Discussion paper: Marginal cost of CER supply and implications of demand sources

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Abstract

In this discussion paper we estimate the marginal cost of supplying certified emissions reduction units (CERs) from projects that are currently registered under the Clean Development Mechanism (CDM). We develop a supply curve using data on the individual ability of projects to potentially supply CERs over the period up to 2020. We analyse changes to the supply curve based on a number of scenarios which restrict the eligibility of CERs based on the timing of emission reductions, the timing of project investment decisions and registration under the CDM, as well as an assessment of the extent to which projects are vulnerable to the risk of discontinuing abatement activities without CER revenues.

We find that, in the absence of any eligibility restrictions, there is a large pool of CERs available to supply the market at prices below € 1 per unit. Much of this potential supply is from projects that are likely to continue delivering emission reductions regardless of any further revenues derived from the sale of CERs. Our analysis is relevant to the ongoing policy negotiations related to the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), amongst other sources of demand. The results indicate that, if CERs are accepted as eligible units of compliance under CORSIA without any restrictions, the demand for offset credits from international aviation to 2035 is unlikely to either materially impact the current price level for CERs or alter the overall level of greenhouse gas abatement undertaken. An effective way for CORSIA, and other schemes, to incentivise emission reductions beyond those that are likely to occur anyway would be to ensure that demand is targeted at projects that are at risk of discontinuing abatement activities and to encourage the development of new projects that deliver additional emission reductions.

Kurzbeschreibung

In diesem Diskussionspapier werden die Grenzkosten des Angebots von zertifizierten Emissionsreduktionen (CER) aus Projekten, die derzeit im Clean Development Mechanism (CDM) registriert sind, geschätzt. Basierend auf Daten zur individuell möglichen Eignung von Projekten bis zum Jahr 2020 zertifizierte Emissionsreduktionen (CER) zu liefern, wird eine entsprechende Angebotskurve entwickelt. Hierbei werden Änderungen der Angebotskurve anhand von verschiedenen Szenarien zur Zulässigkeitsbeschränkung von CERs analysiert. Die ausgewählten Szenarien beziehen sich auf den Zeitpunkt der Emissionsreduktionen, der Investitionsentscheidungen, der CDM Registrierung sowie der Bewertung inwieweit Projekte dem Risiko ausgesetzt sind, ihre Minderungsaktivitäten ohne CER Erlöse einzustellen.

Die Ergebnisse zeigen, dass ohne jegliche Einschränkungen der Zulässigkeit ein sehr großer Pool von CERs zur Verfügung steht, um den Markt zu Preisen von unter 1 € pro Reduktionszertifikat zu versorgen. Ein großer Teil dieses Angebots stammt aus Projekten, bei denen wahrscheinlich auch ohne weiterer Erlöse aus dem CER Verkauf weiterhin Emissionsreduktionen erzielt werden. Die Analyse ist besonders relevant für die aktuellen Verhandlungen der Internationalen Zivilluftfahrt-Organisation (ICAO) zur Ausgestaltung des CO_2-Ausgleichsprogramms für die internationale Luftfahrt (CORSIA). Unsere Ergebnisse zeigen, dass wenn CERs uneingeschränkt als zulässige Einheiten für die Erfüllung der Kompensationsverpflichtungen im CORSIA Programm akzeptiert werden, die Nachfrage nach Emissionsgutschriften aus dem internationalen Luftverkehr bis zum Jahr 2035 wahrscheinlich weder das derzeitige Preisniveau für CERs noch das Gesamtniveau der THG-Minderung wesentlich beeinflussen wird. Um wirksam Anreize für Emissionsreduktionen über die ohnehin stattfindenden zu schaffen, müsste CORSIA sicherzustellen, dass die Nachfrage auf Projekte abzielt, bei denen das Risiko besteht, das die Minderungsaktivitäten ansonsten eingestellt würden oder die Entwicklung neuer Projekte zu fördern, die eindeutig zusätzliche Emissionsreduktionen liefern.

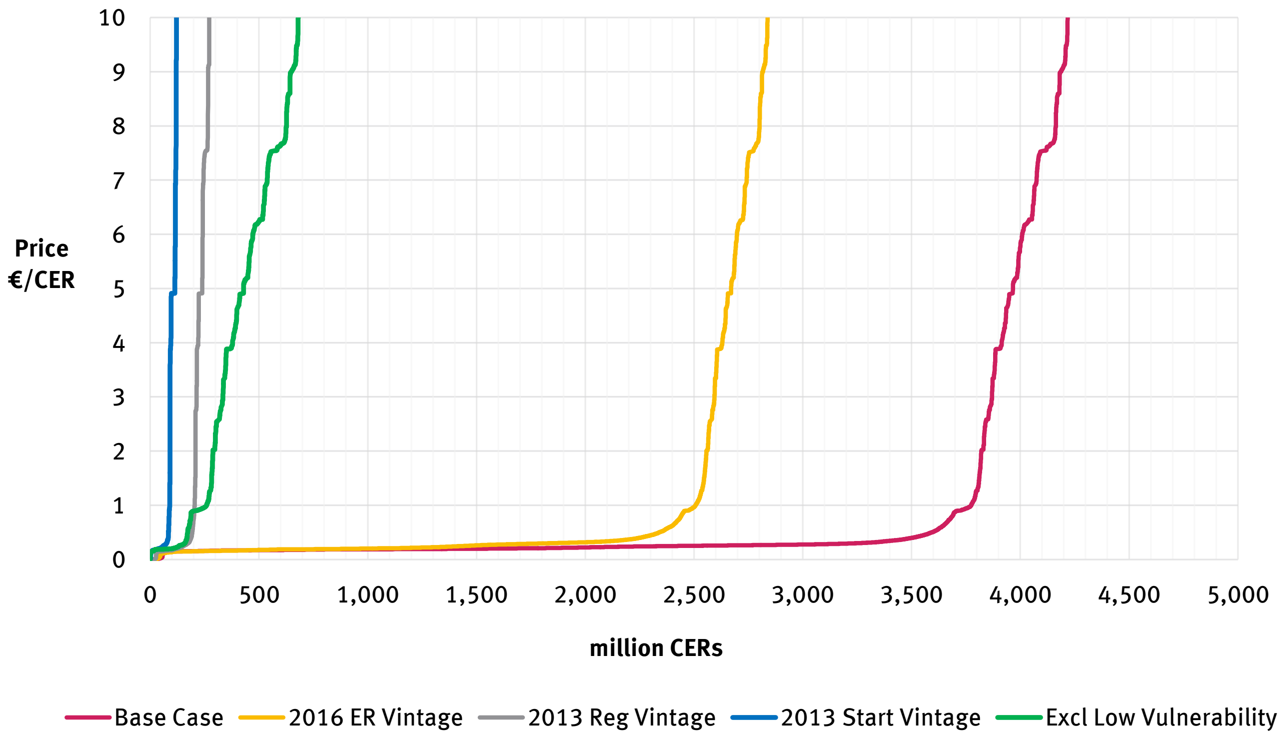
Executive summary

The Clean Development Mechanism (CDM) is the world's largest greenhouse gas (GHG) offsetting mechanism to date. Although its future after 2020 is uncertain, policy-makers are currently considering the use of Certified Emission Reductions (CERs) from emission reductions delivered in the period up to, and including, 2020. In this context, it is important to understand the impact on GHG emissions of using CERs as well as the costs at which further CERs can be supplied.

This paper examines the marginal cost to supply CERs from projects registered under the CDM. We combine previous estimates of the CER supply potential (Schneider, Day, La Hoz Theuer, & Warnecke, 2017) with new estimates of the marginal cost of supplying CERs to develop a CER supply curve. The analysis covers all projects registered by April 2017 and CERs that could be issued in the future for emission reductions in the period 2013 to 2020.

We assess the implications of different restrictions on the potential volume and cost of supplying CERs. Many programmes that purchase or recognise CERs have implemented restrictions related to their use. These restrictions could include vintage restrictions, restrictions to specific project types, or restrictions to specific host countries. The International Civil Aviation Organization (ICAO), for example, is currently considering the use of CERs for compliance under its Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

Our estimate of the supply curve for CERs under our Base Case is summarised in the following chart alongside a number of alternative scenarios that restrict the eligibility of CERs.



Source: Author's calculations (see methodology and data sources in Chapter 2)

Base Case and alternative scenario estimates of CER supply curve to 2020

There is a large pool of CERs that could be supplied at relatively low prices. In our Base Case, up to 3.8 billion new CERs could supply the market at prices below € 1 per unit. This is because a large share of registered projects receive alternative revenue streams, such as from electricity sales, and do no more depend on CER revenues to continue emission reduction activities; we refer to these as "low vulnerability" project types. For these project types, the marginal costs of supplying further CERs are limited to CDM transaction costs.

The CER supply potential would be even larger if CERs from emission reductions delivered by these projects after 2020 were included in the analysis. Moreover, this analysis does not include the large number of CDM projects that have been developed but never requested registration due to the current market situation.

Demand levels for CERs are currently considerably lower than the supply potential from registered CDM projects. This has been the case at least since 2012 and led to a prolonged period of low market prices for CERs. We set out possible demand scenarios for CERs. The most important source of new demand could come from ICAO's CORSIA. ICAO requires the aviation sector to offset any increase in total CO_2 emissions from international aviation above 2020 levels.

Without eligibility restrictions, the demand from CORSIA is unlikely to either materially impact the current price level for CERs or alter the overall level of GHG abatement undertaken. Even if CERs issued up to 2020 from currently registered CDM projects exclusively supplied CORSIA's demand of approximately 2.7 billion up to 2035, the market price level would likely remain below € 1 per CER. Almost all of this demand could be sourced from low vulnerability projects which are likely to continue GHG abatement activities regardless of the price incentives offered by the CDM market.[1]

An effective way for CORSIA, and other schemes, to incentivise emission reductions beyond those that are likely to occur anyway would be to impose eligibility criteria on the offset credits that can be used for compliance. We consider a number of alternative scenarios related to eligibility constraints that may be applied by policy-makers to CERs. Policy-makers may aim to target project types that are in need of support to continue GHG abatement activities. In addition, or alternatively, policy-makers could limit the available supply from existing projects - for example via "vintage" restrictions (meaning restrictions in times of registration or project start) - in order to incentivise the development of new projects that deliver additional GHG abatement.

Scenarios with eligibility constraints have a significant impact in limiting the potential supply of CERs. The future supply potential of CERs in our Base Case is 4.3 billion. A 2016 vintage restriction applied to the *date of emission reductions* removes around 1.4 billion CERs from the available supply, reducing it to approximately 2.9 billion CERs. This option, however, would not incentivise significant emission reductions beyond those that would occur anyway. Further emission reductions could be encouraged in two ways:

- Policy-makers could *exclude CERs from project types with low vulnerability*. This would have a pronounced effect on the supply curve, relative to the Base Case. The potential supply in this scenario is approximately 690 million CERs. Under this scenario demand for CERs would be channelled to project types that are otherwise at risk of discontinuing GHG abatement activities.
- Policy-makers could *impose vintage restrictions that limit supply based on the date of the project investment decision*. Imposing a 2013 vintage restriction on the date of the investment decision (or "start date") fundamentally changes the supply, limiting it to 121 million CERs. Restrictions on the date of the project investment decision could incentivise the development of new projects to meet the additional demand, which might not have gone ahead without CORSIA. These new projects could be developed either within the CDM or under alternative schemes that are approved for use within CORSIA.

Imposing a 2013 vintage restriction on the registration date limits the supply from currently registered projects to 275 million. Restrictions on the registration date may, however, be less effective at incentivising the implementation of new projects. This is because there are a large number of projects within the CDM pipeline that are not yet registered, but which are likely to have been implemented and may still request registration in the future if it were to become financially attractive to do so.

1 The fact that a project is not deemed vulnerable to discontinuing GHG abatement does not contest the assessment of additionality at project inception. Rather, it recognises that, from today's perspective, the project's savings or revenues from continued operation exceed its operational expenditures. Therefore, the distinction between vulnerable and non-vulnerable projects does not relate to the quality of the projects as such, but it has implications for the GHG emissions impact of purchasing or recognising CERs from these projects.

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Abbreviations

Capex	Capital expenditure
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPA	Component Project Activity
EEX	European Energy Exchange
EU ETS	European Union Emissions Trading System
GHG	Greenhouse gas
HCIP	Harmonised Index of Consumer Prices
HFC	Hydrofluorocarbon
ICAO	International Civil Aviation Organization
ICAP	International Carbon Action Partnership
LDC	Least developed country
NACAG	Nitric Acid Climate Action Group
NDC	Nationally determined contribution
N_2O	Nitrous oxide
Opex	Operational expenditure
OTC	Over-the-Counter
PAF	Pilot Auction Facility (World Bank)
PDD	Project design document
PoA	Programme of Activities
t CO_2e	Tonnes of carbon dioxide equivalent
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VI / V&I	Verification and issuance of CERs

1 Introduction

The Clean Development Mechanism (CDM) is the world's largest greenhouse gas (GHG) offsetting mechanism to date. More than 8,000 projects or programmes of activities (PoA) are registered under the mechanism, and more than 1.8 billion Certified Emission Reduction units (CERs) had been issued by the end of 2017. Since 2013, however, prices for CERs at trading exchanges have remained at levels below half a Euro, and considerably lower still for much of that time. This prolonged period of low prices, driven by much higher supply than demand on the market, has significantly reduced financial incentives to develop new projects. It has also decreased revenues from GHG abatement activity undertaken by existing projects that were developed prior to the steep decline in the CER price. Issuance fees alone under the CDM range between $0.10–0.20 (approximately € 0.09–0.17) depending on the quantity of credits requested, leaving little margin to cover additional costs and risks, and to earn profits, under current price levels of around € 0.20 per CER.[2]

While demand for CERs is currently low, it could increase in the future, in particular if CERs were recognised under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) adopted by the International Civil Aviation Organization (ICAO). In this context, it is important to understand the impact on GHG emissions of using CERs as well as the costs at which further CERs can be supplied.

This discussion paper examines the marginal cost to supply CERs from projects registered under the CDM. We combine previous estimates of the CER supply potential (Schneider et al., 2017) with new estimates of the marginal cost of supplying CERs to develop a CER supply curve. The analysis covers all projects registered by April 2017 and CERs that could be issued in the future for emission reductions in the period 2013 to 2020.

A critical aspect for the analysis is under which conditions projects would issue CERs and whether or not the projects would continue GHG abatement without receiving CER revenues. A large number of registered CDM projects have stopped requesting issuance of CERs. Some of these projects have ceased operations altogether and therefore no longer continue GHG abatement (see Warnecke et al., 2015 for a comprehensive review of the status of CDM projects, based on a survey of projects). Other projects – where there are alternative revenue sources available – continue GHG abatement, but choose not to incur the transaction costs associated with CER issuance as these costs are not sufficiently compensated in the current CER market. In this paper, we assess the potential volume and price at which projects would supply CERs. This is based on previous analysis of a project's risk of discontinuing GHG abatement (Warnecke et al., 2017), CDM rules which may inhibit further CER issuance, and the marginal costs of supplying CERs in the future.

To build the supply curve for CERs, this paper assesses the price level that would encourage projects to request issuance of CERs by analysing the different marginal costs faced by registered projects. To do this, we draw on previous work to estimate costs for different types of projects in different regions, including third party estimates and an extensive survey of CDM projects published by NewClimate Institute in 2015 (Warnecke et al., 2015). We also draw on our recent analysis that assesses the potential supply from registered CDM projects over the period 2013-2020 (Schneider et al., 2017).

In chapter 2 we explain our methodology for developing a supply curve, including the data and assumptions that we rely on. Chapter 3 then presents the supply curve for CERs under a range of scenarios and discusses the sensitivity of the results to changes in inputs. In chapter 4 we assess the implications of different demand scenarios before offering concluding remarks in chapter 5.

2 The settlement price for CER Future contracts with delivery in all years to 2020 was listed at € 0.17 on the EEX exchange on 11 December 2017 (https://www.eex.com/en/market-data/environmental-markets/derivatives-market/certified-emission-reductions-futures#!/2017/12/11). These refer to secondary market prices available on commodity exchange platforms. Individual projects may also enter into bilateral or over-the-counter (OTC) trades at price levels above the market which therefore offer additional incentives. However, the price of these trades is not typically disclosed publicly and the secondary market price serves as a relevant benchmark to assess market conditions.

2 Methodology

This chapter sets out our approach to developing a supply curve for CERs. The CER supply curve represents the *marginal* cost of supplying CERs from today's perspective and reflects the number of credits that could come to market at a given price level. As projects vary in terms of the costs they incur to supply CERs, the supply curve is upward sloping with higher price levels incentivising a larger cumulative quantity of CERs. Our analysis is limited to projects registered as of April 2017 and does not include either CDM projects in the pipeline or new projects that could be developed in response to new demand.

In the following sub-sections we start by describing the types of costs that CDM projects face as well as alternative sources of revenues and cost savings, which are relevant to many projects. We then set out which of these apply to different project types before discussing data sources and our modelling approach.

2.1 Categorisation of project financials

The developer of a CDM project incurs a number of different costs and in return typically expects to either earn revenues or make cost savings, or both, that provide a net positive return on the investment.

The key financial elements of CDM projects can broadly be split into four categories:

1. **GHG abatement costs**, i.e. costs associated with the physical development, implementation and operation of the activity which delivers GHG abatement (e.g. costs of planning, constructing, operating and maintaining a wind farm as well as revenues, or cost savings, from the sale, or use, of the electricity that is generated);
2. **CDM transaction costs**, i.e. costs associated with undertaking the administrative process to register and receive credits under the CDM;
3. **Verification and issuance (V&I) margin**, i.e. a margin to provide sufficient incentive to re-engage in CER issuance for those projects that have ceased issuance of CERs or never issued any CERs; and
4. **Revenues** earned from the sale of CERs or **cost savings** from the use of CERs for compliance with regulatory obligations.

Our analysis primarily concerns the first three categories which we outline in more detail in the following paragraphs.

2.1.1 GHG abatement costs

GHG abatement costs comprise of *cost* items – which can be further broken down into capital expenditures (*capex*) and operational expenditures (*opex*) – and *revenues* or *cost savings* which offset the costs:

a) **Capex:** Investments to develop, acquire or upgrade physical assets are known as capex. A large share of these investments is typically made in advance of an asset commissioning and entering operation and are therefore fixed upfront. In the example of building a ground-mounted solar PV farm, this would include the costs associated with acquiring and preparing land, purchasing and installing PV modules as well as cabling to transmit the electricity that is generated, amongst other items. These costs are often largely irreversible and in such a case are referred to as “sunk” costs, once they have been incurred, as is the case for the registered CDM projects that we consider as part of this study.
b) **Opex**: Expenditures made to operate a project, once built, and maintain it throughout its useful lifetime are known as opex. These costs, which cover both physical inputs as well as labour can include both fixed and variable elements. Fixed costs do not directly depend on the level of operation of the project, whereas variable costs tend to be proportionate to the level of operation of the project. As an example of variable opex, a biomass plant requires fuel as input to generate electricity. The higher the level of generation, the more biomass is needed and the higher the opex of the plant.
c) **Revenues or cost savings:** Many CDM projects accrue revenues or cost savings for their activities in addition to those associated with participating in the CDM and either selling or using CERs. Once CERs are issued to a project they can then be sold to buyers via bilateral contracts or on the secondary market (at trading exchanges).

The sale of CERs provides revenues to the project. Similarly, some project developers could use the issued CERs for compliance with regulatory obligations in which case their value, once issued, can be seen as a cost saving relative to procuring the CERs from third parties. For example, CDM projects that use renewable energy sources to generate electricity or heat can sell or use that output. Alternatively, projects that deliver energy efficiency improvements offer cost savings in the form of reduced energy bills. These revenues or savings can partially or completely offset the opex associated with the project's ongoing activities..

The GHG abatement costs are equal to the net cashflow of costs, revenues and savings over the project lifetime, excluding CDM-related cashflows (see next section), divided by the number of CERs delivered by the project. Marginal GHG abatement costs – which are key to build the supply curve – are defined similarly, but exclude any sunk costs amongst the capex and fixed opex.

2.1.2 CDM transaction costs

CDM transaction costs include fixed upfront costs associated with registering a project with the CDM Executive Board, as well as various ongoing costs associated with the verification and issuance of CERs. Once a project is issued CERs it can either sell these and earn revenues or avoid compliance costs if the project developer requires the CERs to meet regulatory obligations. These elements are described in the following paragraphs:

d) **Upfront CDM transaction costs:** Prior to successfully registering a project under the CDM there are a number of steps that the project developer needs to take to satisfy the requirements of the CDM procedures. These include preparing a project design document (PDD), procuring an independent validation and fees for submitting the project for registration. As these costs are incurred prior to a project's successful registration they are not relevant to our current analysis. We focus exclusively on projects that are already registered and for which these costs are sunk.

e) **Ongoing CDM transaction costs**: In order to receive CERs, registered projects must continuously monitor emission reductions,[3] prepare monitoring reports, procure an independent verification of emission reductions, pay an administrative fee for CER issuance, and surrender two percent of the issued CERs to the Adaptation Fund. In instances where a project renews its crediting period, it will incur further costs associated with preparing the relevant supporting documentation and having it independently validated.

2.1.3 Verification and issuance (V&I) margin

f) **V&I margin:** For those projects that have either ceased requesting the issuance of CERs or never requested an issuance of CERs, a margin may be required to incentivise (re-)engagement with the CDM processes, leading to issuance. Project developers (or external consultants supporting them) will only invest in verification and issuance activities if the return is sufficiently attractive both relative to alternative investment opportunities and as compensation for the risks associated with whether and how many CERs will be issued, the level of effort required to achieve issuance, and the price level at which the CERs are sold. The level of margin required, if any, will vary across projects and stakeholders.

2.2 Data and assumptions

2.2.1 Sources of CER supply

For the purposes of this study, we determine the marginal cost of CER supply exclusively for registered projects which have been physically implemented, drawing on information from NewClimate's survey of CDM projects (Warnecke et al., 2015), our recent analysis of this data which sets out the methodological assumptions to estimate the CER supply potential (Schneider et al., 2017) and specific cost data on industrial gas projects (Schneider & Cames, 2014). We estimate that the total supply from all registered projects for emission reductions over the period 2013-2020 could be approximately 4.6 billion CERs. More than 0.3 billion of these have already been issued, leaving a future supply potential of approximately 4.3 billion CERs.

We examine the potential supply of new CERs from both project activities as well as programmes of activities (PoAs) that are registered under the CDM, where the latter may include an unlimited number of component project activities (CPAs). Throughout the report where we refer to "projects" this includes both types of modality for developing projects: either as standalone projects or as PoAs, which cover one or more CPAs.

3 For electricity generation projects monitoring equipment may fall under item b) opex above where it is anyway required to measure output to the grid.

The estimates of the supply of CERs from PoAs as well as the likely costs associated with their supply are potentially more uncertain than for single projects as we have not explicitly analysed PoAs in detail. In particular, the potential supply depends to a large extent on the number of CPAs added to a registered PoA, although there is limited time before 2020 to add significant numbers of new CPAs. We estimate here the supply potential of PoAs based on CPAs that were included in the PoA by April 2017. The marginal costs per CER faced by the PoA will also depend, to some extent, on the number of CERs issued for emission reduction activities. The PoAs with currently included CPAs account for a relatively minor share of the potential supply that we examined. Approximately 150 million (or just over 3 percent) of the 4.3 billion new CERs that we estimate could be supplied for emission reductions over the period 2013-2020 are from PoAs.

Furthermore, our analysis indicates that approximately 16 million out of the 4.3 billion CERs could come from projects that have not yet been physically implemented. Excluding those projects that have not been implemented from our analysis – which we do - therefore has no material impact on our findings.

Registered and implemented projects have already invested the fixed upfront capex and incurred the upfront CDM costs (items (a) and (d) in the previous section); these cost items are therefore excluded when determining the marginal costs of supplying CERs.

2.2.2 Treatment of projects according to vulnerability rating

We segment registered projects according to their vulnerability to discontinuing abatement activities based on previous work (Warnecke et al., 2017). This earlier analysis categorised CDM project types into those with a "high vulnerability" to discontinuing GHG abatement due to inconducive economic conditions, those with a "low vulnerability" (i.e. that would likely continue operations regardless of the CER price), and those that have "variable vulnerability" across the projects and regions assessed. A small number of project types, accounting for just two percent of the supply potential from registered projects between 2013-2020, were not assessed and so the extent of their vulnerability remains unknown. In our analysis we exclude any supply from these project types which include clinker replacement, agriculture, CO_2 usage, energy distribution, tidal energy and transport.

The majority of projects, accounting for 82 percent of the potential future supply of CERs issued for emission reductions between 2013-2020, have a **low vulnerability** to discontinuing GHG abatement activities. The operation of these project types either yields alternative sources of revenues or cost savings which are sufficient to cover their opex-related costs, or ceasing GHG abatement is costlier than continuing, or there are legal requirements in place to incentivise continued GHG abatement. In these cases, emission reductions are likely to continue for the remaining duration of the project's operational lifetime. However, these projects with low vulnerability may choose not to continue their participation in the CDM if the expected revenues or cost savings from doing so are insufficient to justify the additional expense of the ongoing CDM transaction costs. This is the case for a large number of registered CDM projects which have elected not to verify their abatement activity and request issuance of the corresponding CERs in recent years – despite the fact that they do continue to deliver emission reductions.

For projects with low vulnerability we therefore assume that the marginal cost of CER supply is made up of the ongoing CDM transaction costs (item (e) above) which cover monitoring, verification and issuance costs as well as costs related to the renewal of the crediting period, where applicable.

Projects with a **high vulnerability** also face the same ongoing CDM transaction costs. However, in addition they need to cover part, or all, of their opex-related project abatement costs. Some vulnerable projects may have alternative sources of revenues or incur cost savings. However, these alternative revenues and cost savings are insufficient alone to cover the project's operational costs. For vulnerable projects the marginal cost of CER supply is equal to the ongoing CDM transaction costs, plus the marginal GHG abatement costs, i.e. this is equal to (e) + (b) - (c) from the items set out in the previous section.

Projects that are categorised as having **variable vulnerability** will typically fall somewhere in the middle. Some projects may not be vulnerable and therefore require a CER price that just covers their ongoing CDM transaction costs, whilst others may be vulnerable and require that the CER price rises to cover their marginal GHG abatement costs.

We add a V&I margin to all projects, irrespective of their vulnerability, if they were not issued with CERs over the two-year period prior to 17 April 2017 (the information date for our CDM project analysis).

We discuss the data that we have drawn on to estimate these different cost items in the following section.

2.2.3 Cost data

We are primarily interested in two cost categories in this study. First, for projects that are considered vulnerable to discontinuing GHG abatement, we want to estimate their marginal GHG abatement cost to reduce emissions relative to a scenario where GHG abatement is discontinued. Second, we are interested in a project's ongoing CDM transaction costs. These costs are relevant to all registered CDM projects regardless of their vulnerability as they are incurred on an ongoing basis and are prerequisites to the issuance of CERs.

The literature on GHG abatement costs and CDM transaction costs is, for the most part, relatively dated. Some of the main studies examining technology and country-specific abatement costs were published in and around 2012[4], based on data collected in previous years, and others that are widely cited were published in 2007[5]. These data therefore reflect a historic view of costs, which may not be representative of the costs across different countries and technologies today.

A number of studies, such as those noted in the previous paragraph, provide estimates of the abatement cost at project inception, but few identify marginal GHG abatement costs faced by the projects once they are registered and implemented – i.e. excluding the capex and any fixed opex that has been sunk.

The primary source of data we use in this study to approximate each project's marginal cost to supply CERs is NewClimate Institute's survey of CDM projects, published in 2015 (Warnecke et al., 2015). We complement this with two studies that provide information on CDM transaction costs across the main project types (Warnecke et al., 2013 and Vivid Economics, 2013) and one study that reports marginal abatement costs, as well as CDM transaction costs, for industrial gas projects (Schneider and Cames, 2014). These data sources are presented in the following paragraphs.

NewClimate Institute survey

Our main source of cost data for this study is the information collected via NewClimate Institute's survey of CDM projects, published in 2015 (Warnecke et al., 2015). This survey covered a range of *project-related* information and included two cost-related questions, put to representatives from a sample of 1,310 registered CDM projects. The first of the cost questions relates to the overall price level required for a project to undertake the activities required for CER issuance. These include actually delivering verified emission reductions and following the parallel CDM administrative processes. The second of the cost questions specifically focuses on the verification and issuance cycle costs.

The main advantages of using the data from this survey over alternative cost data we have reviewed are three-fold. First, the survey elicits cost information for projects that are already registered under the CDM. Second, the survey covers all the main project types, as well as a wide number of countries in which projects are located. The survey provided responses across 25 different project types (or technologies) and covered 16 countries and regions. Third, the survey provides relatively recent data points as compared to other studies that examine costs. The two questions included in the survey and response options are set out below in Box 1.

4 For example: (Castro, 2012); (Spalding-Fecher et al., 2012); (Rahman, Larson, & Dinar, 2012); (UNFCCC, 2011); (UNFCCC, 2012a).

5 For example: (Bakker et al., 2007) and (Wetzelaer, Van der Linden, Groenenberg, & de Coninck, 2007).

Box 1: NewClimate Institute survey cost related questions and response options

1. **What CER price level is required by the project to continue verification & issuance activities?** *This question allowed the respondent to choose from the following price level ranges per tonne of carbon dioxide equivalent emissions and qualitative responses:*

a) < € 2;

b) € 2-5;

c) € 5-10;

d) € 10-20;

e) > € 20;

f) Project will continue VI regardless of CER price;

g) I do not know;

h) No price will allow continuance of VI.

2. **What is your best estimate on the total costs per verification & issuance cycle until successful CER issuance is achieved (e.g. costs for verifier, internal labour costs)?** *This question allowed the respondent to choose from the following price level ranges per tonne of carbon dioxide equivalent emissions and qualitative responses:*

a) < € 5,000;

b) € 5,000 – 10,000;

c) € 10 - 25,000;

d) € 25,000 - €50,000;

e) € 50,000 - €75,000;

f) > € 75,000;

g) I do not know.

Source: NewClimate Institute's survey of CDM projects (Warnecke et al., 2015).

As all the responses are expressed as ranges, rather than discrete numbers we assign a discrete valuation to the response by taking the mid-point of the range, e.g. where a respondent selected a cost range of € 5,000 – 10,000, we assign a value of € 7,500 to that response. The first response option for both questions did not have a lower bound (i.e. <€ 2) so we assume the lower bound is zero. We assume that the upper bound is € 30 for the price level as CER prices on the secondary market have reached levels close to, but never as high as € 30. It is therefore highly unlikely that investors would have developed the project based on an expectation of selling the CERs at prices in excess of this level. We assume an upper bound of € 100,000 for the verification and issuance cycle costs. Fewer than five percent of respondents selected the highest value among the response options for either of the two questions, so adjusting the upper bound value that we have assumed within reasonable limits does not materially impact our findings.

When using this data source, it is important to consider that survey respondents might have interpreted the questions in different ways. Accordingly, the results need to be interpreted and used carefully. The intention of the first question was to elicit the CER price level that would be needed for the project to undertake the abatement and CDM-specific activities required for CER issuance. In theory, for vulnerable projects this would include both positive marginal GHG abatement costs as well as the ongoing CDM transaction costs. For projects that are not vulnerable this would include only the ongoing CDM transaction costs. It is possible that the respondents may have interpreted the first question in different ways. Some respondents may have exclusively focused on the costs associated with verification and issuance, ignoring the marginal GHG abatement costs. Alternatively, respondents may have considered the CER price level required at project inception to generate a sufficiently attractive rate of return on the investment. They may also have responded with an aspirational price level that would offer a certain level of profit that they consider to be "fair".

The responses to the first question were relatively high, especially compared to current market prices, other data on CDM transaction costs and, for vulnerable projects, GHG abatement costs. Average valuations at the project type level ranged from € 3-11 per CER across the different project types. The range for projects with low vulnerability is € 5-8 per CER, which is significantly higher than our estimates of CDM transaction costs. A possible explanation, mentioned in the previous paragraph, is that the required price level at project inception was included in some responses. It is also possible that some respondents included a high margin on top of their estimate of costs to both cover risks and allow for a certain level of profit for re-engaging in verification and issuance activities. For these reasons, it is likely that the survey data tends to over-estimate the actual costs of supplying CERs, in particular for project types with low vulnerability.

The second question set out in Box 1 above was intended to relate exclusively to the ongoing CDM transaction costs associated with verification and issuance (e.g. the verifier's fee as well as internal administrative costs associated with coordinating the verification and submitting documentation to the CDM Executive Board to request CER issuance). We assume that respondents did not include any estimates of monitoring costs within their response as these were not included in the examples set out in the question. Furthermore, our comparison of the responses to alternative data sources also indicates that the respondents did not include monitoring costs within their answer. We also assume that the responses do not include the actual issuance fee payable to the CDM Executive Board. The response options were expressed in absolute Euro terms. The average costs per verification and issuance cycle for the different project types covered by the survey ranged from € 12,000-47,000.

In order to use the survey responses to inform the two key cost categories that we are interested in, we assume that the responses to the first question include both the marginal GHG abatement costs as well as ongoing CDM transaction costs, although – as noted above – some respondents may have included a consideration of capital investments that are already sunk in their answers. To isolate the first component – the marginal GHG abatement costs - we subtract an estimate of the ongoing CDM transaction costs. We do this by converting the responses to the second question into costs per CER and then deducting this, as well as an estimate of the issuance fee, from the responses to the first question. This approach requires an assumption on the frequency that a project might undertake a cycle of verification and request issuance. We assume that projects generating emission reductions of at least 50,000 tCO_2e per year follow an annual verification and issuance cycle and projects generating fewer emissions reductions follow a biennial cycle. This follows the approach adopted in Warnecke et al., 2013.

We use the responses to the second survey question to inform our analysis of the second key cost component – the ongoing CDM transaction costs.

Alternative cost estimates

We identified three studies from the literature on GHG abatement and CDM transaction costs to complement and compare to the results from the NewClimate Institute survey. These sources are summarised in the following bullet points. The first two studies provide estimates of ongoing CDM transaction costs. The third study examines industrial gas projects in detail, providing an assessment of both GHG abatements costs as well as ongoing CDM transaction costs.

- **Warnecke et al., 2013:** This study examined opportunities for the continued implementation of CDM projects within a climate of low CER prices. It includes estimates of GHG abatement costs for new projects, but does not split out the fixed upfront capex from the ongoing opex, which is necessary for our analysis of registered projects. The study also includes CDM transaction costs broken down into different stages within the CDM process based on different studies and a review of information contained in project design documents (PDDs). The study reports high and low costs estimates for both monitoring and verification costs separately across different project types.
- **Vivid Economics, 2013:** Vivid Economics considered the impact of different designs for a CDM capacity fund to boost demand for CERs. The study reports estimates of annual monitoring, verification and certification costs across a wide range of project types, including several project types that account for a relatively small share of supply and which were not covered by the NewClimate Institute survey. The estimates are reported for five regions (Africa/Middle and Near East; Asia (excluding China); China; Latin America; and Others). These cost estimates group monitoring, verification and certification costs together and are not broken down into their component parts.

- **Schneider and Cames, 2014:** This study exclusively assesses costs of industrial gas projects in the CDM (HFC-23, adipic acid and nitric acid). The analysis includes estimates of marginal GHG abatement costs for implemented projects as well as ongoing CDM transaction costs. It therefore covers the two key cost categories that are of interest in this study but only for three CDM project types.

We carried out a mapping of the different project types covered by the three studies as well as the NewClimate Institute survey response analysis and compared estimates across the matching data points. The NewClimate Institute survey and the Schneider and Cames, 2014, study provide the only sources of marginal GHG abatement costs amongst these sources for projects that have been physically implemented. The range of cost estimates for nitric acid projects is wider in the Schneider and Cames, 2014, study (€ 0.15 – 6.60) than in the NewClimate Institute survey (€ 1.47 – 4.61). The middle estimates for these projects is also lower in the Schneider and Cames, 2014, analysis - ranging between € 0.69-1.68 depending on the type of nitric acid project – than the average estimate across all nitric acid projects of € 3.01 in the NewClimate Institute survey.[6] Schneider and Cames, 2014, estimates for HFC-23 projects are also lower than the findings from the NewClimate Institute survey. For adipic acid projects, the survey did not receive any responses, so no comparison can be made.

For the ongoing CDM transaction costs the estimates included in the Vivid Economics, 2013, and Warnecke et al., 2013, studies are broadly similar. The responses to the NewClimate Institute survey in the majority of cases are slightly lower than the two other studies. This appears to be explained by the lack of any explicit mention of monitoring costs in the second cost-related question shown above in Box 1. By adding the monitoring cost estimates for different project types set out in the Warnecke et al., 2013, study to the NewClimate Institute survey estimates the total levels per monitoring, verification and issuance cycle are well-aligned across the three sources.

2.2.4 Application of cost data

The main source we rely on for both marginal GHG abatement and ongoing CDM transaction cost data is the NewClimate Institute survey (as detailed in section 2.2.2 above). Our analysis of the survey responses provides estimates of the average cost by project type covered by the survey and also at the level of the host country and project type pairing. In our Base Case supply curve we use the more granular host country and project type level data and apply this to each project. We also test the impact of applying the aggregated project type average cost across projects from all geographies.

For industrial gas projects (HFC-23 and N_2O abatement) we use the data points from the Schneider and Cames, 2014, study as this analysis was based on a more comprehensive review, specific to these technology types and covering a larger sample size.

For the ongoing CDM transaction cost estimates we add estimates of the monitoring costs from the Warnecke et al., 2013, study to the NewClimate Institute survey cost estimates. The Warnecke et al., 2013, study does not differentiate these costs across countries, so we apply the same monitoring costs per project type across all countries.

There are a number of project types that are not covered by the NewClimate Institute survey, although these account for a relatively minor share (less than 10 percent) of the potential supply from all registered projects. We use the ongoing CDM transaction cost estimates from the Vivid Economics, 2013, study where they exist for project types that are not included within the NewClimate Institute survey. For any remaining project types we apply the population average cost levels from our analysis of the survey data.

In a sensitivity analysis, we also test the impact of drawing exclusively on the ongoing CDM transaction costs included in both the Warnecke et al., 2013, and Vivid Economics, 2013, studies.

All cost data from across the different sources is converted into real 2016 prices, expressed in Euros.[7]

6 Note that these cost estimates have been converted into 2016 prices.

7 As all the data is expressed in Euros in its original form the costs just required adjusting for inflation. We used the HCIP inflation rate published by Eurostat, here: http://ec.europa.eu/eurostat/web/hicp/data/database. None of the cost data sources provide explicit information related to any adjustments made to the costs for inflation. We therefore assume that reported cost estimates are all nominal values related to the year of the publication of the report. The NewClimate Institute survey was conducted in 2014 so we assume that the responses were expressed in 2014 prices.

2.2.5 Application of V&I margin

We add a fixed margin on top of the ongoing CDM transaction cost component for all projects that have not been issued with CERs in the two years prior to 17 April 2017. We assume that projects that did not request CER issuance in the two years prior to the information date used for our analysis of CDM projects, or projects that have never been issued with CERs, will only (re-)engage in verification and issuance activities if it is likely to offer a positive return on their investment, rather than simply cover the costs of the activities alone. The appropriate level of this margin is uncertain. We assume here a level of € 20,000 and test the sensitivity of our results to alternative margin levels.

2.2.6 Verification and issuance cycles

We separate the issuance fee from the other ongoing CDM transaction costs. The issuance fee is based on a defined payment structure per CER.[8] We assume that projects would verify their emission reductions and request issuance only once by 2020. This cycle would then cover the full amount of the supply potential in one go. The rationale for this simple approach to estimating the verification and issuance costs is that most projects require a higher price signal to undertake these activities than the current market offers. Demand from international aviation under the CORSIA appears to be the most probable source of this signal but the precise details of the scheme design are unlikely to be known until 2018 or later, leaving limited time for projects to initiate verification and issuance procedures. To the extent that projects might carry out additional verification and issuance cycles over the period to 2020, our assumption will underestimate the actual cost.

2.3 Model

The CER supply curve is derived using a bottom-up model that determines the potential for and cost of supplying CERs for each registered project. The model draws on earlier work by the authors to estimate the CER supply potential for registered projects (Schneider et al., 2017) and the categorisation of the vulnerability of projects to discontinuing GHG abatement (Warnecke et al., 2017). For the purpose of this paper, we amend this model by incorporating data on the marginal GHG abatement cost and ongoing CDM transaction cost information, as set out in the previous section. Key assumptions and data sources are described in section 2.2 above.

To calculate the marginal cost of CER supply for each registered project we use information on the project type (technology), the country it is located in, and our categorisation of its vulnerability to discontinuing abatement. Based on this information, we determine for each project its ongoing CDM transaction costs, and where applicable, include the V&I margin. For projects with a high vulnerability, we also include the marginal GHG abatement costs. In the case of project types that have variable vulnerability we randomly divide the projects into three equal groups. We assume that one third of the projects have a low vulnerability and one third have a high vulnerability and treat these as per all other projects falling within these respective categories. For the third group, we assume that the projects face some, but lower marginal GHG abatement costs than vulnerable project types. For these we assign each of the projects a random number between zero and one and multiply this by the marginal GHG abatement costs estimated for that project. This approach assigns, on average, half of the marginal GHG abatement costs across all projects within this third group. However, it does so in such a way that the marginal GHG abatement cost component varies between close to zero and the full cost at the level of individual projects. We then generate a supply curve by sorting the projects in ascending order in terms of their marginal cost and calculating the cumulative supply of CERs at each price level from projects whose marginal cost is equal to or lower than that price.

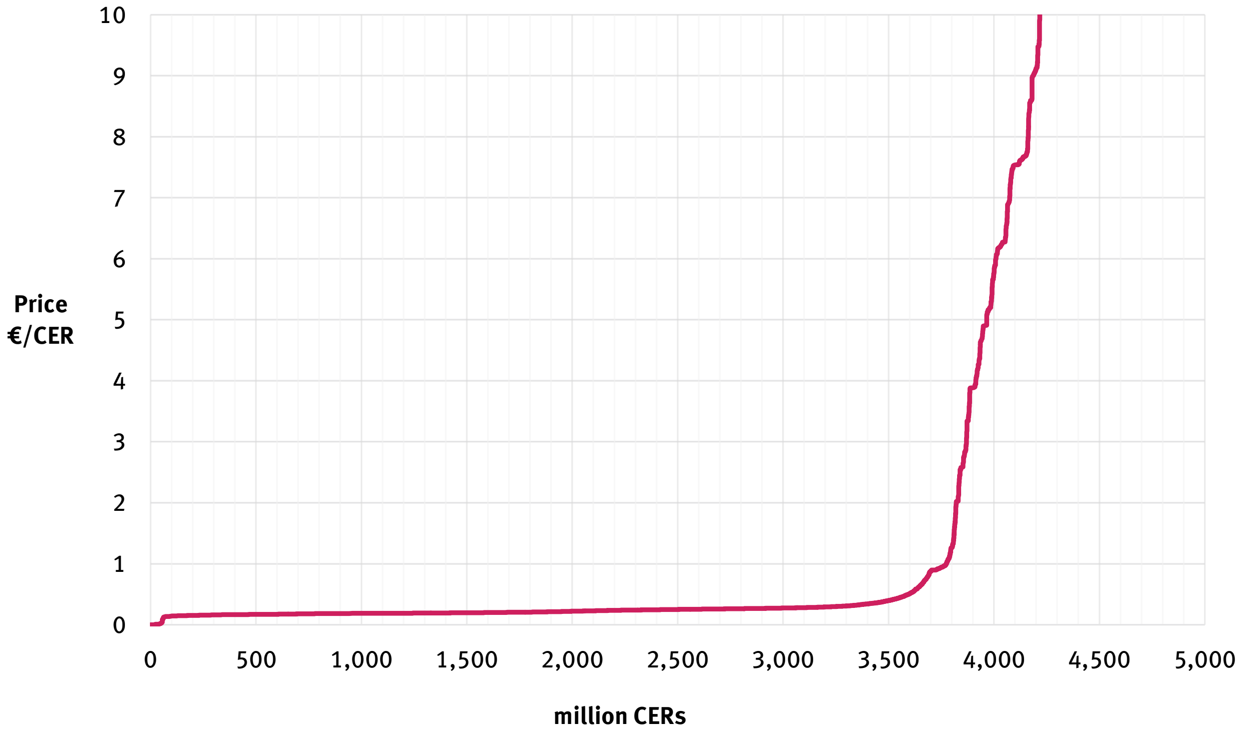
8 The issuance fee is $0.10 for the first 15,000 CERs issued to a project in a given year, and $0.20 for all CERs in excess of 15,000. A share of 2 percent of the total CERs that are eligible for issuance is placed in the Adaptation fund. For Least Developed Countries (LDCs), who do not pay any issuance fee or contribution to the Adaptation fund, these components are set at zero in our model.

3 Results: Supply curve

We present the results of our analysis in this chapter. First, we present a „Base Case“ of the CER supply curve. The Base Case represents a scenario in which all registered projects and CERs are deemed eligible and in which the assumptions and data sources described in chapter 2 above are used. We then apply a number of scenarios which limit the eligibility of projects or CERs and examine the impact this has on the supply curve. We also present and discuss a number of sensitivity analyses to test the influence of our assumptions and data choices on the main findings.

3.1 Base Case supply curve

Figure 1 shows the CER supply curve in the Base Case scenario. The curve illustrates the volume of CERs that could be supplied by registered projects at different prices levels. The CER volume is based on emission reductions occurring from 2013 to 2020, excluding CERs that have already been issued.



Source: Author's calculations (see methodology and data sources in Chapter 2)

Figure 1: Base Case supply curve for CERs to 2020

Figure 1 shows that there is a large pool of CERs that could become available at relatively low-prices. In the Base Case, up to 3.8 billion new CERs could supply the market at prices below € 1 per unit. This is because most registered and operational projects have low vulnerability to discontinuing GHG abatement and their marginal cost of CER supply is estimated solely based on their ongoing CDM transaction costs and the V&I margin, where applicable. The CER supply potential would be even larger if CERs from emission reductions after 2020 were included in the analysis.

3.2 Supply curve under alternative scenarios

In this section, we consider a number of alternative scenarios to the Base Case supply curve to reflect possible eligibility restrictions that policy-makers could apply to credits from certain projects. Purchasing CERs from projects with low vulnerability is unlikely to materially alter the level of abatement undertaken by these projects.[9]

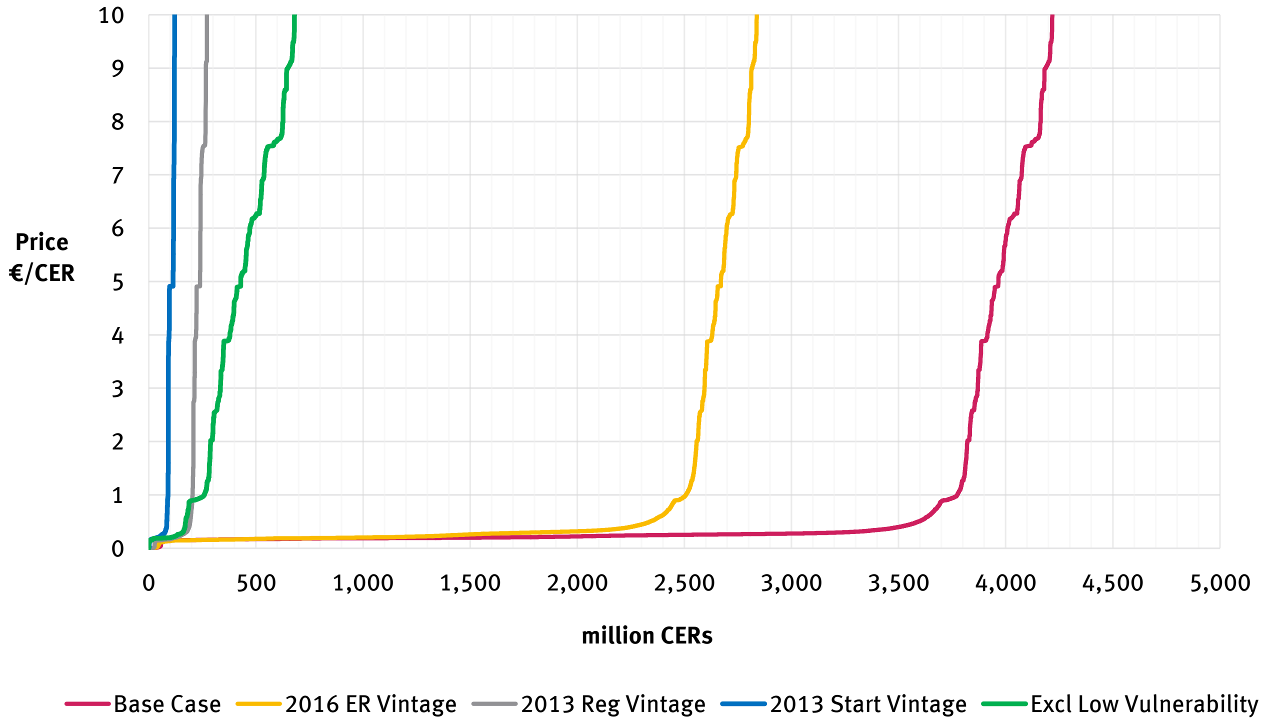
9 The fact that a project is not deemed vulnerable to discontinuing GHG abatement does not contest the assessment of additionality at project inception. Rather, it recognises that, from today's perspective, the project's savings or revenues from continued operation exceed its operational expenditures. Therefore, the distinction between vulnerable and non-vulnerable projects does not relate to the quality of the projects as such, but it has implications for the GHG emissions impact of purchasing or recognising CERs from these projects.

Policy-makers may therefore aim to target project types that are in need of support to continue GHG abatement activities. They may also limit the available pool of CERs from existing projects in order to incentivise the development of new projects that deliver additional GHG abatement.

We assess the impact of two types of eligibility constraints: First, we assess different "vintage" restrictions, which relate to either the timing of project milestones – such as investment decisions, physical implementation or registration under the CDM - or to the timing of emission reductions delivered by the project. Second, we assess restrictions based on the vulnerability of projects to the risk of discontinuing GHG abatement activities. These two types of constraints are highly relevant for ensuring that a programme purchasing or recognising CERs triggers further emission reductions, beyond those that would occur without the programme.

In addition to the Base Case, we consider four main alternative scenarios, which are presented below in Figure 2. All of the inputs and assumptions for these scenarios are the same as those used in the Base Case, with the exception of the following adjustments:

- **Vintage restrictions applied to the date of emission reductions:** CERs are only eligible if they were issued for emission reductions delivered after the relevant date. For example, a vintage restriction on the date of emission reductions from 2016 limits the supply to CERs issued for GHG abatement that took place on or after 1 January 2016. As our analysis is limited to the supply potential from 2013 to 2020 we implicitly apply a 2013 vintage restriction to the emission reduction date in the Base Case scenario. In an alternative scenario, we assess the impact of a vintage restriction for emission reductions occurring as of 1 January 2016 (shown by the light orange line and labelled "2016 ER Vintage").
- **Vintage restrictions applied to the registration date:** This form of vintage restriction applies at the project level and limits the supply of eligible credits to projects that were registered by the CDM Executive Board on or after the relevant date. In an alternative scenario, we assess the impact of applying a 2013 registration date vintage restriction (shown by the grey line and labelled "2013 Reg Vintage").
- **Vintage restrictions applied to the start date:** This vintage restriction is similar to that applied relative to the registration date in the sense that it restricts the eligibility of credits at the project level. In this case, credits are only eligible if the "start date" of the project is on or after the date of the vintage restriction. A CDM project's start date is defined under the CDM and refers to the date "project participants commit to making expenditures for the construction or modification of the main equipment or facility" (UNFCCC, 2012b), i.e. the date of the investment decision to proceed in developing the project. We assess the impact of applying a 2013 start date vintage restriction (shown by the blue line and labelled "2013 Start Vintage").
- **Exclusion of low vulnerability projects:** All project types that are considered to have a low vulnerability of discontinuing GHG abatement are excluded from the supply curve, leaving project types with high and variable vulnerability (shown by the green line and labelled "Excl Low Vulnerability").



Source: Author's calculations (see methodology and data sources in Chapter 2)

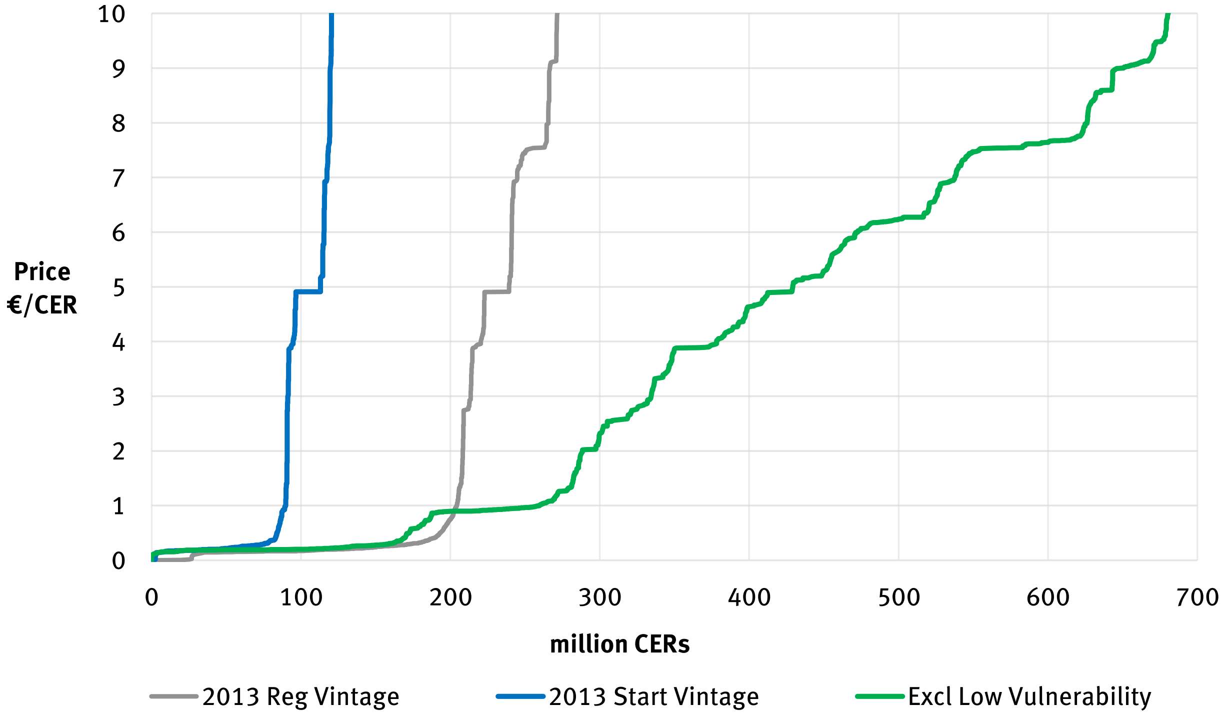
Figure 2: Supply curves under eligibility constraints for CERs to 2020

These alternative scenarios have a significant impact on the shape of the supply curve. A 2016 vintage restriction applied to the date of emission reductions removes approximately 1.4 billion CERs from the available supply, relative to the Base Case. However, even in this scenario up to 2.5 billion CERs could be supplied at a price level below € 1.

Imposing the 2013 vintage restrictions on the registration date or start date of the project fundamentally changes the supply curve, limiting it to 275 million and 121 million CERs respectively. As the project's start date typically precedes registration under the CDM, imposing the same vintage date to the start date constrains supply more than when applied to the registration date.

Excluding CERs from project types with low vulnerability also has a pronounced effect on the supply curve, relative to the Base Case. The total supply in this scenario is approximately 690 million CERs.

Figure 3 represents three of the alternative scenarios with a reduced x-axis scale to provide a better visualisation of the shape of the supply curves under these alternative scenarios with significantly lower supply potential than in the Base Case.



Source: Author's calculations (see methodology and data sources in Chapter 2)

Figure 3: Supply curves under selected eligibility constraints for CERs to 2020 (reduced x-axis scale)

In the registration and start date vintage restriction scenarios, as per the Base Case, a large share of the available CERs is provided from low vulnerability projects. In the 2013 registration date vintage restriction case, approximately 200 million CERs could be supplied to the market for under € 1, after which we estimate that prices would increase steeply. In the 2013 start date vintage restriction case, approximately 90 million CERs could be supplied to the market for under € 1. We also test the impact of applying a 2016 date to these vintage restrictions, for which the total potential supply is reduced to 22 million CERs in the registration date case and just 1 million CERs in the start date scenario. This reflects the fact that very few new projects have registered under the CDM in recent years.

The gradient of the supply curve in the scenario that excludes low vulnerability projects is shallower compared to the vintage restriction scenarios. This is because it consists of projects with variable or high vulnerability for which the marginal GHG abatement costs differ between projects, and in some instances, countries. Projects with variable vulnerability account for a larger share of the total supply under this scenario. A third of all the projects with variable vulnerability are treated as if they have a low vulnerability to discontinuing emission reduction activities (as set out in section 2.3 above) and these make up most of the left-hand end of the supply curve below € 1.

3.3 Sensitivity testing

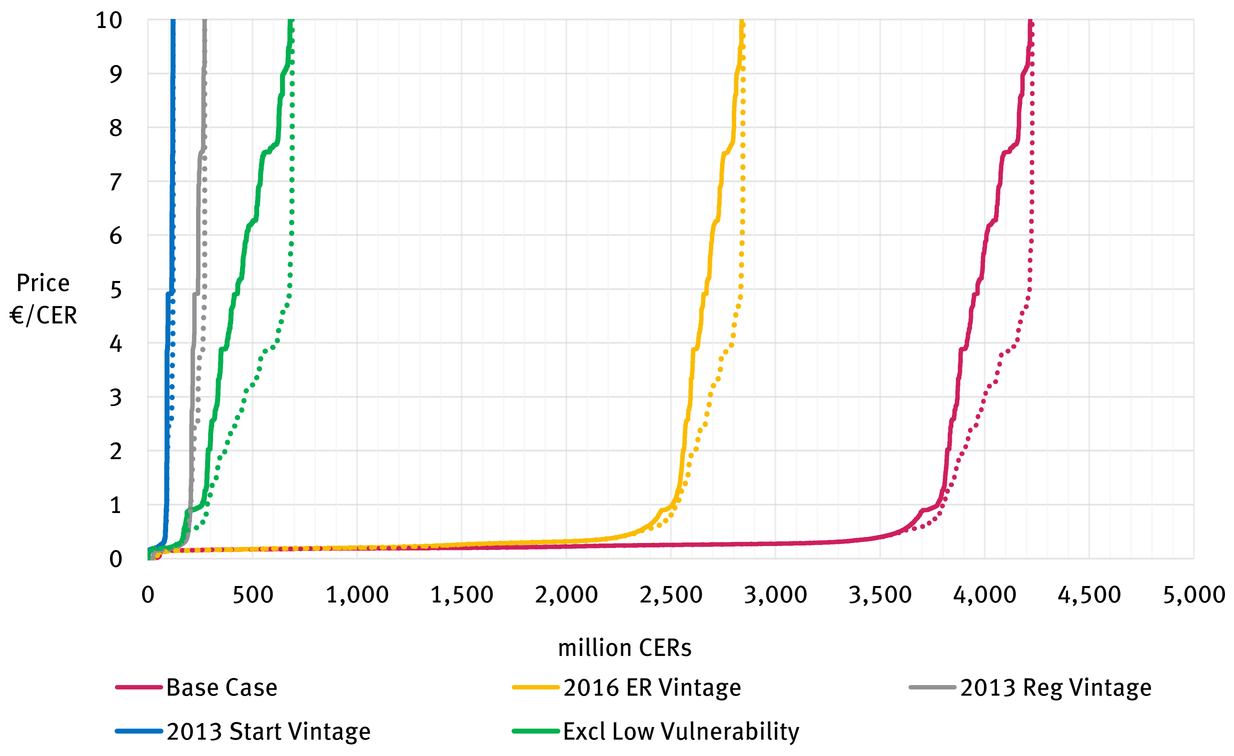
We have carried out sensitivity testing of the key assumptions to determine how the results respond to changes in our assumptions and choice of data sources. The following sub-sections set out the variables that we have tested and the key findings.

Cost data sensitivity

To test the robustness of the cost data we carry out a number of different sensitivity tests to each of our five scenarios. First, instead of using the cost data from the NewClimate Institute survey at the level of each host country and project type pairing, we applied the project type average to all applicable projects, regardless of their location. Second, we run the scenarios using the ongoing CDM transaction cost estimates from the Vivid Economics (2013) study and then the Warnecke et al. (2013) report in place of the cost data collected and analysed from the NewClimate Institute survey. These two sensitivity tests do not have a material impact on the results.

The supply curves under these two sensitivity tests are visually difficult to differentiate between when displayed in a chart and are therefore not shown.

For project types with variable or high vulnerability, we estimate the marginal GHG abatement costs. These estimates are based on the responses to the first cost-related question in the NewClimate Institute survey (see Box 1 above) and adjusted to remove the CDM related ongoing transaction cost elements. We note in the description of the data in section 2.2.2 that respondents may have interpreted the question in different ways, which would either over- or under-estimate their valuation relative to what we are interested in for this study. The price levels indicated in the responses to the survey suggest over-estimation is more likely. As we did not identify any alternative recent sources of marginal GHG abatement costs for registered CDM projects we test the impact of halving the marginal GHG abatement costs derived from the survey responses. Figure 4 shows the impact of halving the marginal GHG abatement cost estimates on our Base Case and the four alternative scenarios (the sensitivity analysis with marginal GHG cost estimates halved are depicted by the dotted lines in the same colour as the corresponding main scenario results).



Source: Author's calculations (see methodology and data sources in Chapter 2)
Note:The solid lines show the scenario results and the dotted lines (with the same colour) show the corresponding sensitivity analysis with the marginal GHG abatement cost estimates halved.

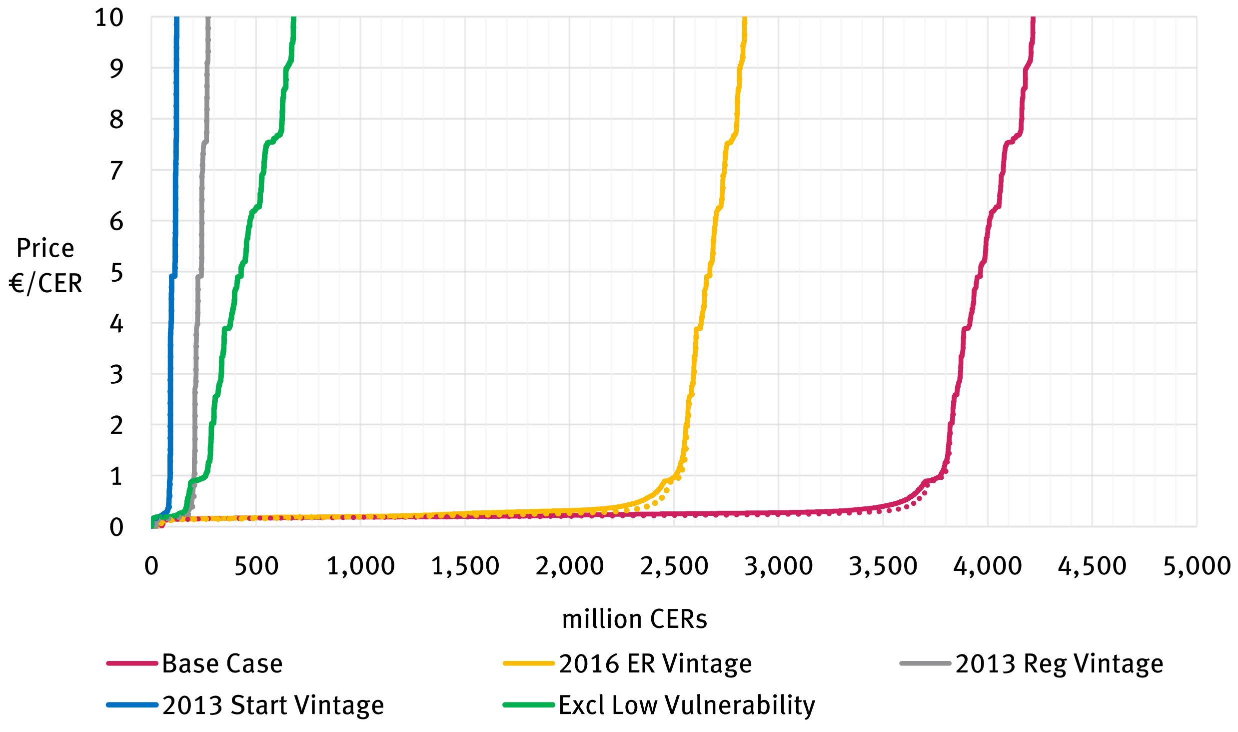
Figure 4: Sensitivity analysis: Marginal GHG abatement costs halved

This sensitivity test shows that, whilst halving the GHG abatement cost estimate clearly impacts the shape of the supply curve under each of the respective scenarios by shifting it to the right, such an adjustment does not materially impact the overall picture of the results. As expected, the most material change is in the scenario which excludes projects with low vulnerability. In the main scenario that excludes low vulnerability projects approximately 400 million CERs could be supplied at prices at or below € 5. If marginal GHG abatement costs are actually half the level that has been derived from the NewClimate Institute survey, then almost all of the supply potential in this scenario of approximately 700 million could be supplied at prices at or below € 5.

V&I margin sensitivity

In our Base Case and alternative scenarios, we include a margin of € 20,000 for projects that have not been issued with CERs in the two years prior to 17 April 2017. This margin is included because we assume that an additional incentive might be necessary to (re-)engage project developers (or external consultants) with CDM verification and issuance activities, since, without this incentive, the expected returns from selling CERs would only cover the ongoing CDM transaction costs and therefore may not be sufficiently attractive to justify the effort. The level of margin that would make the effort of (re-) engaging with the CDM processes attractive is uncertain.

We test the sensitivity of this margin by first removing it altogether and then increasing it to € 50,000. Figure 5 shows the impact of removing the margin altogether (dotted lines). A margin level of € 50,000 has a similarly negligible impact.



Source: Author's calculations (see methodology and data sources in Chapter 2)
Note: The solid lines show the scenario results and the dotted lines (with the same colour) show the corresponding sensitivity analysis with the margin set to zero.

Figure 5: Sensitivity analysis: Zero margin

Overall, the sensitivity testing shows that the results are relatively robust to changes to assumptions and data sources.

4 Demand for CERs

To understand the implications that the shape of the supply curve might have on the market for CERs it is important to consider the range of potential demand levels. The supply curves developed in this study and presented in the previous chapter show the potential supply of CERs associated with emission reductions occurring between 2013 and 2020 (or a subset of these in the scenarios where vintage restrictions were applied). These estimates of the potential supply do not include the approximately 340 million CERs that have already been issued by the CDM Executive Board over as of 17 April 2017.

In the remaining period to 2020 the main source of demand for CERs is likely to be for compliance use under the Kyoto Protocol. Additional demand may also be derived from voluntary pledges made by countries in the context of the Cancun Agreements made at COP16 in November 2010, from development banks and agencies that agree to purchase CERs and from the voluntary cancellation of credits.[10] New sources of demand that are likely to be in place from 2020 include the CORSIA - which aims to ensure carbon neutral growth for international aviation through a combination of abatement measures as well as offsetting – as well as countries looking to use offsets in part to help meet their obligations under the Paris Agreement, although it is not yet clear to what extent and under what conditions this will be allowed. Based on negotiations to date it is likely that at least CORSIA will provide some level of demand for CERs that are associated with emission reductions delivered up to 2020. In the following sections we discuss the potential demand, both up to 2020 and post-2020, for CERs issued in the period to 2020.

4.1 Demand for CERs to 2020

An analysis by Schneider and La Hoz Theuer, 2017, assessed the potential demand for CERs from Kyoto Protocol compliance buyers, countries looking to meet their voluntary pledges, development banks and agencies and private or public actors involved in the voluntary cancellation of credits, drawing on third party analysis by organisations such the European Commission, ICAP and the UNFCCC. They estimated that demand for compliance under the second commitment period of the Kyoto Protocol, adopted through the Doha Amendment, would be approximately 340 million CERs, stemming from the EU ETS and the Swiss ETS and from government purchase programmes. They estimated demand associated with the Cancun Agreements of approximately 150 million CERs, demand from results-based financing approaches from development banks and agencies of approximately 60 million CERs and voluntary cancellation of roughly 20 million CERs based on assumptions about the continued growth the voluntary market and the relatively small share of this market that is accounted for by the CDM. This leads to a total estimate of demand for CERs over the period 2013-2020 of 660 million. Given that almost 340 million CERs had already been issued for the corresponding period by April 2017, this leaves less than half, or approximately 320 million CERs, of remaining demand. From the supply curve analysis in the Base Case scenario presented above - which considers supply from all registered projects - it is evident that further demand of the order of 320 million CERs, or even several times that amount, is unlikely to have a material impact on the market price of CERs; approximately 3.8 billion CERs could potentially supply the market at prices below € 1.

4.2 Post-2020 demand for CERs

CORSIA will be implemented from 2021 in a series of phases. The pilot phase (2021-2023) and the first phase (2024-2026) are voluntary, although in practice countries representing almost 90 percent of international aviation activity have already indicated their intention to participate.[11] The second phase (2027-2035) will be mandatory for all countries that either account for at least 0.5 percent of total international aviation activity or if, when countries are ranked in terms of their activity levels from those with the highest to those with the lowest, the country is included in the cumulative share of the top 90 percent of total emissions. The precise rules for CORSIA are still under negotiation so there is currently no confirmation that CERs issued in the period to 2020 could be used for compliance. According to the ICAO assembly resolution that adopted CORSIA, offset programmes will have to comply with emissions unit criteria. Moreover, the resolution refers to a „vintage“ of eligible offsets. As noted above in section 3.2, how such a vintage restriction for emission units eligible under CORSIA should be implemented is part of the ongoing negotiations.

The 2017 study by Schneider and La Hoz Theuer includes estimates of the total demand under CORSIA based on an unpublished modelling study estimating aircraft engine emissions (van Velzen & Cames, n.d.). This suggests that demand in the pilot phase would be 120 million emission units, or 40 million per year on average; in the first phase demand would rise to 270 million emission units, or 90 million per year on average; and over the course of the second phase demand would total 2.3 billion emission units, or approximately 260 million per year on average.[12]

10 Examples include the World Bank's Pilot Auction Facility (PAF), the Nitric Acid Climate Action Group (NACAG) purchasing initiative launched by the German Government or the German Federal Government's commitment to offset the climate impact of its employees' business trips by purchasing CERs.

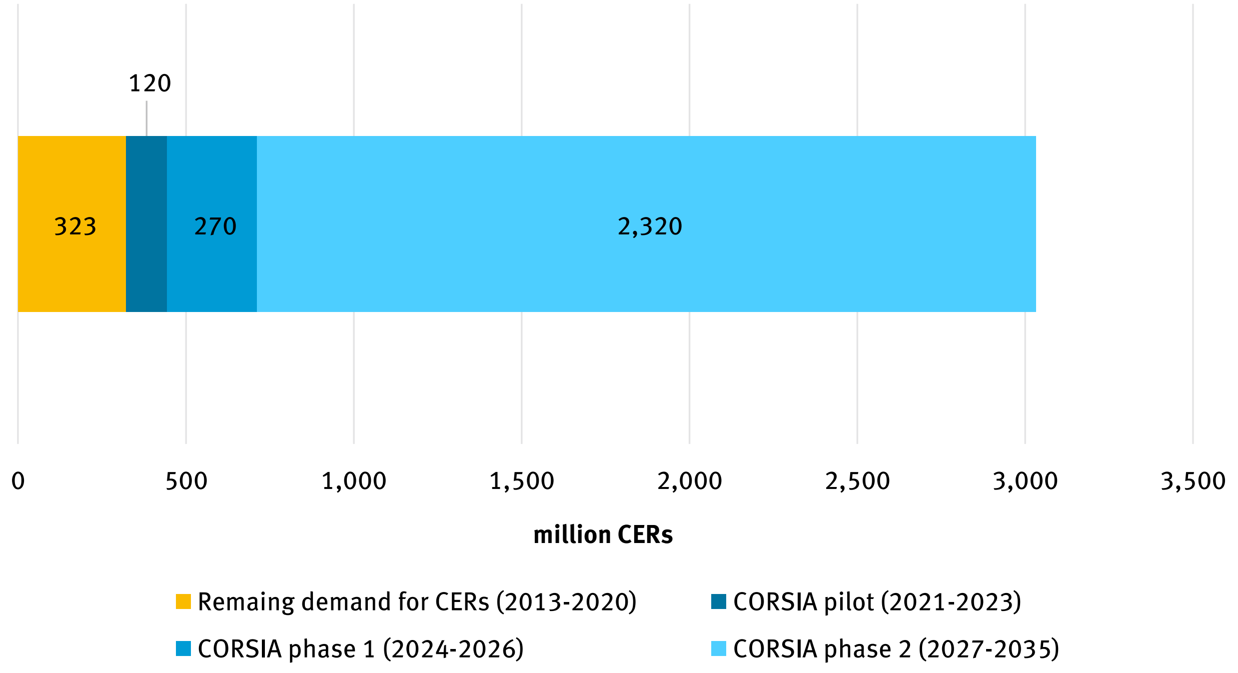
11 As of 11 January 2018, 73 States, representing 87.7 percent of international aviation activity have indicated their intention to voluntarily participate in CORSIA from the beginning of the pilot phase. See: http://www.icao.int/environmental-protection/Pages/market-based-measures.aspx. (accessed on 29 January 2018)

12 As international aviation activity is expected to grow over time the average annual estimates will typically overestimate the offset requirements in the initial year(s) of the phase and underestimate them in the latter year(s).

Over the three phases the combined demand would be on the order of 2.7 billion emission units. This therefore represents a significant potential source of new demand for the CDM. However, as highlighted above the eligibility of CERs within the scheme has not yet been confirmed. Even if the CDM is included as an eligible source of credits, it is possible that alternative offset programmes – such as voluntary carbon offsetting programmes – will also be approved for compliance use within CORSIA meaning that part of this demand could be channelled away from the CDM. Moreover, bodies under ICAO are considering the use of allowances from emission trading schemes under CORSIA.

In addition to CORSIA, it is conceptually feasible that additional demand for CERs may stem from countries looking to use offset credits to help them meet their Nationally Determined Contributions (NDCs) under the Paris Agreement. The role of the CDM under the framework of the Paris Agreement is still unclear. Although a number of countries have indicated their interest to engage in international market mechanisms in the context of Article 6 of the Paris Agreement, most of this interest was to enable domestic projects to supply a potential international market, rather than interest in buying international units and thereby providing demand for credits. It is highly uncertain what this may mean in terms of demand for CERs issued for emission reductions in the period to 2020. We have therefore not included here any estimates associated with using CERs to achieve NDCs or any ambition raising efforts under the Paris Agreement. It is also feasible that countries or private actors continue to voluntarily cancel CERs from emission reductions up to 2020 in the period after 2020, although – given the current levels of cancellation – this does not appear likely to alter the overall balance of supply and demand.

Figure 6 summarises the demand estimates set out in the previous paragraphs.



Source: Author's analysis of Schneider and La Hoz Theuer, 2017

Figure 6: Summary of potential demand for CERs

It is clear that, taken as a whole over the period to 2035, CORSIA offers the largest potential demand source for CERs. However, much of this demand is likely to occur in the second half of the 2020s and into the 2030s. Whether or not CERs issued for emission reductions pre-2020 will be eligible remains to be confirmed. And, even if they are permitted, it is likely that there will also be other offsetting programmes, and possibly allowances from emission trading schemes that could offer additional sources of supply from which this demand can be met.

4.3 Implications of the expected supply and demand

Implications for the period up to 2020

The estimates of demand for CERs up to 2020 cover a range of different purchasing sources, including compliance buying, voluntary offsetting and demand from development banks. Some of this demand targets certain CER vintages, project types or host countries in order to achieve specific policy objectives, such as a greater impact on GHG abatement or sustainable development goals. We have not analysed purchasing activities in detail as part of this work, but most existing purchase policies target specific project types, countries or CER vintages, and not just the cheapest available credits within the supply curve.

In principle, Parties to the Kyoto Protocol can use all type of CERs to meet their Kyoto targets. As noted above the available supply of cheap credits is several orders of magnitude higher than the expected level of demand. If certain countries voluntarily target more vulnerable projects then they may face higher prices. If all the approximate compliance demand of 320 million CERs up to 2020 were met exclusively by CERs from project types with variable or high vulnerability this could cost up to around € 5 per CER.

Implications for the period after 2020 without restrictions

Without restrictions related to the eligibility of CERs, the demand from CORSIA is unlikely to materially impact the price level for CERs. Even if CERs issued for emission reductions between 2013 and 2020 from currently registered CDM projects exclusively supplied CORSIA demand of approximately 2.7 billion up to 2035, plus the pre-2020 demand for CERs of approximately 0.3 billion, the price level would likely remain below € 1 per CER. Almost all of this demand could be sourced from low vulnerability projects which are likely to continue GHG abatement activities regardless of the price incentives offered by the CDM market. Purchasing CERs from projects with low vulnerability is therefore unlikely to materially alter the level of abatement undertaken by these projects. It will also likely not offer many project developers and investors the level of returns they anticipated at the project outset that would fully compensate them for their upfront capital expenditures. Nor will it offer further incentives for investment in new projects.

Implications for the period after 2020 with restrictions

An effective way for CORSIA, and other schemes, to incentivise emission reductions beyond those that are likely to occur anyway would be to impose eligibility criteria on the offset credits that can be used for compliance. Our analysis shows that imposing eligibility constraints on the use of CERs for compliance with CORSIA can have a significant impact.

A **2016 vintage restriction applied to the emission reduction date** reduces the availability of credits, but still leaves approximately 2.5 billion CERs available at prices around or below € 1. According to current projections, this could satisfy CORSIA demand until 2034. This option would, however, not incentivise significant emission reductions beyond those that would occur anyway.

Policy-makers could impose vintage restrictions that limit supply based on the date of project milestones. Imposing **2013 vintage restrictions on the project's start or registration date** has a material impact on the supply curve. In the case of the 2013 *start date* vintage restriction, supply from already registered projects in the period to 2020 would only provide a sufficient quantity of CERs to meet demand in CORSIA's pilot phase. Under the 2013 *registration* date vintage restriction, the supply from already registered projects would extend to cover part, but not all, of expected demand through both the pilot and first phases, running to 2026.

Under such vintage restrictions it is clear that the total CORSIA demand over the period to 2035 will exceed the supply potential from registered CDM projects over the period from 2013 to 2020.[13] CER prices could rise up to and in excess of € 10 or to levels required by projects or schemes outside of the scope of our analysis. These may be projects that are not yet registered under the CDM, projects from alternative eligible programmes that would be incentivised to enter the market, or emission units that can be transferred from eligible emission trading schemes.

The analysis in this paper is, however, limited to projects that are already registered. Under the CDM, there are up to 8,000 further projects that have not yet been registered but secured the right to register at any time in the future.

13 In a forthcoming study, we examine the available supply of credits from the CDM and a selection of voluntary market schemes over the period to 2035 under a range of different policy scenarios and assumptions.

Many of these projects have likely been implemented and could further supply the market if a vintage restriction based on a registration date is introduced. The CER supply potential from these projects is uncertain; it has been estimated at about 1 billion in the period up to 2020 (Schneider and La Hoz Theuer, 2017). Therefore, vintage restrictions based on the registration date may be less effective than restrictions based on the start date of the project, if policy-makers intend to ensure that further GHG abatement is triggered by new sources of demand. For these reasons, the CER price level under such vintage restrictions is also uncertain. It depends not only on the CER supply curve provided here, but also on the extent to which projects that are not yet registered, but exist in the CDM pipeline, would seek registration in response to new demand. New projects that are not currently in the CDM pipeline may also be developed or existing CDM projects might continue issuing credits after 2020, for example, if they were transitioned to a new mechanism set up under Article 6.4 of the Paris Agreement.

Another approach for policy-makers to encourage further emission reductions could be to exclude CERs from project types with low vulnerability. Imposing **restrictions on the supply of credits from low vulnerability project types** reduces the total supply potential from CERs associated with emission reductions between 2013 and 2020 to well below the expected level of total demand under CORSIA. Depending on the pre-2020 demand for CERs from vulnerable project types, sourcing the approximately 400 million emission units required in the pilot and first phase of CORSIA may cause prices to rise to somewhere in the range of € 4-10 per CER. This assumes that CERs will only be issued until 2020 and that there is no additional supply from either new projects registering under the CDM, or from eligible alternative programmes and emission trading schemes. Again, sourcing demand for CORSIA into its second phase may trigger the delivery of additional emission reductions.

5 Conclusions

In this study, we estimated the cost of supplying CERs from registered projects up to 2020 under a range of different scenarios. The findings presented in our Base Case highlight that there is a large potential supply of CERs – on the order of 3.8 billion – that could be issued at prices below € 1.

Demand levels for CERs are currently considerably lower than the supply potential from registered CDM projects, which has been the case at least since 2012 and led to a prolonged period of low market prices for CERs. Estimates of remaining demand for CERs over the period to 2020 for compliance with the Kyoto Protocol, voluntary pledges made within the Cancun Agreements and voluntary cancellation of credits are estimated to be on the order of just over 300 million CERs.

CORSIA represents the most likely source of significant additional demand for CERs. The eligibility criteria for emission units under CORSIA are still under negotiation, so uncertainty remains around whether the use of CERs will be permitted and, if so, what restrictions might be applied. Moreover, it is uncertain how much supply may come from CDM projects after 2020 and from potential alternative offset programmes or emission trading schemes, beyond the CDM.

Without restrictions related to the eligibility of CERs, the demand from CORSIA is unlikely to materially impact the price level for CERs. Even if CERs issued for emission reductions between 2013 and 2020 from currently registered CDM projects exclusively supplied CORSIA demand of approximately 2.7 billion up to 2035, plus the pre-2020 demand for CERs of approximately 0.3 billion, the price level would likely remain below € 1 per CER. Almost all of this demand could be sourced from low vulnerability projects which are likely to continue GHG abatement activities regardless of the price incentives offered by the CDM market. Purchasing CERs from projects with low vulnerability is therefore unlikely to materially alter the level of abatement undertaken by these projects. It will also likely not offer many project developers and investors the level of returns they anticipated at the project outset that would fully compensate them for their upfront capital expenditures. Nor will it offer further incentives for investment in new projects.

Our analysis suggests that the most effective way for CORSIA, and other sources of demand, to incentivise emission reductions beyond those that are likely to occur anyway would be to impose eligibility criteria on the emission units that can be used for compliance. A 2016 vintage restriction applied to the *date of emission reductions* removes around 1.4 billion CERs from the available supply, reducing it to approximately 2.9 billion CERs. This option, however, would not incentivise significant emission reductions beyond those that would occur anyway. Further emission reductions could be encouraged in two ways:

- Policy-makers could *exclude CERs from project types with low vulnerability*. This would have a pronounced effect on the supply curve, relative to the Base Case. The potential supply in this scenario is approximately 690 million CERs. Under this scenario demand for CERs would be channelled to project types that are otherwise at risk of discontinuing GHG abatement activities.
- Policy-makers could *impose vintage restrictions that limit supply based on the date of the project investment decision*. Imposing a 2013 vintage restriction on the date of the investment decision fundamentally changes the supply, limiting it to 121 million CERs. Restrictions on the date of the project investment decision could incentivise the development of new projects to meet the additional demand, which might not have gone ahead without CORSIA. These new projects could be developed either within the CDM or under alternative schemes that are approved for use within CORSIA.

Imposing a 2013 vintage restriction on the registration date limits the supply from currently registered projects to 275 million. Restrictions on the registration date may, however, be less effective at incentivising the implementation of new projects. This is because there are a large number of projects within the CDM pipeline that are not yet registered, but which are likely to have been implemented and may still request registration in the future if it were to become financially attractive to do so.

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