Offset credit supply potential for CORSIA

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Abstract

The International Civil Aviation Organisation is in the process of finalising the design of a scheme – the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) – to address carbon dioxide emissions from international aviation. In this discussion paper we estimate the potential supply of carbon offset credits to meet demand from international aviation under CORSIA under a number of different scenarios which include different types of restrictions imposed on the eligibility of offset credits. Our analysis considers supply from the four largest offsetting programmes: the Clean Development Mechanism, the Verified Carbon Standard, the Gold Standard and the Climate Action Reserve for emission reductions over the period from 2013 – 2035.

We find that existing projects under the four programmes could supply approximately 18 billion offset credits or more than six times the total demand anticipated for CORSIA over its intended duration. In the absence of robust eligibility restrictions, CORSIA will not result in significant emissions reductions beyond those that would occur without the scheme. This is because over 80 percent of the supply comes from projects that are likely to continue abatement regardless of whether they can sell offset credits. Allowing the use of all of these credits would therefore undermine the objective of the scheme to achieve carbon neutral growth. To address these risks, we recommend that policy-makers apply eligibility restrictions that either promote new emission reduction projects or support existing vulnerable projects that require offset credit revenues to continue GHG abatement.

Kurzbeschreibung

Die Internationale Zivilluftfahrtorganisation ist in der entscheidenden Phase zur Ausgestaltung eines globalen marktbasierten Klimaschutzinstruments (Carbon Offsetting and Reduction Scheme for International Aviation, CORSIA) zur Verringerung von Kohlendioxidemissionen im internationalen Luftverkehr. In diesem Diskussionspapier ermitteln wir das potenziell zur Verfügung stehende Angebot an CO_2-Ausgleichsgutschriften, um die Nachfrage aus dem internationalen Luftverkehr unter CORSIA zu bedienen. Die Abschätzungen berücksichtigen eine Reihe verschiedener Szenarien, die verschiedene Arten von Beschränkungen für die Inanspruchnahme von Ausgleichsgutschriften beinhalten. Unsere Analyse berücksichtigt das Angebot aus den vier größten Kompensationsprogrammen: dem Clean Development Mechanism (CDM), dem Verified Carbon Standard, dem Gold Standard und der Climate Action Reserve. Das Potenzial wird für Emissionsminderungen ermittelt, die im Zeitraum von 2013 bis 2035 erzielt werden können.

Wir können aufzeigen, dass bereits bestehende Projekte im Rahmen der vier Programme etwa 18 Milliarden Minderungsgutschriften bereitstellen könnten. Dies entspricht mehr als das Sechsfache der für CORSIA erwarteten Gesamtnachfrage während der vorgesehenen Laufzeit. Ohne strenge Zulassungsbeschränkungen wird CORSIA nicht zu signifikanten Emissionsminderungen führen, die nicht auch ohne die Projekte aufgetreten wären. Dies resultiert daraus, dass mehr als 80 Prozent des Angebots aus Projekten stammen, die wahrscheinlich unabhängig davon, ob sie Emissionsgutschriften verkaufen, weiterlaufen werden und kontinuierlich Emissionen vermeiden. Gutschriften ohne anspruchsvolle Zulassungskriterien zuzulassen, würde daher das Ziel von CORSIA – ein kohlenstoffneutrales Wachstum zu erreichen – unterminieren. Um diesen Risiken zu begegnen, empfehlen wir den politischen Entscheidungsträgern, Zulassungsbeschränkungen zu etablieren, die entweder neue zusätzliche Minderungsprojekte fördern oder solche bestehende Projekte unterstützen, die ohne die Erlöse aus Gutschriftenverkäufen die Treibhausgasminderungsaktivitäten einstellen müssten.

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Abbreviations

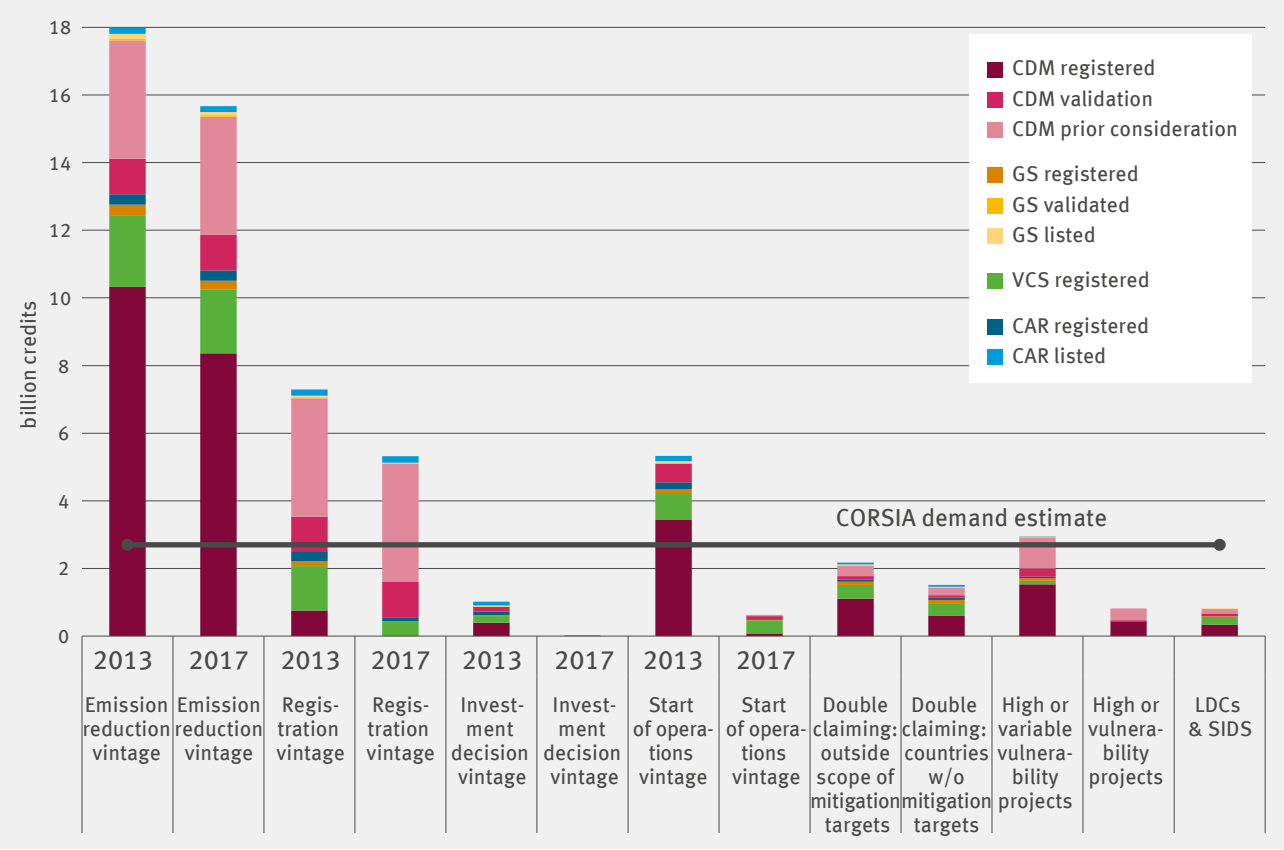
ARB	Air Resources Board (in California)
ARBOC	Air Resources Board Offset Credits
CAR	Climate Action Reserve
CDM	Clean Development Mechanism
CER	Certified emission reductions (issued by the CDM)
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPA	Component project activity
CTR	Climate Reserve Tonnes (issued by the CAR)
ETS	Emissions Trading Scheme
EUC	Emission Unit Eligibility Criteria
GHG	Greenhouse gas
GS	Gold Standard
HFC	Hydrofluorocarbon
ICAO	International Civil Aviation Organization
ITMO	Internationally transferred mitigation outcomes
LDCs	Least Developed Countries
NDC	Nationally determined contribution
PDD	Project design document
PoA	Programme of activities
ROC	Registry Offset Credits (issued by the CAR)
SIDS	Small Island Developing States
UNFCCC	United Nations Framework Convention on Climate Change
VCS	Verified Carbon Standard
VCU	Verified Carbon Unit (issued by the VCS)
VER	Verified Emission Reduction (issued by the GS)

Executive summary

Policy-makers at the International Civil Aviation Organisation (ICAO) are currently considering the detailed rules of a scheme to address carbon dioxide emissions from international aviation: the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The overarching objective of the scheme is to achieve carbon neutral growth in the international aviation sector from the beginning of 2021 via a combination of measures, including purchasing offset credits for emission reductions delivered in other sectors. One of the critical elements in the ongoing negotiations concerns whether, and how, to restrict the eligibility of offset credits that can be used under the scheme. This study aims to inform these considerations by estimating the supply potential from the four largest offsetting programmes: the Clean Development Mechanism (CDM), the Verified Carbon Standard (VCS), the Gold Standard (GS) and the Climate Action Reserve (CAR).

We estimate the future supply potential for offset credits for emission reductions achieved during the period 2013 to 2035 from existing projects. This excludes offset credits that have already been issued for emission reductions during the period. We consider a realistic potential supply in the case that project owners have sufficient economic incentives to proceed to the issuance of offset credits, by incorporating practical constraints that could limit the ability of a project to generate offset credits. Further supply for CORSIA could come from new projects that are implemented in response to this new demand or from using allowances from emissions trading schemes. Here we do not analyse these alternative potential sources of supply.

The study builds on earlier analyses by the authors of the potential supply of offset credits from the CDM in three ways: first, it extends coverage to the three largest non-governmental offsetting programmes. Second, it estimates the potential supply out to the end of 2035. And third, this study analyses the implications of different scenarios for the availability of offset credits for CORSIA. These include scenarios for restrictions based on the "vintage" or timing of emission reductions and project milestones; scenarios for the situation that host countries of projects are not ready or willing to address double claiming of emission reductions; scenarios which channel demand towards projects that are more vulnerable to discontinuing GHG abatement; and a scenario in which eligible offset credits are limited to projects located in LDCs and SIDS. Figure ES1 shows our estimates of the potential supply of offset credits across the scenarios we analysed.



Authors calculations (see methodology and data sources in Chapter 3)

Figure 1: Supply potential under different scenarios

We find that *existing* projects under the four programmes could supply approximately 18 billion offset credits for emission reductions achieved from 2013 to 2035, or more than six times the total demand anticipated for CORSIA from 2021 to 2035. On top of this *future* supply potential there is a current stock of approximately 600 million unused credits available from amongst the CDM, VCS and CAR.

In the absence of any eligibility restrictions, CORSIA will not result in significant emissions reductions beyond those that would occur without the scheme. This is because over 80 percent of the 18 billion offset credit supply potential comes from projects with a low vulnerability to discontinuing GHG abatement, meaning that these projects are likely to continue abatement regardless of whether they sell offset credits. Allowing the use of all of these credits would therefore undermine the objective of the scheme to achieve carbon neutral growth.

To address these risks, we recommend that policy-makers apply eligibility restrictions that either promote new emission reduction projects or support *existing vulnerable* projects that require offset credit revenues to continue GHG abatement:

- **To allow only new emission reduction projects, ICAO could restrict eligibility to projects that make their investment decision or start operations in the future, e. g. after offset credit programmes are approved as eligible under CORSIA.** New projects would also be promoted – though to varying degrees – with restrictions based on historical dates, as these would limit the supply from existing projects. Among the options tested, a 2017 investment decision vintage restriction would be most effective. A 2013 investment decision vintage restriction and a 2017 start of operations vintage restriction would encourage the development of some new projects.

  Restrictions based on when the emission reductions occurred or based on the date of project registration would not be at all effective in promoting new projects, since both types of restrictions would allow a large number of already implemented projects to supply offset credits for CORSIA.

- **To promote projects that require offset credit revenues to continue abatement, ICAO could restrict the eligibility of existing projects to *vulnerable* project types.** Figure ES1 shows the available supply from projects which we categorise with either a variable or high vulnerability to discontinuing GHG abatement as well as a "high vulnerability projects" scenario. The latter would be the more effective of the two at ensuring CORSIA stimulates emission reductions that would otherwise not occur.

The willingness or readiness of host countries to take the necessary action to avoid double counting of emission reductions could also impact the available supply. Figure ES1 shows the "worst case" outcome in terms of available supply in which no host country would be willing or ready to account for the use of offset credits under CORSIA. The scenarios reflect two possible ways in which offset credits from emission reductions outside the scope of NDC mitigation targets might be accounted for.

Eligibility restrictions could also be used to channel support towards certain countries. Figure ES1 shows the implications if only offset credits from LDCs and SIDSs were eligible. However, only 255 of the 810 million offset credits available in this scenario – are from projects that have high or variable vulnerability to discontinuing GHG abatement activities vulnerable.

In conclusion, our analysis shows that it is critical that ICAO adopts robust eligibility restrictions to ensure that CORSIA achieves its objective of carbon-neutral growth and delivers emission reductions outside of the international aviation sector that would not have occurred in the absence of the scheme. Without robust eligibility restrictions there is a significant risk that existing projects that would continue GHG abatement regardless of the demand from CORSIA will be able to supply several times the expected demand from CORSIA.

1 Introduction

In 2016, the Parties to the International Civil Aviation Organisation (ICAO) – a United Nations specialised agency – agreed to establish a scheme to address carbon dioxide emissions from international aviation: the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Policy-makers are currently in the process of finalising the design of the scheme, which will begin with a pilot phase running from 2021 – 2023 and continue with phase 1 (2024 – 2026) and phase 2 (2027 – 2035). The over-arching objective of the scheme is to achieve carbon neutral growth in the international aviation sector from the beginning of 2021, relative to the carbon dioxide levels emitted in 2019 and 2020. This scheme is designed to achieve this via a combination of measures, including a requirement for aeroplane operators to offset the increase in emissions through the purchase of offset credits from other sectors.

An important element of the design of CORSIA is to define which offset credits will be eligible for use by aeroplane operators. Offset credits are issued by international, national or non-governmental offsetting programmes. These programmes establish protocols that define which mitigation activities qualify for issuing offset credits and how emission reductions are quantified. For a project to be registered under an offsetting programme, it must satisfy various conditions – including that the project would not be implemented in the absence of the incentives created through the offset credits. Projects are issued with offset credits corresponding to the amount of the emission reductions achieved and verified by an approved third party. These credits can then be sold on to buyers, looking to offset their emissions, either via direct purchase agreements or via a traded marketplace.

Under CORSIA, programmes are reviewed and approved by the ICAO Council as eligible programmes in order to supply offset credits to aeroplane operators. To date, the largest offsetting programme is the Clean Development Mechanism (CDM), which was established under the Kyoto Protocol and allows developed countries to achieve their emission reduction commitments by purchasing offset credits from countries not included in Annex I of the Convention. There are also a number of non-governmental programmes that initially offered opportunities for voluntary offsetting of emissions by businesses, individuals and governments. These programmes could potentially apply and be approved by ICAO as eligible programmes under CORSIA.

This study estimates the potential supply of offset credits from the four largest existing offsetting programmes: the CDM, the Verified Carbon Standard (VCS), the Gold Standard (GS), and the Climate Action Reserve (CAR). We estimate the *future* supply potential for offset credits for emission reductions achieved during the period 2013 to 2035. This excludes offset credits that have already been issued for emission reductions during the period, but includes historic emission reductions for which offset credits are yet to be issued. In addition to the main results we estimate the current stock of unused credits from each of the programmes. This stock could potentially also be used by aeroplane operators under CORSIA. The supply potential is estimated only for projects that already exist in the project pipeline of the respective programmes. Further supply for CORSIA could come from new projects that are implemented in response to this new demand or from using allowances from emissions trading schemes (ETS). So far, however, no rules have been developed under CORSIA for the use of allowances from ETSs. Here we do not analyse these alternative potential sources of supply. This study builds on previous work analysing the supply potential from the CDM carried out by the authors, including: an assessment of the supply potential from registered CDM projects over the period 2013 – 2020 (Schneider, Day, La Hoz Theuer, & Warnecke, 2017); an extension of this to non-registered projects in the CDM pipeline and application of a number of scenarios to restrict the eligibility of offset credits (Schneider & La Hoz Theuer, 2017); an analysis of the marginal cost to supply CERs from existing registered projects under a number of different offset credit eligibility scenarios (Fearnehough, Day, Warnecke, & Schneider, 2018); and a synthesis of these research findings for the specific context of CORSIA (Warnecke, Schneider, Day, La Hoz Theuer, & Fearnehough, 2019).

We expand the earlier work in two key ways. This paper extends the analysis of the supply potential to cover the period beyond 2020, up to the end of CORSIA's second phase in 2035. It also broadens the coverage of supply sources to include three other offset crediting programmes in addition to the CDM. The results are intended to provide ICAO policy-makers with critical information on the potential supply of offset credits from existing projects listed under the four largest programmes under a range of different eligibility restriction scenarios. These offer important insights into the impact of different policy choices with regards to the impact CORSIA may have in driving emission reductions that would not have occurred without the scheme's implementation.

In Chapter 2 we present the range of scenarios considered in this study covering different approaches to establishing eligibility restrictions on offset credits. Chapter 3 sets out the methodology for quantifying the supply potential from the different programmes and the implementation of the scenarios, including data sources and assumptions that we have taken. In Chapter 4 we present the findings of our analysis across scenarios both at an aggregate level and broken down into programme-level results before discussing their implication for CORSIA. We then provide concluding remarks in Chapter 5.

2 Scenarios for offset credit supply

The purpose of this work is to analyse the potential supply of offset credits up to 2035 from four programmes that could potentially supply offset credits to be used for CORSIA: the CDM, GS, VCS and CAR. We select these programmes because they represent the four largest existing crediting programmes – not considering Joint Implementation for which it is uncertain whether offset credits will be issued in the second commitment period of the Kyoto Protocol.

We limit the scope of our analysis to projects that are publicly listed under at least one of these programmes. These projects are either already registered with the programme, or at earlier stages of the administrative process. For example, in the case of the CDM, in addition to registered projects we consider the pipeline of projects that are not yet registered but which are likely to have been physically implemented and are eligible to request registration in the future. We consider non-registered projects because the programmes – in particular the CDM – have a large pipeline of non-registered projects which, if registered, could supply a very large amount of offset credits over the period under consideration.

In this section, we define a number of scenarios for the supply of offset credits that could be used for compliance under CORSIA. In a base case scenario, we assume that all offset credits from all four of the programmes issued for emission reductions delivered from 1 January 2013 can be used for CORSIA. We then analyse several alternative scenarios that reflect different considerations with regards to the eligibility of offset credits. First, rules under ICAO are likely to limit the type of offset credits that are eligible under CORSIA. For example, the assembly resolution adopting CORSIA (ICAO, 2016, para. 21) refers to an "eligible vintage and timeframe" of units. Second, it is possible that ICAO decides to limit or exclude specific offset programmes, project types, or projects. Third, it is possible that some ICAO requirements cannot be met by specific offset programmes, project types, or projects. And fourth, it is possible that countries or aeroplane operators, when implementing CORSIA, prioritise certain credits, such as credits that offer a higher assurance of environmental integrity – and thus face fewer reputational risks – or credits from countries that most need international support. Table 1 summarises the main scenarios that we consider in this study.

Table 1: Overview of eligibility scenarios

Scenario type	Scenario name	Brief scenario description
Base case	2013 Emission reduction vintage	**Emission reductions** must have taken place from 1 January **2013**
Vintage scenario 1	2017 Emission reduction vintage	**Emission reductions** must have taken place from 1 January **2017**
Vintage scenario 2	2013 Registration vintage	Project must have been **registered** on or after 1 January **2013**
Vintage scenario 3	2017 Registration vintage	Project must have been **registered** on or after January **2017**
Vintage scenario 4	2013 Investment decision vintage	Project **investment decision** must have been made on or after 1 January **2013**
Vintage scenario 5	2017 Investment decision vintage	Project **investment decision** must have been made on or after 1 January **2017**
Vintage scenario 6	2013 Start of operations vintage	**Start date** of project operations must be on or after 1 January **2013**
Vintage scenario 7	2017 Start of operations vintage	**Start date** of project operations must be on or after 1 January **2017**
Double claiming scenario 1	Double claiming: outside scope of mitigation targets	Only offset credits for emission reductions outside the scope of mitigation targets communicated in Cancun pledges and NDCs (see further detail below)
Double claiming scenario 2	Double claiming: countries w/o mitigation targets	Only offset credits from projects located in countries without mitigation targets in Cancun pledge and NDCs (see further detail below)
Vulnerability scenario 1	High or variable vulnerability projects	Projects deemed to have either **high** or **variable** vulnerability to discontinuing GHG abatement
Vulnerability scenario 2	High vulnerability projects	Projects deemed to have **high** vulnerability to discontinuing GHG abatement
Host country scenario 1	LDCs & SIDS	Projects located in **LDCs** and **SIDS**

2.1 Scenarios for vintage restrictions

Paragraph 21 of ICAO Resolution A39-3 refers to a possible decision by the ICAO Council on the "vintage and timeframe" of eligible emissions units. Such restrictions involve establishing timerelated limits for the eligibility of units, and could be employed, for example, to promote new mitigation action. If using offset credits from already implemented projects would raise concerns about the overall GHG emissions impact from CORSIA, for example, then limiting the supply from existing projects could create the need to develop new projects in order to satisfy CORSIA demand.

A vintage restriction could be defined in two ways:

- As a restriction on the timing of *emission reductions* achieved; or
- As a restriction on the timeline of the implementation or registration of the *projects or activities* that generate emission reductions

Restrictions on the *timing of emission reductions* would mean that offset credits are eligible if the emission reductions occurred after a defined point in time. We consider here restrictions on the years in which emission reductions take place. It is important to note that the timing of *emission reductions* differs from the timing of *verification activities* or of *issuance* – the latter two relate to administrative processes which can typically take place at any time after the emission reductions took place. These dates are not meaningful options to restrict eligibility, as project participants could adjust the timing of verification or issuance in response to such restrictions.

Establishing restrictions on the *timeline of project activities* would mean that units can be deemed eligible if the project passed a development milestone after a defined point in time. We consider here restrictions based on the date of investment decision, the start of project operations, and the date of registration. Policy-makers could then consider a range of dates for setting a vintage restriction. We assess here the implications of two options for two points in time: 1 January 2013 and 1 January 2017.

The types of restrictions, alongside the different dates, result in the following scenarios:

- Vintage scenario 0 (base case): The emission reductions must have taken place from 1 January 2013.
- Vintage scenario 1: The emission reductions must have taken place from 1 January 2017;
- Vintage scenario 2: The project must have been registered on or after 1 January 2013;
- Vintage scenario 3: The project must have been registered on or after 1 January 2017;
- Vintage scenario 4: The investment decision must have been made on or after 1 January 2013;
- Vintage scenario 5: The investment decision must have been made on or after 1 January 2017;
- Vintage scenario 6: The start date of project operations must be on or after 1 January 2013;
- Vintage scenario 7: The start date of project operations must be on or after 1 January 2017.

2.2 Scenarios related to double counting risks

Double counting of emission reductions means that a single GHG emission reduction is counted more than once towards mitigation targets or efforts. Double counting can occur in three ways (Schneider, Kollmuss, & Lazarus, 2015):

- **Double issuance** occurs if more than one unit is issued for the same emission reduction and used towards a mitigation target.
- **Double use** occurs if the same unit is used twice, e. g. if one country or aeroplane operator uses the same unit in two different years to attain mitigation pledges.
- **Double claiming** occurs if the same emission reduction is counted twice towards attaining mitigation pledges, once by the country where the emission reductions occur and once by the user of the offset credit. In the context of CORSIA, double claiming would occur if an aeroplane operator under ICAO used an offset credit to fulfil its offsetting requirements under CORSIA and the country where the reductions occur used the same emission reductions to achieve its mitigation target (Schneider, Füssler, Kohli, et al., 2017). Double claiming does not occur if offset credits are generated from emission reductions that fall outside the scope of current and future mitigation targets.

The CORSIA Emissions Unit Eligibility Criteria, as included in the attachment C to the ICAO State Letter and recently adopted by the ICAO Council, include "Design Elements for Programs" and the "Carbon Offset Credit Integrity Assessment Criteria". Both include provisions for avoiding double counting and the "Carbon Offset Credit Integrity Assessment Criteria" require addressing all three types of double counting (ICAO, 2017). In the context of CORSIA, double *claiming* is most challenging to address: if an offset credit is issued for emission reductions that fall within the scope of a mitigation target of the host country, then, to avoid double claiming, the host country would have to account for the use of the offset credit by the airline, e. g. by applying an adjustment to its reported GHG emissions (Schneider, Füssler, Kohli, et al., 2017). Addressing double claiming thus not only requires actions by crediting programmes or aeroplane operators, but also requires involvement of national government authorities.

An important and open question is for which type of climate mitigation efforts double claiming will be avoided under the CORSIA. The CORSIA Emissions Units Eligibility Criteria in the State Letter require avoiding double counting with the "climate change mitigation efforts" of the host country (ICAO, 2017, p. C-18). This could include mitigation targets adopted or communicated as part of *international treaties*, including commitments under the Kyoto Protocol ("Kyoto targets"), countries' 2020 pledges and Nationally Appropriate Mitigation Actions under the Copenhagen Accords and the Cancun Agreements ("2020 targets"), Nationally Determined Contributions (NDCs)[1] under the Paris Agreement, as well as commitments related to the consumption and production of ozone depleting substances and hydro-fluorocarbons (HFC) under the Montreal Protocol and its Kigali Amendment. In addition, double claiming may be avoided with legally separate domestic or regional mitigation efforts, such as a regional emissions trading system. In this study, we consider all forms of international mitigation targets put forward by countries under UNFCCC; however, we do not consider domestic or regional mitigation efforts, nor targets under other environmental conventions.

It is still unclear how the use of offset credits for CORSIA will be accounted for under the UNFCCC. The Kyoto Protocol only avoids double counting of emission reductions within its boundaries and does not have explicit provisions to account for the use of units under other frameworks, although the procedures for cancellation of units could be used towards this end. The Convention and its Cancun Agreements do not provide an accounting framework to effectively avoid double counting. In the negotiations following the adoption of the Cancun Agreements, Parties agreed however that "various approaches, including opportunities for using markets … must meet standards that … avoid double counting of effort" (decision 2/CP.17, paragraph 79). Decision 1/CP.21, adopting the Paris Agreement, also refers to avoiding double counting in the context of action prior to 2020, urging "host and purchasing Parties to report transparently on internationally transferred mitigation outcomes, including outcomes used to meet international pledges, and emission units issued under the Kyoto Protocol with a view to promoting environmental integrity and avoiding double counting" (Schneider & La Hoz Theuer, 2017).

Under the Paris Agreement, provisions to ensure robust accounting have partially been adopted as part of the Katowice Climate Package, while some provisions are still under negotiation. The decision on the enhanced transparency framework ("Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement") foresees that countries account for their NDCs in the form of a "structured summary". This structured summary establishes a balance which allows comparing a country's net GHG emissions with its NDC target. The decision further specifies that internationally transferred mitigation outcomes (ITMOs) as well as mitigation outcomes used for "international mitigation purposes other than achievement of its NDC" should be accounted for. The latter is commonly understood to include CORSIA.

Such accounting is implemented through the application of "corresponding adjustments", as referred to in paragraph 36 of decision 1/CP.21. However, Parties have not yet agreed on relevant decisions for Article 6 of the Paris Agreement. Moreover, the reporting tables to implement the structured summary are supposed to be completed by 2020. This means that it is still unclear how exactly adjustments will be implemented.

Among several issues under consideration, one controversial and unresolved question is particularly important for the supply potential for CORSIA: whether and under which conditions emission reductions that are not covered by NDCs are eligible for international transfers under Article 6 and for use under CORSIA. Some countries argue that corresponding adjustments by the transferring country are not necessary for mitigation outcomes that are generated *outside* the scope of NDC targets. Indeed, in such cases there is no risk of double claiming and, hence, it could be argued that a corresponding adjustment is not necessary on the side of the transferring country (such transfers may still be reported as memo items by the transferring country for transparency purposes). Other countries argue that adjustments should be applied regardless, in order to avoid perverse incentives for countries not to broaden the scope of their mitigation targets (Obergassel, 2017; Spalding-Fecher, 2017).

Similar questions arise for the use of offset credits by aeroplane operators under the CORSIA. Adjustments are necessary where the transferred emission reductions fall within the scope of mitigation targets, but it is less clear whether the UNFCCC or bodies under the ICAO will require that such adjustments will also be applied if the emission reductions fall *outside* the scope of mitigation targets.

1 The NDCs submitted by countries contain targets pertaining to mitigation, adaptation and other issues. For brevity, throughout this report we use "NDCs" to refer specifically to the mitigation component.

The choice of approach that is adopted could have implications on the availability of offset credits for CORSIA. The CORSIA Emissions Unit Eligibility Criteria require programmes to "put measures in place" to avoid double counting. To effectively avoid double claiming, programmes will likely require that host countries confirm that they will apply or have applied adjustments for offset credits that are used under CORSIA. It is, however, possible that some countries may not be ready or willing to apply such adjustments. In turn, this could imply that programmes cannot issue CORSIA compliant credits for emission reductions generated in these countries. If the application of an adjustment for transfers to CORSIA is only required for offset credits from emission reductions *within* the scope of mitigation targets, then programmes may still be able to issue offset credits for CORSIA from emission reductions generated *outside* the scope of mitigation targets.

We therefore provide two scenarios to illustrate possible risks that the actual supply may be lower due to double counting requirements. We conservatively assume the "worst case" outcome in terms of the supply potential that no host country would be ready or willing to account for the use of offset credits under CORSIA through respective adjustments. In one scenario we assume that only offset credits from countries without mitigation targets would be eligible. In another scenario, we assume that, in addition, also offset credits from emission reductions outside the current scope of NDCs would be eligible. The scope of current NDC targets may, however, be expanded when NDCs are updated. Article 4.4. of the Paris Agreement envisages that developing countries move over time towards economy-wide targets. It is therefore uncertain whether the supply potential that falls outside the scope of current NDCs will continue do so once NDC targets are updated. As a simplified approach, we assume here that the current scope of NDC targets remains valid until 2030, which is the target year in most current NDCs (see scenario description below).

Two scenarios are considered:

- **Double claiming scenario 0 (base case)**: Host countries of emissions reduction activities are ready and willing to account for the use of offset credits by aeroplane operators under CORSIA through respective adjustments, such that programmes can issue offset credits from all countries and all eligible project types.
- **Double claiming scenario 1:** None of the host countries of emission reduction activities are ready or willing to account for the use of offset credits by aeroplane operators under CORSIA through respective adjustments. Under the UNFCCC and ICAO, adjustments to account for transfers to CORSIA are only required for emission reductions generated *within* the scope of international mitigation targets. As a consequence, programmes can only issue offset credits that are eligible for CORSIA from emission reductions generated *outside* the scope of existing international mitigation targets. We assume that the scope of current NDCs will not change until the year 2030. Thereafter, we assume that all countries – except for Least Developed Countries (LDCs) and Small Island Developing States (SIDS) – will move towards economy-wide emissions targets, as envisaged under Article 4.4 of the Paris Agreement.
- **Double claiming scenario 2:** None of the host countries of emission reduction activities are ready or willing to account for the use of offset credits by aeroplane operators under CORSIA through respective adjustments. Under the UNFCCC and ICAO, adjustments to account for transfers to CORSIA are implemented for emission reductions, regardless of whether they are generated *within* or *outside* the scope of international mitigation targets. As a consequence, programmes can only issue offset credits for CORSIA from countries that do not have international mitigation targets. For 2020 targets, this includes a broad range of developing countries which have not communicated a pledge under the Cancun Agreements. For NDCs, this includes mainly LDCs and SIDSs but also other countries which did not communicate a mitigation target but only non-quantitative actions, such as the measures to promote renewable energy. As in double claiming scenario 1, we assume that current NDC targets do not change until 2030 and that after 2030 all countries – except for LDCs and SIDS – will have economy-wide emissions targets.

2.3 Scenarios related to the type of project activities used

Under CORSIA, the Emission Unit Eligibility Criteria (EUCs) – which will define the criteria for offset eligibility for use within the scheme – are expected to be applied at the programme level (ICAO, 2017, p. C-17), and not at project or methodology level. However, it is possible that the type of eligible activities from a programme will be limited. It is also possible that a programme does not meet all requirements for a specific project type, such that the programme is granted only partial eligibility. It is also possible that aeroplane operators prioritise specific projects, or that countries under CORSIA impose additional requirements on aeroplane operators. Such limitations for the available supply for CORSIA would likely apply to specific project types, rather than to individual projects. To define possible scenarios for limited eligibility of project *types*, we identify here the main features – other than double counting considerations – which determine whether CORSIA triggers further emission reductions.

Under crediting mechanisms, the quality of offset credits is in principle ensured if the mitigation action is: (a) additional (that is, it would not occur in the absence of the incentives from the crediting mechanism); and (b) the emission reductions are not overestimated (Schneider, Füssler, La Hoz Theuer, et al., 2017). Yet the supply of offset credits has outstripped demand in recent years, affecting in particular the CDM and, perhaps to a lesser extent, the voluntary carbon market. If in such a market situation projects have already been implemented, a further important consideration for the overall emissions impact from CORSIA is whether they are *vulnerable to (or at risk of) discontinuing GHG abatement*.

For some project types, such as hydropower or wind power projects, ongoing revenues from electricity sales typically exceed ongoing operational expenditures. Once implemented, these projects have strong economic incentives to continue GHG abatement, regardless of carbon market revenues, because continuing GHG abatement generates more income than discontinuing GHG abatement. These projects have a low risk of discontinuing GHG abatement. By contrast, other projects have ongoing operational costs but insufficient financial benefits beyond carbon market revenues. For example, the abatement of N_2O from nitric acid production requires the regular replacement of catalysts but does not save costs or generate income other than revenues from selling offset credits. These projects have a high risk of discontinuing GHG abatement, because continuing GHG abatement is only economically attractive if they have ongoing financial support (Schneider & Cames, 2014a; Warnecke et al., 2017).

A project that is vulnerable to discontinuing GHG abatement is by definition additional. However, it is important to note that if a project is not vulnerable today, it could still have been additional at the project outset, prior to incurring the initial capital costs. The lack of vulnerability recognises only that, from today's perspective of sunk investment costs, the project's ongoing revenues or cost savings – other than carbon market revenues – exceed its ongoing operational expenditures for the GHG abatement. Projects also might continue GHG abatement because policies promote or require continuation or because discontinuation is technically not viable.

If new demand from CORSIA is targeted at offset credits from projects at risk of discontinuing GHG abatement, this could enable them to continue GHG abatement. CORSIA would thus trigger actual emission reductions. By contrast, if new demand is targeted at offset credits from projects that will continue GHG abatement regardless of whether they can sell offset credits, then this would not trigger further emission reductions to those that would occur anyway. Thus, where supply already exceeds demand, the impact of new demand on global GHG emissions differs between *already implemented* and new projects: a new source of demand – such as CORSIA – would only trigger emissions reductions to the extent that (a) the implementation of new GHG abatement projects that are additional is triggered (and the emission reductions are not over-estimated), and/or (b) already implemented projects that are at risk of discontinuing GHG abatement are spurred to continue GHG abatement (and the emission reductions are not over-estimated).

In this report, we estimate the offset credit supply from projects that are already registered and – in the case of the CDM – from projects that are as yet not registered, but exist in the pipeline. The available empirical information suggests that most of the projects that are registered under the CDM have been implemented (Warnecke, Day, & Klein, 2015). Moreover, the available evaluations of crediting mechanisms conclude that there is limited risk of over-estimating emission reductions. This is because most methodological standards use conservative approaches to estimate emission reductions, including through the selection of the emission sources and gases considered in monitoring and calculating emission reductions, the use of conservative default values – e. g. for emission factors – or the use of conservative assumptions – e. g. with regard to the baseline scenario (Cames et al., 2016). Given the large potential supply volume from already implemented projects (Schneider, Day, et al., 2017), the main feature determining the GHG emissions impact from CORSIA is thus the risk of projects to discontinue GHG abatement.

The risk for discontinuing GHG abatement differs strongly between project types: Warnecke et al. (2017) assessed the vulnerability to discontinuing GHG abatement for all major CDM project types and classified the risk in three categories: "high" for project types that are likely to require carbon market revenues to continue abatement; "low" for project types that have strong economic incentives to continue GHG abatement, even without carbon market revenues); and "variable" for project types where the risk depends on the specific circumstances of the project.

Based on these considerations, we investigate three scenarios:

- **Vulnerability scenario 0 (base case):** Offset credits from all already implemented project types are eligible for use under CORSIA.
- **Vulnerability scenario 1:** Among the already implemented projects, only those deemed to have "high" or "variable" vulnerability to discontinuing GHG abatement are eligible to supply offset credits for use under CORSIA.
- **Vulnerability scenario 2:** Among the already implemented projects, only those deemed to have "high" vulnerability to discontinuing GHG abatement are eligible to supply offset credits for use under CORSIA.

2.4 Scenarios for specific host countries

Policy-makers or aeroplane operators could aim to promote emission reductions in specific host countries or regions, notably in Least Developed Countries (LDCs) and Small Island Developing States (SIDS). This could be done by restricting the eligibility of emissions units to emission reductions delivered by projects hosted in those countries, or by providing particular incentives for the use of emissions units generated projects hosted in these countries. We consider two scenarios:

- **Host country scenario 0 (base case):** No limitation or prioritisation on the basis of the host country of the emissions reduction activity.
- **Host country scenario 1:** Only offset credits generated from emission reductions in LDCs and SIDS are used.

2.5 Scenarios combining different criteria

Policy-makers could also pursue combinations of the restrictions discussed above. In particular, such combinations could aim to ensure higher environmental integrity while still ensuring that sufficient offset credits can be supplied to aeroplane operators. For projects that are already implemented this could be achieved, notably, by applying different vintage restrictions depending on the projects' vulnerability to discontinuing GHG abatement. A combination of restrictions could, for example, determine that non-vulnerable project types are only eligible if the investment decision date of the project is on or after 1 January 2017, whereas for vulnerable project types no vintage restrictions would apply. To provide a better understanding of the supply potential under such scenarios, we also combine the two scenarios for project vulnerability with the other ten scenarios. For example, in addition to quantifying the supply from *all* projects assessed to have a variable or high vulnerability to discontinuing abatement, we estimate the potential supply from further limiting eligibility to vulnerable projects that started operations after 2013.

3 Methodological approach

This Chapter sets out our approach to quantifying the potential supply of offset credits under each of the scenarios presented in the previous Chapter. Our analysis does not provide a forecast of the likely amount of offset credits that might supply the market under current, or expected future, market conditions. Instead we consider a realistic potential supply of offset credits from existing projects in the case that project owners have sufficient economic incentives to proceed to the issuance of offset credits. The *realistic* potential supply is lower than a *theoretical maximum* as we incorporate practical constraints that could limit the ability of a project to generate offset credits.

3.1 Scope

The following bullet points summarise the scope of the quantification of the potential supply of offset credits for use under CORSIA:

- **Programmes: CDM, GS, VCS and CAR**

  We analyse the potential supply from projects listed or registered with the Clean Development Mechanism, the Gold Standard, the Verified Carbon Standard and the Climate Action Reserve. Some projects are registered under more than one programme: the CDM and either the GS, or the VCS. Using information provided in the GS and VCS project databases as well as a matching of project names and host countries across programmes, we identify those projects that appear in the data-base of more than one programme. Where a project appears in the records of more than one programme we assign its contribution to the aggregate supply potential to the CDM. At the aggregate level of the total supply potential from all four programmes, this avoids double counting the potential supply from emission reductions undertaken by the same project. It also means that the programme level results for the VCS and the GS may be underestimated and the CDM results may be overestimated. In our base case – covering the potential supply of all offset credits for emission reductions between 2013 to 2035 – the estimate of the CDM supply is 5% higher than it would be if it excluded supply from projects also registered with the VCS or GS. The VCS supply potential in the base case would increase by almost 30% and the GS supply potential by approximately 40% if they also included the supply from projects also registered with the CDM. Programme specific results are presented in section 3.4.

- **Projects: existing projects listed on public registries**

  The analysis of supply covers both registered projects as well as projects at earlier stages of the administrative process, prior to registration, where they are listed publicly by the respective programmes. This is based on information in programme registries at the end of 2017 for the voluntary market programmes and the CDM Registry as at April 2017. The results of our analysis – presented in Chapter 4 – break down the supply potential based on the administrative status of the project within its respective programme. We do not consider any supply from new projects that have been added to the programme registries since these dates, nor consider new projects that may be developed over the period to 2035.

  We examine the potential supply of offset credits from both project activities as well as programmes of activities (PoAs), where the latter may include an unlimited number of component project activities (CPAs). Here we consider only CPAs included as of April 2017 for the CDM; November 2017 for the GS; and January 2018 for the VCS. 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.

- **Timeframe: emission reductions from 2013 – 2035**

  In the base case we quantify the potential supply of offset credits for emission reductions delivered in the period from 1 January 2013 to 31 December 2035 to the extent that project circumstances – such as the expected lifetime, crediting period and programme rules – allow a project to continue to receive offset credits over that period. We assume that the four programmes continue to operate for the duration of the period, or at least that the projects would be able to transition to a replacement programme, and that emission reductions from the projects will continue to be eligible to receive credits subject to the constraints of existing programme rules.

We estimate the *future* potential supply of offset credits from projects for emission reductions over the period, thereby excluding credits that have already been issued for emission reductions since 2013 from our main results. Separately we estimate the current stock of unused credits from the programmes, which could potentially also be used by aeroplane operators under CORSIA.

3.2 Supply potential

To estimate the supply potential for each of the four programmes we use a bottom up model which calculates the potential emission reductions at the project level for all years over the period from 2013 to 2035. We use a similar modelling framework to estimate the potential supply of certified emission reduction (CER) credits under the CDM for the period 2013 to 2020 in previous studies. Further details of the methodology are provided in Schneider, Day, et al., 2017; and Schneider & La Hoz Theuer, 2017. We apply the approach taken to estimate supply from the CDM to the other programmes where possible. In general, the availability of data is more comprehensive for the CDM. Specific approaches or assumptions we make for the individual programmes are set out in section 3.4 below. In general, to the extent that information is available, we draw on project and project-type level information on the following key parameters to inform our quantification of the supply potential:

1. The **technical implementation and operation status** of projects, including whether the project is likely to have been implemented and continues GHG abatement;
2. The **crediting periods and emission reduction calculations**, including the length of crediting periods and any conditions and restrictions on their renewal, such as the use of revised methodologies at renewal that may change the number of offset credits a programme can generate;
3. The **availability of data to monitor emission reductions**, which could in some instances limit the ability of project owners to issue offset credits (e. g. if a full monitoring system has not been in place for a period due to lack of offset demand); and
4. The **project performance**, including whether the project belongs to a project type that typically underperforms or over performs as compared to exante emission reduction estimates prepared when registering the project.

3.3 Scenario implementation

We set out the thirteen main scenarios considered for this study above in Chapter 2, which we summarise in Table 1. The base case quantifies the potential supply of offset credits from projects for emission reductions over the period 2013 to 2035 without any restrictions. The other twelve scenarios restrict this supply based on certain characteristics of the project and the timing of emission reductions.

3.3.1 Vintage restrictions

Scenarios that limit supply based on a defined "vintage" or timing constraint are based on:

1. The timing of when emission reductions are expected to take place, based on annual estimates of emission reductions at the project level; or
2. The timing of project milestones, including the investment decision, the start of operations and the date of registration.

In the first case, where restrictions relate to the timing of emission reductions, we only consider the supply potential from emission reductions after that date (e. g. 1 January 2017).

In the second case, where restrictions related to the timing of project milestones, the supply potential from a project for the entire time frame (2013 to 2035) is either included or excluded depending on whether the project has passed the milestone before or after the date of the vintage restriction. Registration dates are available for all programmes, where registration has taken place. For projects that have not yet registered, the registration would occur at some future date and therefore the supply potential is automatically included if the registration date is used as vintage restriction. The availability of information on the investment decision date and the start date of operations differs across programmes and in some instances is incomplete. The approach and assumptions we have taken are set out for the respective programmes in section 3.4 below.

3.3.2 Double counting risks

For the scenarios related to double counting risks we estimate the supply potential for emission reductions that are not covered by mitigation targets communicated in pledges made under the Cancun Agreements or NDCs communicated under the Paris Agreement (double claiming scenario 1), as well as for emission reductions from countries that have not communicated any mitigation targets under the Cancun Pledges or the Paris Agreement (double claiming scenario 2). We evaluate the scope of Cancun pledges and NDCs and map for each country which sectors and types of GHGs are covered by mitigation targets. For each combination of country and project type we then determine whether the emission reductions occur within or outside of the scope of these pledges.

We include in this analysis not only NDCs but also assess whether emission reductions from projects are covered by mitigation targets under the Cancun Agreements. This is because the double counting provisions in the CORSIA Emissions Unit Eligibility Criteria are formulated relatively broadly, suggesting that double counting should be avoided with "mitigation efforts" and "mitigation obligations". Moreover, decision 1/CP.21 adopting the Paris Agreement and decision 2/CP.17 call on countries to avoid double counting in the context of 2020 mitigation targets. Lastly, the issue is important given the potentially large supply potential from offset credits in the period up to 2020 alone.

In the "double claiming: outside scope of mitigation targets" scenario, if the emission reductions from a project are deemed to be covered by a mitigation target communicated under a Cancun pledge – for example because the country it is located in has made a pledge to limit emissions in the same sector as the project – we exclude the potential supply over the period 2013 to 2020. Similarly, if the emission reductions from a project are deemed to be within the scope of a current NDC mitigation target, we exclude the potential supply over the period from 2021 to 2030. As described in section 2.2 above we assume that NDC mitigation targets are extended to cover all countries and all sectors of the economy in the period from 2031 – 2035, except for LDCs and SIDS. This therefore means that in the "narrow scope" scenario for some projects that are located outside of LDCs and SIDS and in a sector currently excluded from the scope of the country's NDC mitigation target we *include* the supply potential for the years 2021 through to 2030, but exclude any supply from 2031.

In the double claiming: countries w/o mitigation targets" scenario, we exclude all supply over the period to 2020 from projects located in countries that communicated a mitigation target in their Cancun pledge. We also exclude all supply over the period 2021 – 2035 from projects in countries that communicated a mitigation target in their current NDC. For projects located outside of LDCs or SIDS in countries which did not include a mitigation target in their current NDC, we exclude the supply potential from 2031 – 2035 as we assume that after 2030 the country commits to an economywide mitigation target.

Our analysis of NDC country, sector and GHG coverage is based on information included in a number of sources, accessed on 12 October 2016 (IGES, 2016; PIK, 2016; WRI, 2016). It does not include any sub-sequent revisions to NDCs or additional NDCs submitted since that time. Our analysis includes the current NDC of the United States of America, despite its stated intention to withdraw from the Paris Agreement.

3.3.3 Vulnerability of project activities

For the scenarios considering the extent to which a project activity is vulnerable to discontinuing GHG abatement we draw on previous analysis carried out for the CDM which determines whether a project has a low, variable or high vulnerability to discontinuing abatement (Warnecke et al., 2017). This is based on the project type and the country the project is based in. In the "potential vulnerability" scenario we include the supply potential from all projects that are categorised as either having a variable or high vulnerability to discontinuing GHG abatement activities. In the "high vulnerability" scenario we only include the supply potential from projects that we categorise as being highly vulnerable to discontinuing abatement.

The project types included in the VCS, GS and CAR overlap with the project types included within the CDM, but do not match exactly. For these programmes we map the categorisation of vulnerability from our CDM analysis with the project types from the other programmes. Where the project type is either the same or similar, we used the results from the CDM analysis to determine a project's level of vulnerability. Where a programme includes a project type that is not covered by our CDM analysis – for example, forest management and REDD projects – we do not categorise its level of vulnerability and we do not include the supply potential from these projects within either of the scenarios that limit the eligibility of projects to those with variable or high vulnerability to discontinuing GHG abatement. This may underestimate the supply potential under these two scenarios. The supply potential from project types from the VCS, GS and CAR that do not map to our CDM vulnerability analysis is however included within the other scenarios.

3.3.4 Host countries

For the scenario that limits the supply of offset credits to projects located in LDCs and SIDS, we use information on the host country included in our model. In the case of multi-country PoAs, we assume – as a simplification – that the emission reductions originate from the country with the largest share within the PoA.

3.4 Programme specific methodology

The following sections describe any specific approach or assumptions taken to estimate the supply potential from each of the four programmes we analyse. In particular, the focus of these sections is to highlight instances where we deviate from the general methodology to calculate the supply potential and implement scenarios described above in sections 3.2 and 3.3.

3.4.1 Clean Development Mechanism (CDM)

Data sources and scope

As noted above, our analysis of the supply potential follows the methodology adopted in previous related work estimating the supply potential for CERs for emission reductions in the period 2013 to 2020 (Schneider, Day, et al., 2017; Schneider & La Hoz Theuer, 2017).The overall methodology and assumptions are described in these reports. We use the same database with information on CDM projects – both registered and within the pipeline – which is based on information from April 2017. This section focuses on the specific assumptions, data sources and methods applied in extending this earlier analysis.

The key development in this study is an extension of the timeframe for quantifying emission reductions from existing projects to 2035 to the extent that project characteristics and CDM rules (in particular crediting periods) allow the continuation of credit supply. Existing projects could continue to supply CERs throughout this period if the CDM continues to exist. It could also be the case that these projects migrate to another programme after 2020. This could, for example, include the other programmes analysed here (VCS, GS, CAR) or a new mechanism set up under Article 6.4 of the Paris Agreement.

Our analysis of the CDM covers both registered and non-registered projects. Non-registered projects have undertaken administrative steps in relation to the CDM, but have not yet registered. This includes projects that started validation, as well as projects that submitted a notice of prior consideration that they intend to register under the CDM. A large share of these projects is likely to have halted their process to registering as a CDM project due to the environment of low CER prices over recent years. These projects could still seek registration at a future point in time should the market provide sufficient incentives for reengagement with the CDM. As in Schneider & La Hoz Theuer, 2017 we assume that those non-registered CDM projects that could still register are registered on 1 January 2019.

Milestone dates and crediting period

Many of the projects that are yet to complete validation are likely to have been implemented prior to, or around, the significant fall in the price of CERs around 2012. For projects at the validation stage we limit the period during which CERs can be issued by an approximation of the technical lifetime of the project where this earlier than the end of the crediting period. Technical lifetime estimates are derived from a methodological tool developed under the CDM (UNFCCC, n. d.). For project types that use technologies that are not covered by the tool we assume a default lifetime of 25 years. For certain project types – including afforestation, reforestation and cement – whose continued GHG abatement is less dependent on equipment with a finite technical lifespan, we assume no technical lifetime limitation on the ability of the project from continuing to generate offset credits up to the end of 2035. For each project, we calculate the end of its technical lifetime by adding the typical technical lifetime by project type to the estimated start of physical operations of the project.

The UNFCCC database on CDM projects that is used to estimate the supply potential for each project (UNFCCC, 2017) does not include information on the start date of a project's operations (the "start date" in CDM terminology refers to the date of an investment decision in the project). For projects of all administrative statuses within the CDM we use either the actual start of the crediting period, or the estimated start established by the project participants in the project design document (PDD) for projects that have not yet registered and formally begun their crediting period, as a proxy for the start date of physical operations.

The availability of data on projects that have only submitted a notification of prior consideration is limited and the supply potential estimates therefore serve only to provide an order of magnitude estimate of the CERs that these projects could supply, under favourable market conditions. Amongst prior consideration projects we assume that the distribution of their start of operations and technical lifetimes and respective constraints is the same as for CDM projects that are in the validation stage.

3.4.2 Verified Carbon Standard (VCS)

Data sources and scope

Publicly available data from the VCS covers registered projects only. We base our analysis on data from the VCS project database (Verra, 2018a) and the Verified Carbon Unit (VCU) issuance database (Verra, 2018b), supplemented with additional information on projects provided by VCS staff via email in January 2018. A number of the 1,467 registered VCS projects that we include within our analysis are also registered with alternative offsetting programmes, including the British Colombia Emission Offset Regulation (1 project), the CDM (797) and Joint Implementation (40). We exclude all supply potential from projects that are also registered under the CDM from our main VCS results as this supply potential is already included within our analysis of CDM projects. However, we do explicitly quantify the supply potential from these projects in our discussion of the VCS results in section 4.4.2 below.

Estimates of emission reductions

The VCS project database includes an exante estimate of annual emission reductions for all projects. To estimate the future supply potential we adjust the exante estimate by an issuance success factor, to reflect how actual issuance deviates from estimates made prior to the start of a project's operations. We use issuance success rates calculated for similar project types under the CDM as our analysis of CDM data covers a larger sample of projects and volume of issuance data. By way of comparison we have also analysed data on verified emission reductions under the VCS and estimated the annual average emission reductions for each project that has been issued with VCUs. For each project and project type under the VCS we use the difference between actual verified emission reductions and the exante estimate of annual emission reductions to calculate the issuance success rate.

Across all VCS projects with issuance data the verified emission reductions are approximately 20 percent lower than the exante estimates. This is similar, but slightly lower than the issuance success rate for all projects under the CDM, which is approximately 86 percent.

Milestone dates and crediting period

There is no information collected by the VCS on the *date of the investment decision* for a project (defined as the project "start date" under the CDM). For the majority of projects we do have information on the *start date of operations*. For those where this information is not available, we estimate it based on information on the start of the first crediting period., We assume that the investment decision occurred 880 days (approximately two and a half years) prior to the estimate of the *start date of operations*. This assumption is based on an analysis of CDM projects for which we have information on both the investment decision date and an estimate of the start date of operations. The 880 days are applied to all projects without differentiation across project types. This simplified assumption implies a later estimate than the actual date of investment decision for project types with longer lead times with complex construction and installation requirements, and an earlier estimate than actual date of investment decision for some project types with shorter than average lead times. As we report results for the programme as a whole these two effects should, to some extent, balance each other at the aggregate level.

For many projects (600 out of the total of 1,467 registered projects) the crediting period included in the database is below the maximum allowed by the programme protocols, i. e. below the maximum of 10 years for most project types. For example, there are a number of projects with crediting periods of one or two years. Many of these projects are likely to have temporarily registered with the VCS to receive credits for emission reductions achieved prior to their registration with the CDM. The supply potential from those projects that are also registered under the CDM is reported under the CDM in the main results to avoid double counting of the same emission reductions.

For projects with a stated crediting period of 10 or more years we assume that the project may renew its crediting period up to the maximum number of years permitted. For most project types the maximum is 30 years (2 renewals of a further 10 years each). For forestry projects the maximum is 100 years. For projects with a stated crediting period of less than 10 years, we assume that the stated crediting period is the maximum duration of the crediting period and no renewal is requested.

3.4.3 Gold Standard (GS)

Data sources and scope

Our analysis of the supply potential from the GS is based on the project database provided by GS staff in November 2017 and supplemented with further information on projects and project issuances in June 2018. The data covers projects that are "listed", "validated" and "registered" under the GS programme. Listed projects have passed a preliminary review by the Gold Standard and remain within the validation process. Validated projects have successfully completed an independent validation but have not yet been formally registered. Registered projects have successfully undergone independent validation as well as formal review by the Gold Standard, paid the necessary fees and completed a two-month stakeholder feedback round. The GS has two "project streams": projects can either receive CERs under the CDM to which they can add the GS accreditation, or receive Voluntary Emission Reduction credits (VERs) issued by the GS. In our main results we calculate the supply potential based on projects that are issued with VERs as all projects issued with CERs are already included in the supply potential that we calculate from the CDM. However, we do explicitly quantify the supply potential from GS projects issued with CERs in our discussion of the GS results in section 4.4.3 below. This may be relevant if ICAO decides to allow GS projects for use under CORSIA, but to disallow CDM projects that are not registered with an alternative programme.

Estimates of emission reductions

The GS project database includes an exante estimate of annual emission reductions for all projects. As per the VCS analysis, we adjust these exante estimates by a project type issuance success factor estimated based on an analysis of CDM projects. We use the CDM estimates as they are based on a larger sample of data points, but also calculate the issuance success rates amongst GS projects using data on project issuances. Across all projects with issuance data the verified emission reductions are approximately 70 percent of the exante estimates, which is lower than the average issuance success rate across all CDM projects.

Projects with a status of "listed" or "validated" are not yet registered with the GS. Some projects may not satisfy the programme requirements and therefore will be unable to generate any offset credits. Based on our analysis of the share of projects that achieve registration from different earlier stages in the CDM, we conservatively assume that half of listed projects will meet the requirements to register with the GS. "Validated" projects have already been successfully reviewed by an appointed auditor and are therefore likely to meet the GS requirement to register. We assume that 95 percent of validated projects will be eligible to register.

We do not include an analysis of the stock of credits issued by the GS that are as yet unused due to a lack of data.

Milestone dates and crediting period

The GS project database includes information on project registration dates as well as the crediting period start date. We have assumed that the start of the first crediting period coincides with the *start of operations* of the project, which informs our scenarios with vintage restrictions applied to the date of the start of operations.

As per the VCS analysis described above we have assumed that the investment decision occurred 880 days (approximately two and a half years) prior to the estimate of the *start date of operations* for the project. This assumption is based on an analysis of CDM projects for which we have information on both the investment decision date and an estimate of the start date of operations. It is applied to all projects without differentiation across project types.

3.4.4 Climate Action Reserve (CAR)

Data sources and scope

All CAR projects are located in the US and Mexico. The CAR publishes data on projects at different stages of the administrative cycle. Our analysis is based on information in the CAR offset project registry as at the beginning of 2018 (CAR, 2018), covering 515 projects with a status of listed (103), registered (87), completed (221) and transitioned (4). This was supplemented with further information on project registration and crediting period dates provided by CAR staff. The registry also includes information on credit issuances.

The CAR project database includes both projects which are issued with Climate Reserve Tonnes (CRTs) for use in the voluntary offsetting market as well as projects which are issued with Registry Offset Credits (ROCs), which can then be converted to Air Resource Board Offset Credits (ARBOCs) for compliance use with the Cap-and-Trade program administered by the Californian Air Resources Board (ARB).[2] We include both types of credits within our main analysis of the supply potential because it is possible that projects intended to supply the compliance market could either transition to the voluntary market and be issued with CRTs (and have existing ROCs converted to CRTs) or the ROCs could be retired prior to conversion into ARBOCs should CORSIA demand create sufficient financial incentives to make this attractive. In our discussion of the results for the CAR in section 4.4.4 below, we provide a breakdown of the supply potential from those projects currently listed for voluntary market use and those listed for the compliance market.

Estimates of emission reductions

Estimates of expected annual emission reductions for projects are not included in the CAR project database as it is not a requirement that project developers provide this information. We have therefore used actual issuance data to calculate annual average emission reductions per project and for each project type, where this exists. These have been used to project future supply potential in the following way:

- For projects that have *already been issued* with credits, we have calculated the annual average emission reductions for that project and applied this estimate to future years.
- For projects that have *not yet been issued with credits*, we have applied the annual average emission reductions for the corresponding project type calculated from amongst projects of a similar type for which we were able to analyse issuance data.

2 ROCs are a type of provisional credit issued to projects that are registered with CAR and which have been validated to meet eligibility requirements under the California Cap-and-Trade program. ROCs are issued by CAR and once the ARB approves the issuance, the credits are cancelled in CAR's registry system and re-issued as ARBOCs in ARB's registry system for the Cap-and-Trade program.

- For *reforestation projects* there is no recorded issuance included in the project registry to date. For these projects we have calculated the annual average emission reductions for VCS afforestation and reforestation projects located in the US and applied this estimate to CAR projects to inform their supply potential in future years.

CAR projects – other than forestry projects – are required to have their emission reductions verified and request the issuance of credits within 12 months of the end of a verification period in order to maintain their status within the programme, although it is possible to request a "zero-crediting" period in the case that a project owner does not wish to undertake these activities for a particular period of time. We assume that non-forestry projects which historically have been issued with offset credits, but which have not had credits issued for any period since the beginning of 2015, will no longer contribute to the future supply of CAR offset credits.

Projects with a status of "listed" are not yet registered with the CAR and still need to undergo an independent validation to confirm that they satisfy the programme requirements. Based on our analysis of the share of projects entering the validation process that go on to successfully achieve registration in the CDM, we conservatively assume that half of listed projects will meet the requirements to register with the CAR.

Milestone dates and crediting period

The CAR data includes the registration date and the start date of operations for all projects. There is no information collected by the scheme on the *investment decision date*. As per the VCS and GS analysis described above we have assumed that the investment decision occurred 880 days (approximately two and a half years) prior to the estimate of the *start date of operations* for the project. This assumption is based on an analysis of CDM projects for which we have information on both the investment decision date and an estimate of the start date of operations. It is applied to all projects without differentiation across project types.

The data we analysed includes the "crediting period expiry" date for most projects, which corresponds to the end of the first crediting period. From this we derive the crediting period start date by subtracting the duration of a single crediting period, applicable to that project type. This date is well-aligned with the start date of operations for most projects, although not identical in all cases. For those projects where there is no crediting period expiry date in the data, we assume that the start of the crediting period coincides with the start date of operations.

4 Results

In this Chapter we present the results of our analysis of the potential supply of offset credits from existing projects listed publicly by the CDM, VCS, GS and CAR programmes over the period 2013 to 2035. The aim of the analysis is to provide a realistic assessment of the potential quantity of credits available to meet demand from aeroplane operators under CORSIA. The analysis is not a forecast of the actual supply. The actual supply of offset credits is uncertain and will depend on the demand and price that project developers can expect to receive for offset credits.

The estimates of the potential supply do not cover all current offsetting programmes, nor do they cover the potential supply of allowances from emission trading schemes, which might also be accepted for compliance with CORSIA. Moreover, we do not provide any estimates of additional supply that could be provided by new projects that could be developed in response to new demand from CORSIA or other sources.

Demand for offset credits under CORSIA is expected to be in the region of 2.7 billion over the full period from the beginning of 2021 to the end of 2035 (Schneider & La Hoz Theuer, 2017). We include this level of demand in the figures below to provide a visual comparison of the supply potential estimates with the possible order of magnitude of demand deriving from CORSIA. This demand estimate therefore excludes alternative potential sources of demand for offset credits. We further discuss the implications of our analysis for CORSIA in section 4.6 below.

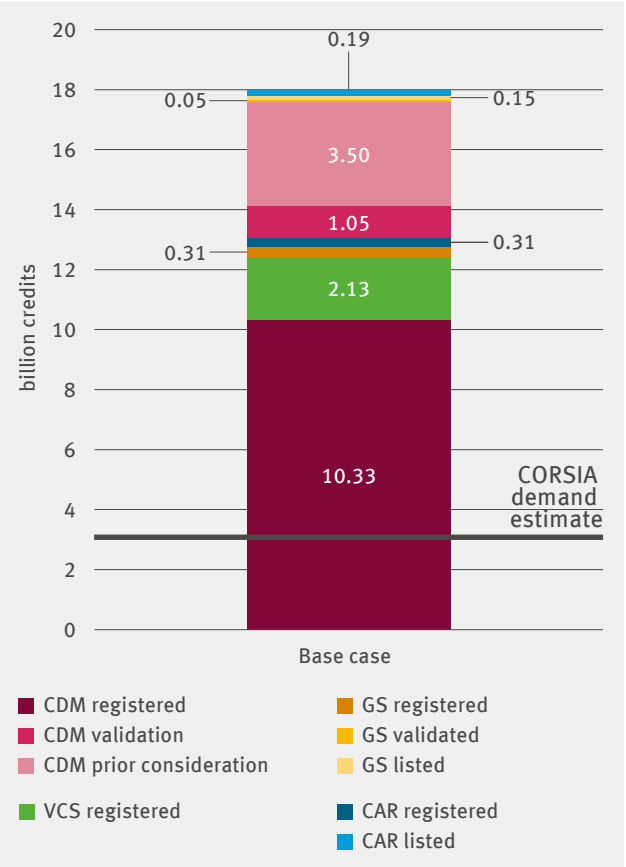
In the following sections we set out our quantification of the supply potential. We first present the base case in which no eligibility restrictions are imposed on the use of offset credits from the four programmes for emission reductions delivered since the beginning of 2013. We then present the results from the different scenarios before setting out the individual contributions from each of the programmes. We finish the Chapter with a summary discussion of the implications of the various results for defining eligibility restrictions under CORSIA.

4.1 Total offset supply

The following charts show the estimated supply potential from the four largest offset credit programmes: the CDM, VCS, GS and CAR. For each of the programmes we include estimates of the supply potential from currently registered projects. Where data exists, we also report estimates of the additional supply potential from non-registered projects which are at different stages of the administrative process to achieve registration.

Figure 2 shows the estimates of the offset credit supply potential in the base case. This includes all credits that could be issued for emission reductions over the period 2013 to 2035. The total supply potential is almost 18 billion credits, of which 13 billion credits are from registered projects. The CDM accounts for the largest share of this, with a potential supply of over 10 billion credits from registered projects and a further 4.5 billion credits from the pipeline of non-registered projects. Registered projects under the VCS could supply just over 2 billion credits. The GS and the CAR could supply approximately 500 million credits each across all projects at different administrative stages.

The following section considers the implications of different scenarios that might limit the availability of offset credits from existing registered projects.



Source: Authors calculations (see methodology and data sources in Chapter 3)

Figure 2: Base case supply potential estimates from all projects

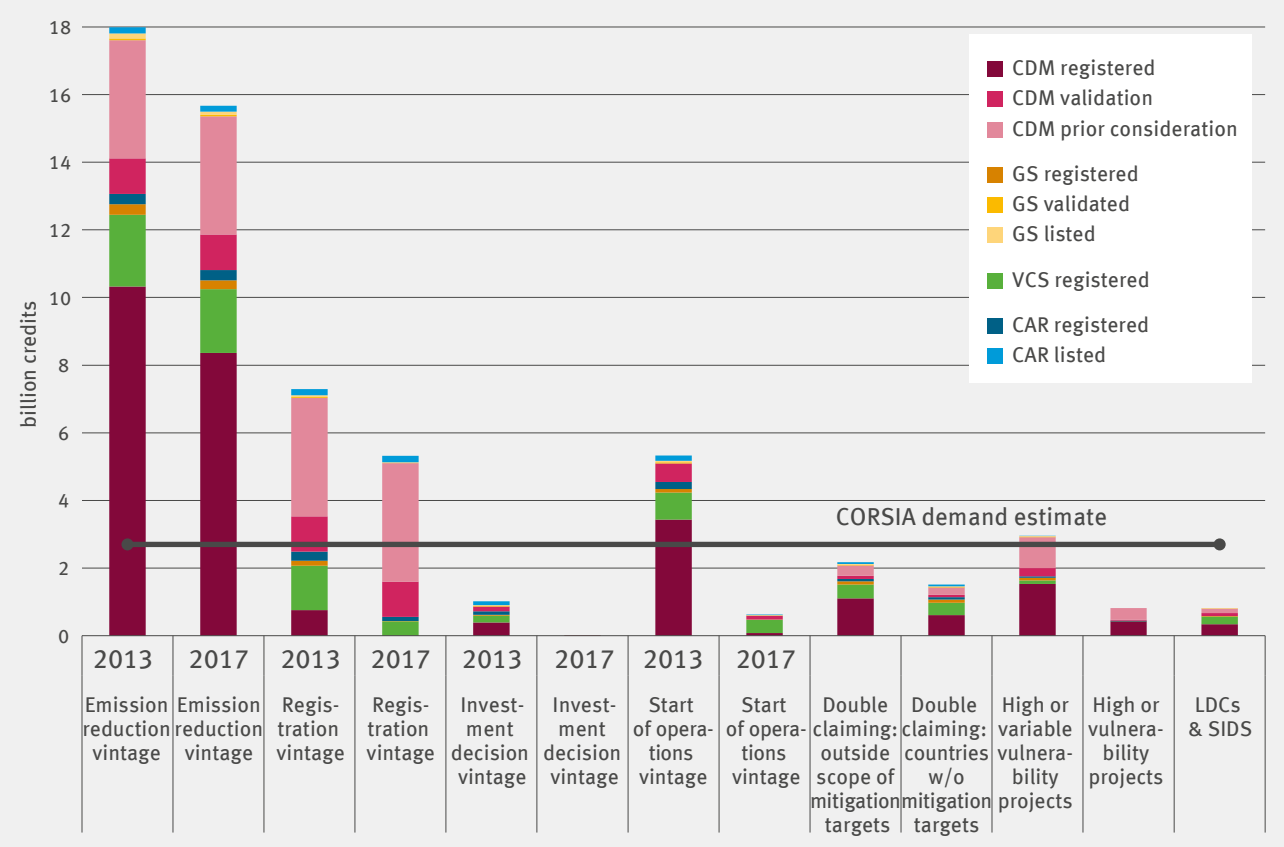
4.2 Offset supply under different scenarios

In Chapter 2 we set out a number of scenarios that may limit the availability of offset credits for CORSIA. In the base case, the only restriction applied is that credits must correspond to emission reductions that occurred from the start 2013 and up to the end of 2035. Figure 3 shows the supply under the base case and twelve alternative scenarios. For reference, the type of scenario, name and a brief description are provided above in Table 1 of Chapter 2.

In the base case (here labelled "2013 Emission reduction vintage"), the supply potential is approximately 18 billion credits. A vintage restriction applied to the date of emission reductions, limiting the supply to emission reductions since the beginning of 2017, reduces the supply potential to less than 16 billion credits.

Vintage restrictions applied to the date of project milestones have a more pronounced effect in reducing the supply potential. If only credits that are issued to projects which registered after the start of 2013 are counted then the supply potential falls to 7.3 billion credits, with the large pipeline of non-registered CDM projects (4.5 billion) accounting for the largest share. A 2017 vintage restriction applied to the registration date limits the supply potential further, to 5.3 billion credits. Only 555 million of the potential supply of credits under the 2017 registration date vintage restriction are from registered projects, most of which are registered with the VCS. However, if such a restriction were to be applied it is important to consider the availability of credits from both these registered projects as well as non-registered projects that have already been implemented, in particular with respect to the large CDM pipeline.

A 2013 or 2017 vintage restriction based on the start of a project's operations limits the supply potential to 5.3 billion and 623 million credits, respectively. If the vintage restriction were applied to the date of investment decision a 2013 cut-off date for projects would reduce the supply potential to 1 billion credits and a 2017 cut-off date would mean that existing projects could only supply less than 6 million credits.



Source: Authors calculations (see methodology and data sources in Chapter 3)

Figure 3: Supply potential under different scenarios

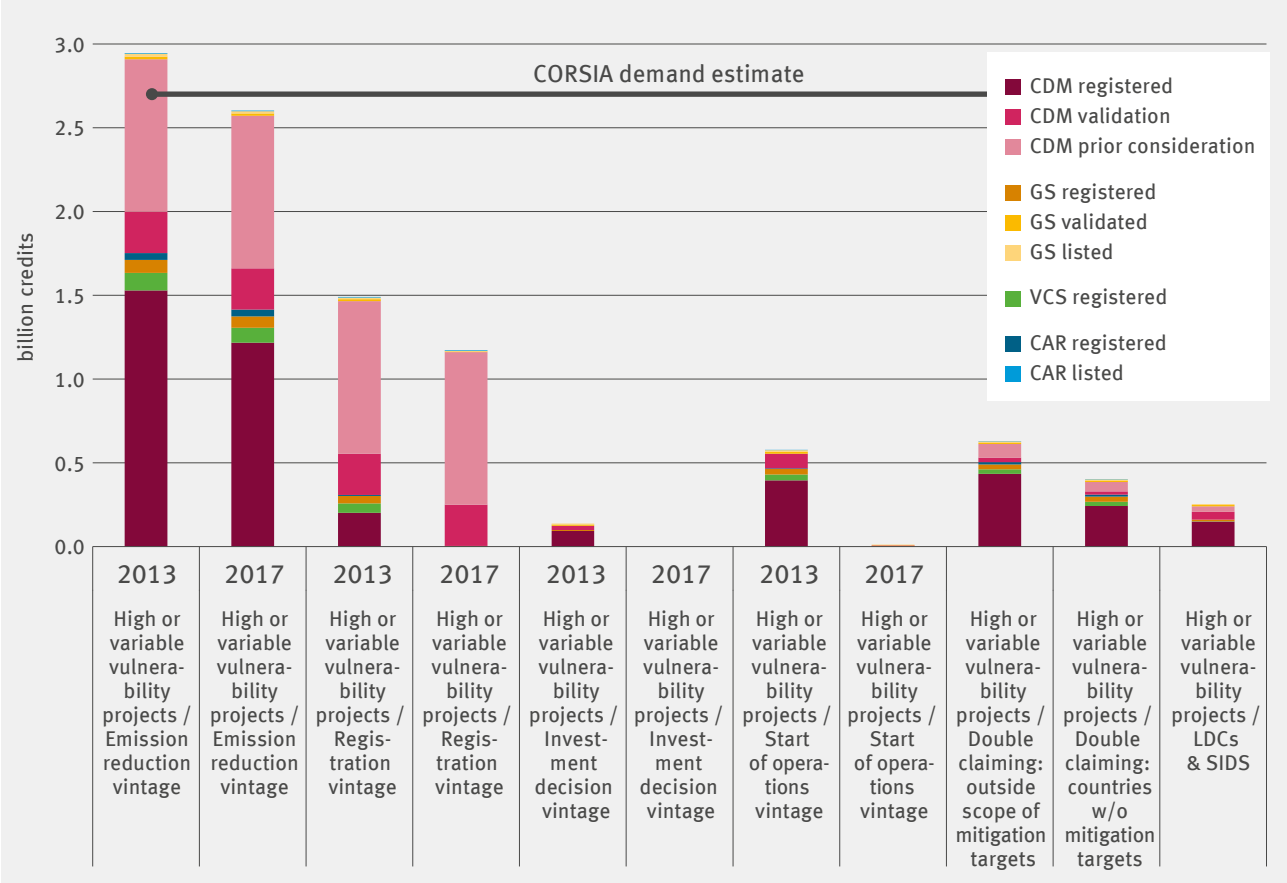
If rules to avoid double counting are put in place and if some countries are not ready to avoid double counting through the application of relevant adjustments, the potential supply of credits relative to the base case could be reduced significantly. Under the first double claiming scenario, emission reductions are excluded from the supply potential if they are covered by a mitigation target communicated under the Cancun Agreements or in NDCs. Under the second double claiming scenario we only consider emission reductions from countries without mitigation targets communicated under the Cancun Agreements or in NDCs. In the first case, the supply potential is 2.2 billion credits. In the second case, the supply potential is reduced to 1.5 billion credits.

We also estimate the supply potential from projects which are considered to be vulnerable to discontinuing their GHG abatement activities in the absence of sufficient revenues from selling offset credits. Projects assessed to have either high or variable vulnerability could supply close to 3 billion credits for emission reductions over the period from 2013 to 2035. Projects considered to be highly vulnerable to discontinuing their GHG abatement activities could supply approximately 815 million credits.

Finally, we consider the supply potential from projects which are hosted by countries classified as LDCs or SIDS. Projects from these countries could supply just over 810 million credits for emission reductions from 2013 to 2035.

4.3 Offset credit supply under combinations of restrictions

Policy-makers could consider combining some of the restrictions described in Chapter 2. We analyse the impact of combining the two vulnerability scenarios with the scenarios for vintage, double claiming and host countries. This would enable policy-makers to target CORSIA demand to more vulnerable projects whilst also limiting the supply of credits based on vintage restrictions or the type of host country.

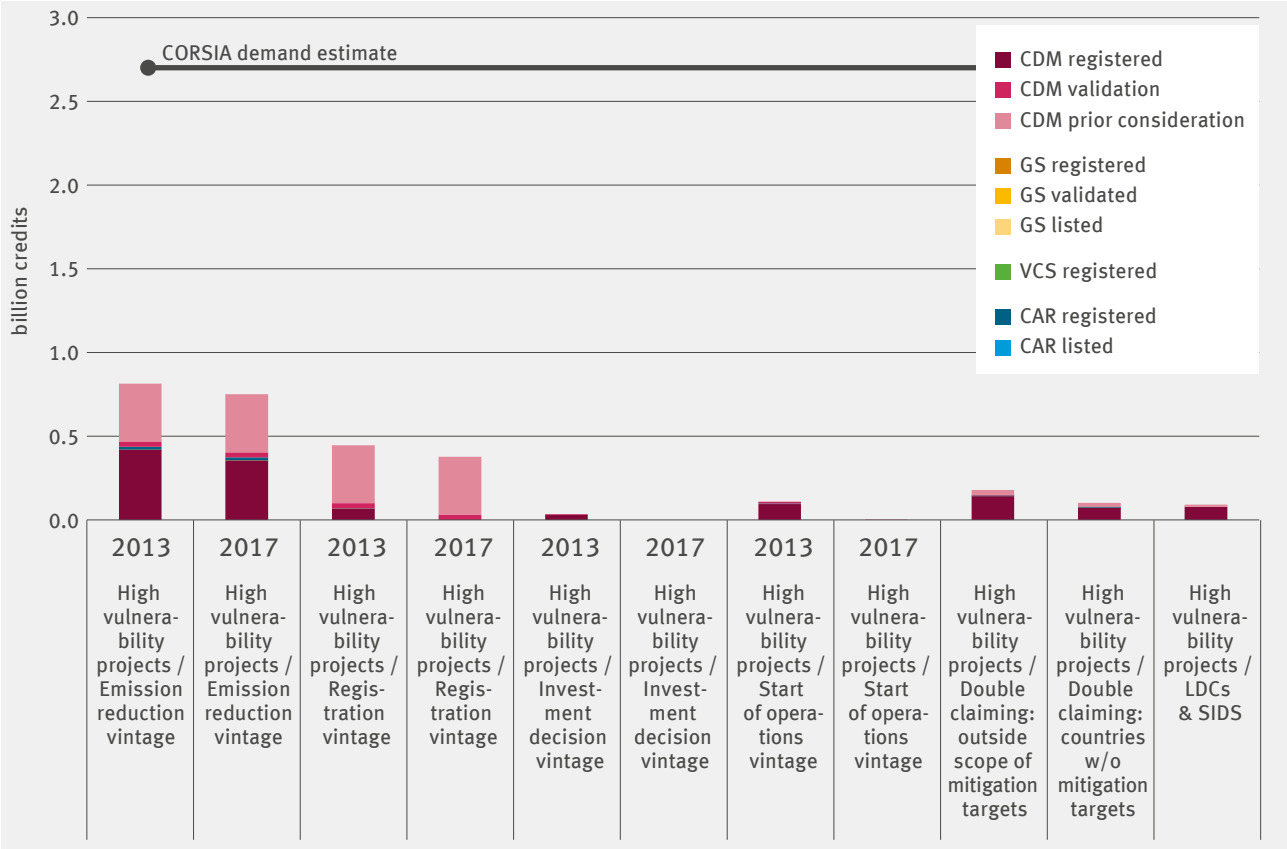


Source: Authors calculations (see methodology and data sources in Chapter 3)

Figure 4: Supply potential from high and variable vulnerability projects in combination with other scenarios

Figure 4 below shows the supply potential for all scenarios but limited to projects that are considered to have either high or variable vulnerability to discontinuing GHG abatement activities. The vertical scale of the chart is significantly reduced relative to the main supply potential scenarios as the analysis here is limited in the pool of projects it includes. Under a combination of the base case (emission reductions from 2013) with the vulnerability scenario, restricting supply to both variable and highly vulnerable projects, the supply potential is, as per the main scenario results shown above, almost 3 billion credits. For other combinations, the potential supply is further reduced, as shown in Figure 4.

Figure 5 shows the supply potential for all scenarios but limited to projects that are considered highly vulnerable to discontinuing GHG abatement.



Source: Authors calculations (see methodology and data sources in Chapter 3)

Figure 5: Supply potential from highly vulnerable projects in combination with other scenarios

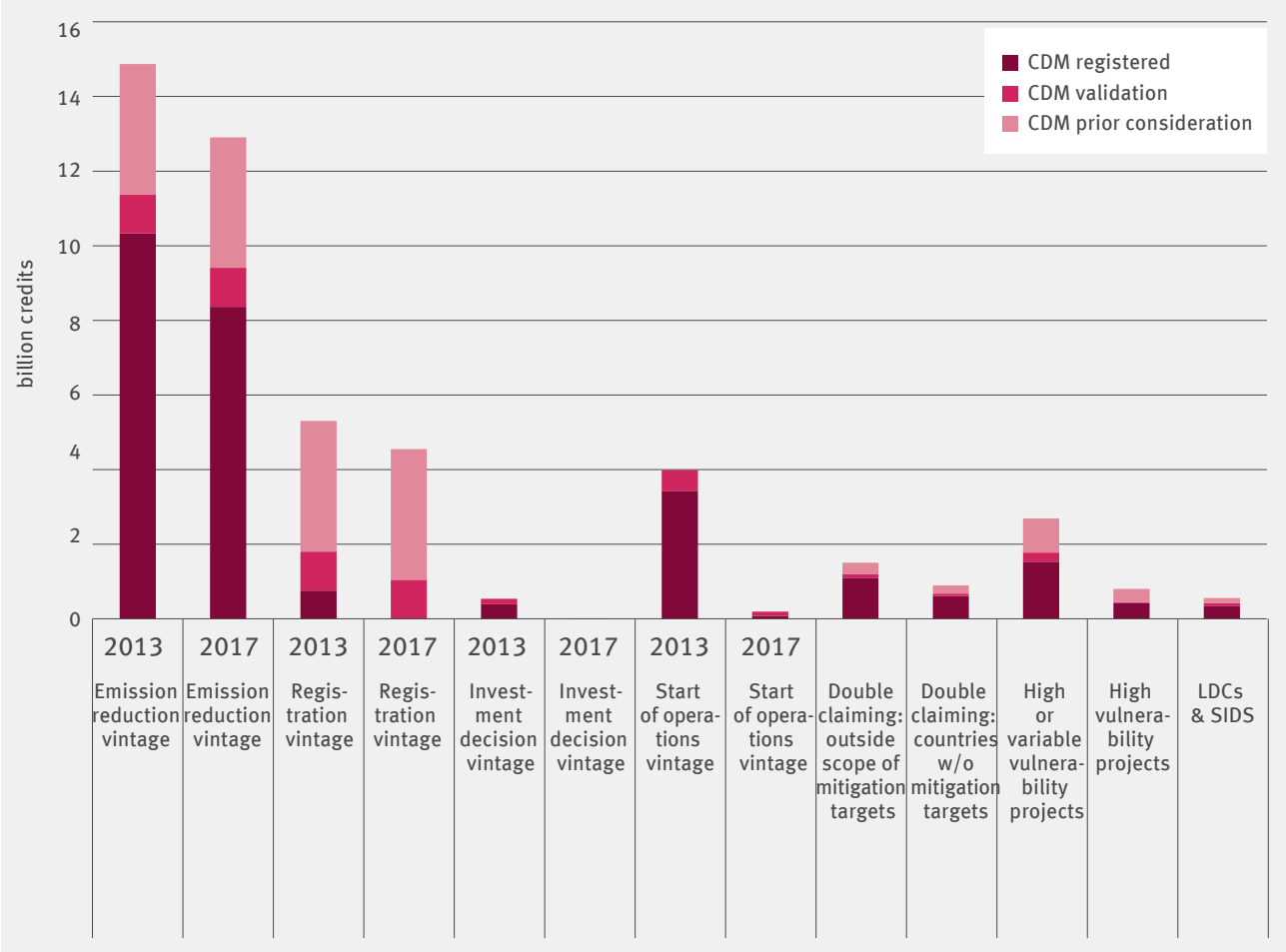
In the base case, where the only restriction is that offset credits must derive from emission reductions delivered after the beginning of 2013, the supply potential is just over 800 million credits, and thus significantly lower compared to the scenario where supply is limited to both variable and highly vulnerable projects shown in Figure 4. For other combinations, the potential supply is further reduced.

4.4 Offset credit supply by programme

This section sets out the credit supply potential results for each of the four programmes individually under the different scenarios we consider. It provides a breakdown of the supply potential shown in sections 4.2 and 4.3 for each of the four programmes.

4.4.1 CDM offset credit supply

The results of the supply potential analysis for the CDM is shown in Figure 6. The CDM offers the largest supply potential amongst the four programmes we have analysed for all scenarios with the exception of the "2017 start of operations vintage" scenario (where the VCS offers the highest supply potential).



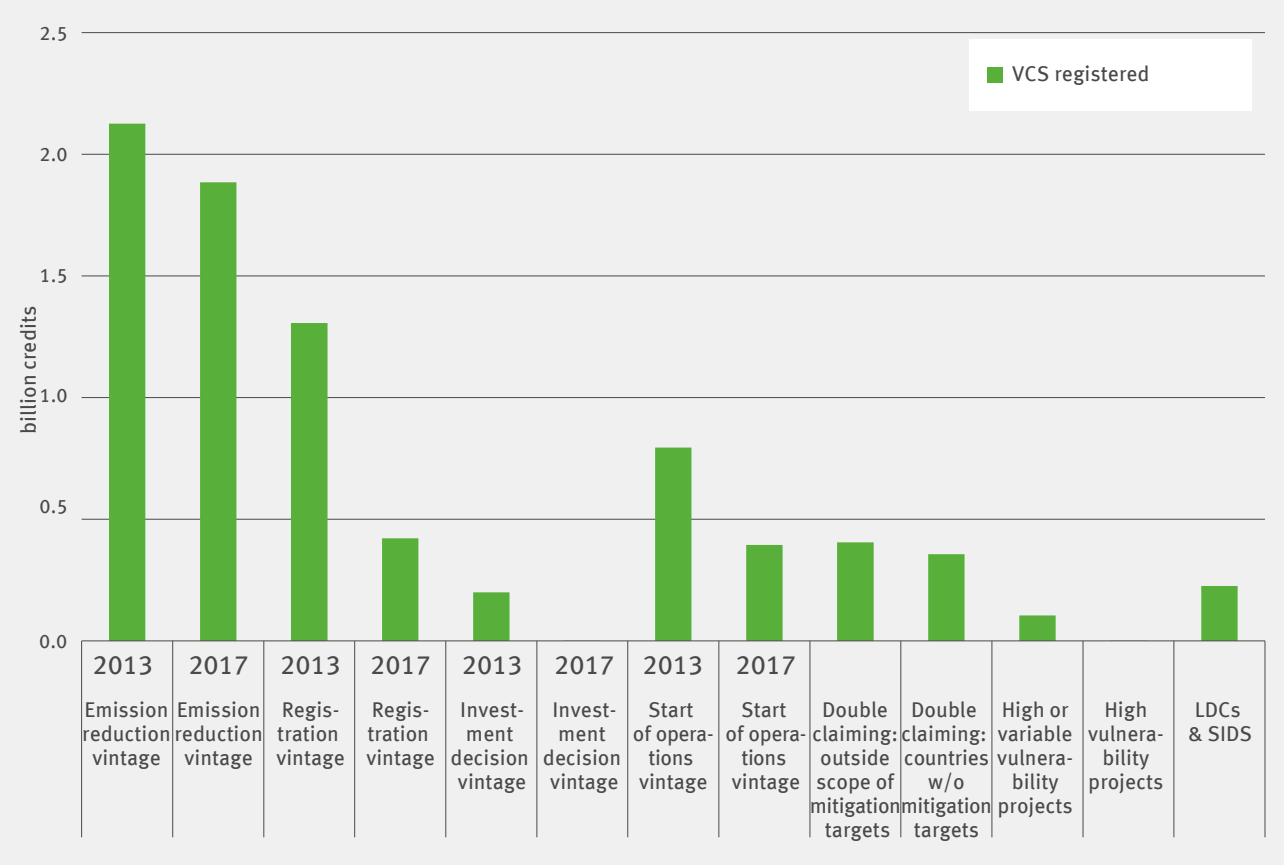
Source: Authors calculations (see methodology and data sources in Chapter 3)

Figure 6: Supply potential from registered, validated and "prior consideration" projects under CDM

The pipeline of non-registered projects is particularly relevant to the analysis of the CDM as there are a large number of projects – and corresponding supply potential – which are likely already physically implemented and operating. Many of these projects might not have completed the registration process due to the prevailing market conditions which offer limited financial incentives to verify emission reductions and request offset credits. This is important to recognise when considering the merits of a vintage restriction applied to the registration date. There is a significant supply potential from projects that have submitted a notice of prior consideration to the CDM Executive Board of their intention to seek registration with the CDM in the future, thereby securing the possibility to register at any future point in time under current rules. Rules governing the CDM and its transition to any future mechanism post-2020 are yet to be determined. New rules intended to limit the supply potential from existing implemented projects in any new market mechanism may prevent the future registration of these prior consideration projects but whether this happens and the timing of such a decision remains uncertain.

4.4.2 VCS offset credit supply

The VCS is the second largest of the offset programmes in terms of the number of projects as well as the supply potential across all scenarios, except for the two scenarios that focus on vulnerable projects. Figure 7 shows the supply potential from the VCS across all scenarios. The publicly available data is limited to registered projects; therefore, these estimates do not include potential additional supply from projects in the VCS pipeline which are not yet registered.



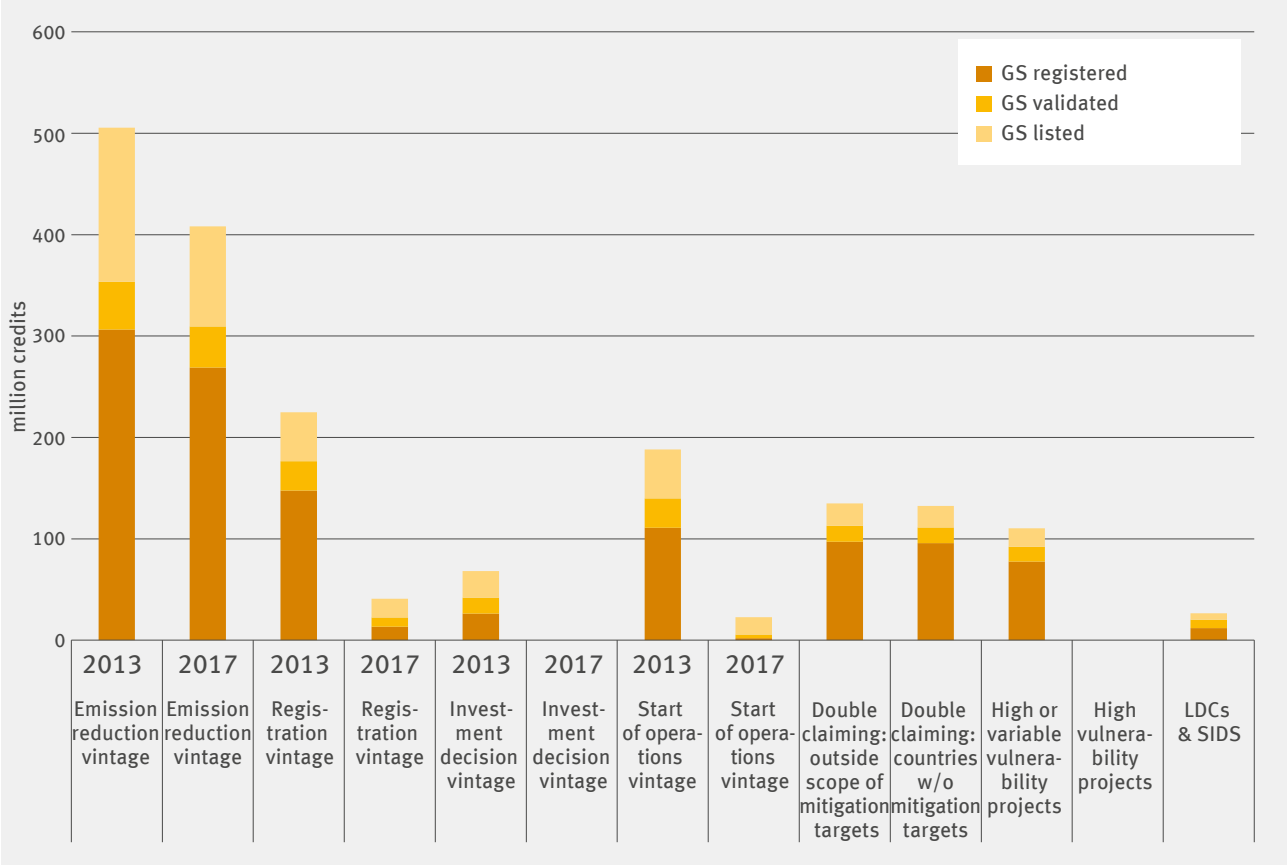
Source: Authors calculations (see methodology and data sources in Chapter 3)

Figure 7: Supply potential from registered projects under VCS

The VCS supply potential included in Figure 7 excludes supply from projects that are also registered with the CDM. These projects could supply a further 580 million offset credits in the base case, in addition to the 2.1 billion credits from projects that are either exclusively registered with the VCS, or with the VCS and other programmes excluded from our analysis.

4.4.3 GS offset credit supply

The GS is the third largest offset credit programme in terms of number of projects and the supply potential in the base case. However, across the different scenarios the supply potential is often lower than that of the CAR, the smallest of the programmes in terms of the number projects. Our analysis of the GS supply potential set out in Figure 8 includes registered, validated and listed projects.



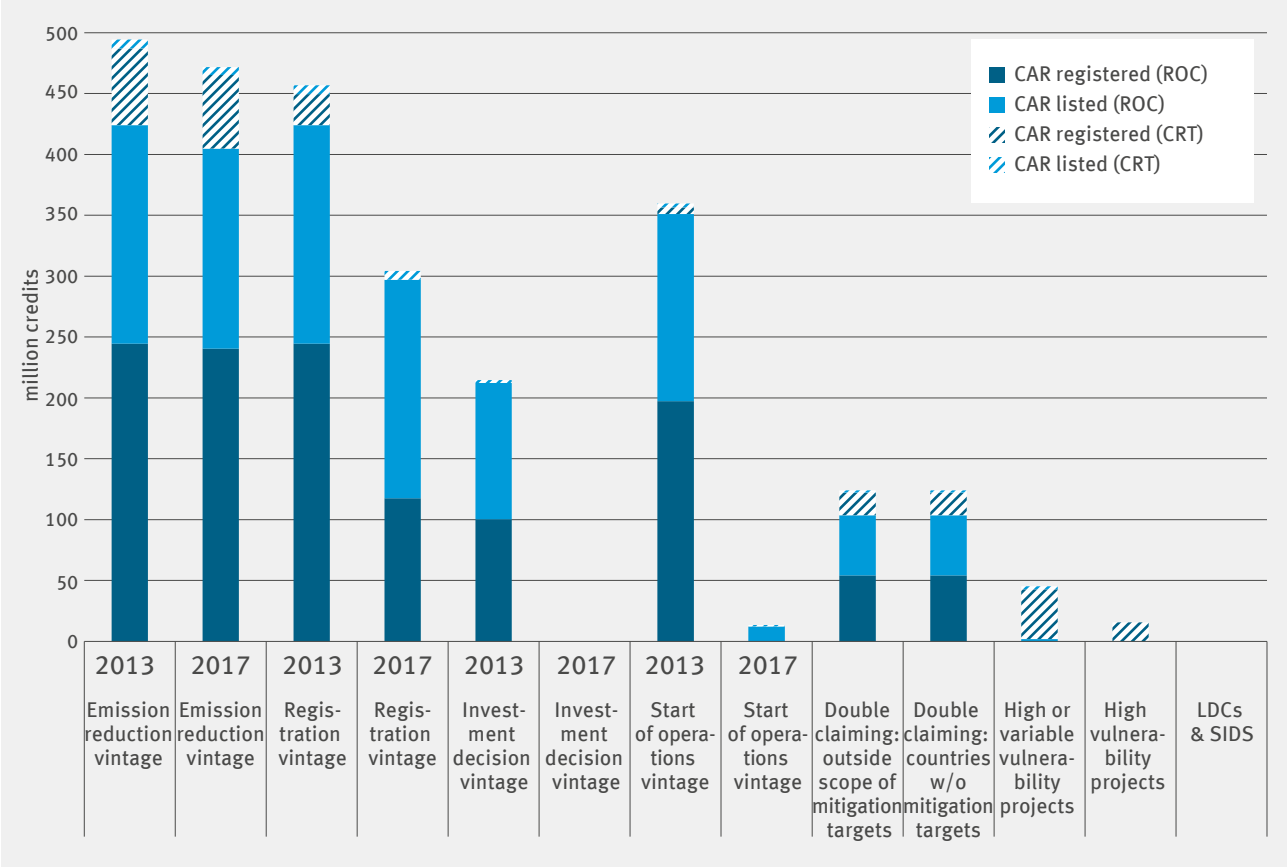
Source: Authors calculations (see methodology and data sources in Chapter 3)

Figure 8: Supply potential from issued, registered, validated and listed projects under GS

The GS supply potential included in Figure 8 excludes supply from projects that are also registered with the CDM. These projects could supply a further 210 million offset credits in the base case, in addition to the 500 million credit supply potential for projects exclusively registered with the GS.

4.4.4 CAR offset credit supply

The CAR includes the fewest projects among the four programmes. All projects are located in either the United States or Mexico. Our analysis shown in Figure 9 covers both registered and listed projects. As noted in the methodology description (section 3.4.4) the supply potential covers both projects that could supply CRTs to the voluntary market as well as projects that could supply ROCs for possible use in the compliance market under the ARB's Cap-and-Trade regulation.



Source: Authors calculations (see methodology and data sources in Chapter 3)

Figure 9: Supply potential from registered and listed projects under CAR

The supply potential for the CAR in the base case is almost 500 million credits. The majority of this is from ARB compliance projects. The supply potential from registered and listed projects that just offer CRTs to the voluntary market is just over 70 million credits, or 14 percent of the total (diagonal shaded area in Figure 9). The share of the total CAR supply potential from voluntary market projects is at least as low as for the base case across all scenarios with the exception of the two that restrict eligibility to vulnerable projects. The voluntary market projects account for over 95 percent of the total CAR supply potential in the scenarios focusing on vulnerable projects.

4.5 Availability of unused offset credits

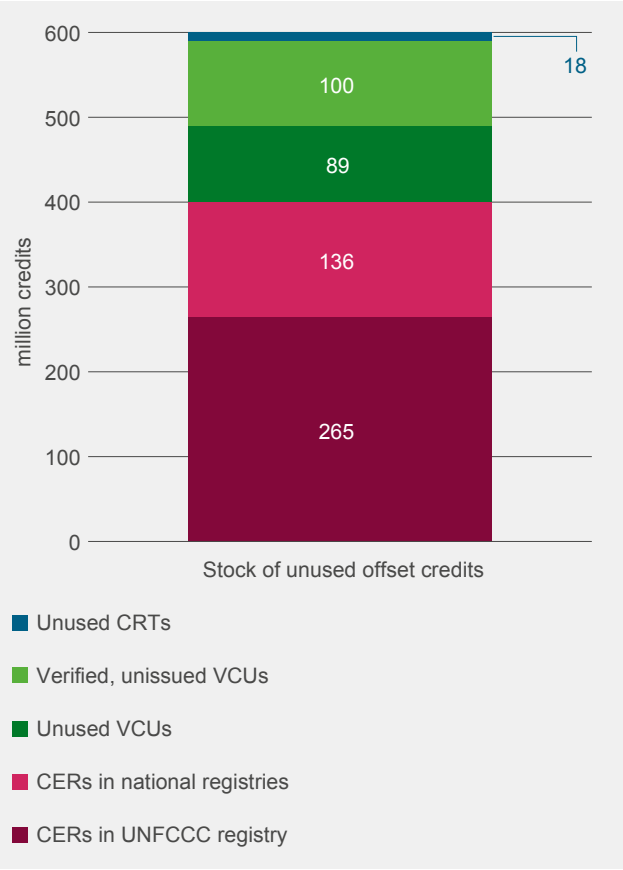
The results above present the *future supply potential* from existing projects from the four programmes. In this section we provide information on the stock of offset credits that have already been issued by the CDM, VCS and CAR but not been used for any purposes. Most of these credits are likely to be readily available to serve new demand, such as from CORSIA, though some of them may have already been sold but not yet retired or cancelled.

For the CDM, unused credits are in the CDM registry and in national registries of countries with commitments inscribed in Annex B. A significant amount of these credits is in the CDM registry's pending account, awaiting the payment of the issuance fee before they can be used. For the VCS and CAR, the stock is calculated by subtracting the number of credits that have either been retired or cancelled under these programmes from the total number of credits issued to date. We do not estimate the stock of credits in circulation from the GS due to a lack of data. The results are summarised in Figure 10.

As of 30 June 2018, there are **265 million** credits in holding or pending accounts of the CDM registry, which correspond to emission reductions since 2013 (UNFCCC, 2018a). We assume that the project developers that requested issuance of these credits do not currently have a buyer. By the end of 2017, another **136 million** are in holding accounts of national registries (UNFCCC, 2018b). Thus, in total, about **400 million** credits are in holding or pending accounts of registries established under the Kyoto Protocol.

The VCS has issued approximately **90 million** credits that remain unused. In addition, the VCS database reports the quantity of historical emission reductions verified during a given period. This quantity of verified emission reductions may exceed the total of credits actually issued because a project developer may elect not to pay the issuance fee for these credits. For example, the project developer may choose to issue the corresponding credits only on confirmation that it is able to sell the credits to a buyer. There are approximately **100 million** emission reductions that are verified under the VCS for which credits have not been issued. These credits could be requested at any time in the future.

There is a stock of approximately **18 million** unused CTR credits issued by the CAR to voluntary market projects. A further **9 million** credits have been issued to ARB compliance projects listed in the CAR database and remain unused, but these may be held for future compliance use by regulated organisations and we therefore exclude them from our estimate of the total stock potentially available for use under CORSIA.



Source: Authors calculations (see methodology and data sources in Chapter 3)

Figure 10: Stock of unused offset credits from CDM, VCS and CAR

Based on our analysis of the CDM, VCS and CAR there is therefore an existing and potential (verified) stock of approximately **600 million** offset credits. It is important to note that not all of these offset credits may be available for CORSIA. Some of these credits may be provided to other demand sources or may already have been sold. However, given the relatively low remaining demand from other sources, it is likely that a significant amount of these offset credits would be available for CORSIA.

4.6 Implications for CORSIA

Demand for offset credits under CORSIA is expected to be in the region of 2.7 billion over the full period from the beginning of 2021 to the end of 2035. Estimates suggest demand in the initial voluntary phases (the pilot and first phase) running from 2021 to 2026 may be approximately 400 million credits. In the second, compulsory, phase running from 2027 to 2035 demand may be around 2.3 billion credits (Schneider & La Hoz Theuer, 2017). The out-turn level of demand will depend on the growth of international aviation emissions in the period up to 2020, the subsequent growth in the sector and the extent to which carbon dioxide emissions are reduced through implementing operational and technological improvements and through the use of alternative fuels.

Our results presented above show that existing projects alone, listed under the four programmes covered by our analysis, could supply several times the demand from CORSIA if no eligibility restrictions are introduced. The supply potential in our base case is more than six times higher than projections of demand from CORSIA. Approximately 15 billion offset credits – or more than 80 percent of the base case supply potential – comes from existing projects that we assess to have a low vulnerability to discontinuing GHG abatement, i. e. they are likely to continue GHG abatement regardless of whether they can sell offset credits to CORSIA. Therefore, if all these programmes are deemed eligible to supply CORSIA without any additional eligibility restrictions imposed on credits or projects there is a risk that CORSIA fails to incentivise any emission reductions beyond those that would have occurred anyway.

Excluding the CDM, the largest potential source of credits, would still leave a potential supply from the VCS, GS and CAR, corresponding to approximately 3.1 billion credits in the base case. With projects that are registered under both the CDM and the VCS or GS, these programmes could supply a further 800 million credits, extending the total supply potential from the non-CDM programmes to approximately 3.9 billion credits. This would exceed the total expected demand from CORSIA over the full period from 2021 to 2035.

ICAO's objective is to offset the growth in CO_2 emissions from international aviation by driving corresponding emission reductions in other sectors. Emission unit criteria provide a tool for CORSIA to support emission reductions that would not have occurred without the scheme. To achieve this, eligibility restrictions on the use of offset credits can aim to incentivise new projects developed in response to CORSIA demand. They can also channel demand towards existing projects that depend on offset credit revenues to continue GHG abatement activities.

The supply potential varies significantly across the twelve scenarios that we consider in our analysis. Under the vintage restrictions limiting credits to emission reductions from 2013 or 2017, the vintage restrictions limiting credits to projects with a registration date from 2013 and 2017 and the vintage restriction applied to projects which started operations from the beginning of 2013, the supply potential from existing projects is well in excess of the likely total demand from CORSIA. These scenarios are therefore unlikely to incentivise the development of new projects. And the majority of credits available under these scenarios come from projects with a low vulnerability to discontinuing GHG abatement.

The 2013 and 2017 investment decision vintage restrictions and the 2017 start of operations vintage restriction limit the supply more strongly. Under these scenarios existing projects would not be able to meet all of the expected demand from CORSIA over the period to 2035. Some new projects which deliver further emission reductions would therefore be required to fully offset the growth in emissions from international aviation. Incentives to develop new projects to meet CORSIA demand would be most pronounced under the 2017 investment decision vintage restriction. We apply vintage restrictions with 2013 and 2017 cut-off dates within this study to illustrate the specific implications of these scenarios; however, policy-makers may consider applying alternative dates and project milestones, including vintage restriction dates in the future.

Eligibility restrictions that limit supply to projects that we categorise with either a high or variable vulnerability to discontinuing GHG abatement channel demand to projects which may depend on offset credit revenues to continue reducing emissions. This is a way for CORSIA to achieve some emission reductions that would otherwise not have occurred. We estimate that existing projects with either high or variable vulnerability could supply approximately 3 billion credits which would cover most, or all, of CORSIA demand over the period to 2035. By including projects with variable vulnerability in this scenario some eligible offset credits could come from projects that do not require offset credit revenues to continue GHG abatement. Directing demand towards only highly vulnerable projects would therefore be a more effective way of ensuring that aircraft operators stimulate emission reductions that would otherwise likely not have taken place. Under this scenario, existing projects could supply over 800 million credits, or at least twice the expected demand during the pilot and first phase of CORSIA, covering the period to 2026. Existing projects could not meet all of the expected demand beyond 2026, which would also stimulate investment in new offset projects.

Many of the emission reduction projects that could supply CORSIA are located in countries with existing GHG mitigation targets. To safeguard environmental integrity, it is important that the emission reductions for which offset credits are issued are not also used to achieve these GHG mitigation targets. To avoid such double counting, the countries that host projects would need to account for the use of offset credits under CORSIA by applying respective adjustments. In the "worst case" outcome in terms of the available supply in which none of the host countries would be willing to apply such adjustments, the available supply of offset credits for CORSIA would be reduced to approximately 2.2 billion, or 1.5 billion in the case that adjustments will be required if a country has a GHG mitigation target but the credited emission reductions occur outside the scope of that target.

Finally, if ICAO wants to channel funds to less developed countries and those most vulnerable to the impacts of global warming it could impose restrictions on the eligibility of offset credits depending on the country the emission reductions were delivered in. The potential supply from existing projects in LDCs and SIDS is approximately 800 million offset credits. The majority of the 810 million offset credits are from low vulnerability projects. A more effective means of directing finance to LDCs and SIDS and incentivising emission reductions that would not occur in the absence of the scheme would be to combine the LDCs and SIDS scenario with one of the vulnerability scenarios.

In addition to the future supply potential from existing projects, the stock of unused offset credits currently available in the market from the CDM, VCS and CAR is about 600 million. Not all of these offset credits may be available for CORSIA. However, given the limited demand for offset credits from other sources, the remaining unused offset credits are likely to constitute a significant amount. If all of these were available for use under CORSIA the existing stock alone could meet the new demand from CORSIA during the entirety of the scheme's pilot and first phase, running from the beginning of 2021 to the end of 2026.

5 Conclusions

Policy-makers are currently considering the detailed rules that will govern CORSIA. One of the critical elements in the ongoing negotiations is the available supply of offset credits and whether, and how, to restrict the eligibility of offset credits that can be used under the scheme. This study aims to inform these considerations by estimating the supply potential from the four largest offset crediting programmes under various scenarios.

The study builds on our earlier analyses of the potential supply of offset credits from the CDM in three ways: first, it extends coverage to the three largest non-governmental offsetting programmes – the VCS, GS and CAR. Second, it estimates the potential supply over the full period currently agreed for the implementation of CORSIA, out to the end of 2035. And third, it discusses the implications of various scenarios that may limit the supply.

We find that existing projects under the four programmes could supply approximately 18 billion offset credits for emission reductions achieved from 2013 to 2035. That is more than six times the total demand anticipated for CORSIA from 2021 to 2035. Over 80 percent of these emissions reductions would come from projects that are likely to continue GHG abatement, regardless of the incentive CORSIA may offer. On top of this future supply potential there is a current stock of approximately 600 million unused credits available from amongst the CDM, VCS and CAR. Even excluding the largest source of offset credits – the CDM – the supply potential from existing voluntary market offset projects would most likely exceed the total CORSIA demand to 2035. These estimates do not include alternative sources of supply, such as from offset projects listed in other programmes, from new projects that could be developed in response to the demand for CORSIA, or from allowances from emissions trading systems. The actual supply potential could thus be even larger, depending on how many new projects could be developed, how many other offsetting programmes apply, and whether ETSs will become eligible under CORSIA.

This study estimates the offset credit supply under several scenarios in order to inform policy-makers about likely impact of different options for restricting the eligibility of offset credits under CORSIA. We also combine a number of scenarios to allow decision-makers to understand the implications of a range of possible outcomes.

Amongst the scenarios we consider, the most effective means to stimulate investment in new emission reduction projects is the application of a vintage restriction that only allows offset credits from projects where the investment decision was made after the beginning of 2017. A 2013 investment decision vintage restriction and a 2017 start of operations vintage restriction would be less effective, but still encourage the development of some new projects. These scenarios would imply that existing projects could meet demand during the initial years of the scheme.

To promote existing projects that require offset credit revenues to continue abatement, ICAO could decide to limit supply to vulnerable projects. Practically, this could be implemented by establishing a list of project types that are more likely to be vulnerable to discontinuing GHG abatement. The list could either be developed by programmes which apply for eligibility under CORSIA or by relevant bodies under ICAO. The determination of the list could draw on relevant existing analyses of the vulnerability of project types to discontinuing GHG abatement (Schneider & Cames, 2014b; Warnecke et al., 2017). Under the high vulnerability scenario, the supply from existing projects would not be sufficient to offset all of the expected growth in international aviation emissions, although it should be sufficient to cover demand for offset credits into the late 2020s. Some new projects would also need to be developed to meet the total demand.

The CORSIA rules require that double counting of emission reductions be avoided. To avoid double counting, the countries where the emission reductions occur would need to apply adjustments to account for the use of offset credits under CORSIA. We test the implications here in two “worst case” out-comes in terms of the available supply, assuming that none of the countries would be ready to apply adjustments. These scenarios would imply that the available supply of offset credits from existing projects would be reduced to 2.2 billion or 1.5 billion, depending on the conditions in which adjustments will be required under international rules.

Lastly, policy-makers could prioritise projects in certain countries. We show that if offset credits could only be sourced from LDCs and SIDS the supply potential from existing projects would be approximately 810 million. Over 555 million of these offset credits are from projects that are likely to continue GHG abatement anyway.

In the absence of eligibility restrictions, the majority of – and potentially all – offset credits used under CORSIA are likely to come from projects that continue GHG abatement, even if the scheme were not put in place. This would mean that CORSIA would not deliver any significant emission reductions beyond those that would occur without the scheme, and it would therefore not achieve its objective of offsetting the growth in CO_2 emissions from international aviation by stimulating corresponding emission reductions in other sectors. To address this risk, we recommend that policy-makers apply eligibility restrictions that either promote new emission reduction projects or support existing vulnerable projects that require offset credit revenues to continue GHG abatement.

6 References

Cames, M., Harthan, R. O., Füssler, J., Lazarus, M., Lee, C. M., Erickson, P., & Spalding-Fecher, R. (2016). How additional is the Clean Development Mechanism? Öko-Institut.

CAR. (2018). CAR Offset Project Registry. Retrieved January 19, 2018, https://thereserve2.apx.com/mymodule/mypage.asp

Fearnehough, H., Day, T., Warnecke, C., & Schneider, L. (2018). Discussion paper: Marginal cost of CER supply and implications of demand sources.

ICAO (2016). Assembly – 39th session: Report of the Executive Committee on Agenda Item 22 (Global Market-based Measure Scheme). Doc nr. A39-WP/530. International Civil Aviation Organization (ICAO).

ICAO (2017). Proposal for the First Edition of Annex 16, Volume IV, concerning Standards and Recommended Practices relating to the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

IGES (2016). IGES INDC and Market Mechanism Database v3.0. Retrieved October 12, 2016, https://pub.iges.or.jp/pub/iges-ndc-database

Obergassel, W. (2017). Shaping the Paris mechanisms : a summary of submissions on article 6 of the Paris Agreement. JIKO Policy Paper, (01).

PIK (2016). Paris Reality Check – pledged climate futures. Retrieved October 12, 2016, from www.pik-potsdam.de/primap-live/indcs/

Schneider, L., & Cames, M. (2014a). Options for continuing GHG abatement from CDM and JI industrial gas projects. Berlin: Öko-Institut.

Schneider, L., & Cames, M. (2014b). Options for continuing GHG abatement from CDM and JI industrial gas projects. Berlin.

Schneider, L., Day, T., La Hoz Theuer, S., & Warnecke, C. (2017). Discussion Paper: CDM Supply Potential up to 2020. German Emissions Trading Authority (DEHSt).

Schneider, L., Füssler, J., Kohli, A., Graichen, J., Healy, S., Cames, M., ... Cook, V. (2017). Robust Accounting of International Transfers under Article 6 of the Paris Agreement. German Emissions Trading Authority (DEHSt).

Schneider, L., Füssler, J., La Hoz Theuer, S., Kohli, A., Graichen, J., Healy, S., ... Broekhoff, D. (2017). Environmental Integrity under Article 6 of the Paris Agreement. Discussion Paper. German Federal Environment Agency (UBA).

Schneider, L., Kollmuss, A., & Lazarus, M. (2015). Addressing the risk of double counting emission reductions under the UNFCCC. Climatic Change, 131(4), 473 – 486. https://doi.org/10.1007/s10584-015-1398-y

Schneider, L., & La Hoz Theuer, S. (2017). Using the Clean Development Mechanism for nationally determined contributions and international aviation. Stockholm: Stockholm Environment Institute.

Spalding-Fecher, R. (2017). Article 6.4 crediting outside of NDC commitments under the Paris Agreement: issues and options. Oslo.

UNFCCC. (n.d.). Methodological Tool: Tool to determine the remaining lifetime of equipment, version 1.0.

UNFCCC. (2017). Database for PAs and PoAs. Retrieved April 13, 2017 http://cdm.unfccc.int/Statistics/Public/files/Database for PAs and PoAs.xlsx

UNFCCC. (2018a). CDM Registry. Retrieved July 24, 2018, https://cdm.unfccc.int/Registry/index.html

UNFCCC. (2018b). National Inventory Submissions 2018. Retrieved from https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2018

Verra. (2018a). VCS Project Database. Retrieved February 22, 2018, http://vcsprojectdatabase.org/#/projects

Verra. (2018b). VCU Issuance Database. Retrieved February 22, 2018, http://vcsprojectdatabase.org/#/vcus

Warnecke, C., Day, T., & Klein, N. (2015). Analysing the status quo of CDM projects: Status and prospects. NewClimate Institute & Ecofys.

Warnecke, C., Day, T., Schneider, L., Cames, M., Healy, S., Harthan, R., ... Höhne, N. (2017). Vulnerability of CDM projects for Discontinuation of Mitigation Activities: Assessment of Project Vulnerability and Options to Support Continued Mitigation. Cologne: NewClimate Institute.

Warnecke, C., Schneider, L., Day, T., La Hoz Theuer, S., & Fearnehough, H. (2019). Robust eligibility criteria essential for new global scheme to offset aviation emissions. Nature Climate Change, 9(3), 218 – 221. https://doi.org/10.1038/s41558-019-0415-y

WRI. (2016). CAIT Climate Data Explorer. Retrieved October 12, 2016, http://cait.wri.org/indc/

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