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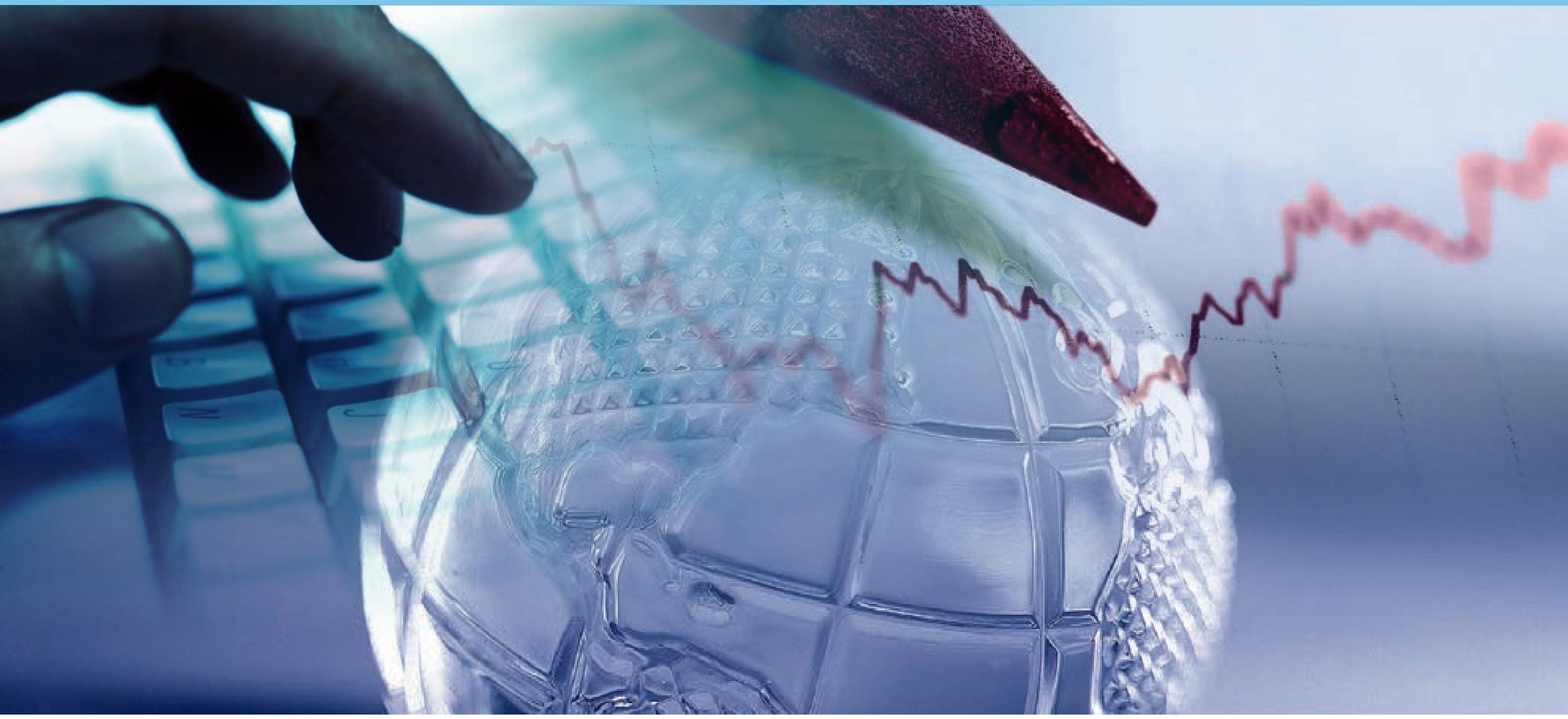

Factors influencing the international trade of carbon offsets from the destruction of ozone depleting substances

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

DEVELOPMENT POLICY, STATISTICS AND RESEARCH BRANCH
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Factors influencing the international trade of carbon offsets from the destruction of ozone depleting substances

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Acronyms

AB32	Assembly Bill 32 – Global Warming Solutions Act of 2006 (California)
ACR	American Carbon Registry
CARB	California Air Resources Board
CAR	Climate Action Reserve
CCA	California Carbon Allowance
CCX	Chicago Climate Exchange
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CFC	Chlorofluorocarbon
CFI	Carbon Financial Instrument
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CRT	Climate Reserve Ton (CAR unit)
CSR	Corporate Social Responsibility
EOL	End of life
EU ETS	European Union Emissions Trading System
GHG	Greenhouse Gas
Gt	Giga tonne (one billion tonnes)
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
IFI	International Financial Institution
IPCC	Intergovernmental Panel on Climate Change
kg	Kilogramme
KP	Kyoto Protocol
LVCC	Low-Volume Consuming Country
MLF	Multilateral Fund
Mt	Mega tonne (one million tonnes)
N_2O	Nitrous Oxide
NAMA	Nationally Appropriate Mitigation Action

ODP	Ozone Depletion Potential
ODS	Ozone Depleting Substance
OTC	Over the counter (bilateral trading)
PCF	Prototype Carbon Fund
t	Tonne (metric)
TEAP	Technology and Economic Assessment Panel
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USA	United States of America
VCM	Voluntary Carbon Market
VCS	Verified Carbon Standard
WCI	Western Climate Initiative

Executive Summary

- Large amounts of ODS can be found in existing equipment, products, waste streams and stockpiles, collectively known as ODS banks. Over time, these stocks of ODS will inevitably leak to the atmosphere, unless they are collected and destroyed.

- Most ODS are powerful greenhouse gases contributing to global warming and depleting the ozone layer. The amount of ODS expected to leak to the atmosphere between 2002 and 2015 is equivalent to about 20 percent of a year's global carbon dioxide emissions.

- These emissions are largely uncontrolled, partly because they fall between the Montreal and Kyoto Protocols. The Montreal Protocol addresses the production and consumption of ODS, but not ODS banks, while the Kyoto Protocol excludes greenhouse gases controlled by the Montreal Protocol. Therefore, most carbon markets do not currently provide significant incentives for the destruction of ODS banks.

- There are two major exceptions to this: new regulatory carbon markets in California and Quebec, and the voluntary carbon market. However, California and Quebec specifically exclude any participation from Article 5 countries. The voluntary carbon market, which is several orders of magnitude smaller, does offer recognition of carbon credits from destruction of Article 5 ODS stocks, but there is very little evidence as yet of 'pure' voluntary demand for ODS credits.

- At present, of the six largest ODS project developers (covering 96 percent market share by volume), only one is interested in pursuing CAR Article 5 projects.

- This suggests there may be a role for UNIDO in helping to encourage increased end-user demand for Article 5 credits. There are several ways in which this could be done, for example, by engaging with policymakers in California and Mexico, helping to raise awareness of the double benefit of ODS credits (ozone protection and climate change mitigation), engaging with standard setters and promoting the highest standards and wider awareness of those standards.

- However, even if demand for Article 5 ODS credits increases, substantial barriers and challenges remain in all parts of the Article 5 ODS to carbon credit supply chain. These include barriers to conducting the collection and management of ODS, barriers to carrying out destruction in Article 5 countries and to implementing ODS carbon credit development.

- A variety of possible solutions are discussed. The potential role for UNIDO includes identifying and promoting best practices in legal/regulatory frameworks; conducting an up-to-date survey of suitable destruction facilities; running targeted capacity building workshops specifically in ODS carbon credit development; linking ODS stock owners, trained local technical partners and experienced carbon credit developers through some form of 'clearinghouse'; and conducting a survey of potential ODS carbon credit developers and retailers to improve clarity on market demand and expected prices.

- In the longer term, an ODS Carbon Facility could be envisaged. Funds from various investors could be pooled here and used to purchase ODS credits from Article 5 projects, or to directly invest in developing such projects and to fund wider capacity-building activities to support the development of the market as a whole. Given the scale of the challenge, the time has come to start seriously considering such an ODS Carbon Facility.

1. Introduction

This paper is based on collaborative research to better understand the factors influencing the participation of stakeholders from developing countries in ozone depleting substances (ODS) destruction projects to generate credits for carbon markets.

The research was carried out in two stages: first, via a desk-based literature review, followed by a set of semi-structured interviews with key ODS and carbon market stakeholders. In total, 17 face-to-face or telephone interviews were conducted between 16 July and 23 August 2012, primarily with stakeholders based in the US, including project developers, ODS destruction experts, carbon standards bodies and regulators. Four additional interviews were conducted between 4 December 2012 and 12 January 2013 with stakeholders in Article 5 countries. An indication of the types of stakeholders interviewed is provided in Annex 3. In order to encourage a frank exchange of views, the identity of the interviewees has been kept confidential. Quotes from interviewees are therefore cited in the text only as (pers. comm.). The authors are grateful to all of the interviewees for their assistance with this research.

This paper is structured as follows:

- Section 2 provides background information on the Montreal and Kyoto Protocols, ODS and gives an overview of carbon markets and how they work;
- Section 3 discusses the opportunities offered by the regulatory and voluntary carbon markets for the management and destruction of ODS banks;
- Section 4 reviews the barriers to development of ODS destruction projects in developing countries;
- Section 5 proposes a number of possible solutions to the identified barriers; and
- Section 6 presents our conclusions and recommendations.

2. Background

2.1 The Montreal and Kyoto Protocols

The 1987 **Montreal Protocol on Substances that Deplete the Ozone Layer** – a subsidiary instrument to the Vienna Convention for the Protection of the Ozone Layer – is an international treaty that aims to reduce and phase out the production and consumption of ozone depleting substances (ODS). The Protocol was the result of increasing awareness about the potential dangers of ODS, which were first outlined in a scientific paper in 1974 (M. J. Molina & Rowland, 1974) and subsequently confirmed by findings in the mid-1980s that there was a large hole in the ozone layer over the Antarctic (Farman et al., 1985). Many have deemed the Montreal Protocol the most successful international environmental agreement to date (see, e.g. Norman et al., 2008; M. Molina et al., 2009). It has reduced the production and consumption of ODS by more than 97 percent from historic baseline levels, and because most ODSs are also potent global warming gases, the Montreal Protocol has also resulted in the elimination of at least 8 billion tonnes of carbon dioxide equivalent (tCO_2e) per year between 1990 and 2010 (Velders et al., 2007).

The 1997 **Kyoto Protocol** is a subsidiary instrument to the United Nations Framework Convention on Climate Change (UNFCCC), which aims to fight anthropogenic climate change by achieving the 'stabilization of greenhouse gas [GHG] concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system' (United Nations, 1992; United Nations, 1998). Both the UNFCCC and Kyoto Protocol explicitly exclude coverage of greenhouse gases which are controlled by the Montreal Protocol. In its first commitment period (2008 – 2012), Annex I Parties to the Kyoto Protocol committed to reducing their GHG emissions by 5.2 percent on average. It has been argued that the GHG reduction target for the Kyoto Protocol's first commitment period is lower than the climate protection achieved as a side effect of the Montreal Protocol (Velders et al., 2007).

One common aspect of the Montreal and Kyoto Protocols is the principle of common but differentiated responsibilities, whereby countries are divided into two broad groups based on whether they have significantly contributed to the current situation (ozone depletion for the Montreal Protocol and climate change for the Kyoto Protocol). The Montreal Protocol distinguishes between 'Article 5 countries', developing countries whose annual calculated level of consumption of ODS is below 0.3 kg per capita, and 'Non-Article 5 countries', developed countries that exceed this per capita threshold. Non-Article 5 countries have more stringent requirements for phasing out ODS and help finance the Multilateral Fund, which supports programmes and pilot projects to help Article 5 countries achieve their goals. In the Kyoto Protocol, only a specified set of developed 'Annex I countries' (so named because they are listed in Annex I of the UNFCCC) have an emission reduction target.

2.2 Ozone depleting substances

Ozone depleting substances are halogen-containing substances that damage the ozone layer in the stratosphere. ODS include chlorofluorocarbons (CFCs), carbon tetrachloride (used to make CFCs), hydrochlorofluorocarbons (HCFCs), halons, methyl chloroform and methyl bromide. ODS are commonly used as refrigerants, solvents, foam blowing agents, fire fighting fluids and as substances for fumigation and soil sterilization.[1]

Table 1: A comparison of the Montreal and Kyoto Protocols (adapted from UNDP, 2009)

	Montreal Protocol	Kyoto Protocol
Chemicals covered	ODS	Six GHGs: CO_2, CH_4, N_2O, HFCs, PFCs and SF_6
Objectives	Limits on consumption and production	Limits on emissions

As mentioned in section 2.1, the Montreal Protocol aims to phase out the production and consumption of ODS. The treaty is structured around several groups of ODS and provides a timetable for the phase-out and elimination of substances under each of these groups. The different groups of ODS and the timetables for their phase-outs in Non-Article 5 and Article 5 countries are summarized in Table 2 below, and a complete list can be found in Annex 2. The overall picture is that the production and consumption of most ODS has now ceased, with three exceptions: certain essential use applications permitted in all countries; methyl chloroform and methyl bromide in Article 5 countries only (to be fully phased out by 2015), and HCFCs, which may still be produced at low levels in non-Article 5 countries and at still relatively high levels in Article 5 countries (to be fully phased out by 2040).

Table 2: ODS production phase-out schedule under the Montreal Protocol (ICF International, 2008)

Ozone Depleting Substance	Non-Article 5	Article 5
Halons	January 1, 1994: full phaseout	January 1, 2010: full phaseout
CFCs	January 1, 1996: full phaseout	January 1, 2010: full phaseout
Carbon tetrachloride	January 1, 1996: full phaseout	January 1, 2010: full phaseout
HBFCs	January 1, 1996: full phaseout	January 1, 1996: full phaseout
Methyl chloroform	January 1, 1996: full phaseout	January 1, 2015: full phaseout
Chlorobromomethane	January 1, 2002: full phaseout	January 1, 2002: full phaseout
Methyl bromide	January 1, 2005: full phaseout	January 1, 2015: full phaseout
HCFCs	January 1, 1996: Freeze at baseline (1989 HCFC levels + 2.8% of 1989 CFC levels)	January 1, 2013: Freeze at baseline (average 2009/2010)
	January 1, 2004: cut by 35%	January 1, 2015: cut by 10%
	January 1, 2010: cut by 75%	January 1, 2020: cut by 35%
	January 1, 2015: cut by 90%	January 1, 2025: cut by 67.5%
	January 1, 2020: cut by 99.5% (can only be used for refrigerator/AC servicing after this date)	January 1, 2030: cut by 97.5%, (can only be used for refrigeration/AC servicing after this date)
	January 1, 2030: full phaseout	January 1, 2040: full phaseout

Source: UNEP 2000, UNEP 2007, UNEP DTIE 2002

As each Protocol deals with a variety of different gases, each with differential effects on the ozone layer and climate, efforts have been made to make these gases comparable in terms of

[1] See http://www.sepa.org.uk/climate_change/solutions/ozone_depleting_substances.aspx

their respective impacts. Hence, the Montreal Protocol assigns each gas a number, known as the ozone depletion potential (ODP), corresponding to its destructive impact on the ozone layer relative to the impact of trichlorofluoromethane or CFC-11. The Kyoto Protocol uses carbon dioxide as the reference gas and assigns each other gas a number known as its global warming potential (GWP), which is a multiple of the climate impact of carbon dioxide measured over a specified time period (by convention, this is almost always 100 years). Using ODP and GWP conversion factors, a given mass (e.g. 1 metric tonne) of any given gas can be expressed in terms of its ozone impact (ODP tonnes) or climate impact (tonnes of carbon dioxide equivalent, CO_2e). The Kyoto Protocol mandates the use of GWPs published in the IPCC Second Assessment Report in 1996, many of which now differ from the most up-to-date figures published in the IPCC Fourth Assessment Report in 2007. Table 3 below presents the ODP and GWP of a selection of ODS commonly stored in banks (using IPCC Fourth Assessment Report figures).

Table 3: The ozone depletion potential (ODP) and global warming potential (GWP) of a selection of ODS commonly stored in banks (United Nations, 2000; IPCC, 2007)

ODS	ODP	GWP
CFC-11	1	4,750
CFC-12	1	10,900
CFC-13	1	14,400
CFC-113	0.8	6,130
CFC-114	1	10,000
Halon-1301	10	7,140
HCFC-22	0.055	1,810
HCFC-123	0.02	77
HCFC-142b	0.065	2,310

This table clearly shows that most ODS have a GWP that is considerably higher than that of carbon dioxide. Hence, the destruction of one tonne of CFC-11, for example, is notionally equivalent to preventing the emission of 4,750 tonnes of carbon dioxide. This concept is what fundamentally underpins the idea of carbon offsetting (see section 2.4).

2.3 ODS banks

Despite the phase-out in production of most ODS, large amounts are still found in existing equipment, products, waste streams and stockpiles. These sources of ODS are commonly referred to as ODS banks and defined as "consumption not yet emitted" (TEAP, 2009, p. 1). Stockpiles are defined as "a specific sub-set of banks which are intermediate stores of material with the intent of future action" (Multilateral Fund, 2006, p. 6).

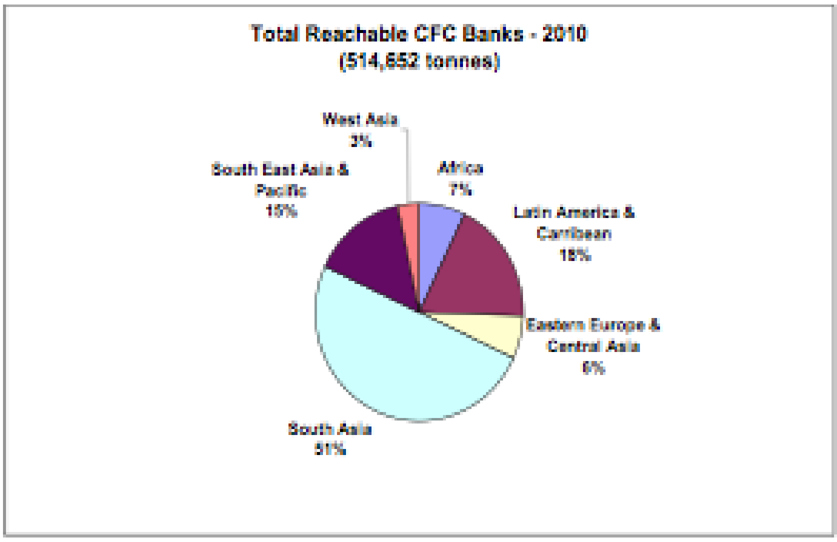
A Special Report by the Intergovernmental Panel on Climate Change (IPCC) and UNEP Technology and Economic Assessment Panel (TEAP) estimated that there were 5.791 million tonnes of ODS in global banks in 2002, with a global warming potential (GWP) of approximately 21 $GtCO_2e$ (IPCC & TEAP, 2005). CFCs comprise approximately 42 percent of this by volume and 76 percent by GWP; HCFCs comprise a further 46 percent by volume but only 19 percent by GWP. The remainder is mainly HFCs, which are not ozone depleting substances but appear frequently mixed with ODS in banks (9 percent by volume and 5 percent by GWP) and halons (3 percent by volume and excluded from the GWP-based calculations because their indirect cooling effect outweighs their direct warming effect on the climate – but they would account for around 2.5 percent by GWP if including only their direct warming effect).

Over time, the stocks of different ODS in banks will change as the gases are deliberately or inadvertently leaked to the atmosphere, destroyed or augmented by continuing production. The IPCC/TEAP Special Report predicted that unless urgent action was taken, about one-third of the ODS banks in existence in 2002 would have been vented by 2015, resulting in emissions of nearly 7 $GtCO_2e$ (IPCC & TEAP, 2005). As CFC and halon production has now ceased, these stocks are projected to decline rapidly, while HCFC and HFC stocks are projected to increase. Overall, the global flow of ODS into banks is expected to peak at 200,000-225,000 tonnes annually in the period 2018-2020.

Many of these banks of ODS are widely dispersed, diluted or difficult to recover, hence, the 'reachable' banks are much lower than the total potentially available ones. CFCs contained in refrigeration and AC equipment have been identified as the most easily reachable and largest accessible ODS banks (UNEP, 2009b; UNEP, 2009a). It has been estimated that the *reachable* banks of CFCs in Article 5 countries were approximately 515,000 tonnes in 2010, of which approximately 50 percent were in foams and 50 percent in refrigerants (Multilateral Fund, 2006; UNEP, 2009a). Over time, reachable banks in refrigerants are expected to reduce relative to foams due to the longer life in service of foams versus refrigeration units. Reachable banks of CFCs are projected to decline to around 375,000 tonnes by 2015, when foams will account for 58 percent and refrigerants for 42 percent of the total (Multilateral Fund, 2006). This translates into an expected loss to the atmosphere of nearly 28,000 tonnes of potentially reachable CFCs per year. The geographic breakdown of accessible CFC banks is shown in Figure 1 below.

The Montreal Protocol does not cover emissions from or require the elimination of ODS banks. These are also not covered by the Kyoto Protocol, as it does not cover gases formally controlled by the Montreal Protocol (see Table 1 above). However, there is a clear need for ODS banks to be recovered and properly treated, as the ODS will otherwise be released to the atmosphere over time through slow leakage, catastrophic leakage and unintentional or intentional venting (UNEP, 2009b). To address this need, the parties to the Montreal Protocol adopted Decision XX/7 in November 2008, which sets out three key objectives, namely i) to perform further studies on the size and scope of existing ODS banks and the cost and benefits of taking action on different categories of banks in relation to the ozone layer and climate change; ii) for the Multilateral Fund to initiate pilot projects with a view to developing practical data and experience, achieving climate benefits and exploring opportunities to leverage co-financing; and iii) to identify funding opportunities for the management and destruction of ODS banks (UNEP, 2008). An important opportunity for funding ODS disposal was identified in the global carbon market.

Figure 1: Regional distribution of CFC banks in Article 5 countries in 2010

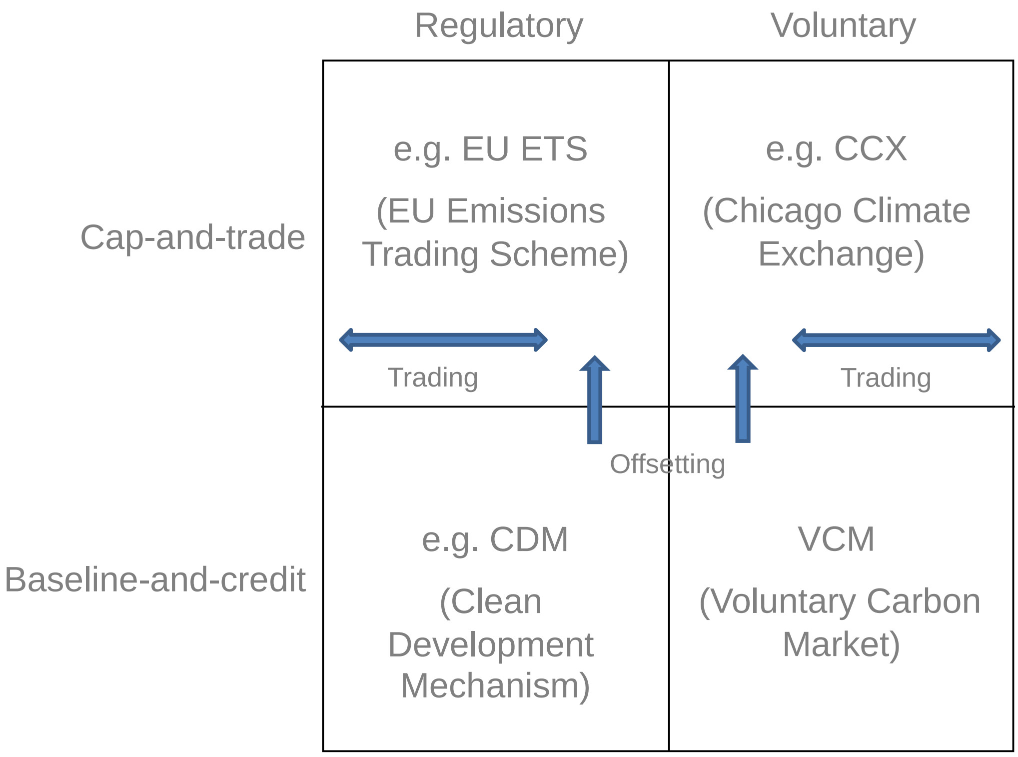


Source: Multilateral Fund, 2006.

2.4 Brief overview of the global carbon market

The global carbon market actually consists of many different markets which can be divided into regulatory (also known as mandatory or compliance) and voluntary markets, and into cap-and-trade and baseline-and-credit schemes (see Figure 2 below).

Figure 2: Overview of the carbon market



Source: Ascui, 2012

In the **regulatory market**, the rules of participation are stipulated by governments and backed by some degree of legal enforcement, while in the **voluntary market**, individuals and/or organizations freely choose to adopt emission limits or to acknowledge emission reductions in one place as equivalent to emission reductions elsewhere (**offsetting**). Entities within a **cap-and-trade** system have a limit on the total amount of greenhouse gases they are allowed to emit. The right to emit greenhouse gases can then be expressed in the form of emission permits or allowances which participants can **trade** with one another. At the end of each year or other specified period, each participant must surrender enough allowances to cover its emissions. **Baseline-and-credit** schemes reward participants for reducing emissions below an established baseline. Reductions below the baseline are turned into carbon credits which can be traded and used to offset emissions elsewhere. Each carbon credit represents an emission reduction equivalent to one tonne of CO_2e.

Today, dozens of carbon markets exist or are being developed around the world, a few of which are illustrated in Figure 2. The European Union Emission Trading System (EU ETS), for example, is a **regulated cap-and-trade** scheme which was introduced in 2005 and is now the largest scheme of its kind in the world. The California Air Resource Board (CARB) recently launched its own regulated cap-and-trade programme which covers major sources of GHG emissions in California.

The Kyoto Protocol's Clean Development Mechanism (CDM), which allows Annex I (developed) countries to buy Certified Emission Reduction (CER) credits originating from projects in non-Annex I (developing) countries to help meet their targets, is the best known and largest **regulatory baseline-and-credit scheme**. The CARB now also has an offset project registry where projects that reduce emissions below a certain baseline and do so by following approved CARB methodologies, can have credits awarded.

The Chicago Climate Exchange (CCX) was a **voluntary cap-and-trade** system in North America that required member entities, who joined voluntarily, to commit to reducing GHG emissions by a specified level. The CCX was North America's largest and longest running GHG emission reduction programme until transactions ceased in January 2011. The CCX now operates as an offsets registry, and together with a number of other different standards, such as the Verified Carbon Standard (VCS) and the Climate Action Reserve (CAR), provides essential standardization and infrastructure to support the **baseline-and-credit side of the voluntary market**.

The main buyers of voluntary carbon credits are corporations, with the principal drivers of demand being corporate social responsibility (CSR), public relations or branding, and pre-compliance (purchasing offsets voluntarily with the expectation that these credits may ultimately be recognized as compliance within a future regulatory scheme) (Peters-Stanley & Hamilton, 2012). In a sense, even when corporations or individuals act alone in purchasing voluntary carbon credits, they behave as though they were in a voluntary cap-and-trade scheme, subject to a cap on their emissions, which is satisfied by a combination of internal abatement and offsets.

Carbon credits in the voluntary market are primarily traded on the decentralized 'over-the-counter' (OTC) market, where buyers and sellers engage directly with one another or through a broker, as opposed to trading a standardized product on an exchange (which is more common in regulatory carbon markets).

Table 4 provides an overview of the volume and value of the different segments of the global carbon market. It should be noted that 'volume' represents transactions, not final demand (i.e. a single carbon credit may be counted several times as it is transacted before finally being 'used' or retired from the market).

The opportunity for ODS destruction in developing countries to benefit from the carbon markets depends on two main factors: **demand** for carbon credits based on such activities, in addition to the ability to **supply** such credits under some form of baseline-and-credit scheme. Demand and supply could be regulatory or voluntary, or both. However, Table 4 shows that regulatory markets are several orders of magnitude larger than voluntary markets. It is also evident that the expected emissions from ODS banks (7 $GtCO_2e$ over 2002-2015) are very large in relation even to regulatory markets, and quite vast in comparison to the voluntary market.

Table 4: Volume and value of the regulatory and voluntary carbon markets (adapted from Peters-Stanley & Hamilton, 2012)

	Volume ($MtCO_2e$)		Value (USD million)	
	2010	**2011**	**2010**	**2011**
EU ETS	6,789	7,853	133,598	147,848
CDM	1,540	2,113	23,843	26,570
Other allowances and exchanges	373	228	1,336	1,033
Total Regulatory Market	**8,702**	**10,094**	**158,777**	**175,451**
Voluntary OTC-traded	128	93	422	572
CCX and other exchanges	4	2	11.2	4
Total Voluntary Market	**133**	**95**	**433**	**576**
Total Carbon Market	**8,835**	**10,189**	**159,210**	**176,027**

2.5 Mechanics of carbon credit supply

To create carbon credits under a baseline-and-credit scheme, project developers must follow a **methodology or protocol** which has been approved by the relevant standard-setting body. Methodologies provide the framework for the quantification of greenhouse gas emission reductions and guidelines for the establishment of a without-project baseline, measurement and monitoring of emission reductions, and the assessment of leakage and project emissions (Olander & Ebeling, 2011). To date, there are 107 approved large-scale, 84 approved small-scale and 19 approved afforestation/reforestation methodologies under the CDM.[2] The VCS allows for projects to use any of its 21 project protocols, as well as any of the methodologies approved by the CDM and the CAR.[3] To date, 13 protocols have been approved under the CAR.[4]

Most baseline-and-credit schemes follow a generic **project development cycle**, which starts with the preparation of project documentation (once a suitable project has been identified and well defined) and ends, if successful, with the issuance of carbon credits by the standard or registry for which it is being developed (see Figure 3). Between these two steps, the project typically needs to undergo a first audit (usually termed validation and carried out by an approved third party), to ensure that the project documentation corresponds to the situation on the ground. It is then registered with the relevant standard or registry. As the project is implemented, the emission reductions are monitored and further periodic audits take place (usually termed verification and may be carried out by the same or another approved third party, depending on the standard). If the verification is successful, the project can request the issuance of credits corresponding to the verified emission reductions achieved. Once these credits are issued, they can be transferred to others and ultimately 'retired' from the market by the final end user to meet a regulatory or voluntary emissions cap. The preparation of the project documentation, validation and registration only take place once at the beginning of the project, while monitoring and verification usually occur annually or each time the project wishes to have credits issued.

Figure 3: Generic carbon project development cycle

It should be noted that the above cycle is generic; some schemes omit or combine various steps, and detailed requirements (e.g. for third party audits) vary considerably.

The most experience to date has been gathered in developing carbon projects on a 'single **project** basis': a distinct emission reduction project in one location with one type of emissions is identified and developed using an approved methodology and following the carbon project development cycle in Figure 3. Many schemes (including the CDM and VCS)

[2] See: http://cdm.unfccc.int/methodologies/index.html
[3] See: http://v-c-s.org/methodologies/find
[4] See: http://www.climateactionreserve.org/how/protocols/

distinguish between various sizes of project with less stringent requirements (such as simplified methodologies) applying to smaller-scale projects. Despite this, the conventional project approach makes it difficult for small projects with diffuse emissions to be developed, both for technical and financial reasons.

To address this shortcoming, the **programmatic approach** was introduced, first in the CDM and then in the VCS and other major carbon standards as well. In a Programme of Activities under the CDM or Grouped Projects under the VCS, a large number of diffuse emission reduction activities can be bundled together to a scale which can earn enough carbon credits to make the programme feasible (Climate Focus, 2011).

A third approach, still at the early stages of definition and development internationally, are **Nationally Appropriate Mitigation Actions** (NAMAs). NAMAs refer to a set of policies and actions that are implemented at the country level to reduce GHG emissions. 'Nationally Appropriate' refers to the different types of actions developing countries should take in accordance with the principles of equity and common but differentiated responsibilities. Developing countries are currently in the process of developing their NAMAs, which are expected to support enhanced scales of activities from a wider range of participants than are possible under a single project or even programmatic approach (Center for Clean Air Policy, 2011). At the time of writing, the destruction of ODS did not feature in any of the NAMAs listed in various NAMA databases.[5] However, it is possible that as NAMAs are developed, some (particularly those in the building or waste sectors) could include recycling, recovery and potentially the destruction of ODS. While any destruction of ODS would still not be counted towards UNFCCC carbon accounting, it could be indirectly incentivized through the support given to NAMAs either domestically or internationally.

3. Opportunities offered by the carbon market for the management and destruction of ODS banks

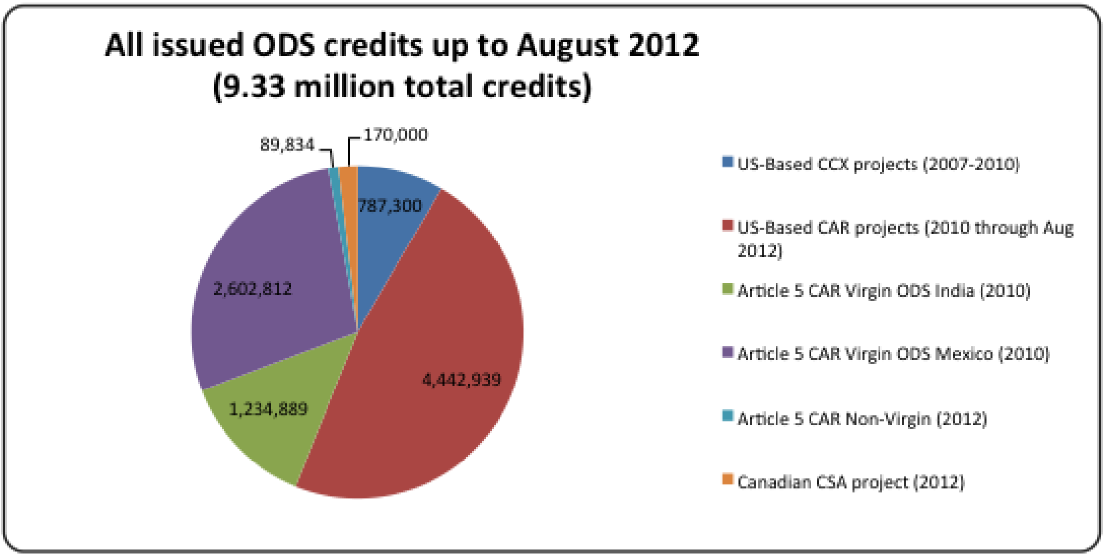
This section explores the potential for carbon markets to provide a financial incentive for the management and destruction of ODS banks. We start by considering which markets could potentially provide a source of demand for carbon credits based on ODS destruction. We then assess the ODS bank-to-carbon-credit supply chain to understand the determinants of delivered cost relative to market value, and hence, which banks might be attractive under present or likely future carbon market incentive levels.

[5] See: http://www.nama-database.org/ and http://namapipeline.org/

3.1 Issued ODS credits to date

To gain full understanding of how carbon markets have and may continue to assist in the development of ODS destruction projects, it is essential to review the credits that have been generated to date and the motivations for their development. We believe that approximately 9.3 million ODS credits have been issued to date. Strictly speaking, all of these have traded in the voluntary carbon market, although most have been developed and purchased with a view to using them to meet future compliance obligations in the US or Canada. Currently issued ODS credits can be segmented into the following distinct categories, summarized in Figure 4 and explained further below:

Figure 4: Summary of ODS credits issued up to August 2012



Sources: CCX project database (available at: https://registry.chicagoclimatex.com/public/projectsReport.jsp) and Climate Action Reserve project database (available at: https://thereserve2.apx.com/myModule/rpt/myrpt.asp?r=111).

1. **Chicago Climate Exchange (CCX) voluntary offsets (2007-09)**: 13 projects from six project developers, all involving the destruction of ODS sourced from within the US, generated 783,000 credits, known as Carbon Financial Instruments (CFIs), intended to be used to meet the emission reduction obligations of companies that committed to the voluntary CCX cap and trade programme.[6] It is unclear whether all of these credits were retired from the market before the CCX closed in January 2011, or whether some may still be in circulation.

[6] See https://registry.chicagoclimatex.com/public/projectsReport.jsp?sortBy=proj_id&sortDir=asc

2. **CAR voluntary credits developed in anticipation of AB32 compliance recognition (2010-end 2012):** These credits can be divided into two groups, corresponding to the two approved CAR protocols for ODS destruction projects:

   a. US-based Projects: 21 US-based ODS destruction projects have been registered under CAR, generating a total of 4.44 million credits of which a little over 1 million have been retired. California's ARB confirmed on 16 December 2010, that US-based ODS credits would be accepted for AB32 compliance. Thus, all of the remaining 3.4 million credits will now be eligible for conversion into AB32 compliance credits from 2013, when the scheme is officially launched.[7] An additional three projects were listed on CAR's registry at the time of writing, but the project details were not available.

   b. Article 5 Imports: Under version 1.0 of CAR's Article 5 ODS Project Protocol, the destruction of virgin imported ODS materials was permitted for a 60-day period in the first half of 2010 (Climate Action Reserve 2010). Three very large virgin import projects (two from India and one from Mexico) were completed within that timeframe, which generated 3.84 million credits.[8] Many of the companies and investors that purchased these credits did so with the speculative expectation that these credits would also gain AB32 compliance status (pers. comm). However, this did not eventuate and these credits are therefore currently being held by a variety of developers and investors without a clear market. No other Article 5 import projects were completed under CAR before December 2010, when California's ARB decision not to accept Article 5 import credits for compliance ended any remaining speculation.

3. **'Pure voluntary' projects: CAR Article 5 imports, VCS and others (2012-ongoing):** In June 2012, OEKO Service Luxembourg and Energy Changes (based in Austria) registered the first non-virgin Article 5 import project under the CAR protocol. The project has generated 89,834 credits from mixed R-12 (CFC-12) imported from Mexico.[9] Two additional Article 5 projects (imports from Argentina,

[7] See https://thereserve2.apx.com/myModule/rpt/myrpt.asp?r=111

[8] See https://thereserve2.apx.com/myModule/rpt/myrpt.asp?r=112

[9] See https://thereserve2.apx.com/mymodule/reg/TabDocuments.asp?r=111&ad=Prpt&act=update&type=PRO&aProj=pub&tablename=doc&id1=826

Brazil and Colombia, and Nepal, respectively) are listed in CAR's project database, but no project details were available at the time of writing. In August 2012, a Canadian foam project became the first ODS destruction project to be validated under the VCS.[10] In June 2012, another Canadian project registered 170,000 credits on the Canadian Standards Association Reductions Registry, following the generic ISO14064 standard and an adaptation of the CAR protocol for US-based projects.[11]

3.2 Future potential demand – regulatory carbon markets

The largest known market for ODS credits at present is California's AB32 scheme – which, however, only allows US-based projects. We consider this scheme in some depth to better understand the likelihood of any future changes which could provide greater opportunities to developing countries. We then consider the potential demand from other major regulatory markets.

California's AB32 Cap & Trade Programme

US-based ODS destruction projects are one of only four offset categories, along with livestock methane, US forestry and urban forestry, eligible to generate compliance offsets under California's AB32 programme.[12] The 'Compliance Offset Protocol Ozone Depleting Substances Projects – Destruction of US Ozone Depleting Substances Banks' (approved on 20 October 2011)[13] covers projects that destroy ODS sourced from and destroyed within the US that would have otherwise been released to the atmosphere. The protocol is based on the CAR US Ozone Depleting Substances Project Protocol (version 1.0, which was adopted by CAR in April 2009). While only CARB can issue compliance offsets directly, CARB decided in December 2010 that credits issued under CAR's US-based ODS protocol for emission reductions achieved between January 2005 and December 2014 would be eligible for future conversion into compliance credits. The conversion will be subject to a desk review by a CARB-accredited verification body prior to final approval.[14] At the time of writing this paper, the desk review procedures had not been finalized, but all ODS stakeholders interviewed for this paper were confident that their credits would be successfully converted. From January 2013, we can expect most US-based ODS destruction projects to register directly with CARB rather than going through CAR and subsequently being converted into compliance offsets.

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[10] See http://www.newswire.ca/en/story/1018065/ecosolutions-recycling-inc-successfully-obtains-validation-of-its-domestic-refrigerators-and-freezers-recycling-project-under-the-mechanisms-and-rules

[11] See http://www.newscanada.com/social-media-release-another-canadian-first-73862

[12] See http://www.arb.ca.gov/cc/capandtrade/offsets/offsets.htm

[13] Available at: http://www.arb.ca.gov/regact/2010/capandtrade10/copodsfin.pdf

[14] See http://www.arb.ca.gov/cc/capandtrade/meetings/040512/earlyaction.pdf

All offsets issued by CARB are subject to possible future invalidation if the emission reductions are subsequently found to have been over-estimated or illegal. This creates a liability risk for buyers of the credits, which results in lower prices for credits perceived as being at higher risk of future invalidation. In 2011, ODS and livestock gas credits enjoyed the highest prices (8.20 and 8.30 USD/tonne, respectively) of the four approved offset categories (compared with the other forestry-related credits at 7.10 USD/tonne), reflecting their lower perceived risk of future invalidation (Peters-Stanley & Hamilton, 2012). This 'clawback' rule is unique to the California market. However, there are some parallels with forest carbon credits issued under the Clean Development Mechanism, which have temporary rather than permanent validity, thus creating a risk of a future liability if, for example, a forest for which credits were issued burns down later. This feature resulted in significantly depressed demand and lower prices for CDM forest carbon credits (Neeff & Ascui, 2009). While the 'clawback' rule seems to be having less of an effect on ODS relative to other carbon credits at present, it could become more of an issue in future, for example, if chains of custody (i.e. the links in the ODS supply chain) become longer and more difficult to verify.

AB32 as a whole has been threatened by a number of legal challenges, such as Proposition 23, a November 2010 state-wide ballot initiative that was rejected by voters by a margin of 23 percent. More specifically, with regard to offsets, a legal challenge was brought by the non-profit groups Citizens Climate Lobby and Our Children's Earth Foundation (among others) in March 2011, challenging the use of any offsets in AB32. The core of the legal argument is whether compliance offsets are truly additional[15] or whether they simply direct funds to offset developers and stakeholders for activities that would occur regardless of compliance incentives.[16] All of the ODS project developers interviewed for this paper were confident that this legal challenge would be unsuccessful.

Table 5 summarizes the eligible gases and source requirements in the CARB protocol. As noted previously, only US-based ODS sources are currently eligible to produce CARB compliant offset credits.

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[15] See formal definition Subarticle 13: http://www.arb.ca.gov/regact/2010/capandtrade10/finalrevfro.pdf

[16] See http://www.ecosystemmarketplace.com/pages/dynamic/article.page.php?page_id=9000 &section=news_articles&eod=1

Table 5: Eligibility requirements for CARB compliant ODS offsets

	Refrigerants	Foams
Eligible ODS	CFC-11, 12, 13, 113, 114, 115	CFC-11, 12 & HCFC-22, 141b
Eligible ODS sources	**Refrigerants:** an offset project may collect eligible ODS refrigerant (see section 2.3.) from industrial, commercial or residential equipment, systems and appliances or stockpiles, and destroy it at a qualifying destruction facility.	**Foams:** an offset project may extract an eligible ODS blowing agent (see section 2.4) from appliance foams and destroy the concentrated ODS foam blowing agent at a qualifying destruction facility; or an offset project may destroy intact foam sourced from building insulation at a qualified destruction facility.
Source requirements	Consists of ODS material produced prior to the U.S. production phase-out that could legally be sold into the U.S. refrigerant market. The ODS must originate from domestic U.S. supplies; imported refrigerant is not eligible under this protocol.	Consists of an ODS blowing agent entrained in foams that, absent a GHG reduction project, would have been released at end of life. The ODS blowing agent must originate from U.S. foam sources; imported foams are not eligible under this protocol.

Source: California Air Resources Board Compliance Offset Protocol ODS Projects (2011)

Approximately half of all global ODS banks are in foam blowing agents, with a roughly equal split between appliance and building insulation foams (pers. comm.). It may therefore seem surprising that nearly all ODS destruction projects in the US have used refrigerants or building insulation foams, and no appliance foam ODS projects have been developed in the US to date. Stakeholders interviewed for this paper indicated that this is partly a function of the low baseline rate at which ODS in appliance foams are assumed to leak to the atmosphere under the CAR and CARB protocols; and the fact that appliance foam recovery costs are higher than recovery costs for the other ODS sources. Previous studies have estimated that the cost to recover and recycle foam contained in domestic refrigerators can cost between US$ 10 and US$ 20 per unit—equivalent to US$ 30 to US$ 60 per kilogramme of ODS (IPCC/TEAP, 2005; TEAP, 2002a). While these costs have now reduced with state-of-the-art demanufacturing technology, offset prices would still need to fetch between US$ 14-20/credit to make appliance foam projects economical (pers. comm.).

The unfavourable assumed baseline leakage rate for appliance foams in the CAR and CARB protocols was identified as a problem by multiple stakeholders (pers. comm.). The current assumptions are based on low decay rates found in previous lab-based studies aimed at determining whether microbes could metabolize CFCs in landfill. These studies were never intended to be used to provide a more generalized baseline leakage rate for appliance foams under real-world conditions (pers. comm.). If these baselines were adjusted and AB32 offset prices were to increase to the required levels, appliance foam recovery could provide an additional stream of ODS projects for US-based ODS developers.

The volume of demand for offsets under AB32 is determined by the permitted percentage of offsets in meeting the overall cap. Initially, this was set at 4 percent, but then increased to 8 percent to assist with cost containment of the programme. This would provide a limit of 28 million offset credits during the first commitment period (2013-2014) and a maximum programme limit of 218 million to 2020 (Kossoy & Guignon, 2012). AB32's allowance budget is displayed in Figure 5 below.

Figure 5: California's AB32 Allowance Budget 2013-2020 (tonnes of CO_2 equivalent)

YEAR	2013	2014	2015	2016	2017	2018	2019	2020
Allowance budget (million units)	162.8	159.7	394.5	382.4	370.4	358.3	346.3	334.2
CAP (net PCR and VRE*)	160.4	157.3	337.7	366.1	354.7	332.3	321.2	310.0

PCR- budgeted for price containment reserve
*VRE- allowance for Voluntary Renewable Electricity
Source: Peters-Stanley & Hamilton (2012)

ODS credits make up approximately half of the currently available (issued, but not already retired) early action credits which will be eligible for conversion to compliance credits under AB32. From 2015, the permitted volume of offset credits more than doubles due to an increase in the overall coverage of the scheme to include transport fuels. Therefore, although ODS credits currently play a dominant role in the AB32 offset market, there is room for further growth in demand to 2020. It is therefore relevant to examine how much further potential supply of US-based ODS credits exists within the constraints of what is permitted under the CAR and CARB protocols.

The stock of ODS contained in appliances, air conditioning and fire suppression equipment in the US has gradually diminished since the phase-out of CFCs in 1996. The US EPA modelled the likely amounts of ODS stocks based on scheduled equipment retirement and industry average equipment leakage rates, which is presented in Figure 6. The model assumes upper bound collection rates of 90 percent, middle at 50 percent and lower at 10 percent (UNEP, 2009a). While the ODS stakeholders interviewed did not all feel that these estimates were accurate, they all agreed that there will be virtually no remaining refrigerant CFCs by 2020-2025, the main source for the past and current CAR protocol projects in the US. The amount of ODS credits developers are likely to deliver to AB32 up to 2020 will largely depend on how rapidly recovery rates can accelerate in the next several years as refrigerant CFC stocks diminish. Under the current CAR and CARB protocols, the only refrigerant gases allowed are

CFCs, and when CFC refrigerant stocks are depleted, only CFCs from foams will remain to be exploited.

Based on feedback from the stakeholders, barring any changes to the current CARB protocol, the number of refrigerant credits will maintain close to the current rate of 2-3 million per annum in the near term and then begin to decline and disappear by 2020 (pers. comm.). These consensus estimates would suggest that approximately 15-20 million additional credits will be generated by 2020, which is slightly above the lower bound estimates of the EPA model. This estimate is broadly consistent with the ODS project pipeline of 13.4 million credits between 2011-2016 reported by project developers in Ecosystems Marketplace's annual market report in 2011 (Peters-Stanley et al,. 2011).

Figure 6: Quantity of ODS in the United States potentially recoverable from retired equipment at EOL and available for destruction

Year	Upper Bound			Middle Bound			Lower Bound		
	CFC	HCFC	Halon	CFC	HCFC	Halon	CFC	HCFC	Halon
METRIC TONS									
2003	13,888	21,486	1,679	7,716	11,937	933	1,543	2,387	187
2004	12,654	22,307	1,384	7,030	12,393	769	1,406	2,479	154
2005	9,131	23,457	1,180	5,073	13,032	656	1,015	2,606	131
2010	2,353	29,137	1,821	1,307	16,187	1,012	261	3,237	202
2015	2,265	39,297	1,087	1,258	21,831	604	252	4,366	121
2020	140	38,281	857	78	21,267	476	16	4,253	95
2025	0	10,904	695	0	6,058	386	0	1,212	77
2030	0	4,546	538	0	2,526	299	0	505	60
MILLONS OF METRIC TONS OF CARBON DIOXIDE EQUIVALENT									
2003	141	39	6	79	21	3	16	4	1
2004	127	40	5	71	22	3	14	4	1
2005	89	42	5	49	23	3	10	5	1
2010	21	52	10	11	29	5	2	6	1
2015	17	70	5	10	39	3	2	8	1
2020	1	67	3	1	37	2	0	7	0

Source: (UNEP 2009a)

The above analysis suggests that the current CAR and CARB protocols restrict the available supply of ODS credits in AB32 in several ways: firstly, by only allowing the use of US-based stocks, secondly, by restricting the cheapest and most easily accessible stock (refrigerants) to CFCs only, the supply of which is declining and likely to be completely exhausted by 2020, and finally, by imposing a low baseline on appliance foam projects, which currently makes them uneconomic. The fact that total AB32 demand for offset credits is much higher than the potential ODS credit supply (under present conditions and prices, without, for example, a drastic improvement in refrigerant recovery rates or a change in the appliance foam baseline) suggests that there is a possibility of regulatory change in future, which could potentially include approving CAR's Article 5 ODS protocol. This may also be driven by linkages between AB32 and other schemes.

3.3 Western Climate Initiative

On 14 December 2011, Quebec finalized its cap-and-trade legislation (National Assembly Bill 42) which is expected to commence in 2013 and run through 2020. While significantly smaller than California's scheme, it has been designed to harmonize and link with AB32 via the Western Climate Initiative (WCI). CARB has recommended linkage with Quebec to the California Governor for formal approval, expected later in 2012.[17] It is anticipated that the linkage will be established despite the incumbent political party, which supported the legislation, losing at the polls on 4 September 2012.[18] CARB supports the linkage in part because Quebec's offset provisions (just 1 million opposed to around 28 million in California in 2013-14) should create scarcity, increase prices and enhance market liquidity.[19] The Quebec programme has approved three offset categories, including ODS destruction from appliance foam in either the US or Canada. Canada has a refrigerant levy programme in place that helps fund the mandated destruction of refrigerant gases at appliance end of life (EOL), thus the carbon price needed to motivate ODS foam destruction is slightly lower in Canada than in the US.

The WCI partnership currently comprises California and the Canadian provinces of Quebec, British Columbia, Manitoba and Ontario.[20] In 2011, six US states dropped out of the initiative and joined an offshoot regional climate group named North America 2050, which aims to reduce GHG emissions through carbon sequestration, sustainable biomass and other offset projects rather than through a cap-and-trade based programme.[21] Fourteen additional jurisdictions, including six Mexican states bordering the US, joined the WCI as 'Observers' in 2007.

On 6 June 2012, the outgoing Mexican President Felipe Calderon signed landmark climate change legislation into law that mandates Mexico's GHG emissions to decrease 30 percent by 2020 and 50 percent by 2050 relative to a business-as-usual scenario. With the election of a new President, Enrique Pena Nieto, in July 2012, it appears that Mexico's new cap-and-trade legislation is already in jeopardy. It is expected that the new president will push for a vast expansion of oil exploration by an estimated 29 billion barrels in the Gulf of Mexico, which will place the new legislation at loggerheads with the pro-fossil fuel-based growth agenda.

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[17] See http://www.montrealgazette.com/business/Quebec+California+link+their+trade+carbon+programs/6863356/story.html

[18] See http://www.carbon-financeonline.com/content/news/california,-quebec-2013-link-still-on-the-cards.html

[19] See http://www.accordgetc.com/english/newdetail.aspx?id=12995

[20] See http://www.c2es.org/us-states-regions/regional-climate-initiatives

[21] See http://ods-destruction-carbon-credits.blogspot.uk/2012/01/california-quebec-plan-joint-emissions.html

According to Eduardo Viola, a global environmental politics scholar at University of Brasilia, “A large part of the legislation will be left to be regulated by the next president and its implementation timing will always depend on the president’s orientation.”[22]

If the legislation is implemented, it will enable international transactions with carbon markets with which Mexico has established bilateral agreements.[23] While the offset mechanisms have not yet been clarified, ODS would appear to be a logical sector for a number of reasons:

- Mexico provided the source ODS for the first completed non-virgin CAR Article 5 ODS project.
- Mexico, with the help of many implementing agencies including the MLF, has had a robust ODS collection, transportation and aggregation/storage system for EOL appliances in place since 2002, as part of their Efficient Lighting and Appliance Program. It is reported that by the end of 2012, 1.6 million appliances (mainly refrigerators) will have been collected and 28.5 tonnes of CFC-12 and 47.4 tonnes of HCFC-22 stockpiled, awaiting destruction (UNEP, 2012c). This represents 310,650 and 85,794 tonnes of CO_2-equivalent, respectively.
- Mexico has ODS destruction capacity, including a Plasma Arc unit owned by Quimobasicos, which has destroyed HFC-23 for registered CDM projects in the past, and pilot ODS destruction tests have occurred in a Holcim cement kiln in 2008 (UNEP, 2012c).

It is crucial for the long-term sustainability of California’s AB32 programme that it is seen to succeed in the first compliance period. This implies that prices neither be too high nor too low, which in turn requires a balance to be struck between relatively modest emission reduction targets and the avoidance of a flooding of the market with cheap offsets. It is also important for offsets to be relatively non-contentious. Limiting supply of ODS offsets to US projects meets these objectives. While inclusion of foreign-sourced ODS in the future cannot be ruled out, it is not anticipated to be seriously considered in the near term. The most sensible expansion would be through the existing policy framework of the WCI, which could include Mexico, given the need for large numbers of offsets in future, particularly after 2015, when the permitted volume of offsets will increase substantially. However, this would probably only occur after all feasible options for increased US supply of offsets have been exhausted. One stakeholder speculated that California Carbon Allowances will trade at US$

[22] See http://www.reuters.com/article/2012/07/24us-mexico-climate-policy-idUSBRE86N0A220120724

[23] See http://cleantechnica.com/2012/02/02/mexico-finalizes-climate-bill-to-cap-carbon/

10-14/ tonne in the first phase (2013-14) and then gradually rise to the low US$ 20s by 2020. These prices would suggest that US appliance foam offsets could become economic between 2015 and 2020, especially if the baseline calculations are updated and approved by CARB, and thus potentially fill the gap as CFC refrigerant projects diminish. This would reduce pressure for Article 5 ODS offsets to be permitted in the scheme.

3.4 The Kyoto Protocol Clean Development Mechanism (CDM)

As mentioned in section 2.1, the Kyoto Protocol does not currently cover ODS and emission reductions from ODS destruction projects would therefore not be eligible for compensation in the form of credits under the **Kyoto Protocol's CDM** (UNEP, 2009b). While it is possible that this may change in the future, gaining access to the CDM would not only require a change in UNFCCC and Kyoto Protocol coverage, but also the development and approval of new methodologies, which is a process that typically takes one to two years. We therefore do not see any agreement on the formal inclusion of ODS destruction in the CDM as being likely to occur before 2015 at the very earliest, with actual implementation unlikely before 2020.

Nevertheless, even if ODS destruction remains ineligible to earn credits under the CDM, it is possible to develop CDM projects that have the destruction of an ODS as a 'side effect'. The most concrete example of this is energy efficiency projects targeting chillers, where existing chillers are replaced with new, more energy efficient ones (UNIDO, 2008). Such projects can be developed using CDM methodology AM0060 'Power saving through replacement by energy efficient chillers'.[24] This methodology entails the following requirements that are relevant to the destruction of ODS:

- That the existing chiller is destroyed and that its destruction is monitored and certified according to an established protocol;
- That the refrigerant in the existing chiller is recovered and destroyed or stored in suitable containers within suitable premises to ensure that the recovered, stored refrigerant gases can be monitored and tracked.

However, there are currently no projects in the CDM pipeline that use this methodology. This could be indicative of the significant initial transaction costs associated with this type of project. As carbon credits are only awarded for the energy efficiency improvement component and not for ODS destruction, the financial incentive gained from the CDM is

[24] Available at: http://cdm.unfccc.int/filestorage/9/W/Q/9WQMVLRC9VIYMZ1BZS0B6KII6IIQB3/Power%20saving%20through%20replacement%20by%20energy%20efficient%20chillers.pdf?t=clp8bTVpa2MyfDAZTTL60IjudbE6WM54tQ_j

relatively low (UNIDO, 2008). Furthermore, it is not an absolute requirement that the ODS contained in the chillers is disposed of, and as such, while such projects (if implemented) would definitely contribute to managing unwanted ODS banks, they would not necessarily result in their destruction.

3.5 Other regulatory markets

Many other regulatory carbon markets exist or are under development.

- The **EU ETS**, for example, was the first and is now the largest emission-trading scheme of its kind. It allows for CDM credits to be used by participants to meet their emission reduction targets. As ODS destruction projects are currently not eligible under the CDM, the EU ETS does not presently constitute a viable avenue for such projects.

- The **New Zealand Emission Trading Scheme (NZ ETS)** is a national all-sectors, all-GHGs emissions trading scheme, which also allows for the use of CDM (and other Kyoto Protocol) credits.[25] 'Synthetic' GHGs are included in the NZ ETS, but at present, this only includes the synthetic gases covered by the Kyoto Protocol and not other ODS.[26]

- The **Regional Greenhouse Gas Initiative (RGGI)** is another regulatory programme to help reduce emissions in the US in a cost effective way. It covers nine states that jointly plan to reduce their CO_2 emissions from the power sector by 10 percent by 2018.[27] RGGI also allows credits from carbon offset projects to be traded, however, these are currently limited to five categories that do not include ODS destruction.

- Other future compliance markets that are emerging in **South Korea, Australia, China** and elsewhere could also provide a potential for ODS in future, given the precedents in California and Quebec.

3.6 Future potential demand – voluntary carbon market

As noted in section 3.1. above, all of the ODS credits issued to date have technically been developed in the voluntary carbon market, although most have been developed with the expectation of being able to use the credits in a future regulatory market. ODS destruction as an offset category first emerged in 2007 with the adoption of an ODS protocol by the Chicago Climate Exchange (CCX). In 2010, the Climate Action Reserve (CAR) followed with its two ODS protocols, and in September 2011, the Verified Carbon Standard (VCS) adopted the

[25] See http://www.climatechange.govt.nz/emissions-trading-scheme/
[26] See http://www.climatechange.govt.nz/emissions-trading-scheme/participating/synthetic-gases/
[27] See http://www.rggi.org/

most expansive ODS methodology that allows for ODS collection and destruction to occur anywhere in the world.

Table 6 provides an overview of the characteristics of these three standards and how they are relevant to ODS destruction projects. The next section discusses in greater detail which ODS sources are eligible under each of these standards and the likely future demand for such credits.

3.7 Eligibility of ODS sources in the voluntary market

Chicago Climate Exchange (CCX)

One methodology exists for developing ODS destruction projects under the **Chicago Climate Exchange (CCX)**. The 'Chicago Climate Exchange Offset Project Protocol – Ozone Depleting Substances Destruction'[28] only allows for destruction projects located in the US. Projects can use ODS imported from outside the US, as long as these meet all national and international requirements for imported ODS. Whilst this protocol acted as the catalyst that initiated the initial ODS destruction projects from 2007-2010, it is not considered a likely source of projects in the future. We believe the reasons for this includes the fact that the last ODS project to be completed under the CCX was in 2009; the CCX protocol is much shorter and seen as less rigorous than the much longer, more detailed CAR protocol, which effectively updated and superseded it; and because CCX credits are not recognized for compliance under the California carbon market, it has lost much of its former attractiveness as a standard. As a result, CCX credits (for all project types) now attract very low prices (less than US$ 0.10 in 2011) compared with an average of US$ 8 for CAR credits (Peters-Stanley & Hamilton, 2012).

[28] Available at: https://www.theice.com/publicdocs/ccx/protocols/CCX_Protocol_ODS_Destruction.pdf

Table 6: Comparison of the CCX, CAR and VCS

	CCX	CAR	VCS
Description	Until 2010: Offsets programme for a voluntary cap-and-trade programme in North America. Since 2011: CCX Offsets Registry Programme is a standard under which emission reductions can be registered	National carbon offsets programme in the US that works to establish standards for GHG reduction projects in North America	Global standard for voluntary carbon offsets
Transaction volume (2011)	2.1 $MtCO_2e$	9 $MtCO_2e$	41 $MtCO_2e$
Share of voluntary market (2011)	3%	12%	58%
Eligibility	CCX Offsets Registry Programme: any project developer	Any project developer. The project developer must have an account with the Reserve. Anyone may apply for an account regardless of location and affiliation.	Any project developer
Geographic scope – ODS sources	US, with some allowance for internationally imported ODS	US, with some allowance for internationally imported ODS	US or internationally sourced ODS
Geographic scope – ODS destruction facility	US	US	US or international
Eligible ODS materials	See 'Eligibility' section below	See 'Eligibility' section below	See 'Eligibility' section below
Eligible ODS sources	See 'Eligibility' section below	US: See section 3.2. above Article 5: See 'Eligibility' section below	See 'Eligibility' section below
Methodologies for ODS destruction	One methodology approved	Two methodologies approved	One methodology approved
Issuance fee per credit	US$ 0.10	US$ 0.20	US$ 0.10

Sources: ICF International, 2010; Climate Action Reserve, 2012; Verified Carbon Standard, 2011; Chicago Climate Exchange, 2012; Peters-Stanley & Hamilton, 2012.

Climate Action Reserve (CAR)

As previously noted, the CAR has two approved ODS protocols, one for US stocks and the other for ODS imported from Article 5 countries (but still destroyed in the US). While the former will continue to exist, it is now effectively superseded by the nearly identical CARB protocol, and the higher value of credits in the AB32 market effectively precludes their use in the voluntary market. In this section we therefore concentrate on CAR's Article 5 protocol.

The scheduled production phase-out of CFCs in Article 5 nations in 2010 opened the door for CAR to develop the first version of their Article 5 protocol in that same year. An updated version was approved in 2012.[29] Only Annex A, Group 1 CFCs (CFC-11, 12, 113, 114 and 115) used in refrigeration applications are eligible under this protocol (Climate Action Reserve 2012). There are four types of stockpiles of the approved ODS refrigerants that can be used under this protocol (ibid):

1. Privately held stockpiles of used ODS refrigerants that can legally be sold to the market. Privately held and saleable virgin ODS refrigerants are not eligible under this protocol;
2. Article 5 government stockpiles of seized ODS refrigerants that can legally be sold to the market;
3. Article 5 government stockpiles of seized ODS refrigerants that cannot be legally sold to the market; and
4. Used ODS refrigerants recovered from industrial, commercial or residential equipment at servicing or end of life.

Further specific restrictions on each of these categories are shown in Table 7 below.

Used and recovered eligible refrigerants deliver the maximum 100 percent, while the stockpiled sources yield 94 percent or lower. Stockpiles are defined in CAR's Article 5 Protocol as, *"ODS stored for future use or disposal in bulk quantities at a single location. These quantities may be composed of many small containers or a single large container"* (Climate Action Reserve 2012, p. 40). This definition does not explicitly refer to a time threshold for storage, although it does clearly define a 12-month maximum project duration from the date of export to the date of destruction (ibid). The first version (1.0) of CAR's Article 5 protocol, in fact, specified this time limit starting from the date of collection of ODS from EOL appliances.

[29] For all protocol versions, see: http://www.climateactionreserve.org/how/protocols/ozone-depleting-substances/

Table 7: CAR Article 5 Protocol refrigerant baseline scenarios

Refrigerant Origin	Baseline Scenario	Applicable Annual Emission Rate	10-year Cumulative Emissions (%)[16] (ER_{refr})
1. Privately held stockpiles of used ODS refrigerant that can legally be sold to the market	Use for recharge of existing refrigeration equipment	25%[17]	94%
2. Article 5 government stockpiles of ODS refrigerant that can legally be sold into the refrigerant market	Use for recharge of existing refrigeration equipment	25%[17]	94%
3. Article 5 government stockpiles of ODS refrigerants that cannot legally be sold into the refrigerant market	Continued storage	Site specific emission rate as documented (see Equation 5.2)	$1-(1-ER_{stock})^{10}$
4. Used ODS refrigerant recovered from end-of-life equipment	End-of-life release to the atmosphere	100%	100%

Source: (Climate Action Reserve 2012)

As noted in section 3.1 above, privately held virgin stockpiles were permitted under the first CAR Article 5 protocol for a limited 60-day window after its approval, but this opportunity was eliminated in version 2.0 (Climate Action Reserve 2012). This led to the development of three large projects totalling 3.84 million credits.[30] One large project was developed by Reclamation Technologies (RemTec) with ODS sourced from Mexico (2.6 million credits) and two other projects totalling 1.2 million credits were sourced from India. Several stakeholders pointed to lobbying efforts by some members of the CAR protocol working group as the reason for the temporary inclusion of these virgin projects (pers. comm.). As mentioned earlier, these credits were purchased by many investors and companies with the anticipation that they would be granted compliance status in future by either CARB or under a federal US cap-and-trade scheme (pers. comm.). One project developer stated that they had sold all of their credits, while another disclosed that they still possess a portion of their credits and that recent offers from potential buyers ranged from US$ 1-1.50 per credit (pers. comm.). Many stakeholders were not pleased that these virgin projects were permitted, and noted that **these credits may act as a barrier for the sale of new non-virgin Article 5 projects** in future.

Verified Carbon Standard (VCS)

In September 2011, the VCS approved their first ODS methodology (VM0016, v.1.0). The VCS operates differently from CAR insofar as CAR specifies its own protocols in a top-down fashion, while VCS accepts a range of methodologies from other standards (including CAR), and also allows project developers to develop and put forward their own methodologies for approval (pers. comm.). After receiving a proposed new methodology, a 30-day public

[30] See https://thereserve2.apx.com/myModule/rpt/myrpt.asp?r=112

consultation is held, after which two different independent evaluators perform an assessment of the methodology. This process typically takes 3-12 months, depending on how thoroughly the original draft is written, and costs US$ 15-20k for each independent validation in addition to the time needed by the stakeholder to write the methodology (pers. comm.). As an incentive for new methodology submissions, the VCS offers a rebate mechanism of US$ 0.02/VER (arising from the US$ 0.10/VER issuance fee charged by VCS) to the methodology author for each credit issued by a project that uses that particular methodology.

This current VCS ODS methodology is more expansive than the CAR Article 5 protocol, as it allows for the collection and destruction of ODS to occur in any country (Verified Carbon Standard 2011). As a point of clarification, the destruction can occur in a different country than the country of collection. The VCS methodology does not include any stockpiled ODS, only gas that has previously been used. While the CAR Article 5 ODS protocol only covers Annex A, Group 1 CFCs from refrigerants, the VCS covers all Group 1 ODS from Annexes A, B and C (Verified Carbon Standard 2011). The eligible sources in the VCS methodology and a comparison to the CAR Article 5 eligible sources are listed below:

1. Refrigeration equipment, systems or appliances; (permitted in CAR Article 5)
2. Air conditioning equipment, systems or appliances; (permitted in CAR Article 5)
3. Fire suppression equipment or systems; and (NOT permitted in CAR Article 5)
4. Thermal insulation foams. (NOT permitted in CAR Article 5).

Unlike the CAR Article 5 protocol, the VCS does not permit any projects from stockpiled sources and also does not place any time limit on project development cycles (ibid). **This offers international project developers much more flexibility.**

Current and future VCS projects

The first VCS ODS project to pass the validation stage was developed by EcoSolutions Recycling, an appliance demanufacturer and recycling company based near Montreal. This was also the first foam-based ODS project developed anywhere in the world. The size of the project is unknown at this time because it is not yet listed in the VCS project database.[31] The project is likely to be small, based on the press release from EcoSolutions Recycling and the number of appliance units that are expected to be processed annually.[32] Given that Canada has a legal requirement to destroy ODS refrigerants, the only remaining potential for ODS destruction in Canada involves foam projects. At present, the VCS offers the only avenue for

[31] VCS project database available at: http://www.vcsprojectdatabase.org/
[32] See http://www.newswire.ca/en/story/1018065/ecosolutions-recycling-inc-successfully-obtains-validation-of-its-domestic-refrigerators-and-freezers-recycling-project-under-the-mechanisms-and-rules

development of Canadian foam ODS projects, until the Quebec system is fully functional and able to directly register projects itself. Nevertheless, any volumes of Canadian projects registering under the VCS are expected to be limited, as the projected annual volume of all Canadian foam projects is estimated at only 500,000 credits.[33]

Until the point is reached at which other non-compliance-related voluntary Article 5 VCS projects have generated credits and established a price in the marketplace, it is unlikely that there will be significant VCS project growth (pers. comm.). None of the project developers interviewed were planning to develop any VCS projects. The key reasons cited were the following:

1. The certainty of working with an experienced destruction partner (Clean Harbors), which is strictly regulated by the US EPA and is proven to have always fulfilled the stringent reporting requirements demanded by CAR and TEAP;
2. The most labour-intensive aspects of an ODS project are the EOL appliance recycling, ODS collection, transportation for aggregation, ODS testing and mixing and transportation for export. These elements deliver a majority of the employment opportunities to host countries in totality versus the value derived from destruction, validation and monitoring, which are the riskiest elements for inexperienced parties; and
3. The relatively small cost of transportation to the US as a percentage of overall project development costs is a small price to pay for the certainty of destruction in a trusted US facility.

Other additional reasons that stakeholders did not explicitly mention but would also suggest their preference of CAR over VCS include:

1. **The perceived price superiority of Article 5 CRTs versus international ODS VERs**. Whether or not this is an accurate assessment of the voluntary market's attitude, it has been assumed in several project proposals the MLF has considered for funding (UNEP, 2011; UNEP, 2012b; UNEP, 2012a);
2. **The possibility of CARB accepting Article 5 ODS CRTs in the future**. Given that all four offset categories utilize CAR's protocols and the projected shortfall in the supply of offset credits discussed in section 3.2 above, this is a distinct possibility; especially from countries that are exploring cap-and-trade systems that could potentially link with the WCI (e.g. Mexico, Colombia, Chile and Brazil); and
3. **Familiarity.** Current project developers are familiar with, and in some cases authored the CAR protocols.

Other voluntary market options

The **Gold Standard** is a very rigorous and well respected offset standard. However, it currently only covers renewable energy and energy efficiency projects. As such, it is not suitable for developing ODS destruction projects, although energy efficiency projects that

[33] See http://www.climateactionreserve.org/wp-content/2009/05/Quebec-Offsets-Webinar-June-2012.pdf

have ODS destruction as a 'side effect' (as described in section 3.7 above) could be developed under the Gold Standard. The **American Carbon Registry (ACR)** is a US carbon market standard and registry.[34] It has 13 approved methodologies, however, they mainly focus on forestry projects and none are related to ODS destruction. The **Swiss Charter Standard** is a voluntary standard specifically developed for ODS destruction by a company called SENS International (now re-named Fair Recycling), which was launched in late 2008. However, it is essentially a single-company standard which has until now only been applied to a single project in Brazil, which claimed to have reduced 100,000 tCO_2e by the end of 2012.[35] In the absence of competition, this standard could have offered a viable route to market for Article 5 ODS destruction projects. However, as it essentially follows the same approach as the VCS, it is highly unlikely to gain significant market share against the dominant incumbent, now that VCS has an approved methodology for ODS destruction projects.

In summary, of the three available options for Article 5 ODS projects in the voluntary carbon market, **CCX can be ruled out altogether and the potential of both CAR and VCS seems to be limited.** The CAR Article 5 protocol suffers from the negative experience of having allowed large volumes of credits from virgin stockpiles to enter the market under version 1.0 in 2010, and requires ODS to be exported for destruction in the US. The VCS methodology has wider applicability, allowing destruction to take place in Article 5 countries, but suffers from relative unfamiliarity to the current small pool of ODS project developers and a perception of being less likely to be approved by CARB in future. Given that the regulatory market is so much larger than the voluntary market, even an unfounded expectation of future regulatory acceptance is likely to be sufficient to sway the market, both in terms of volumes of projects seeking to register under a particular standard, and the price their offsets can command in the market. In the next section, we look at barriers to development of ODS destruction projects in developing countries in more detail.

4 Barriers to development of ODS destruction projects in developing countries

The scope for developing countries to develop ODS destruction projects has been very limited to date. The primary source of demand for carbon credits from ODS destruction has been the prospect of future cap-and-trade schemes in the US (and, to a lesser extent, Canada). The US is a critical jurisdiction because it has not ratified the Kyoto Protocol, hence, it has no need to ensure that its carbon accounting systems perfectly align with the Kyoto Protocol. Nearly all of the 9.1 million ODS credits issued to date were motivated by the prospect of future

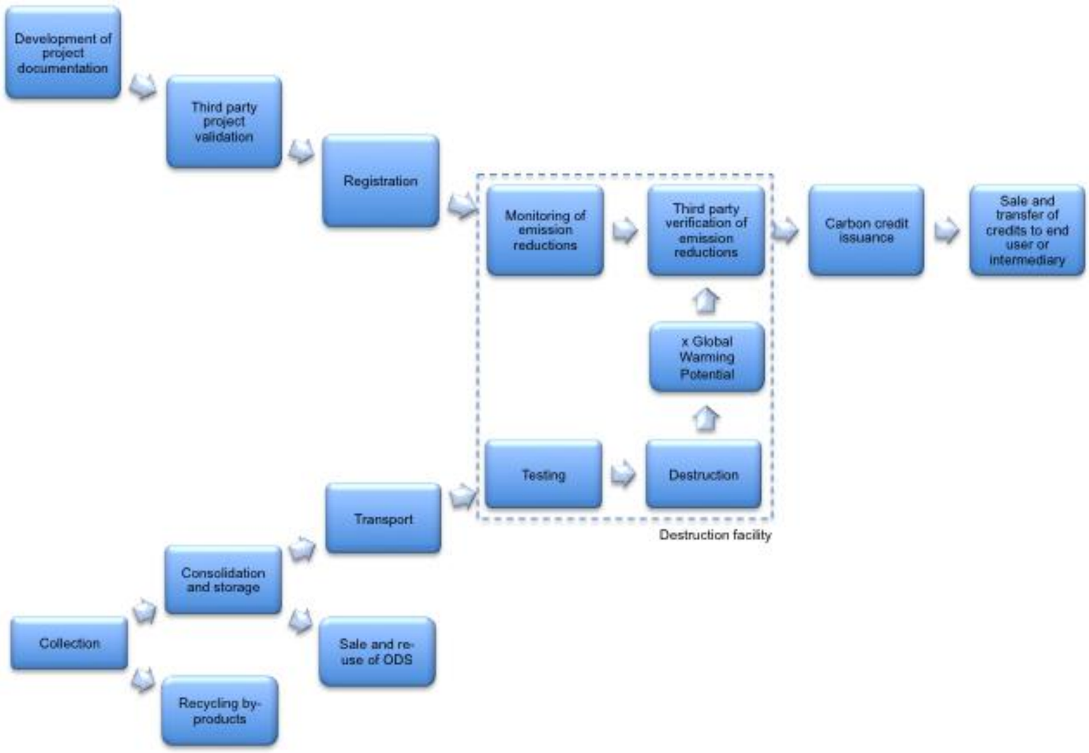
[34] See http://americancarbonregistry.org/
[35] See http://fair-recycling.com/en/about-us/organisation/

compliance status, mainly in the US. Now that the rules governing offsets have been clarified for California, the largest US regulatory carbon market, it is evident that only US stocks will be eligible in this market, and likewise, the Quebec market will only allow for the destruction of US and Canadian foam stocks. This leaves the voluntary market, and specifically only CAR's Article 5 protocol and the VCS's VM0016 as the only near-term options for development of ODS destruction projects using stocks from Article 5 countries, and only the latter allows for destruction to take place in an Article 5 country.

Until now, the only way developing countries have benefited from carbon market support for ODS destruction has been through selling their ODS stock to project developers, who then import it into the US and destroy it there under CAR's Article 5 protocol, creating credits which are ultimately used by US firms mainly for voluntary carbon offsetting purposes. As the supply of eligible Article 5 stocks is greater than the current demand from the voluntary carbon market, competition can be expected to drive prices down to the opportunity cost of those stocks, i.e. the re-sale (for re-use) value of recovered ODS. Developing countries, therefore, do not benefit from any of the added value inherent in the creation of carbon credits from the destruction of their ODS stocks. It is worth noting, however, that if demand for eligible stocks were to exceed their supply, competition would be expected to drive the price of those stocks up to a level reflecting the actual value of the resultant carbon credits, less the transaction costs incurred higher up in the supply chain. This has happened in the US, where market prices of CFC refrigerant gases have increased to reflect the value these gases now possess due to their ability to generate compliance offsets under AB32 (pers. comm.). A side effect of this has been to enhance the incentive for owners of older refrigeration equipment to upgrade to newer, more energy efficient equipment using lower ODP and GWP refrigerant gases (pers. comm.).

The figure below shows how the carbon credit development cycle interacts with the ODS collection and destruction process to form an ODS-to-carbon credit supply chain. At present, because the CAR Article 5 protocol requires destruction in the US, developing country participation typically ends at the consolidation and storage stage, perhaps involving some degree of transportation, depending on the point of hand-over. In the following sections, we discuss the barriers to developing countries to increasing their involvement in the ODS-to-carbon credit supply chain, based on a literature review and stakeholder interviews.

Figure 7: The ODS-to-carbon credit supply chain



4.1 Barriers to carrying out the collection and management of ODS

A number of economic, technical and policy barriers exist that prevent developing countries from establishing and operating systems for the collection and management of ODS contained in their banks (UNEP, 2009b). While these barriers are not directly related to accessing the carbon market, they are important because even if the other barriers outlined in subsequent sections can be overcome, projects would not necessarily materialize unless these ODS supply-side barriers are dealt with first. These barriers include:

- **Funding constraints**: There are significant costs associated with managing ODS from banks, whether in developed or developing countries. In developing countries, it is estimated that to manage all easily accessible banks ('low effort'), a total of US$ 26.56 to 35.38 billion would be required. Adding less accessible banks ('medium effort') would increase the total cost to developing countries to US$ 70.43 to 93.40 billion (TEAP, 2009). A large share of 'high effort' banks is still in use, particularly in insulating foams. There is limited experience with managing these banks and therefore, no estimates of the costs are currently available (ibid). There is a lack of grants and financial incentives to push through these projects in developing countries (UNEP, 2009b).

- **ODS destruction on its own is typically not a sufficient driver for the creation of ODS collection infrastructure**: in most developed countries, regulations (or voluntary agreements such as the Responsible Appliance Disposal Program in the US) provide strong incentives for end of life collection and recycling of appliances, thus subsidizing the necessary infrastructure for ODS collection. However, in many Article 5 countries, there are no such regulations and hence, appliance recycling rates are low or non-existent (further exacerbated by the common practice of keeping appliances in use beyond their normal end of life). Another factor which could potentially incentivize the establishment of an ODS collection infrastructure is the re-use value of reclaimed ODS refrigerants. However, with HCFC consumption unrestricted in Article 5 countries until the end of 2012 and only being phased out gradually to 2040, there is (as yet) little incentive to recycle reclaimed refrigerants. Mexico's Efficient Lighting and Appliance Program (ELAP) is widely regarded as a model for other developing nations. Since 2002, nearly 1.6 million appliances have been collected, demanufactured and replaced with more energy efficient appliances (UNEP, 2011). As a result, 166.7 tonnes of CFC-12 have been collected and are now the subject of a pilot destruction project implemented by the Government of France and UNIDO, which will reinvest funding in more high-tech ODS demanufacturing infrastructure that will add enhanced capacity and the ability to collect foam blowing agents (ibid). Nevertheless, the key driver of the ELAP was not to collect and destroy ODS, but rather to reduce electricity demand and cost, which the government of Mexico will subsidize in an amount of US$ 15.3 billion from 2005-2009 (ibid). The total programme cost is estimated at US$ 700 million, much of which was spent on subsidizing and financing replacement appliances, but significant costs were also incurred to set up 98 demanufacturing centres and 14 ODS recovery centres (which were supported by the MLF) (ibid). While this programme has been very successful, it demonstrates how much coordinated effort is needed to develop and implement ODS collection infrastructure in an Article 5 country.

- **Opportunity cost of ODS destruction:** the prices of CFC 11 & 12 in the US have been driven to be higher over the past five years because of scarcity of supply (due to the production and import ban of the Montreal Protocol), and because of the opportunity cost of selling the ODS for destruction and the generation of carbon credits thereby (pers. comm.). In July 2012, the prices of CFC-11 were US$ 17-20 per pound, with CFC-12 selling in the low US$ 20s (pers. comm.). At these market prices and given the lower GWP value of CFC-11, it has been more economical to resell reclaimed CFC-11 to equipment users instead of destroying it to generate carbon credits (pers. comm.). Each Article 5 country will have unique market characteristics with respect to market prices of refrigerant gases, current and projected future demands for these gases, cost to reclaim and potential alternatives and substitutes for ODS equipment or the utilization of non-ozone depleting refrigerants in the existing equipment.

Figure 8: Example ODS destruction project cost calculations

Project Description	Project Size	Total Project Cost (thousands of US$)†	Carbon Credits Generated (tCO_2e)‡	Break-even Carbon Market Price (US$/$tCO_2e$)
Refrigerator Collection:* Collection of CFC-containing refrigerators, and recovery and destruction of CFC-12 refrigerant and CFC-11 foam	1,000 units collected	$151	3,599	$42.07
	10,000 units collected	$430	35,990	$11.94
	100,000 units collected	$3,212	359,900	$8.93
Bulk ODS: Destruction of stockpiled CFC-12	0.5 tonnes destroyed	$124	5,450	$22.72
	1 tonne destroyed	$127	10,900	$11.67
	10 tonnes destroyed	$187	109,000	$1.72
Large AC Units: Recovery and destruction of CFC-12 refrigerant from large stationary AC units	1 tonne per system/ facility	$142	10,900	$13.00
	1,000 tonnes per system/facility	$21,310	10,900,000	$1.96
	10,000 tonnes per system/facility	$212,011	109,000,000	$1.95

* Assumes that 0.06 kg of CFC-12 and 0.62 kg of CFC-11 are recovered from each unit.
† Includes project transaction costs and average costs of recovery, transport, and destruction. These costs are based on those shown in Table 2 and Table 3, but could be higher or lower depending on the local costs of recovery, transport, and destruction, as well as whether local or international consultants are engaged for project preparation. The higher bound of the project transaction costs were used for this analysis, so costs could be lower if, for example, project preparation is carried out in-house at no or low cost, or third-party validation costs are not incurred.
‡ In this table, the calculation of carbon credits generated is gross, i.e., it is not net of project emissions such as emissions during the destruction process or CO_2 emissions from the transport of ODS to the destruction facility. Credits are calculated using AR4 GWPs (as is used in all calculations in this report).

Source: (ICF International, 2010)

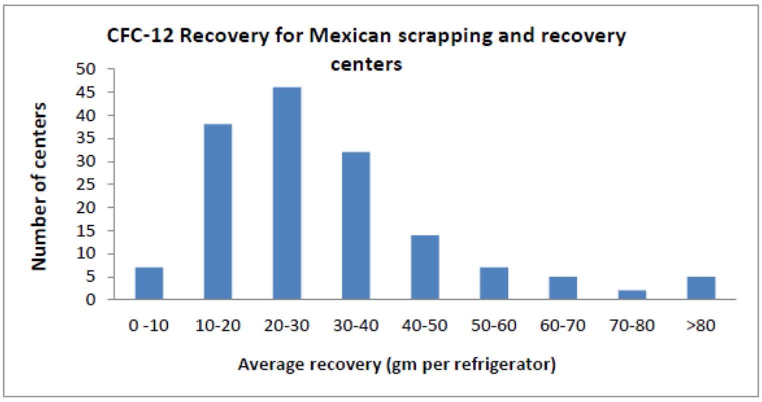
- **Low volume and dispersed ODS sources:** some developing countries have low volumes of recoverable ODS (these are known as "low-volume consuming countries" – LVCCs), often dispersed across the country. Given the economies of scale associated with projects with larger volumes, these countries are faced with a cost effectiveness problem, even if they were to access the additional financial incentives offered by the carbon market (ICF International, 2010). The figure below shows that economies of scale can drastically reduce the per credit cost of project development. Developing countries often lack the concentrated sources which are crucial for achieving economies of scale.

- **Impurity of ODS sources:** ODS reclaimed from appliances in developing countries are often impure due to poor controls over appliance retrofitting (pers. comm.). If the

ODS bank is impure, additional costs may be incurred in purification and transport to and from a purification facility. The availability of such purification facilities varies widely between countries: for example, Mexico has a purification facility in almost every state, whereas India has an acute lack of such facilities (pers. comm.). Additional barriers may result from the fact that only purified ODS may be exported between countries which are signatories to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (the Basel Convention) (ICF International 2008). Alone the perception that an ODS bank could be contaminated may be a barrier to its exploitation: as one interviewee commented in relation to a project in Africa, "ODS gases were lying in the process chillers of various oil companies, but no one was prepared to buy these gases as the purity could have been very low, though it was never tested" (pers. comm.).

- **Lack of trained personnel:** technically proficient personnel are required for the proper management and disposal of ODS so that the gases are not released to the atmosphere and potential revenue squandered. Many developing countries lack this technical expertise. When asked whether a lack of trained personnel could be a barrier for ODS projects in the developing world, one stakeholder responded, "It's a challenge [even] in the US" (pers. comm.). Another stakeholder stresses the importance of collaborating both with partners who are industry experts (e.g. JACO appliance recycling experts) and project partners in the host nations to ensure project success (pers. comm.). Training is a challenge, even in the instances where the MLF has provided support. In the case of Mexico's ELAP, large variations in ODS recovery rates were observed across demanufacturing centres, as demonstrated in Figure 9, which may possibly be attributed to differences in technical capacity.

Figure 9: Variation in CFC-12 recovery rates in Mexico's ELAP



Source: (UNEP, 2012c)

- **Lack of awareness about necessary tools and infrastructure**: in many countries, there is a lack of information and knowledge about the best available technologies and infrastructure needed for ODS destruction (UNEP, 2009a). Even when that knowledge is available, the process of developing the necessary infrastructure can be time consuming and costly, and as such presents a major barrier for many developing countries (ICF International, 2008).

- **Lack of appropriate and supportive regulatory and legal frameworks**: many developing countries lack the regulatory framework to promote ODS destruction (ICF International, 2008). Issues with legal barriers have caused significant delays (reported at six months) in the importation of material from Mexico to the US in the development of the first non-virgin CAR Article 5 ODS project (pers. comm.). It is significant that this occurred despite the project developer being experienced and diversified. The Gulf States, as part of an ODS phase-out programme, do not allow for the import or export of any ODS, despite possessing large unwanted quantities (ICF International, 2010; pers. comm.). Many legal barriers like this exist in different developing countries, which not only create barriers for project development in that specific country, but in aggregate create a barrier to geographic diversification. The Basel Convention (and other similar conventions controlling transboundary waste movements) prohibits movements of waste between signatory and non-signatory countries (except under a bilateral or multilateral agreement) and also places administrative requirements on the exporter, for example, to obtain prior written consent from the receiving country (Multilateral Fund, 2006; ICF International, 2008). These administrative requirements can be costly, and perhaps more importantly, require specialist expertise to negotiate.

4.2 Barriers to carrying out the destruction of ODS

One of the most critical stages of the ODS-to-carbon credit supply chain is the destruction process. The Montreal Protocol TEAP Task Force on Destruction Technologies has agreed on a set of approved ODS destruction processes, summarized in Table 8 below. It has also prepared a 'Code of Good Housekeeping', including guidance on pre-delivery, arrival at facility, unloading from delivery vehicle, testing and verification, storage and stock control, measuring quantities destroyed, facility design and maintenance, quality control and quality assurance, training, code of transportation, monitoring, measurement of ODS and control system which destruction facilities are to follow.[36]

[36] See http://www.unep.fr/ozonaction/topics/disposal.htm

Table 8: Approved ODS destruction processes (UNEP, 2009a)

	Concentrated sources	**Diluted sources**
Thermal Oxidation	Cement kilns, liquid injection incineration, gaseous/fume oxidation, reactor cracking, rotary kiln incineration, Internally Circulated Fluidized Bed (ICFB) incineration and fixed hearth incinerator.	Municipal solid waste incinerators. Rotary kiln incinerator.
Plasma Destruction	Argon plasma arc, nitrogen plasma arc, microwave plasma, Inductively Coupled Radio Frequency Plasma (ICRF) and air plasma.	
Other Non-Incineration Technologies	Superheated steam reactor and gas phase catalytic dehalogenation.	

As of 2008, there were 147 destruction facilities that were known to operate in 25 countries around the world, with most located in Western Europe, Japan and North America, as shown in Figure 10 below.

Many large nations, including India and China, and entire regions such as the Middle East and Africa, **lack destruction capacity** (UNEP, 2009b). Given the scarcity of suitable destruction facilities, **transport of the ODS from its source to a destruction facility** can present a potential logistical challenge and often elevated costs.

In addition to adequate destruction capacity, **local material handling and reporting capabilities** and the **rigour of regulatory oversight** were deemed to be critical factors by many stakeholders interviewed. According to some stakeholders (including members of the CAR protocol working group), the decision to prohibit destruction of Article 5 material outside the US was largely due to concerns over the rigour of environmental oversight in each respective host nation (pers. comm.). In the US, once reclaimed, ODS are reclassified as hazardous waste. Only destruction facilities that are authorized to destroy hazardous waste, and are hence tightly regulated by the US EPA, are allowed to destroy ODS. As the ultimate consumers of ODS carbon credits are currently primarily US companies, it is likely that there will be continued demand for a similarly rigorous environmental oversight of ODS destruction in any facility outside the US.

Case study: destruction of confiscated ODS in Nepal

In 2001, the Nepal customs department seized 74 tonnes of unlicensed imported CFC-12. At the subsequent Meeting of the Parties to the Montreal Protocol, Nepal was allowed to use part of the seizure for domestic consumption. Around 12 tonnes of the gas remained unused when the complete ban on consumption entered into force in 2010. At this point, the Government of Nepal approached UNEP to identify possible solutions to manage this stock, and a Multilateral Fund technical assistance project was approved. UNEP evaluated various options for destruction of the CFCs, including use of a mobile plasma destruction unit, destruction in cement kilns in Nepal and export for destruction elsewhere. It was finally decided to transport the material to a suitable destruction facility in the US, where the ODS would be destroyed at a Climate Action Reserve (CAR) approved facility, and carbon benefits would be sold in the voluntary carbon market. The implementation of the project is being led by UNEP, with EOS Climate, a project developer identified through international competitive bidding, responsible for the transport, destruction, verification and issue of credits, while working closely with UNEP and the Government of Nepal. It is estimated that the project will lead to the issuance of 70-80,000 CRTs.

In the course of project preparation and implementation, several challenges were faced, including:

- Bureaucratic barriers to achieving the level of inter-departmental coordination which was required to overcome national regulation which prohibited export of ODS (pers. comm.);
- The lack of financial and technical resources within the country to manage ODS, which deterred project formulation without external assistance (pers. comm.);
- Testing the purity of the stock to assess its ability to qualify for CRTs and to arrive at accurate projections for CRT issuance (pers. comm.);
- Ensuring equity in the disbursement of carbon benefits to preserve the interest of the country (pers. comm.); and
- The low price of CRTs, which reduced the financial attractiveness of the project and the prospect of self-funding (pers. comm.).

At the time of preparation of this report, this project was still ongoing. On completion, the project is expected to shed further light on the challenges of managing ODS stocks in low-volume consuming countries (LVCCs) and on the integration of carbon finance into the financing of ODS destruction projects.

Figure 10: Global ODS destruction facilities by country

Country	Number of Known ODS Destruction Facilities in Operation	Technologies Utilized	ODS Destruction Capacity (except where indicated)	Destruction Costs (US$)
1. Argentina	NA	NA	NA	NA
2. Australia	1	Argon Plasma Arc	600 MT/year	$7/kg
3. Austria	1	NA	NA	NA
4. Belgium	2	Rotary Kiln	NA	NA
5. Brazil	NA	Rotary Kiln	NA	NA
6. Canada	1	Rotary Kiln	5 kg/hour (~40 MT/year, assuming 6,000 hours of operation/year)	$12/kg
7. Czech Republic	1	Rotary Kiln	40 MT/year	NA
8. Denmark	4	NA	NA	NA
9. Estonia	1	NA	NA	NA
10. Finland	1	Rotary Kiln	545 MT/year	NA
11. France	2	NA	NA	NA
12. Germany	6	▪ Hazardous Waste Incinerator ▪ Reactor Cracking	1,600 MT/year[a] (reactor cracking)	NA
13. Hungary	5	▪ Rotary Kiln ▪ Liquid Injection Incineration	▪ 13 MT/year (liquid injection incineration) ▪ 75 MT/year[a] (rotary kiln)	NA
14. Indonesia	1	Cement kiln	100 kg/hour (~ 600 MT/yr, assuming 6,000 hours of operation/year)	NA
15. Italy	12	NA	NA	NA
16. Japan	80	▪ Cement Kilns/Lime Rotary Kilns (7) ▪ Nitrogen Plasma Arc (8) ▪ Rotary Kiln Incineration/ Municipal Solid Waste Incinerators (24) ▪ Liquid Injection Incineration (7) ▪ Microwave Plasma (5) ▪ Inductively Coupled Radio Frequency Plasma (1) ▪ Gas-Phase Catalytic Dehalogenation (1) ▪ Superheated Steam Reactors (25) ▪ Solid-Phase Alkaline Reactor (1) ▪ Electric Furnace (1)	▪ 36 MT/yr (one catalytic facility) ▪ 2,600 MT/year[b] (one incinerator)	▪ Rotary kilns: $4/kg ▪ Superheated steam: $5/kg ▪ Plasma arc: $9/kg ▪ Reactor cracking: $4-6/kg ▪ Gas Phase Catalytic Dehalogenation: $5-7/kg
17. Netherlands	6	NA	NA	NA
18. Poland	1	NA	NA	NA
19. Slovakia	1	NA	NA	NA
20. Spain	1	NA	NA	NA
21. Sweden	4	Air Plasma, among others	100 MT/year (air plasma)	NA
22. Switzerland	> 4	Rotary Kiln, among others	▪ 910 MT/year[b] (rotary kiln) ▪ > 320 MT/year (others)	NA
23. United Kingdom	2	High-Temperature Incineration	NA	NA
24. United States	< 10	▪ Rotary Kilns ▪ Plasma Arc ▪ Fixed Hearth Units ▪ Liquid Injection Units ▪ Cement Kilns ▪ Lightweight Aggregate Kilns	318 MT/year (plasma arc) 6,188,600 MT/year[b] (US total hazardous waste destruction capacity)	$2 - $13/ kg
25. Venezuela	NA	NA	NA	NA

Source: ICF international, 2008

Destruction facilities in Article 5 countries may also lack the systems and reporting capabilities necessary to satisfy independent verification of the strict ODS protocol requirements. This is critical for carbon credit generation purposes, as credits can only be issued if these verification requirements are met. The importance of project developer confidence in the reliability of a facility's quality and reporting systems can be illustrated by the fact that although there are over ten ODS destruction facilities in the US, one facility alone (Clean Harbors in El Dorado, Arizona) has been used for 60 percent of all the 43 ODS destruction projects carried out in the US to date (pers. comm.).

The **cost of destruction** widely ranges globally from US$ 2 - 12 per kg, with an average price of US$ 6 per kg (ICF International, 2008). Again, while some Article 5 countries have the physical capacity to destroy ODS, the cost of doing so may be higher than average. For example, a recent proposal in Mexico quoted a price of US$ 10 per kg from a Plasma Arc facility, while cement kilns in Nigeria required US$ 15 per kg to destroy ODS (UNEP, 2011; UNEP, 2012a). Reasons for higher prices could include a lack of familiarity with ODS, lack of reporting capacity to protocol standards or increased wear to equipment. In the case of Nigeria, the cement industry was unwilling to implement costly modifications (UNEP, 2012a).

Finally, **excess highly qualified and reliable destruction capacity in the US** could be a barrier to the development of new destruction capacity in Article 5 countries. According to informed stakeholders, US facilities could easily handle a doubling or trebling of throughput (pers. comm.).

4.3 Barriers to undertaking carbon credit project development

Project developers in developing countries face a series of barriers associated with developing projects that supply carbon credits for the carbon market. Some of these barriers are specific to the development of ODS projects, while others are challenges that developing countries, and especially least developed countries, generally face in accessing carbon finance. The following barriers to undertaking carbon credit development have been identified:

- **Limited carbon finance capacity**: the capacity and know-how for developing projects for the carbon market varies widely among developing countries. While countries such as China, India and Brazil have been very active in developing carbon projects to date, and as such are in principle in a good position to develop ODS destruction projects for the carbon market, carbon finance capacity in other developing countries, and especially in least developed countries in Africa, is limited. Despite various efforts to build capacity (for example, through the World Bank's Carbon Finance Assist, UNEP Risoe, and the Nairobi Framework), many African countries have never developed any form of carbon project, and there is hence also limited local capacity and knowledge to develop ODS destruction projects (ICF International, 2010).

- **Limited project developer capacity and limited interest in Article 5 projects**: currently, only 16 firms have developed an ODS destruction project. Most are based in the US or Canada, and none are headquartered in an Article 5 country. Most of these firms are companies with long histories in the refrigerant distribution and reclamation industry, which have vertically integrated into the carbon credit project development business and typically collect ODS themselves, or have strong supply networks to obtain ODS materials. The five largest project developers have realized 73 percent of the projects and generated 96 percent of the credits according to the CAR and CCX project databases.[37] During the research for this paper, the largest six project developers were interviewed to gain their market perspective. The overwhelming consensus was an intent to focus on CAR US-based opportunities, as these credits will be convertible into AB32 compliance credits (see box below). While other ODS project developers may emerge in future, it will take time for any new firm to become familiar with the requirements of this particular offset category, and the fact that only one of the top five firms which dominate the market at present is interested in Article 5 projects means that the opportunities for developing country firms to learn from the US experience are very limited.

- **Costs associated with developing a carbon project**: each of the steps in the carbon credit development cycle (see Figure 8 above) entails a cost, and typically, a project developer only receives income from sales of credits once they have been issued and successfully transferred to a buyer. The need for up-front financing to cover the transaction costs associated with developing a project for the carbon market constitutes a barrier to many project developers in developing countries (Michaelowa et al., 2003). This problem is particularly acute for smaller-scale projects, as there is currently no alternative simplified methodology for smaller-scale projects that could help reduce transaction costs, with the result that such costs are proportionately greater for smaller projects.

- **Lack of knowledge of where low cost accessible banks exist**: the lack of comprehensive data on ODS banks on a country-by-country basis, information on the cost of accessibility and the level of in-country ODS collection infrastructure and capacity creates a barrier for both international and local ODS project developers by raising the search costs involved in finding a viable project opportunity.

- **Uncertainties about carbon prices, low prices and the perceived VCS price discount**: Given that there have not yet been any transactions of credits sourced from non-virgin Article 5 ODS projects, many developers are unable to estimate the potential revenue that may be generated from such projects. This price uncertainty is a major barrier to further project development. In the case of Article 5 projects seeking funding from the MLF, many project proposals have included price estimates for credits that are not adequately justified and often severely penalize the option to utilize the VCS rather

[37] A summary of all ODS project developers can be found in Annex 5.

than the CAR standard. Table 9 below summarizes the carbon prices assumed in several recent Article 5 project proposals.

4.4 Demand-side barriers

ODS destruction projects also present a number of challenges from the buyers' perspective. These include:

- **Limited availability of standards for ODS project development and associated approved methodologies**: whilst a number of different avenues for developing ODS projects for the carbon market exist (as outlined in section 3 above), only the VCS presently allows for ODS destruction to take place outside the US. The VCS methodology for ODS destruction was only recently approved (September 2011), and only one project using this methodology has been completed to date.

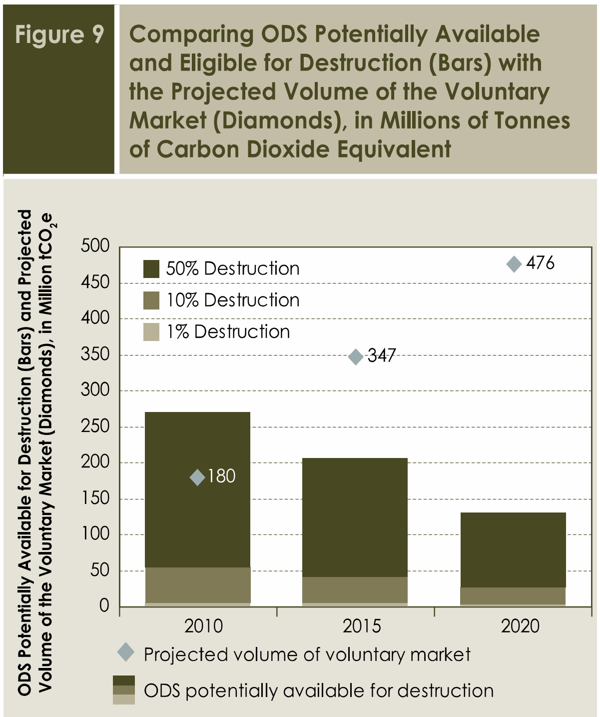
- **Limited demand for voluntary ODS credits:** given that ODS destruction is a relatively new project category, it does not come as a surprise that the level of awareness of ODS offsets is quite low. A search of 2,000+ companies that responded to the Carbon Disclosure Project yielded only one company that reported the purchase of ODS offsets (CDP, 2011).

- **Reputational concerns**: corporate social responsibility, public relations and branding were found to be the main motivators for buyers in the voluntary carbon market last year. In fact, in 2011, 49 percent of carbon credits in the voluntary markets were purchased by businesses to voluntarily offset their own emissions, retiring them upon purchase (Peters-Stanley & Hamilton, 2012). Reputation is therefore of prime importance for buyers, who have become very selective about the type of credits they buy and choose to be associated with. ODS destruction projects may have some problems differentiating themselves from other industrial gas abatement projects, and especially from HFC-23 destruction projects which have been exposed to a significant level of criticism in the past (Walravens & Filzmoser, 2010).
- **Potential market flooding with ODS credits**: currently, it appears that the demand for credits from ODS destruction projects is insufficient compared to the potential supply. Although ODS destruction projects could potentially overwhelm the entire voluntary carbon market if they were developed to their absolute full potential (see Figure 11 below), it is more realistic to think of the voluntary market as comprising various segments, corresponding to the different motivations of voluntary buyers. As yet, the size and price point of the Article 5 ODS segment is entirely unknown.

Table 9: Summary of pricing assumptions in recent Article 5 project proposals

Country/ Project	Price (US$/ tonne)	Protocol	Explanation given	Issues
Mexico Efficient Lighting and Appliances Program (UNEP 2012c)	US$ 3.50	CAR	According to market prices, CRTs are traded within a price range of US$ 7 – 10 on average. Therefore, to take the most conservative option, prices are assumed at half the price of lowest priced current CRTs.	Considered all CRTs, including non-ODS project categories. The only figures available for ODS CRTs are for US-based credits which sell at a premium (US$ 8.20 on average in 2011 according to Peters-Stanley & Hamilton (2012)) because they are eligible as early action credits for AB32.
	US$ 0.40	VCS	As per market experience, recent prices of large VCS projects have dipped to levels as low as US$0.60/tonne. Adding to that, industrial gas destruction projects (which are large in volume and have significantly less visible co-benefits) are not favoured by buyers. Unfortunately, ODS destruction is included as it is considered industrial gases. Therefore, VCS credits generated by such a project are expected to sell at US$ 0.40/tonne.	Assumes that they will sell at the same level as industrial gas projects. Assumes a voluntary buyer will pay vastly different prices for credits from the exact same project under a different standard.
Mexico Phase-out of HCFC-22 and HCFC-141b in aerosols (UNEP 2011)	US$ 3.00	VCS	UNIDO assumes a conservative price of US$3.00/tonne based on 2009 CAR & VCS price data.	Old estimate and assumes average prices from all CAR & VCS categories. In 2011, the average price in the VCS was US$ 3.70 with a range of US$ >1 to 30.
Nigeria Pilot ODS waste management and disposal (UNEP 2012a)	US$ 2.00	CAR	Based on the trends in global carbon markets, the value of the CRTs generated from the ODS destruction projects in the US are around US$2.00 per CRT.	Given that no imported Article 5 recycled ODS projects have been developed or sold yet, that price would only apply to the virgin imported stockpiled projects. Voluntary buyers would likely value these very differently.
	US$ 0.50	VCS	None given	
Turkey Pilot ODS waste management and disposal (UNEP 2012b)	US$ 3.00	CAR	Higher prices based on 2010 quarterly data CRTs vs. VERs for all categories.	Price data was out of date and included all VERs vs. CRTs, including all price categories.
	NA	VCS	VCS dismissed in first phase but favoured in the second due to lower price expectations from 2010 quarterly data CRTs vs. VERs for all categories.	Price data was out of date and included all VERs vs. CRTs, including all price categories.

Figure 11: Comparison of ODS potentially available (in 1%, 10% and 50% destruction scenarios) and projected size of the voluntary carbon market (ICF International 2010)



5 Possible solutions to the identified barriers

5.1 Dealing with barriers to carrying out the collection and management of ODS

There is no easy solution for overcoming the barriers outlined in section 4. Solutions to these barriers should be considered within the context of international cooperation and collaboration. It has been suggested that other global chemicals management agreements should be consulted, such as the Stockholm Convention or UNEP's Strategic Approach to International Chemicals Management, as these could provide some useful insights (ICF International, 2008). The institution of a facility or fund for ODS destruction projects (as further elaborated in section 5.4 below), or an approach to ODS destruction driven by the implementation of Nationally Appropriate Mitigation Actions (NAMAs) (as mentioned in section 2.5 above) could be effective ways to incentivize actions to overcome these general barriers.

Public sector intervention will be needed to deal with the cost effectiveness problem in countries with **low volume and dispersed ODS sources**. For example, a national government could destroy ODS confiscated at customs, which could be a low-cost, high-profit project and use the profits to fund a programme to collect refrigerators at end of life to recover and destroy the associated ODS (ICF International, 2010). Alternatively, the government could impose a tax on the sale of credits earned through ODS destruction projects and the revenues from this could be put in a fund and used to provide up-front financing for less cost effective projects (ibid). Trying to improve the cost effectiveness of smaller projects would be another option. This could be done by coupling ODS destruction projects with other activities eligible for the carbon market, such as energy efficiency improvements. This would allow project developers to apply for both types of credits and thereby increase revenues (ibid).

Other means of overcoming the general issue of **lack of awareness about necessary ODS tools and infrastructure** could include further collaboration between the MLF and existing ODS project developers (and/or other experts) to offer this insight and expertise in the host countries where the MLF has supported ODS infrastructure measures. By 2009, it was reported that the MLF had financed at least 100 recovery and recycling centres globally that attained varied levels of success (UNEP, 2009b; Environmental Investigation Agency, 2009); linking these successful efforts with experienced ODS developers should be a priority. The suggestion has also been made that the role of the Ozone Secretariat should be expanded to provide a 'clearinghouse' function to link ODS suppliers with project developers and investors and to offer a registry platform (ICF International, 2010). One project developer reported that their experience has been highly variable in the host Article 5 countries they are currently working in, stating: "*It really helps to have industry partners to deploy in-country to assist with the project partners. If you simply have standards on paper but your project partners have a particular level of technical capabilities with equipment or training it is important to have a harmonized process with oversight from the implementing agency (or even project developer) or you could not achieve the highest project cost effectiveness. We feel it is critical to have partners that have experience, have proven technologies, monitoring and data tracking in place.*" (pers. comm.).

The issue of **the lack of appropriate and supportive regulatory and legal frameworks** in Article 5 nations is real and created complications with the first non-virgin Article 5 import project from Mexico (see section 3.3 above). The two other non-virgin Article 5 ODS projects that are currently being developed are reported to have gone quite smoothly, albeit with some time delays relative to a US-based project, but working with implementing agencies has been of great assistance (pers. comm.). A possible further role for MLF implementing agencies might be to work with host nations that are likely candidates for ODS projects to draw up comprehensive lists of all procedures, permits, etc. that need to be completed at each stage of development of a project to reduce the search costs and uncertainty for project developers.

5.2 Dealing with barriers to carrying out destruction of ODS

Only the relatively recently approved VCS methodology allows for the destruction of ODS to take place outside the US. Now that this methodology is in place, a survey could be conducted of the nearly 150 known destruction facilities to determine whether each facility can meet the required destruction specifications, perform the ancillary functions required and support independent verification, and to inquire about regulatory oversight, pricing and general interest in engaging in ODS projects. This would help establish a short-list of facilities where destruction under the VCS methodology is realistically possible.

Beyond this, the MLF implementing agencies should continue to consider assisting host countries with establishing, converting, upgrading or otherwise supporting suitable destruction facilities in key geographic locations in proximity to accessible ODS banks.

5.3 Dealing with barriers to undertaking carbon credit project development

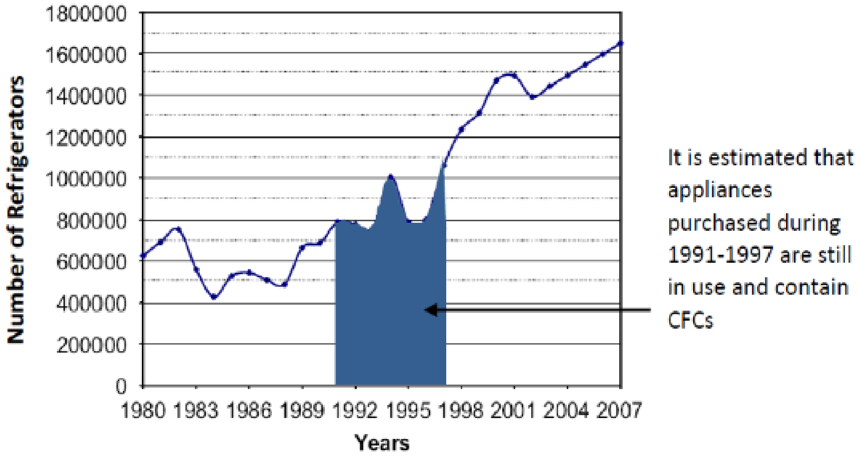
It will not be easy to deal with the problem of **limited carbon finance capacity** in some developing countries. Targeted capacity building and training for ODS stock holders and regulators on carbon markets and how to develop carbon projects would help build the necessary skills on the ground to develop ODS destruction projects for the carbon market. Given that funds for such capacity building will likely be limited, it is suggested for efforts to first of all be focussed on countries with the largest and most concentrated ODS stocks. Given the lack of regional and country-by-country granular data of ODS banks by cost of accessibility, one possible solution is to partner with refrigerant manufacturers and/or consultancies to determine the sales of appliances and equipment containing ODS. Similar analysis was conducted on projects in Turkey and Mexico (Table 10 and Figure 12 below).

Table 10: Turkey's manufacturing, domestic sales and export data for refrigerator production (x1000 units) 1992-2004

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Production	1087	1247	1265	1637	1638	1850	1875	2139	2446	2483	3 319	4 286	5 308
Domestic sales	796	927	767	834	963	1230	1410	1258	1468	1018	1088	1362	2 004
Export	281	397	586	802	695	784	818	1046	1088	1530	2247	3035	3 014
Export/Prod. (%)	26	32	46	49	42	42	44	49	44	62	68	71	63

Source: (UNEP, 2012b)

Figure 12: Refrigerators sold in Mexico from 1980-2007



Source: (Arroyo-Cabañas et al., 2009)

To overcome the hurdle of **high up-front transaction costs** associated with developing ODS carbon projects, international financial institutions (IFIs) could play an important role by providing up-front financing, at least in an initial pilot phase (ICF International, 2010). Transaction costs could also be reduced by grouping a number of projects together, for example, projects in different municipalities, under a programme of activities. An unorthodox suggestion offered by one of the stakeholders interviewed to overcome the cost barriers is for the MLF or implementing agencies to offer a set price for specific ODS gases and allow the market to attempt to deliver them.

Uncertainty about market prices is a very difficult barrier to address. Tracking price trends on a real-time basis could be helpful for stakeholders, although this may not be possible for OTC transactions in the voluntary market (ICF International, 2010). There are only a small number of voluntary ODS projects and obtaining their transacted prices will be difficult, as discovered during the process of this research. One option that could address this and other demand-side barriers is to complete a survey with non-ODS project developers, wholesalers and retailers in addition to the ODS project developers identified through this research. Such a survey could address the following questions:

- Whether non-ODS project developers have any intention of developing ODS projects;
- Current and future market demand for voluntary ODS credits from Article 5 countries;
- Price expectations from a number of different hypothetical ODS projects. These could include: a) destruction outside the US (to address the CAR vs. VCS perceived price issues; b) EOL ODS from different countries (African,

Asian, Middle East, etc.); c) Government seized sources; d) Inquire about the current level of differentiation of ODS from industrial gas and the ability for ODS to be further differentiated.

A list of ODS project developers can be found in Annex 4 and an extensive list of project developers and wholesalers can be found on CAR's website.[38] Another alternative would be to reach out to Ecosystem Marketplace, which maintains an extensive database of voluntary market participants who are surveyed each year to generate data for their annual *State of the voluntary carbon markets* reports (see, for example, Peters-Stanley & Hamilton, 2012).

5.4 Dealing with demand-side barriers

Carbon market **standards and methodologies for developing ODS destruction projects** in developing countries are extremely limited. However, it is encouraging that the VCS has recently approved an ODS destruction methodology. We can be hopeful that once the first few projects are developed under the VCS, there will be a snowball effect with an increasing number of new projects being registered which can capitalize on the experience gained from the first few projects.

The only long-term solution to the **limited demand for voluntary ODS credits** is to expand into future cap-and-trade schemes (see section 2.4. One stakeholder noted that once the ODS 'story' is told, people understand and embrace it (pers. comm.). ODS projects have many of the elements that a compliance offset needs, such as tangibility, ease of establishing additionality, being highly verifiable, transparent, having a short project lifecycle, co-benefits and a small probability of credit revocation (ibid).

There have been broadly positive developments in the increased demand for voluntary credits of all types in both project volume and value growth in 2011. The strongest growth regions included many developing nations, as well as a near trebling in Africa and significant gains in Asia and Oceania (see Figure 13 below) (Peters-Stanley & Hamilton, 2012). Additional demand for credits developed in LDCs is expected, along with the change in rules for CERs allowed in the EU ETS from 2013, which, in addition to CERs from existing projects, will only allow CERs from new projects in LDCs. While these overall trends in the voluntary market will not necessarily apply to ODS as a specific credit type, they are generally encouraging for Article 5 countries in Africa and Asia, in particular.

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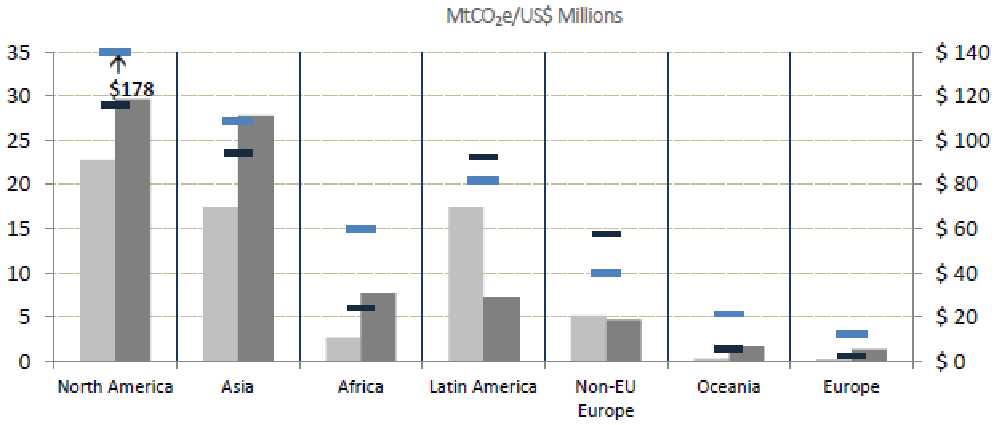
[38] See http://www.climateactionreserve.org/how/crt-marketplace/

Figure 13: Change in volume and value by region, OTC, 2010 vs. 2011



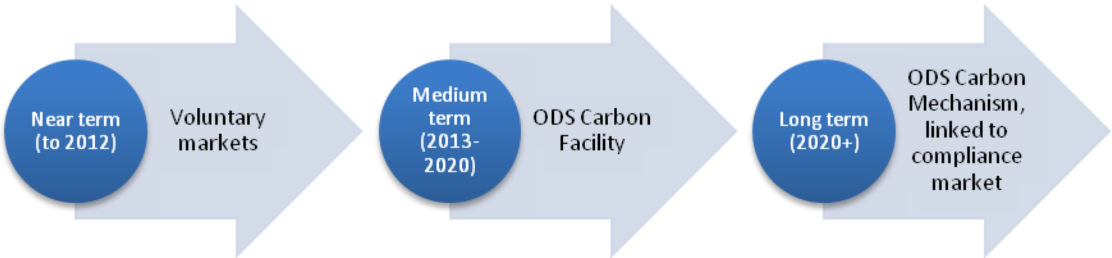
Source: (Peters-Stanley & Hamilton, 2012)

To overcome challenges associated with the uncertain **reputation of ODS projects**, it will be crucial for them to be packaged in a way that appeals to buyers and their stakeholders. This could include presenting an appealing story of the project, emphasizing the value added benefits of the credits it generates (ICF International, 2010). Aspects to highlight could include the fact that ODS only qualifies for destruction where it has been prohibited from new production or import under the Montreal Protocol (this is a key requirement in most of the ODS methodologies) and, hence, there cannot be an adverse incentive to produce ODS for the sake of getting credits. If the ODS being destroyed is replaced with another high GWP compound, then it should be made clear to prospective buyers that this has been accounted for in the emission reduction calculations (again, existing methodologies include this aspect). Finally, it should be highlighted that unlike other industrial gas projects that allow for very cheap reductions, disposing of ODS is costly. In fact, an ODS destruction project has been estimated to cost up to 200 times more than an HFC-23 destruction project (IPCC & TEAP, 2005). It should be noted that it may be easier for projects destroying ODS from end of life equipment to tell a story of this kind than projects disposing of virgin stockpiles (ICF International, 2010). The recommendation provided in section 5.3 of conducting a survey to better determine price expectations of future voluntary ODS credits could also include questions pertaining to the **perceived reputational concerns** of ODS credits and their differentiation from industrial gas projects.

To deal with the problem of potential **lack of demand and subsequent market flooding**, UNDP has put forward the idea of establishing an **ODS Carbon Facility** to link ODS carbon credits to sufficient demand and to ensure regulatory robustness. It has been suggested that in the medium term, the facility could take the form of a fund supported voluntarily by government sponsors. Donors would be allowed to retire credits from the facility when they need them and add PR value and reputational advantages from being part of this initiative. Money could be invested in future credits value, either for monetization or compliance purposes. The rationale behind establishing an ODS Carbon Facility is to set up robust regulatory procedures and gather data for use in future baselines. The facility will also be able to signal to markets the possible inclusion of ODS credits in the next international climate change agreement. The ODS Carbon Facility could have a similar role to that of the World Bank's Prototype Carbon Fund (PCF), which substantially contributed to kick-starting the CDM market from 2000, five years before the Kyoto Protocol had even come into force.[39]

In the long term, the facility could be turned into an **ODS Carbon Mechanism**, linked into international compliance markets to ensure demand. Being linked to compliance markets will ultimately ensure a more cost effective and fully integrated approach (UNDP, 2009).

Figure 14: Possible timeline for ODS projects to access carbon finance (adapted from UNDP 2009)



Source: UNDP, 2009

6 Conclusions

Despite the phase-out in production of most ODS, large amounts can still be found in existing equipment, products, waste streams and stockpiles, collectively known as ODS banks. Over time, these stocks of ODS will inevitably leak to the atmosphere unless they are collected and destroyed.

Most ODS are powerful greenhouse gases contributing to global warming, in addition to depleting the ozone layer. It has been estimated that about one-third of the existing ODS banks in 2002 will have been vented by 2015, resulting in emissions equivalent to nearly seven billion tonnes of carbon dioxide (IPCC & TEAP, 2005). This is a significant amount – close to one-fifth of a year's global carbon dioxide emissions.

These emissions are largely uncontrolled, partly because they fall between the jurisdictions of the two major international policy instruments that control ODS and greenhouse gases, the

[39] See http://wbcarbonfinance.org/Router.cfm?Page=PCF&FID=9707&ItemID=9707&ft=About

Montreal and Kyoto Protocols, respectively. The Montreal Protocol addresses production and consumption of ODS, but not ODS banks, while the Kyoto Protocol excludes greenhouse gases controlled by the Montreal Protocol. Therefore, most carbon markets currently do not provide significant incentives for the destruction of ODS banks in order to achieve relatively cheap greenhouse gas emission reductions.

There are two main exceptions to this: new regulatory carbon markets in California and Quebec, and the voluntary carbon market. As the US never ratified the Kyoto Protocol and Canada has withdrawn, carbon markets in these countries have less reason to align their carbon accounting with the Kyoto Protocol. Under California's AB32 programme, ODS destruction is one of only four categories eligible to generate compliance offsets. However, the ODS must be both sourced from and destroyed in the US. Quebec's much smaller scheme also allows ODS destruction to generate compliance offsets, with a similar restriction to ODS sourced and destroyed either in the US or Canada. Therefore, the two main regulatory carbon markets currently providing incentives for ODS destruction specifically exclude any participation from Article 5 countries.

The three major standards under which voluntary projects have been developed are the CCX, CAR and VCS. The CCX as a trading platform closed in January 2011, and while it continues to exist as a standard and registry for offset credits, it is unlikely to be used by any further ODS projects. CAR has two ODS destruction protocols, one for US stocks (which builds on and effectively superseded the CCX protocol) and another for Article 5 imports. In both cases, the ODS must be destroyed in the US. In September 2011, the VCS, which is the dominant standard for the voluntary carbon market as a whole (58 percent market share in 2011 - Peters-Stanley & Hamilton, 2012), broke new ground with its new methodology VM0016 which allows ODS to be sourced and destroyed in any country.

However, there are reasons to be cautious about the scope for voluntary carbon market demand for ODS credits and, in particular, for credits from the destruction of Article 5 stocks. Most ODS destruction activity in the voluntary carbon market to date has been motivated by anticipation of future recognition in a regulatory carbon market. Nearly all such projects have taken place in the US or Canada, using US or Canadian stocks. We have only been able to identify six projects which have been developed to date using stocks from Article 5 countries. Of these, three were very large projects importing virgin materials from India and Mexico under the first version of CAR's Article 5 ODS Project Protocol, which allowed such virgin imports for a 60-day period in the first half of 2010 (allegedly as a result of lobbying by some ODS project developers involved in the development of the protocol). Virgin imports became ineligible under the second version of the protocol and are now also ineligible under California's AB32 programme. Credits from these projects now have no clear market and transact at very low prices. The surplus of these credits and their somewhat negative associations may act as a barrier to voluntary demand for credits from non-virgin Article 5 ODS destruction projects in future.

The fact that total AB32 demand for offset credits is much higher than the potential US-based ODS credit supply (under present conditions and prices) suggests that there is a possibility of regulatory change in future, which could potentially lead to the market being opened up to Article 5 participation. However, there are several other options which would almost certainly be considered first, including:

- Increasing the supply of credits from the other three currently approved project types;
- Approving further (non-ODS) project types;
- Amendment to the appliance foam baseline calculations, with the effect of making US-based appliance foam ODS destruction projects more economic; or
- Adding further gases or eligible materials to the current US-based CARB ODS protocol.

All of the above would have the advantage of retaining the scheme's current focus on US-based offsets, which in turns means US jobs. As it is extremely important for the scheme to be seen as a success in its first commitment period (2013-2014), we believe it is unlikely that credits from Article 5 ODS sources would be considered before late 2014 at the very earliest.

Another way in which Article 5 ODS credits could benefit from Californian demand would be through a potential future linkage (perhaps in the period 2015-2020) between Mexico and the Western Climate Initiative (which currently provides a linkage between the California and Quebec carbon markets). However, at present, the outlook for a Mexican carbon market remains uncertain, and linkage to the Western Climate Initiative even more so. Nevertheless, this is one to watch.

In summary, **the first prerequisite for Article 5 countries to benefit from carbon credits for the destruction of their ODS stocks is that there must be sufficient demand for those credits.** At present, the main source of demand for ODS credits in general is the regulatory carbon market in California, followed by Quebec, neither of which is open to Article 5 credits. That leaves only the voluntary carbon market, which is several orders of magnitude smaller than the regulatory carbon markets. On the one hand, the fact that both CAR and VCS now have approved methodologies that allow for credits from the destruction of Article 5 ODS stocks is encouraging, as these two standards have 70 percent of voluntary market transaction value between them (Peters-Stanley & Hamilton 2012). However, on closer examination, there is as yet very little evidence of 'pure' voluntary market demand for ODS credits, as most activity to date has been driven by expectations of future compliance. It is significant that at present, none of the six largest ODS project developers intends to use the VCS methodology, despite its greater flexibility, and only one is interested in pursuing CAR Article 5 projects.

This suggests there may be a role for UNIDO in helping to encourage increased end-user demand for Article 5 credits. There are several ways in which this could be done, for example:

- In relation to regulatory markets, engaging with key policymakers, for example, in California and Mexico, to ensure that the case for future recognition of Article 5 ODS credits in these schemes is as convincing as possible;
- In relation to the voluntary market, helping to raise awareness of the double benefit of ODS credits (ozone protection and climate change mitigation), and of the urgency of the situation with respect to ODS banks leaking to the atmosphere. This could be achieved through various means such as publications and reports, workshops or conferences, side events at climate negotiations and direct engagement with initiatives such as the Carbon Disclosure Project, which in turn have influence on corporate responses to climate-related issues.[40] In addition, UNIDO could engage directly with CAR and VCS to ensure that the relevant methodologies are suitable for Article 5 countries. It would also be in UNIDO's interests to promote the highest standards and appropriate regulatory oversight in areas such as collection, destruction and monitoring, reporting and verification, as well as wider awareness of those standards.

[40] The Carbon Disclosure Project requests all major global companies to report their climate-related risks and opportunities, on behalf of more than 655 institutional investors representing in excess of US$ 78 trillion in assets in 2012. See https://www.cdproject.net/en-US/WhatWeDo/Pages/investors.aspx

6.1 Supply-side barriers and possible solutions

Even if demand for Article 5 ODS credits increases, substantial barriers and challenges remain in all parts of the Article 5 ODS-to-carbon credit supply chain. Barriers to carrying out the collection and management of ODS include:

- Funding constraints;
- The fact that ODS destruction on its own is typically not a sufficient driver for the establishment of an ODS collection infrastructure;
- The opportunity cost of ODS destruction (particularly the reuse market);
- Low volume and dispersed ODS sources;
- Impurity of ODS sources;
- Lack of trained personnel;
- Lack of awareness about necessary tools and infrastructure; and
- Lack of appropriate and supportive legal and regulatory frameworks.

These are generic barriers that UNIDO is well aware of and has already engaged in addressing. In relation to the issues around lack of awareness and lack of trained personnel, it should be noted that, even in developed countries, the relevant expertise is highly specialized and confined to a relatively small pool of experts. This, in turn, suggests a possible role for UNIDO in linking those experts and expertise with the relevant needs in Article 5 countries. Similarly, in relation to the lack of appropriate legal and regulatory frameworks, UNIDO could identify and promote best practices or help Article 5 countries clarify legal and regulatory requirements in order to reduce search costs and uncertainty for project developers.

Destruction is a critical stage because it is also the point at which the ODS supply chain intersects with the carbon credit supply chain. Therefore, if Article 5 countries wish to capture more of the added value of the carbon credit, it may be necessary to carry out destruction in an Article 5 country as opposed to exporting the ODS for destruction elsewhere. Barriers to carrying out destruction in an Article 5 country include:

- Limited suitable facilities;
- Transport challenges and costs;
- Lack of material handling and reporting capabilities;
- Higher costs of destruction; and
- Excess highly qualified and reliable destruction capacity in the US.

Of these, the last is possibly the most intractable, and may ultimately override efforts to overcome the other barriers, such as conducting an up-to-date survey of suitable facilities specifically to ascertain suitability under the new VCS standard, and assisting host countries with establishing, converting, upgrading or otherwise supporting suitable destruction facilities in key geographic locations in proximity to accessible ODS banks. It may be best to be philosophical about this, particularly given the evidence from US stakeholders that Article 5 domestic destruction was not permitted under the CAR protocol because of concerns about local environmental regulatory oversight: it is better for Article 5 countries to gain some revenue from exporting their ODS stocks than no revenue at all from domestic destruction, if the market does not support this.

Finally, there are barriers to undertaking carbon credit development in Article 5 countries, including:

- Limited carbon finance capacity in general (outside a few countries such as China, India, Mexico and Brazil);
- Limited project developer capacity and limited interest from existing project developers in Article 5 projects;
- Costs associated with developing a carbon project;
- Lack of knowledge of where low cost accessible banks exist; and
- Uncertainties about carbon prices, low prices and the perceived VCS discount.

There are a variety of actions that UNIDO could undertake to address these barriers, such as running targeted capacity building workshops specifically in ODS carbon credit development; linking ODS stock owners, trained local technical partners and experienced carbon credit developers through some kind of 'clearinghouse'; and conducting a survey of potential ODS carbon credit developers and retailers to improve understanding on market demand and expected prices.

In the longer term and at a much grander scale, an ODS Carbon Facility could be envisaged. Like the World Bank's Prototype Carbon Fund, this could pool funds from various investors (which might include national governments, IFIs, as well as corporations and other private sector investors). These funds would be used to purchase ODS credits from Article 5 projects or to invest directly in developing such projects, and also in part to fund wider capacity-building activities to support the development of the market as a whole. Again following the example of some of the World Bank carbon funds, such a facility could have the flexibility to offer up-front funding to certain projects, take on development costs in return for a lower but guaranteed return for others, or simply facilitate third-party financing by offering a bankable, guaranteed off-take agreement. Given the scale of the greenhouse gas emissions associated with ODS banks, the short timeframe over which they will leak to the atmosphere, the scale of funding required to tackle this problem and the time scales involved in setting up such a facility, the time has come to seriously start considering such an ODS Carbon Facility.

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Annex 1: Montreal Protocol phase-out timetable

[41]	Non-Article 5 Parties	Article 5 Parties
ANNEX A – GROUP I: CFC-11, CFC-12, CFC-113, CFC-114, CFC-115		
Base level	1986	Average of 1995-1997
Freeze	1 July 1989	1 July 1999
Reductions	75%, 1 January 1994	50%, 1 January 2005
	100%, 1 January 1996 (with possible essential use exemptions)	85%, 1 January 2007
		100%, 1 January 2010 (with possible essential use exemptions
ANNEX A – GROUP II: HALON 1211, HALON 1301, HALON 2402		
Base level	1986	Average of 1995-1997
Freeze	1 January 1992	1 January 2002
Reductions	100%, 1 January 1994 (with possible essential use exemptions)	50%, 1 January 2005
		100%, 1 January 2010 (with possible essential use exemptions)
ANNEX B – GROUP I: CFC-13, CFC-111, CFC-112, CFC-211, CFC-212, CFC-213, CFC-214, CFC-215, CFC-216, CFC-217		
Base level	1989	Average 1998 – 2000
Freeze	-	-
Reductions	20%, 1 January 1993	20%, 1 January 2003
	75%, 1 January 1994	85%, 1 January 2007
	100%, 1 January 1996 (with possible essential use exemptions)	100%, 1 January 2010 (with possible essential use exemptions)
ANNEX B – GROUP II: CARBON TETRACHLORIDE		
Base level	1989	Average 1998 – 2000

[41] Adapted from http://ozone.unep.org/new_site/en/Treaties/treaties_decisions-hb.php?sec_id=6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24

Freeze	-	-
Reductions	85%, 1 January 1995	85%, 1 January 2005
	100%, 1 January 1996	100%, 1 January 2010 (with possible essential use exemptions)
ANNEX B – GROUP III: 1,1,1-TRICHLOROETHANE (METHYL CHLOROFORM)		
Base level	1989	Average 1998 - 2000
Freeze	1 January 1993	1 January 2003
Reductions	50%, 1 January 1994	30%, 1 January 2005
	100%, 1 January 1996 (with possible essential use exemptions)	70%, 1 January 2010
		100%, 1 January 2015 (with possible essential use exemptions)
ANNEX C – GROUP I: HCFCs (CONSUMPTION)		
Base level	1989 HCFC consumption + 2.8% of 1989 CFC consumption	AVERAGE 2009 - 2010
Freeze	1996	1 January 2013
Reductions	35%, 1 January 2004	10%, 1 January 2015
	75%, 1 January 2010	35%, 1 January 2020
	90%, 1 January 2015	67.5%, 1 January 2025
	99.5%, 1 January 2020, thereafter consumption restricted to the servicing of refrigeration and air conditioning equipment existing on that date	97.5% (averaged over 2030 – 2040), 1 January 2030, thereafter consumption restricted to the servicing of refrigeration and air conditioning equipment existing on that date
	100%, 1 January 2030	100%, 1 January 2040
ANNEX C – GROUP I: HCFCs (PRODUCTION)		
Base level	Average of 1989 HCFC production + 2.8% of 1989 CFC production and 1989 HCFC consumption + 2.8% of 1989 CFC consumption	Average 2009 – 2010

Freeze	1 January 2004, at the base level for production	1 January 2013
Reductions	75%, 1 January 2004 (at the base level for production)	10%, 1 January 2015
	90%, 1 January 2015	35%, 1 January 2020
	99.5%, 1 January 2020, thereafter restricted to the servicing of refrigeration and air conditioning equipment existing on that date	67.5%, 1 January 2025
	100%, 1 January 2030	97.5% (averaged over 2030 – 2040), 1 January 2030, thereafter restricted to the servicing of refrigeration and air conditioning equipment existing on that date
		100%, 1 January 2040
ANNEX C – GROUP II: HBFCs		
100% reduction	1 January 1996 (with possible essential use exemptions)	1 January 1996 (with possible essential use exemptions)
ANNEX C – GROUP III: Bromochloromethane		
100% reduction	1 January 2002 (with possible essential use exemptions)	1 January 2002 (with possible essential use exemptions)
ANNEX E – GROUP I: Methyl bromide		
Base level	1991	Average of 1995 – 1998
Freeze	1 January 1995	1 January 2002
Reductions	25%. 1 January 1999	20%, 1 January 2005
	50%, 1 January 2001	100%, 1 January 2015 (with possible essential use exemptions)
	70%, 1 January 2003	
	100%, 1 January 2005 (with possible essential use exemptions)	

Annex 2: Interviewees

Interviews were conducted with 21 different ODS destruction project stakeholders including project developers, ODS destruction experts, carbon registries, standards bodies and regulators. Interviews were conducted face-to-face and by telephone between 16 July 2012 and 12 January 2013. A full list of stakeholders that were interviewed can be found below.

Stakeholder Category	Title	Date
ODS Reclaimer Project Developer ODS Destruction Facility	Vice President	22/8/12
Exclusively an ODS Project Developer	Co-founder	31/7/12
Exclusively an ODS Project Developer	VP Technology	31/7/12
ODS Reclaimer Project Developer	Owner	6/8/12
Diversified Project Developer	CFO & Portfolio Manager	23/7/12
ODS Reclaimer Project Developer	President & Co-founder	6/8/12
Diversified Project Developer	Project Manager	25/7/12
Carbon Standard	Chief Program Officer	24/7/12
Carbon Standard	VP Business Development	18/7/12
Carbon Standard	Economist	6/8/12
California's Cap-and Trade Administrator	Manager	30/7/12
Verification Specialist	Certified ODS Verifier	30/7/12
Broker	ODS Broker	NA
ODS Destruction Facility	Chief Marketing Officer	25/7/12
ODS Destruction Facility	Project Manager	8/8/12
Appliance Demanufacturer & ODS Reclaimer	President	22/8/12
ODS Expert	Environmental Consultant	17/8/12
UN Agency	Programme Officer	4/12/12
ODS Expert	Senior Consultant	24/12/12
Commercial refrigeration company	Managing Director	29/12/12
Industry body	Consulting Editor, Air Conditioning and Refrigeration Journal	12/01/13

Annex 3: Global ODS destruction facilities

The TEAP, in collaboration with UNEP DTIE OzonAction Programme, ran a survey on commercial destruction facilities in 2005 and found that only nine of them met their good housekeeping criteria. These are listed in the table below.

Country	Company	Name of facility	Type of technology	ODS that can be destroyed
Australia	DASCEM Holdings Pty Ltd	Australian National Halon Bank	Argon plasma arc	CFCs, Halons, HCFCs, Other (suitable for destruction of all liquid and gaseous ODS
Belgium	INDAVER N.V.	INDAVER N. V.	Rotary kiln incineration	CFCs, Halons, HCFCs, Foam that contains ODS
Brazil	TdB Incinerecao Ltda	TdB Incinerecao Ltda	Rotary kiln incineration	CFCs, Halons, HCFCs, Foam that contains ODS, methyl bromide
Canada	Earth Tech Canada Inc	Swan Hills Treatment Centre	Rotary kiln incineration	CFCs, Halons, HCFCs, Foam that contains ODS, methyl bromide, other
Finland	Okokem Oy Ab	Okokem Oy Ab	Rotary kiln incineration	CFCs, Halons, HCFCs, Foam that contains ODS, methyl bromide
Germany	Solvay Fluor GmbH	Solvay Fluor GmbH	Reactor cracking	CFCs, HCFCs, HFCs
Hungary	Onyx Magyarorszag Ltd	Onyx Magyarorszag Ltd	Rotary kiln incineration	Halons
Japan	INEOS Fluor Japan Limited	Mihara Site of INEOS Fluor Japan Limited	Gaseous/fume oxidation	CFCs, Halons, HCFCs, methyl bromide
Switzerland	Valorec Services AG	RSMVA (Regional Hazardous Waste Incinerator)	Rotary kiln incineration	CFCs, Halons, HCFCs, Foam that contains ODS, methyl bromide, other (methyl iodide)

Source: http://www.unep.fr/ozonaction/topics/disposal.htm

Since this survey was conducted in 2005 over 40 ODS projects have successfully been implemented in three destruction facilities in the US without a report of incident; it is presumed that these facilities would be included if the list of recognized facilities were updated.

Annex 4: ODS project developers

ODS Project Developers	Type of Project Developer	# of Projects	Total Credits	Article 5 ODS Source
Reclamation Technologies Inc. (Remtech)	Refrigerant Distributor	5	3,172,734	1 virgin
EOS Climate Inc.	ODS Project Developer	5	2,428,792	2 in process
COOLGAS, INC.	Refrigerant Distributor	4	1,596,761	2 virgin
Environmental Credit Corp	Diversified Project Developer	9	1,216,004	
Pure Chem Separation LP	Refrigerant Distributor	7	667,873	
Wilshire Stanford Offsets	No Details Available	2	133,718	
Blue Source Canada (for Quebec)	Diversified Project Developer	1	118,000	
EcoSolutions Recycling (for Quebec)	Appliance Recycler	1	???	
(OEKO) Developed by Energy Changes	Diversified Project Developer	1	89,834	1
Polar Technology, LLC (only CCX)	Refrigerant Distributor	2	58,000	
Honeywell	Conglomerate	1	49,621	
Dupont (CCX Only)	Conglomerate	1	40,600	
Refrigerant Exchange Corp.	Refrigerant Distributor	1	21,418	
Hudson Technologies Company (only CCX) **now a partner with EOS Climate*	Refrigerant Aggregator	1	9,100	
Perfect Score Technologies	Refrigerant Distributor	1	???	
Diversified Pure Chem	Refrigerant Distributor	1	???	

Source: CCX and CAR Project Databases (2012)

Of the five largest ODS project developers, only one (Environmental Credit Corp) would be classified as a diversified offset developer; it develops organic waste and livestock methane projects in addition to ODS. The other diversified offset developers have only completed one project each, and it is unclear whether they intend to continue pursuing ODS projects.

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