby generating biogas which may be partially flared and partially utilised.
Countries analysed	India, Malaysia, Thailand

Risk of discontinuation of mitigation activity

Like for manure management projects, Table 3 shows that in the absence of significant barriers, the continuation of the activity with utilisation of biogas for on-site energy generation, and potentially selling electricity to the grid, is the most economically rational option: analysis of project conditions shows that the ability to sell electricity from biogas to the grid makes continuation highly lucrative.

Some projects in India, Malaysia and Thailand may face problems to continue GHG abatement due to barriers to feed electricity into the grid or the local availability of alternative cheap fuels. However, such barriers are not considered to be significant for the majority of projects; indeed, these activities are now very common for wastewater treatment even without the CDM. As such, it is determined that projects in India, Malaysia and Thailand are likely to continue GHG abatement.

Table 3: Summary of assessed scenarios for wastewater projects

Scenario *Scenarios in bold are deemed the most economically rational (see decision chart, Figure 1)*	**Compatible with regulations**			**Financial conditions**	**Potential barriers**
	IND	MAL	THA		
Scenarios resulting in continuation of the mitigation activity					
Activity continues with utilisation of biogas for grid connected electricity generation and on-site energy demands.	✓	✓	✓	Very positive	Low (grid connection delays)
Activity continues with utilisation of biogas for on-site electricity and steam generation.	✓	✓	✓	Positive	Low (alt. fuel availability)
Activity continues and the captured biogas is primarily flared.	✓	✓	✓	Negative	None
Scenarios resulting in discontinuation of the mitigation activity					
Effluent wastewater is discharged directly to land or waterways.	×	×	×	n.a.	n.a.
Wastewater is anaerobically treated in lagoons/tanks to reduce COD value, before it is discharged. During the treatment process, the wastewater digests with uncontrolled release of methane.	✓	✓	✓	Neutral	None
Wastewater is aerobically treated to reduce COD value, before it is discharged. The use of the aerobic treatment system (ATS) technology also results in the reduction of methane emissions.	✓	✓	✓	Neutral	High (Upfront capital costs of tech.)

Palm oil solid waste composting

Summary of activity Dedicated biomass composting facilities source residues – primarily empty fruit bunches – from palm oil processing mills, and co-compost the residues to create organic fertiliser.

Countries analysed Malaysia

Risk of discontinuation of mitigation activity

Table 5 shows that two scenarios for palm oil solid waste composting projects both have potentially positive economic implications: the activity may continue with the sale or utilisation of organic compost, or it may cease with the palm oil solid waste resides being sold for alternative uses. Which of these scenarios is most likely is highly variable across local regions, as it depends upon the maturity of the market for alternative uses of palm oil processing residues.

Where these local markets are more mature, competition for residues is greater and the sale of residues for other uses may be a more economically rational action than composting. The **risk of project discontinuation for composting projects in Malaysia is identified as *uncertain***, due to the variability of conditions across individual projects. Although some projects are likely to continue, there is considerable uncertainty due to changeable local market conditions, and some projects are understood to be in the process of dismantling

Table 4: Summary of assessed scenarios for palm oil solid waste composting projects

Scenario *Scenarios in bold are deemed the most economically rational (see decision chart, Figure 1)*	**Compatible with regulations** Malaysia	**Financial conditions**	**Potential barriers**
Scenarios resulting in continuation of the mitigation activity			
Continuation of activity with sale or own utilisation of organic compost.	✓	Positive	Highly variable across local regions
Continuation of activity without sale of organic compost.	✓	Very negative	None
Scenarios resulting in discontinuation of the mitigation activity			
Composting operation stops. EFBs are left on the ground and not collected.	✓	Slightly positive	None
Composting operation stops. EFBs are burned in open burning process.	×	n.a.	n.a.
Composting operation stops. EFBs are burnt for on-site steam generation.	n.a. Not considered an alternative scenario. Occurs in parallel with all other scenarios.		
Composting operation stops. EFBs used for mulch for young palms without a composting process.	✓	Negative	None
Operation stops. EFBs previously composted are discarded on tips & open air lagoons, with uncontrolled release of methane from decay.	✓	Very negative	None
Operation stops. EFBs are sold for alternative uses.	✓	Positive	Highly variable across local regions

Potential for supporting continuation of vulnerable projects in Malaysia

Although some of these projects may be at risk discontinuation, **the direct mitigation impact from the continuation of these activities may not be significant**, since discontinuation would likely imply that the palm oil solid wastes are used for other activities, which would also avoid the GHG emissions from decay of the solid wastes. The emission reductions may thus continue, even if the CDM projects discontinue.

Biomass Energy

Biomass is used in a variety of ways in CDM projects. Three major sub-types were assessed in detail: Use of bagasse for on-site power generation; use of biomass by independent power producers (IPPs); and other uses of biomass energy for captive energy generation at industrial sites.

Bagasse power

Summary of activity	Bagasse is used as the primary fuel for energy generation. The energy output (heat and electricity) is used to meet industrial on-site energy needs and sold to a third-party, usually the grid. These projects are integrated in the sugar industry and utilise bagasse directly from the industries' own residues.
Countries analysed	India and Brazil

Risk of discontinuation of mitigation activity

Table 6 shows that the single feasible scenario that entails the continuation of the mitigation activity is the most economically rational pathway to pursue; analysis of project conditions shows that revenues from power exports may amount to more than double the ongoing operating expenditures. Bagasse power projects in the sugar industry are thus at **low risk of discontinuation in both India and Brazil**; indeed, the practice of using bagasse for captive cogeneration in the sugar industry is common, and the extension of bagasse utilisation for grid electricity export has highly positive economic conditions.

Table 5: Summary of assessed scenarios for bagasse power projects

Scenario *Scenarios in bold are deemed the most economically rational (see decision chart, Figure 1)*	**Compatible with regulations** IND	BRA	**Financial conditions**	**Potential barriers**
Scenarios resulting in continuation of the mitigation activity				
Energy generation for on-site and power export with bagasse continues	✓	✓	Very positive	Minor
Scenarios resulting in discontinuation of the mitigation activity				
All bagasse is sold to third parties and own electricity and heating needs are met through grid power and other fuels.	✓	✓	Neutral / slightly negative	Significant: unreliab-le market for sale of bagasse
Bagasse is partially used for on-site energy needs, with remainder sold	✓	✓	Neutral / slightly positive	
Bagasse is partially used for on-site energy needs, with remainder disposed	✓	✓	Negative	None

Biomass independent power producers (IPPs) and captive biomass energy

Summary of activity	IPPs: Biomass is used to generate electricity in standalone dedicated power plants for the sale of the electricity. Captive energy: Procured biomass is utilised for on-site heat and/or electricity generation at industrial facilities, displacing existing or proposed fossil fuel powered alternatives.
Countries analysed	India and Thailand (IPPs); India (captive biomass energy)

Risk of discontinuation of mitigation activity

The conditions of biomass IPP and captive energy projects are highly variable and dependent on local conditions; specifically, the price of biomass and the reliability of its supply. Table 7 shows that **the continuation of IPP projects in Thailand is highly likely**, since biomass prices remain similar to those predicted by project developers at the start of the project, and ongoing electricity revenues amount on average to approximately 140-160 % of operating expenditures. In India, however, the price of biomass has soared in recent years, partly due to competing uses. In addition, the biomass supply chain remains somewhat informal and unreliable. As such, IPP and captive biomass energy projects in India are generally considered to be at high risk of discontinuation, since the high biomass costs and unreliable supply makes continuation a too costly option. These barriers are very dependent on specific local market conditions, and there may be some projects that do not face the same risks.

Table 6: Summary of assessed scenarios for biomass IPP and captive energy projects

Independent power producers				
Scenario *Scenarios in bold are deemed the most economically rational (see decision chart, Figure 1)*	**Compatible with regulations** IND	 THA	**Financial conditions**	**Potential barriers**
Scenarios resulting in continuation of the mitigation activity				
Power generation using biomass continues	✓	✓	Positive (Thailand); Neutral to negative (India)	High unreliability of biomass supply in India
Scenarios resulting in discontinuation of the mitigation activity				
Closure of power plant.	✓	✓	Neutral	None

Captive biomass energy			
Scenario *Scenarios in bold are deemed the most economically rational (see decision chart, Figure 1)*	**Compatible with regulations** India	**Financial conditions**	**Potential barriers**
Scenarios resulting in continuation of the mitigation activity			
Energy needs continue to be supplied by the use of biomass in the biomass dedicated technologies	✓	Higher cost option	Unreliability of biomass supply
Scenarios resulting in discontinuation of the mitigation activity			
The facility feeds coal into the boilers installed under the project activity, for their energy needs	✓	Higher cost option	Usually, at least one of these options is feasible for projects
The facility reverts to use of existing standby technologies that use coal and/or electricity sourced from the grid, for energy needs.	✓	Lower cost option	
The facility procures new coal fired boilers for their energy needs	✓	Medium cost option	Significant: upfront capital needs

Potential for supporting continuation of vulnerable biomass projects in India

The potential emission reduction impact of project continuation support depends on the extent to which the biomass would be used for other purposes if CDM projects discontinue, and whether biomass supply increases as a result of interventions. In the case that the supply of biomass cannot be increased, the mitigation impact could be as low as nil, since the competing uses of the biomass may also result in similar emission reductions at a different site.

However, it is generally understood that a significant surplus of potential biomass does not reach the biomass supply market; if biomass supply would be increased so that the continuation of CDM projects would utilise additional biomass supply, then **the mitigation impact of project continuation could be as high as 2.7 M t CO_2e per year for captive energy projects in India and 4.4 M tCO_2e per year for existing IPP projects in India and Thailand.**

Domestic policy programmes that address the unreliability of the supply chain for biomass are likely to have the greatest impact on barrier removal for continuation. **Restored CER demand may support some projects** by increasing the financial attractiveness of biomass use, especially when used in combination with other measures to address the reliability of the market supply.

Household Energy Efficiency

Energy efficient lighting and cook stoves are the main projects in this category and are assessed here.

Energy efficient lighting

Summary of activity	Replacement of GHG-intensive lighting in households by more efficient alternatives (i.e. CFLs and LEDs) subsidised by the project developer.
Countries analysed	India, Mexico and Pakistan

Risk of discontinuation of mitigation activity

Energy efficient lighting projects for households are considered to be at **low risk of discontinuation in India, Mexico and Pakistan.** As Table 9 shows, new regulations in Mexico nowadays require the continued use of efficient lightbulbs. In India and Pakistan, households are likely to finance replacement of bulbs due to their increasing market presence, the decreasing costs and improving knowledge on their benefits.

Table 7: Summary of assessed scenarios for household energy efficient lighting projects

Scenario *Scenarios in bold are deemed the most economically rational (see decision chart, Figure 1)*	**Compatible with regulations** IND	 MAL	 THA	**Financial conditions**	**Potential barriers**
Scenarios resulting in continuation of the mitigation activity					
CFL/ LED continues to be used by the householder and is replaced with an efficient lightbulb by the CDM project developer.	✓	✓	✓	Very negative	None
CFL /LED continues to be used by the householder and is replaced with an efficient lightbulb by the householder.	✓	✓	✓	Positive	Minor: Awareness and affordability
Scenarios resulting in discontinuation of the mitigation activity					
CFL /LED continues to be used by the householder but is replaced with an inefficient lightbulb.	✓	✓	✗	Neutral/negative	None
CFL/ LED is not used but sold and replaced with an inefficient light-bulb.	✓	✓	✗	Negative	None

Energy efficient cook stoves

Summary of activity Traditional inefficient cook stoves in households are replaced by more efficient cook stoves or by alternative renewable energy solutions.

Countries analysed India and Kenya

Risk of discontinuation of mitigation activity

Energy efficient cook stove projects for households are considered to have a **high risk of discontinuation in India and Kenya**, once the existing stoves cease operation. Regulations do not require the use of efficient stoves in either country. Third-party project owners have no incentive to continue financing the replacement of stoves and households are unlikely to finance their replacement themselves – despite that this might be the best option for ongoing costs – due to barriers related to the affordability of new stoves, knowledge of benefits and cultural preferences.

Table 8: Summary of assessed scenarios for energy efficient cook stove projects

Scenario *Scenarios in bold are deemed the most economically rational (see decision chart, Figure 1)*	Compatible with regulations IND	 KEN	Financial conditions	Potential barriers
Scenarios resulting in continuation of the mitigation activity				
Clean cook stove continues to be used and once broken is replaced with a clean cook stove by the CDM project developer	✓	✓	Very negative	None
Clean cook stove continues to be used and once broken is replaced with a clean cook stove by the householder.	✓	✓	Neutral to positive	High: Upfront costs, preferences, awareness.
Scenarios resulting in discontinuation of the mitigation activity				
Clean cook stove continues to be used by the householder but once broken is replaced with a traditional cook stove.	✓	✓	Neutral (case specific)	None
Clean cook stove is not used but sold and replaced with a traditional cook stove.	✓	✓	Negative	None

Potential for supporting continuation of cook stove projects in India and Kenya

Programs supporting the continued use of clean cook stoves should carefully consider how emission reductions are quantified: although the **emission reduction impact of project continuation for cook stove projects in India and Kenya could be up to 0.53 M t CO_2e and 0.72 M t CO_2e per year, respectively**, according to estimates in PDDs, some studies indicate that CDM methodologies may over-estimate potential emissions reductions in real-world usage (Aung et al. 2016; Bailis et al. 2015).

Restored CER demand may be an effective means of supporting project continuation due to the provision of an incentive for the re-engagement of the third-party project owner, who may re-assume responsibility for monitoring use of stoves and administering repairs and replacements where necessary. Unilateral or internationally supported **domestic measures may also have high impact**, for example through innovative finance models that address the upfront affordability of replacement stoves, or capacity building programmes to address household awareness of the potential economic and social benefits from the equipment as well as cooking preferences.

Conclusions

General Characteristics of Project Vulnerability

In addition to the findings for project vulnerability from the project types assessed in detail, this study also uncovered broader insights for other project types. These insights could be explored in greater detail in subsequent research in order to obtain a clearer picture on the status and prospects of mitigation activities under the CDM as a whole up to 2020.

Projects for renewable energy generation from hydro, wind and solar power technologies, which account for approximately half of the CDM's emission reduction potential between 2013 and 2020[1], may have entailed large capital costs for implementation, but are generally at low risk of discontinuation once implemented due to significant revenues from electricity sales and relatively limited operating expenditures. As previously highlighted, this assessment considers only the situation of projects at the current point in time: whether the economic conditions favour continuation of the activity or not in the absence of CERs at the present time is not in any way a reflection or even an indication of the additionality of projects at the point of their inception. Conditions for biomass energy are not as positive as for other renewable energies, as discussed in the previous section. Projects for energy efficiency, which account for nearly 10 % of the CDM's emission reduction potential up to 2020, are usually also at low risk of discontinuation once implemented, due to significant ongoing cost savings and very limited or no continued additional operating expenditures. In some cases, these projects can physically not be reverted. Conditions for household cook stove projects are likely to deviate from these trends, as analysed in this study and summarised in the previous section.

In contrast, project types which do not accrue significant ongoing financial benefits aside from CER revenues are often generally at higher risk of discontinuation. For these project types, continued mitigation is typically only ensured as long as financial support, either through subsidies or carbon market instruments, is provided or unless regulations require mitigation. The study shows for example that efficient cook stoves may face the risk of discontinuation in case that households are unlikely to finance their replacement themselves. All the experiences mentioned in the study might be relevant when considering the most effective means of long-term support for mitigation at new project sites or emission sources, pre- or post-2020.

Another key insight from this study is that ownership structures for project implementation matter a great deal to the long-term sustainability of action. Projects which involve multiple parties – i.e. the site or property owner, the investor and the operator of the mitigation activity are not all the same entity, or associated with that entity – are more likely to be vulnerable to discontinuation, regardless of the general economic attractiveness of the activity. The division of financial benefits between project parties may be such that the parties operating the activity have no incentive or not the necessary capacity to remain engaged with the project without CER revenues (e.g. household cook stoves, or commercial livestock manure management in some countries). The experience with these projects under the CDM might provide valuable lessons for future approaches for new projects: project approaches relying on significant third party participation – which includes a large proportion of new PoA projects, and could be a common characteristic of some approaches for sectoral crediting mechanisms (in particular *up-scaled project based crediting*) – should pay close attention to capacity building and transfer of knowledge to optimise the prospects for long-term impact after the withdrawal of the third parties due to crediting period expiry or unforeseen circumstances.

Supporting Continuation of Vulnerable Projects for Pre-2020 Mitigation

For the specific project types found to have a high vulnerability for the discontinuation of emission reductions, this study analysed options for supporting project continuation pre-2020, and estimated the potential emission reductions.

A key insight from the analysis is that the continuation of vulnerable projects may not always result in further emission reductions. For some project types, economy-wide GHG emissions could be the same, whether or not the project continues the mitigation activity, since the emission reductions would continue at other sites.

1 According to ex-ante project estimations from PDDs (UNEP DTU 2016)

For example, the mitigation outcome for the continuation of two project types analysed in this study – palm oil solid waste composting in Malaysia and biomass energy in India – is highly uncertain, since competition for biomass resources and solid wastes may mean that the biomass or waste may be used elsewhere if the CDM project activity discontinues. Assessing the local conditions and causal relationships with other activities is thus important to determine whether continuation of the activity at the project site will result in further emission reductions at the economy level. This insight does not contest the assessment of *additionality* at project inception, but recognises that changes in circumstances since project inception may mean that further emission reductions cannot always be expected from the continuation of vulnerable projects today.

The continuation of vulnerable projects could be supported in different ways. This study assessed both domestic and international carbon market instruments as well as the implementation of domestic policies with or without international support.

Several initiatives have recently been launched with the aim to support continuation of vulnerable projects through the provision of new sources of demand for CERs. Such sources may include, for example, multilateral or bilateral credit purchase facilities, such as the Pilot Auction Facility operated by the World Bank, or offsetting programmes under domestic mechanisms, such as the use of CERs in the ETS in South Korea or to meet potential tax obligations in Mexico and South Korea. The restoration of CER demand was found to have a potential positive influence on project continuation on some, but not all projects. Firstly, not all vulnerable project types face now the same barriers as they did at the conception of their project; and hence restored CER finance may not remove the barriers for all vulnerable project types. Secondly, even in the cases that restored CER demand is able to support project continuation, this is sometimes found to have only a short-term impact; CER revenues may help to temporarily circumnavigate some barriers, but will not always lead to those barriers being removed in the long-term, after carbon finance is eventually withdrawn.

Whilst the provision of support for continuation through restored CER demand is found to have variable suitability for different project types, support through domestic policies and incentive programmes, initiated unilaterally or through international support, was found to have high potential for removing the various financial and non-financial continuation barriers of all the project types assessed. There is significant potential in many sectors for policy programmes to be initiated unilaterally based on existing regional best practices (Healy et al. 2016). Proposals for supported Nationally Appropriate Mitigation Actions (NAMAs) may be an effective channel for attracting support where international finance and/or technical expertise is required. For some project types, sector-level crediting mechanisms may also offer an appropriate channel for supporting a policy and programme oriented approach driven at the sector level, although the limited development of these concepts mean that only a pilot based approach would likely be feasible before 2020.

Implications for Design of Future Post-2020 Mechanisms

Article 6 of the Paris Agreement introduces cooperative approaches based on internationally transferred mitigation outcomes (ITMOs) (Art 6.2), a mitigation and sustainable development mechanism (Art 6.4), and non-market approaches (Art 6.8). Article 6.1 frames these mechanisms explicitly as ambition raising mechanisms, which may constitute a significant difference to the flexibility mechanisms of the Kyoto Protocol. The fundamental design features of these mechanisms are not yet determined. The various experiences and lessons from the CDM are key to informing the design of these future mechanisms, to ensure that they effectively meet their objectives.

Achieving the goals of the Paris Agreement will require all countries to fully decarbonise their economies this century (mid-century for CO_2 emissions) (UNEP 2016). This marks an important change: the full decarbonisation of all sectors will require transformational change and avoidance of lock-in to carbon intensive technologies. Mechanisms intended to raise collective ambition to meet the PA goals should be clear about their specific objectives and whether support for certain project types is suitable based on these objectives; support channels and mechanisms will be needed to target emission reductions that can have a lasting long-term impact and the introduction of net-zero emission technologies, although mechanisms for short-term mitigation may also play an important role for currently stranded projects.

The findings of this research lead to the following insights with relevance for future mechanism design:

- The design of future mechanisms or purchase facilities should consider the risks that some project types could become stranded and discontinue mitigation in the case of market collapse.
- For lasting impact of emission reduction outcomes, international support for mitigation options or the development of modalities and guidances under Art. 6 PA should seek the long-term removal of a range of financial and also non-financial barriers as the continuation of projects will not always be dependent on finance aspects as the CDM also has lifted non-financial barriers.
- If project-level crediting is to continue under mechanisms of the Paris Agreement, safeguards should be considered to avoid the situation that vulnerable projects stop mitigating, once carbon finance ceases. For example, the Nitric Acid Climate Action Group initiative, launched by Germany in 2015, makes crediting support contingent on the introduction of supporting policies.
- Domestic policy-level approaches, driven at the national or sector level, might be best able to remove financial and non-financial barriers for mitigation action in the long-term. Such approaches seem to be key towards the end of triggering transformational change and ensuring integrated planning that avoids lock-in to carbon intensive technologies. Sector-level crediting mechanisms might be a potential channel to drive domestic policy-level approaches, but further road-testing of such mechanisms is needed to gain experiences for the further consideration of this option and its potential role.

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See the full report for a full list of references consulted for the analysis.

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