2022

Integrating Carbon Pricing Approaches

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For
Senior Thesis
Fall 2022
5 December, 2022

Abstract:

Concerns about global climate change and its effects have been steadily growing around the world in recent years. The Paris Agreement has laid out ambitious targets for countries to cut their emissions in order to limit global warming to 1.5 degrees and to achieve net zero emissions by 2050. Carbon pricing mechanisms are an inventive instrument that can help achieve these emissions reductions by placing a price on greenhouse gas emissions, creating incentives for organizations to reduce their emissions. These mechanisms can also help enable the transfers from wealthy nations to developing nations that will be essential for ensuring a just transition to net zero. This thesis evaluates the present state and potential of the three major carbon pricing instruments: compliance carbon markets, carbon taxes, and voluntary offsets. It then presents the issues with each mechanism which need to be addressed for them to function more effectively. Finally, it outlines a manner in which these three mechanisms can be integrated to leverage each of their strengths.

Acknowledgements

I would first like to thank Professor Ascher for his constant support, tremendous patience, insightful guidance, and his unwavering belief that this thesis would write itself. I had never have imagined writing a policy thesis until my classes with Professor Ascher, who sparked a deep interest in me for the policy sciences. I thoroughly enjoyed our meetings where you pushed me to think more deeply about issues.

Second, I would like to thank all my professors at CMC and the Claremont Colleges for always challenging me to view issues through an interdisciplinary lens. Specifically, I want to thank Professor Williams for helping me navigate the nuances of the environmental science aspects of climate change, Professor Evans for helping me understand the economic aspects of environmental policy, and Professor Jurewitz for deepening my knowledge of natural resource economics and my understanding the economics behind energy markets globally.

Third, I would like to thank everyone I have interacted with during my internships throughout my time in college, who have helped me learn how to view sustainability challenges pragmatically. I would especially like to thank Mr. Manish Dabkara, Mr. Pavan Kumar Kundi, and the rest of the EKI Energy Services team for patiently helping understand how carbon markets function in the real world.

Fourth, I would like to thank my family and friends for their never-ending encouragement, support, and willingness to listen to me talk about the nuances of carbon pricing and climate change for longer than is perhaps socially acceptable. I would especially like to thank my aunt, who helped me improve my writing and more generally, to be a better student.

Finally, I want to thank my parents for their ceaseless support, advice, and support not only while writing this thesis, but throughout my time at college. I could not have done this without you.

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Introduction

Climate change is a growing concern around the world and is likely to significantly affect economies around the planet. There is a broad consensus in the scientific community that the rapid increase in greenhouse gases (primarily Carbon Dioxide) since the industrial revolution is perhaps the largest driving force behind this change in global climate. To reduce the extent to which the planet's climate changes, it is critical that GHG emissions are significantly reduced moving forward and that economies transition to lower carbon intensity. However, given the present carbon intensity of economies around the world, this transition will likely take decades, require significant investment and substantial policy support from governments.

The physical evidence for climate change, along with its socio-economic impacts is growing around the world and millions of people have already begun experiencing its results. These effects are likely not only to continue growing but will also accelerate in their impact until GHG emissions are drastically cut, and if possible, their concentration in the atmosphere is reduced. Considering these risks, governments and companies across the globe are committing to drastically cut their emissions and accelerate their climate action.

The United Nations' Intergovernmental Panel on Climate Change (IPCC) has been particularly influential in raising awareness about climate change and in predicting some of the potential effects it may cause. The IPCC released its Special Report on Global Warming of 1.5C in 2018, which drew from thousands of scientific articles and outlines the potential climate impacts of a variety of scenarios that correspond to average increases in global temperatures in 2050 above pre-industrialization levels. The report suggests that a 1.5-degree increase is likely the most ambitious target that is achievable by the global community. However, achieving this goal will require transitioning energy, land, urban, infrastructure (including transport and buildings), and industrial systems at an unprecedented scale in order to rapidly reduce their emissions. The IPCC's Sixth Assessment Report estimates that global emissions will need to be cut by 43 percent before 2030 to limit temperatures rising by 1.5 degrees. The capital expenditure requirements for such a transition are presently estimated at $275 trillion[i] and will require international cooperation to succeed. Increases in average global temperatures above the 1.5-degree level will likely lead to exponentially worse climate outcomes, with an increase of just 2 degrees increasing the number of people exposed to climate-related risks by several hundred million[ii].

Climate systems around the world are already changing and will continue to do so regardless of how much action is taken to limit further changes. Millions of people around the world are already facing the challenges this has created, and the number of people exposed will only increase with time.

The impacts of these increasingly worsening changes will almost certainly be felt unequally across the planet. Countries are likely to experience the effects of climate change to varying extents due to the complexity of climate systems and a variety of physical factors such as their location, geography, and the manner in which their climate systems function. However, the varied effects of climate impacts will likely be amplified by the different levels of resources at their disposal to deal with these changes. Developed nations with high levels of income will have significantly greater resources and technology to mitigate and cushion the impact of climate change on their citizens while developing countries with lower incomes will be far more vulnerable to adverse climate events.

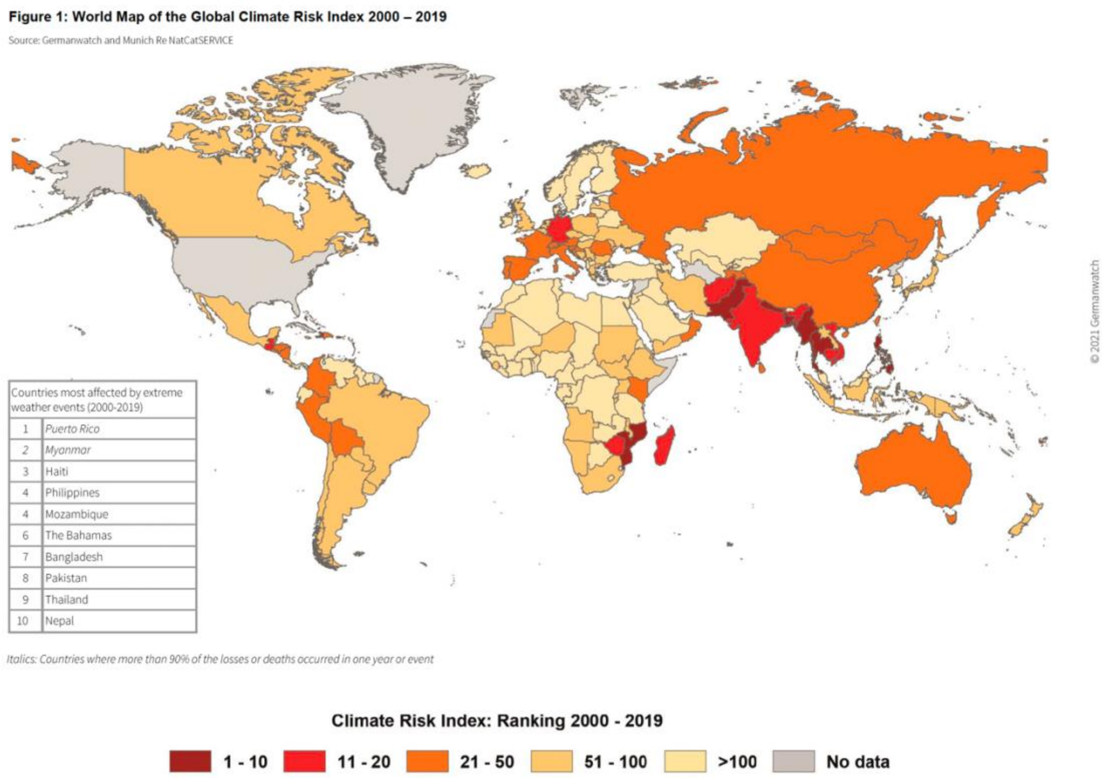

Figure 1. A map showing each country's rank on the Climate Risk Index. Darker colors indicate a higher rank.

Evidence for this phenomenon is already visible today. According to the Global Climate Risk Index 2021, which ranks countries based on climate-related fatalities and economic losses, the ten countries most affected by extreme weather events from 2002-2019 were all developing nations, largely concentrated in South and Southeast Asia, Southern Africa, and various island nations. Forward-looking climate vulnerability studies also indicate that developing countries (especially in Africa and Asia) are at the highest risk for climate-related risk[iii].

In addition to being at the least able to mitigate climate-related risks, developing countries are also simultaneously the least responsible for, and are worst equipped to adapt to fight climate change. These nations tend to be less industrialized, indicating that they are not responsible for the bulk of historical emissions since the Industrial Revolution, and have ultimately contributed less towards climate change. Moreover, they presently possess the fewest financial and technological resources to reduce their emissions and transition their economies to achieve sustainable development. This makes international climate finance mechanisms that provide transfers (financial and technological) from developed to developing countries a critical piece of the puzzle in combatting climate change.

The United Nations Framework Convention on Climate Change

Encouragingly, the global community has recognized the disparity in the abilities of countries to fight climate change, and the principle was formalized in the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro in 1992 as the Common But Differentiated Responsibilities (CBDR) principle. The CBDR principle is mentioned under Article 3.1 of the UNFCCC, under which all countries are responsible for protecting the climate system, but that developed countries should take the lead in combatting climate change[iv]. Article 3.2 of the same framework states that developing countries that are acutely vulnerable to the effects of climate change should receive special consideration from other nations to ensure that its effects are minimized. Articles 3.3-3.5 further expand on the importance of integrating international cooperation with nations' national development policies to ensure that policies relating to combating climate change are carried out in a cost-effective manner which ensures that global benefits are achieved at the lowest cost.

The UNFCCC also divides its 198 parties into three main groups, based on their differing commitments[v]:

1. Annex 1 Parties: These include forty-three industrialized economies that were part of the Organization for Economic Co-operation and Development (OECD) in 1992 and fourteen Economies in Transition (EITs) which consist largely of former Soviet Republics and Russia.
2. Annex 2 Parties: These consist only of OECD members from Annex 1, and not the EIT parties. These parties are required to finance developing countries to undertake

emissions reduction activities under the convention and adapt to the adverse effects of climate change through the Convention's financing mechanism (Article 11). They are also required to "take all practicable steps" to promote development and environmental technology transfers to both EITs and developing countries.

3. Non-Annex 1 parties: These mainly consist of developing countries, some of which are specially recognized by the Convention as being especially vulnerable to climate change.

   The 49 parties that are classified as Least Developed Countries (LDCs) by the UN receive special consideration due to their further limited ability to respond and adapt to climate change. All parties are "urged to take full account" of the especially weak position of LDCs while considering financing and technology transfer.

This classification is helpful as it outlines responsibilities for the parties based on their commitments, which are also correlated to their historical role in contributing to climate change. Most Annex 1 parties underwent heavy industrialization during and/or shortly after the Industrial Revolution. This industrialization was largely carried out using fuels such as coal which emit large amounts of GHGs, meaning that economic growth was directly linked to the countries' emissions. Presently, these countries also consistently emit far more per capita than other nations, which also makes them most responsible for emissions in the present. Lastly, these nations are also on average, far wealthier and have far larger and more technologically advanced economies than other groups, meaning that they can bring far more resources to bear in combatting climate change.

However, the historical link between economic growth and increased emissions does not justify an expectation for developing countries to compromise on their growth to keep their emissions low. Instead, Annex 1 countries should assist developing nations both financially and technologically to ensure that they have the opportunity to grow in a sustainable and low-emissions manner without compromising their ability to grow and improve the livelihoods of their citizens.

Since climate change is a global issue, nations should target emissions reductions worldwide, regardless of where they occur. Addressing and viewing the issue at the global level presents distinct advantages, such as cost-effectively reducing emissions. This is because it tends to be far cheaper to reduce emissions in non-Annex 1 (or developing) countries than in Annex 1 countries. This is due to a variety of factors ranging from stricter emissions regulation in developed countries to the tendency of developing countries to be more reliant on cheaper fossil fuel-based sources of energy such as coal. These factors can perhaps be summarized as 'low-hanging fruit' (which can be addressed through technology transfers and financing), especially when compared to the costs and complexity of reducing emissions in developed countries. In addition to these factors, developing countries' GHG emissions also tend to be associated with high levels of conventional pollutants (such as SO_2, NOx, particulate matter, etc.) since these countries often burn dirtier fuels such as coal. These pollutants produce significant health costs which often dramatically affect the well-being of people. By assisting developing countries transition away from emissions intense processes, developed nations can not only reduce global emissions in a more cost-effective manner, but they can also significantly improve both, health outcomes (and their associated economic benefits) and the quality of lives in developing countries.

However, developed countries should not exclusively help developing countries reduce their emissions. They should also focus on reducing their emissions and investing in technologies that decarbonize emissions-intensive processes. This is because developed nations still emit far more than developing nations and will need to make deep cuts to their emissions to achieve carbon neutrality. Moreover, developed nations tend to be more capable of innovating new technological solutions to reduce emissions (especially in hard-to-abate sectors), which will be necessary after low-hanging opportunities are exhausted.

The Paris Agreement

The Paris Climate Agreement of 2016 was a landmark accord signed by 196 parties (and ratified by 190) and covers a wide range of topics related to climate change and is built on the efforts of the UNFCC. It set a target of preventing the increase in mean average temperatures to 2 degrees Celsius, with a preference to limit the increase to 1.5 degrees. Furthermore, each signatory would create their own Nationally Determined Contribution (NDCs), a roadmap for their climate change mitigation and emissions reduction plans over time. The Paris Agreement is designed to be implemented through the NDCs that the signatories created, which, in turn, would outline their national policies regarding climate change. The agreement also created frameworks to improve international climate finance and technology transfers to accelerate the sustainable transition of developing countries.

While the agreement was applauded for building consensus around climate action, the Paris Agreement was criticized by many environmentalists as it consisted mainly of promises and aims but contained little in terms of firm commitments or binding targets. Specifically, the NDC framework was non-binding and consisted of commitments proposed by national governments. Furthermore, the emissions reduction targets contained in the NDCs presently outlined by the signatories only constitute 20 percent of the emissions reductions needed to limit the mean temperature increase to 2 degrees Celsius[vi] and will lead to at least 2.4 degrees of warming by 2050. Moreover, analysis by the International Energy Agency (IEA) indicates that there is a significant gap between countries' pledges and what their existing policies can achieve[vii]. These data suggest that there is an urgent need for nations to dramatically update both their NDCs and their national policies to limit climate change. Encouragingly, the Glasgow Pact, signed in 2021 as part of the annual United Nations Climate Change Conference (better known as COP27) called on countries to update their NDCs before the next conference scheduled in November 2022, and several large economies such as India, Brazil, South Korea, and the United Arab Emirates have done so[viii].

Article 6 of the Paris Agreement identifies voluntary cooperation between signatories as a mechanism to achieve their NDCs and promote sustainable development. Article 6.4 outlines a mechanism through which private and public entities from one nation can "contribute to the reduction of emission levels"[ix] in another nation to "fulfil [the former nation's] nationally determined contribution". In essence, this mechanism calls for the use of voluntary carbon offsets as a tool for nations to invest in projects that can reduce emissions in other countries. This mechanism will be used to channel transfers from wealthy nations to developing nations, in line with the concept of Common But Differentiated Responsibilities under the UNFCCC. However, the modalities for operationalizing Article 6 have not been completely agreed on as of writing, due to disagreements over how to deal with corresponding adjustments. Corresponding adjustments are an emissions accounting tool used to determine which country can claim the emissions reductions in instances where a nation supports emissions reductions in another.

Carbon Pricing:

Carbon pricing is an innovative mechanism that shows considerable promise in enabling the emissions reductions that will be needed to achieve the goal of net-zero emissions in 2050. Carbon pricing mechanisms force emitters to internalize the environmental cost of their emissions by placing a price on them instead of freely emitting and treating their emissions as an inevitable negative externality. This price on emissions creates a financial incentive to reduce emissions.

Several forms of carbon pricing exist, each of which has its own merits and demerits, and countries around the world have adopted a wide range of mechanisms (shown in fig 1).

Currently, 68 carbon pricing mechanisms exist globally, varying widely by type and jurisdiction. These include 37 carbon taxes and 34 emissions trading systems (some jurisdictions have adopted both). These pricing mechanisms cover an estimated 23% of global GHG emissions.

Present in 38 national jurisdictions and covering over 75% of the emissions under a carbon pricing mechanism (and 17.49% of global emissions)[x], emissions trading systems are by far the most popular form of carbon pricing.

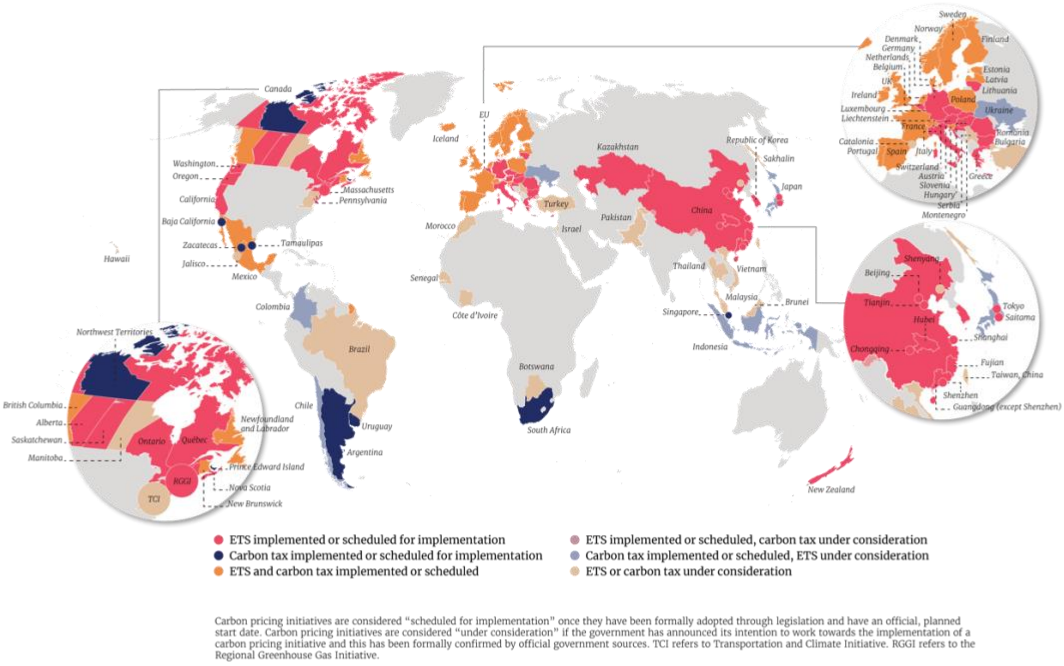

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Figure 2: Status of carbon pricing mechanisms around the world.

The 32 ETS programs implemented across 38 nations make up the regulatory compliance carbon market. Governments, transnational organizations (and regulated corporations) use the regulatory market to trade in credits to ensure their compliance with ETS programs. Most ETS programs operate within the jurisdictions of the nations which implement them[1] with national governments either directly issuing or laying out guidelines for the issuance of credits. The credits issued tend to only be valid within the ETS programs under which they were issued and are of no value outside the jurisdiction of the ETS. For example, a power generation company in the EU can only use EU ETS credits to comply with emissions regulations and cannot use credits issued under the China National ETS for compliance purposes. Therefore, each region with an ETS has its own market for credits. Consequently, the price of credits varies considerably across ETS programs (shown in fig 2) based on several factors including (but not limited to) the number of credits available, the stringency of enforcement, the carbon intensity of the sectors covered under the ETS, and other government policies. In 2021, the regulatory compliance market had an estimated total value of $26.1 billion, with EU ETS contributing the majority with $22.5 billion.

A rapidly growing international voluntary carbon market consisting of offsets issued under various standards also plays a sizeable role in carbon pricing initiatives. As of 2021, the voluntary carbon market is valued at just over $2 billion. This market is expected to undergo explosive growth in the coming years, with estimates of its size in 2030 ranging widely from $10-$200 billion[xii]. However, this market is very unorganized due to the variety of standards and offset types and will require significant reform to grow.

Carbon Taxes

A carbon tax is a form of explicit carbon pricing in which a government sets a price per unit of carbon dioxide (or equivalents) emitted. Industries under the tax regime must pay the tax based on how many units they emit in a certain period, usually with sharp penalties for non-compliance. Carbon taxes can also be placed on consumers by taxing their consumption of

[1] With the notable exception of the EU ETS which applies to all 27 EU member states, three EEA-EFTA states, Iceland, Lichtenstein, and Norway.

energy products such as petrol, diesel, and electricity. Governments then choose how to utilize revenues raised by these taxes.

Tax revenues are generally fungible sources of income for governments, making it difficult to track precisely where revenues raised by a specific tax are spent. Tax revenues are usually aggregated and discussions around how to use new tax revenues typically center around similar broad fiscal policies: new spending, tax cuts, or reduced borrowing by the government. However, since carbon taxes are cast as targeted instruments that incentivize emissions reductions, the policy goals of their associated revenues should be recast to focus on climate change[xiii].

Potential Uses for Carbon Tax Revenues:

1) Offsetting the burdens that the carbon tax will place on the economy
2) Supporting further GHG emissions reductions
3) Mitigating the effects of climate change, including extreme weather events
4) Funding public expenditures unrelated to climate

<u>Offsetting burdens on the economy:</u>

As the scope of carbon taxes grow, they will eventually place a burden across all sectors, especially in the short term since at present, most economic activity produces a certain level of emissions either directly or indirectly. This creates a burden on producers, which is eventually passed on to consumers with higher costs and may cause distributional issues which affect certain groups more than others.

For example, carbon taxes are likely to increase energy prices (especially fossil fuel based) most as the sector will remain reasonably carbon-intensive in the short-to-medium term. This creates distributional consequences as energy expenses constitute a larger share of the budgets of low-income families, and studies suggest that a carbon tax will place a much larger burden on these groups than on higher-income families[xiv]. Similarly, carbon taxes will likely disproportionately place a burden on communities reliant on industries with hard-to-abate emissions (such as coal mining or steel production).

Carbon tax revenues can therefore be used to reduce the distributional effects that carbon taxes may create for certain communities. This can be done in a variety of ways ranging from targeted increases to social welfare programs, reducing regressive taxation, and re-training those affected by the carbon tax, among others. Such uses of carbon tax revenues are also politically useful as they will likely decrease popular resistance to the tax since it reduces the impact it will have on those most exposed to its effects.

Supporting further GHG emissions reductions:

While carbon taxes incentivize reducing emissions, they cannot completely eliminate emissions. Carbon taxes place a fee on emitting GHGs and for some businesses and individuals, the marginal benefit they can receive from emitting GHGs will exceed the marginal cost imposed by the tax. Moreover, it is impossible for certain hard-to-abate sectors (such as cement or agriculture) to eliminate their emissions, regardless of the tax level.

If used to support further GHG emissions reductions, carbon taxes and their associated revenues can be used as sticks and carrots, punishing emissions while incentivizing decarbonization. The tax revenues can be used to create incentives in two main ways: to fund non-specific/general efforts to reduce emissions and to fund targeted efforts to reduce or offset emissions in hard-to-abate sectors. Non-specific efforts to reduce emissions cover a wide range of initiatives, ranging from renewable energy subsidies to building out electric car infrastructure or even funding research into technologies that may help decarbonize. Targeted initiatives, meanwhile, could include subsidizing upgrades to steel or concrete plants that reduce their emissions or encouraging farmers to follow agricultural practices that reduce emissions such as methane and NOx.

This use of carbon tax revenues has the potential to maximize the effect of the carbon tax as it not only incentivizes reducing emissions but also induces behaviors that reduce emissions with the revenues it raises. However, this strategy may be risky since governments decide how to deploy the revenues. Governments are often influenced by special interests and other political economy considerations, which may lead to an inefficient allocation of resources that does not maximize the potential of the revenues to reduce emissions. Moreover, even well-intentioned governments may lack the technical skills and organizational ability to execute certain technical programs and are generally slow at adapting to new information or feedback.

Mitigating the effects of climate change:

As atmospheric carbon levels continue to rise over the next several years, the negative effects of climate change are likely to manifest themselves in a variety of ways. These include (but are not limited to): increasing average global temperatures, rising sea levels, the destruction of sensitive ecosystems such as coral reefs, and the rising frequency and intensity of extreme weather events such as heatwaves, wildfires, and hurricanes. Such events will become more frequent and intense while becoming less predictable. Governments will therefore need to develop the ability to deal with these growing challenges more regularly and effectively. Damages from climate change will also manifest beyond increasingly frequent extreme weather events and will take the form of structural issues such as permanent and temporary displacement as rising sea levels make previously inhabited regions unlivable and increasingly intense floods destroy entire communities and livelihoods.

Governments can therefore utilize carbon tax revenues to mitigate these effects of climate change on their citizens. They may choose to do this in a variety of ways such as by building infrastructure to reduce the effects of sea level rise, helping coastal communities to relocate to less vulnerable regions, to compensating and assisting flood victims, and helping farmers adjust their agricultural practices in the changing climate. The tax revenues can also be used for a variety of climate change adaptation efforts that impact less acutely affected populations such as upgrading existing infrastructure to be more climate-resilient and effective in the long term. Wealthier nations may also choose to provide financial assistance to developing nations through multilateral frameworks since developing nations are simultaneously most likely to be affected by and least equipped to deal with climate change.

Funding public expenditures unrelated to climate:

Governments may also choose to treat carbon tax revenues as other tax revenues and then utilize according to their respective budget priorities. This can take the form of virtually any priority of a government, from reducing a fiscal deficit to investing more in public education.

While this last approach is almost certainly the least impactful in reducing climate change, it raises an important issue; carbon tax revenues are fungible and are therefore difficult to track, especially when considered alongside existing government tax revenues. Moreover, since many potential uses of carbon tax revenues mentioned have broader benefits or also serve other social or policy objectives, it can be difficult to measure how/ how much of these revenues are being utilized for specific climate-related projects. This means that while in principle, governments can earmark carbon tax revenues for specific purposes, it is very difficult to accurately measure if a policy exclusively targets climate objectives since the policies will likely have co-benefits that serve other policy areas.

Such misrepresentations may not necessarily be bad- using carbon taxes to supplement other insufficiently funded budget priorities that create a positive climate impact can constitute their responsible use. This is because it is often difficult to divide the budgets for these programs based purely on their environmental- and non-environmental impact. Such misrepresentations create room for policymakers to misuse revenues, even if they are explicitly allocated for climate-related priorities.

Emissions Trading Systems/ Compliance Carbon Markets

Emissions Trading Systems (ETS) are another form of explicit pricing and are commonly implemented either as cap-and-trade or baseline-and-credit schemes. For a cap-and-trade scheme, governments set a limit (or cap) on emissions for a defined period. Tradable allowances to emit GHGs are then either allocated for free or auctioned based on criteria set by the government to various market players. Emitters must either own or purchase adequate allowances to cover their emissions for the period under consideration. Baseline-and-credit systems meanwhile are usually established by sector and do not set a fixed limit on total emissions. Instead, entities in the given sector can earn credits if they release fewer emissions than the baseline set for the sector. These credits can then be sold to entities that exceed the baseline. At the end of the compliance period, regulated entities must surrender sufficient credits to cover their emissions to the designated regulatory agency which verifies the entity's emissions level.

While cap-and-trade systems are agnostic to the level of output of a sector/producer, baselines (under baseline-and-credit) are usually set per unit of output. Ideally, caps/baselines are reduced over time, thereby reducing the overall emissions in the economy. These instruments also incentivize emitters with lower costs of emissions reduction to pursue these measures, while giving industries with higher costs or longer time horizons for reducing emissions more time to adapt to do so.

Allocating allowances in compliance markets/ under an ETS:

An often-contentious issue when establishing or operating an emissions trading scheme is how to allocate allowances to regulated entities. This is because by capping permitted emissions, allowances become scarce resources that have economic value, reflected by their prices. Furthermore, if producers pass on these additional costs to consumers, their allocation can directly influence how the costs are distributed across society. Therefore, governments must carefully consider the objectives they wish to achieve through an ETS system before determining how to allocate allowances.

Among the fundamental objectives of an ETS is creating incentives for regulated entities to reduce emissions cost-effectively. Since ETSs force entities to internalize the cost of their emissions, production is likely to shift towards entities with lower carbon intensities (ceterus paribus) since they would effectively have lower costs of production. The internalization of the cost of emissions also creates incentives for entities to decarbonize their production since by doing so, they reduce the number of allowances they require. This lowers their cost of production or can create a surplus of credits in their possession, which can be sold to other entities. ETS systems also increase production costs for entities in proportion to their carbon intensity. Since these entities may pass on some of these increased costs to consumers, demand for emissions-intense products will likely fall, as customers substitute these products with those that emit less (and likely have lower costs associated with them).

Given the complicated nature of ETS systems, policymakers must also ensure that they can win support for it from the wide range of stakeholders that they affect. This especially includes the entities that will be regulated under the program since ETS programs by their very nature seem like novel and complicated mechanisms for these entities, especially in their early stages. It is therefore essential to build institutional capacity in both the system's regulators and regulated entities to ensure that they can comfortably navigate the ETS. Moreover, policymakers must ensure that producers understand how ETS systems can significantly alter the structure of an industry (especially those with a high carbon intensity) in the long term through the increased costs they create, so that producers can create plans to minimize the likelihood of economic losses through stranded assets and undesirable impacts on their consumers. Producer awareness can also encourage early investments in decarbonization as producers with low costs of abatement can benefit from new sources of revenue through allowances. While in general, regulators may choose to ease the transition to an ETS through the initial overallocation of free allowances or by relaxing rules, doing so directly undermines the effectiveness of the system in the short term.

An important element of winning the support of regulated entities and ensuring the system's effectiveness is to create structures that prevent producers outside the jurisdiction of the ETS (who do not have to pay for allowances) do not undercut regulated entities through their lower costs. This may cause regulated firms to lose market share in the short term and may lead to better capitalized regulated firms setting up production facilities in regions without carbon pricing to lower costs. Such effects are extremely undesirable as they substantially reduce popular support for the ETS, weaken the domestic economy, affect smaller-scale firms more, and undermine the desired environmental impact of the ETS through carbon leakage. Common approaches to addressing this issue include increased import taxes or tariffs and Carbon Border Adjustment Mechanisms which differentially tax imports based on the carbon intensity of the industry in the product's country of origin. However, such mechanisms are technically complex to implement due to the large amounts of data that are required to estimate country-wise and industry-specific benchmarks of carbon intensity. Other countries also have strong incentives to underreport the carbon intensity of their industries as doing so provides their industries a competitive advantage. Designing a CBAM is also complicated as policymakers must contend with the international fallout that such a mechanism may create such as worsened bi-/multi-lateral relations with trading partners and challenges from other members of the World Trade Organization who perceive the mechanism as unfair. Such mechanisms also create so-called 'walled gardens'[2] within their jurisdictions and substantially increase administrative costs, both

[2] Walled gardens refer to the fact that revenues (and therefore benefits) generated under such a program remain within their jurisdiction. This prevents transfers from wealthy nations to developing nations,

of which can affect global trade in the short term, especially for developing countries that tend not to have carbon pricing mechanisms. In the long term, however, such mechanisms also create strong incentives for countries to establish carbon pricing mechanisms to ensure that their industries can participate in global trade. The European Union is the only major economy considering such a mechanism and will institute a reporting system to gather data in 2023, followed by the CBAM's implementation starting in 2026[xv].

When deciding how to allocate allowances, policymakers should also aim to create a robust secondary market for allowances to ensure their price stability. Doing so encourages the participants to balance supply and demand over time, enabling dynamic price discovery in step with changing economic conditions. That is to say, the price of allowances can change in between auction dates to reflect the economic environment; strong economic growth drives up the price of allowances while slowdowns lower the price of allowances. Creating a robust secondary market can also encourage financial institutions to participate in the market, where they can play an important role in market-making, providing liquidity in the market and reducing price volatility by creating financial instruments that allow participants to hedge against future price volatility. Most regulated entities tend not to directly trade allowances among themselves as they do not have the expertise to do so efficiently. Financial institutions that have this expertise can play a key role in facilitating these transactions through market-making and broking these allowances. Financial institutions may also choose to take long-term positions in allowances if they believe that prices are either too high or too low in the short term relative to their long-term price outlook, lowering the short-term volatility in allowance prices. Allowing financial institutions to participate can also improve short-term liquidity for regulated entities during industry-wide financial downturns as these institutions can purchase allowances from them, providing them with working capital. However, while they have been shown to improve the functioning and efficiency of markets[xvi], it is critical to calibrate the role that financial institutions play in these markets to prevent excessive speculation. Such speculation can lead to increased prices and volatility for allowances which can significantly affect not only regulated entities but can also undermine the system's desired climate objectives. Financial firms' ability to participate in the market should therefore be restricted to a market facilitation and volatility-reducing role which enables them to generate normal profits but also prevents them from dictating the prices of allowances.

Policymakers can also create in-built market intervention mechanisms for these systems such as market stability reserves, auction reserve prices, price floors, and ceilings to reduce price volatility. Market stability reserves act as buffers that purchase allowances during periods of oversupply and sell allowances during supply crunches based on pre-determined criteria such as keeping prices within a certain range. Such interventions can help restrict price volatility, but also must not be overused as they can create price distortions in the market, weakening incentives to reduce emissions.

Methods for Allocating Allowances:

i) Open Auctions: In this method of allocation, regulators periodically invite regulated entities to bid for allowances for a compliance period. This method is a straightforward and efficient method of allocation as entities that value the allowances the most can receive them. This method also raises the largest revenues for the governments since they directly receive auction revenues. These revenues, like carbon tax revenues, may be used in a variety of ways such as lowering the distributional effects the ETS might create.

ii) Free Allocation through Grandparenting: This method utilizes an entity's historical emissions, usually from a common base year, to determine its allocation of allowances. The entities initially receive an allocation of allowances equal to this value. The quantity of allowances is then decreased every year based on how aggressively the regulator desires to reduce emissions. This approach is considered[xvii] to be among the least effective forms of allocation as it produces weak incentives for entities to lower their emissions and creates the potential for firms to gain windfall profits when entities that have low marginal costs of abatement (perhaps due to a historical lack of investment in abatement). Moreover, it can create perverse incentives for firms to emit more during years that are set as the baseline when grandparenting baselines are updated as this would directly increase their allowance for the following compliance period. However, this method of allocation is usually more appealing to regulated entities than its alternatives and is perhaps best suited to being a transitional method of allocation to increase compliance from regulated entities.

iii) Free Allocation through Fixed Historical Benchmarks (FHA): This method of allocation applies sector-specific process- or product-based benchmarks of emissions intensity based on entities' actual emissions. This means that entities that use the same process or produce the same product have the same benchmark of emissions intensity. The firm's output (and not emissions) from a common base year is this multiplied by its emissions intensity to determine the entity's total allowance allocation. As with other allocation methods, the initial emissions intensity is then reduced over time. This allocation method is particularly effective as it levels the playing field for entities since they share the same emissions intensity benchmark, thereby rewarding early movers who reduce their emissions intensity. However, the benchmarks can be difficult to establish in certain cases, such as when entities that produce similar products use different processes to make them. Since establishing these benchmarks is not necessarily a completely objective and exact process, entities may also attempt to influence the methodology of calculation in a manner that gives them an advantage. This method can also affect newly established entities in a sector since they do not have historical output levels for which they can receive a free allocation. In a similar vein, it also discourages the entities from growing rapidly while using similar processes since they will not receive free allowances for additional output over the historical benchmark. Conversely, entities that reduce production from one compliance period to the next will be allocated more free allowances to which they should be entitled. Therefore, short-term changes in production can alter the demand for allowances, causing their prices (and ultimately the incentive to cut emissions) to be distorted, undermining the effectiveness of the ETS. This effect will likely be felt most strongly in cyclical industries for which economic cycles cut across compliance periods.

iv) Free Allocation through Output-Based Benchmarks (OBA): This allocation method uses the same methodology for establishing emissions intensity benchmarks as the previous method but multiplies emissions intensity by the entity's *actual output* during the compliance period rather than a historical value. This method has distinct advantages over FHA since new entrants are not penalized. OBA also reduces the cascading effects of variable production on allowance allocation to a sector, which stabilizes allowance prices and incentives for producers. However, since a sector's cap (and therefore emissions) under OBA is determined by its level of output, this method of allocation makes it difficult for regulators to control the sector's overall emissions intensities, it also has the same disadvantages in terms of the complexity of setting these benchmarks.

Voluntary Carbon Markets

In addition to the regulatory compliance market, there also exists a voluntary carbon market. As its name suggests, voluntary carbon markets do not fall under the jurisdiction of national or transnational authorities or ETS programs. Therefore, unlike the regulatory compliance market, which deals in carbon credits (which allow their holder to emit a 1 ton CO2/e), the voluntary market deals in carbon offsets. These offsets effectively act as certificates that represent the removal, sequestration, or avoidance of greenhouse gas (emissions) and are usually denominated in tCO_2/e. This means that each offset represents one ton of carbon dioxide/ equivalent GHG emission that has been removed from the atmosphere, permanently sequestered, or avoided by certain activities.

Offsets are generated through projects which are evaluated and certified based on standards set by various organizations such as Gold Standard and Verra among others. These organizations are usually non-profits that fund their activities through fees for certifying projects for credits. To meet these standards and generate credits, the projects must adhere to certain core principles including:

- Additionality: The project's GHG reductions are additional if they would not have occurred in the absence of revenues from the carbon market. If the project could have proceeded without offset revenues (i.e., it was economically viable/ was receiving other forms of funding), then the GHG reductions are not additional, and the project does cannot generate carbon offsets.
- Avoiding overestimation: The project's GHG reductions in tons of CO_2/e must be equal to the number of credits it generates. Furthermore, the number of credits generated should account for the emissions caused by the project's development. The project must then be monitored carefully to ensure that claimed GHG reductions are actually achieved throughout its life cycle.
- Permanence: The reduction in GHGs from the project must be permanent and non-reversible as far as possible. In other words, the project must result in a net reduction in GHGs across a long period.
- Exclusivity: Each claim of a ton of GHG reductions can only be used once and is retired after an offset is issued. This is important to prevent the double counting of a project's emission reductions.

- Avoiding social and environmental harm: The project must demonstrate that it does not create significant social or environmental harm at any point of its life cycle. Furthermore, it must comply with the laws of its jurisdiction and should, as far as possible, produce co-benefits in line with the UN's Sustainable Development Goals.

The demand for offsets is primarily driven by corporations and individuals looking to offset emissions caused by their activities. Recently, offsets have become a popular instrument for large corporations to achieve their net-zero targets, with European and energy companies dominating the market.

Lifecycle of Voluntary Offsets

While the process to obtain voluntary offsets varies slightly based on the type of certification being obtained, the overall process is very similar. Outlined below are the steps for obtaining credits that are certified by Verra, one of the largest voluntary credit accreditation programs globally:

First, the proponents/developers of the project must prepare a Planning Document Draft (PDD) for their proposed project. This document is an exhaustive and highly detailed description of the proposed project which is often hundreds of pages long. The PDD consists of 5 main sections: project details, safeguards, application of methodology, quantification of GHG emissions reductions and removals, and monitoring.

The project details section of the report contains general information about the project such as its location, what type of project it is, whether it will be carried out at a single location or if it aggregates activities across several locations, information about all the parties involved in the project, the ownership structure of the project, potential sources of carbon leakage that the program may cause, and an estimate of how many credits the program will generate across its life. Additionally, it also requires developers to disclose if the proposal has been rejected by other GHG programs, if the project reduces emissions from activities that are covered under another emissions trading program or mechanism, and if the project will be used to obtain other forms of environmental credit (such as renewable energy certificates). Developers must also justify that they have the ability to execute the project by providing relevant documents such as regulatory approvals, land deeds, contracts with third parties, etc. as appropriate.

The safeguards section outlines potential negative impacts and the efforts made (or that will be made) by developers to ensure that the projects are carried out in a manner that is not harmful to any of its stakeholders. The section consists of a summary of potential negative and/or socio-economic impacts of the projects, the proposed stakeholder consultation process, how public comments received for the project are assessed, and a summary of environmental impact assessments of the projects if applicable.

In the application of methodology section, developers apply a Verra-approved methodology to estimate the reduction in emissions and other environmental benefits that their project will produce. Methodologies are Verra-approved procedures for quantifying the real GHG benefits of a project. They help developers determine project boundaries, set baselines, assess additionality, and quantify GHG emission reductions. In essence, they are detailed manuals for estimating how many credits a project will generate depending on its type and where it is being carried out. Verra accepts methodologies approved by the Clean Development Mechanism and has approved over fifty additional methodologies itself, with many more in the approval pipeline. In the PDD, developers must choose the appropriate methodology for their project, justify their selection, and provide a summary of their results. Developers must also demonstrate the additionality of their projects in this section, either by applying the additionality tools present in methodologies or through performance methods as outlined in Verra's Standardized Methods for Baselines and Additionality[xviii]. Developers are required to provide detailed information on how the project meets additionality criteria by providing sufficient data for readers to reproduce their analyses to get the same results.

In the quantification of GHG emission reductions and removals, developers must describe the procedure they followed to quantify baseline emissions and/or removals in accordance with a methodology by including all relevant calculations and justifying any deviations from the methodology. Furthermore, developers must provide detailed information about how they quantified potential leakage from their projects based on the methodologies.

The final section of the PDD outlines how the developers obtained the data they utilized while preparing the PDD, identifies data and parameters that developers will monitor throughout the project, and a monitoring plan to collect data for their project which include: the organizational structure and competence of the people responsible for monitoring, procedures for internal auditing and managing non-conformance with the monitoring plan, and detailed information on sampling approaches used (if appropriate) such as target precision levels, sample sizes, etc. After the PDD is completed, it is submitted to Verra.

Upon receiving the PDD, Verra creates a record of the proposal on its registry, thereby formally confirming its receipt. Verra then reviews the PDD to ensure that the project as proposed is an appropriate candidate for the issuance of credits and complies with the prescribed format. If appropriate, Verra approves the project for listing on its registry. If the PDD is deemed to be inadequate in some way, Verra provides the developer with feedback and suggests changes to the proposal. Developers may re-submit PDDs up to two times before Verra automatically rejects a proposal if it is not acceptable by its third submission. Verra charges the developer on a sliding scale per credit the program estimates it will generate.

If approved, the developer must hire a Verra-approved third-party Validation/Verification Body (VVB), usually an environmental consulting/ auditing firm that is a member of the International Accreditation Forum, to validate the information it provides in the PDD. This process requires the VVB to ensure that the developer has the necessary permissions and ability to execute the project, in addition to verifying that the developer has correctly estimated the project's emissions reductions by applying the appropriate methodologies. Once the VVB is satisfied with a PDD, it issues a certificate verifying the PDD to the developer. The developer then submits the PDD along with the certificate to Verra for evaluation.

Developers usually implement their proposals after submitting these documents to Verra. The developers must then ensure that they follow the monitoring plan that details how to track and report the GHG emissions reductions and other data related to the project to periodically create Monitoring Reports, which must then be audited by another VVB to ensure that the data collected by the developer is accurate.

Developers then submit their verified monitoring reports to Verra at the end of each crediting period of the project. Verra reviews the developer's submitted documents for completion and if appropriate, issues VCUs (Verified Carbon Units, the denomination of Verra units), which are then deposited into the developer's account on the registry. Each VCU is assigned a unique serial number, which enables it to be easily tracked across its life cycle in the database, from generation to retirement.

Once the credits are deposited into the developer's account, they may be sold either end-to-end consumers or financial speculators who re-sell the credits. The end consumers for these credits are usually companies seeking to offset their emissions. These companies, who also maintain accounts with the registry, then retire as many credits as necessary based on their commitments. Since credits are retired through accounts with the registry, Verra can track the retirement of specific credits through their unique serial numbers, which prevents their re-use.

The Kyoto Protocol and The Clean Development Mechanism:

The first, and perhaps most ambitious attempt at international carbon pricing was the Clean Development Mechanism (CDM), which was established under Article 12 of the Kyoto Protocol in 1997. The Kyoto Protocol was an international treaty signed by 192 parties with the goal of reducing global GHG emissions to a level that would prevent dangerous changes to the climate system. It recognized countries’ ‘Differing national circumstances’ź[xix] in their ability to combat climate change on account of their level of economic development in accordance with the CBDR principle. It obligated certain countries (listed as Annexure 1 countries) to reduce their GHG emissions over time. The protocol laid out emissions reduction commitments (in annexure B) for these countries as a percent of their emissions in a base year (determined under Article 3.5 of the agreement) and required them to achieve these reductions during the first commitment period from 2008-2012 with clauses requiring the countries to demonstrate progress towards these goals by 2005. The Protocol recognized that the marginal costs for reducing emissions differed greatly by country and established flexibility mechanisms to help Annex 1 countries achieve their targets. These mechanisms were designed to reduce the overall cost and improve the economic efficiency of abating emissions since the marginal cost of abatement in Annex 1 countries was usually far higher than in developing countries. These flexibility mechanisms were:

i. International Emissions Trading: Annex 1 parties could transfer or acquire units to/from other Annex 1 parties as long as both parties satisfied their commitment period reserves (CPR), which required each party to hold a certain number of credits in reserve to meet short-term commitments under the Protocol.

ii. Joint Implementation (JI): Annex 1 countries could invest in emissions-reducing projects in other Annex 1 countries. The emission reductions were measured in Emissions Reduction Units (ERUs), each of which represented a reduction in 1 tCO2/e emissions. These ERUs could be converted to the emissions reductions units that the country needed to satisfy.

iii. The Clean Development Mechanism (CDM): Also, a project-based mechanism, the CDM allowed Annex 1 countries to acquire credits generated through emissions reduction projects or afforestation/reforestation projects in non-Annex 1 parties. Such projects would need to meet detailed verification standards set under the CDM and ensure that reductions/ removals were additional to what would happen in their absence. The CDM board would establish methodologies, approve projects, and issue Certified Emissions Reductions (CERs) generated by these projects. The CDM, in essence, was an international voluntary carbon credit program

The Kyoto Protocol also laid out detailed procedures and rules outlining the accounting procedures for credits, country-wise reduction targets, and transaction rules for exchanging credits. Of the three flexibility mechanisms outlined in the Kyoto Protocol, the Clean Development Mechanism is perhaps the most significant in terms of the number of projects listed under it and is also by far the most controversial mechanism.

The process for creating Certified Emissions Reductions (CERs), the credits generated under the Kyoto Protocol is quite similar to the process for generating credits for the voluntary market outlined earlier. Annex 1 countries that want to fund or participate in CDM projects in developing countries must first obtain consent from the host country to carry out the project. The Annex 1 and host countries then prepare a document similar to a voluntary offset PDDs which outlines a formal proposal for the project which demonstrates additionality, contributes to sustainable development in the host country, and utilizes a CDM-approved methodology to estimate the project's emissions reductions. This document is then validated by a third-party CDM-approved Designated Operational Entity (DOE) to verify the project's additionality and its estimated emissions reductions. After validation, Designated National Authorities (DNAs), which are usually governmental agencies (such as environmental ministries) must review the PDD and determine whether the project contributes to sustainable development based on pre-defined criteria that the DNA sets. The CDM's Executive Board then reviews verified proposals and decides whether to approve the proposal. If approved, the project is executed and CERs are issued to project participants based on the real emissions reductions of the project, verified by the DOE throughout the project's life.

Since its inception, and until 2020, 7,844 projects have been registered under the CDM across 99 host countries by 30 Annex 1 countries. Of these projects, 3,451 projects have been issued a cumulative 5.3 billion CERs[xx]. Together, these projects represent $303.8 billion invested in climate and sustainable development projects, 152 million trees planted, and a reduction of nearly 2 billion tCO2/e reduced in the developing world[xxi]. This data suggests that the CDM operated at a far larger scale than any other climate-based transfer scheme.

The Clean Development Mechanism: A Brief Timeline

The first few years after the adoption of the Kyoto Protocol witnessed very few projects being undertaken under the CDM, however, this was not unexpected given the novel nature of the program which also resulted in the CDM's oversight bodies being understaffed and underfunded[xxii]. Moreover, the first commitment period of the Kyoto Protocol was only scheduled to run from 2008-2012, and countries were, therefore, cautious before submitting their first projects for this brand-new scheme. The CDM began gaining momentum only in 2005 when these initial teething issues were addressed and the first trades of CERs began. From 2005 onwards, and until the end of the first compliance period in 2012, the market for CERs saw steady growth, and CERs were widely traded at major commodity exchanges around the world. It is worth mentioning here, that demand for CERs was also strongly driven by the EU ETS compliance program, which was launched in 2005, and allowed CERs to be freely converted to EU ETS credits at a 1:1 ratio.

The CDM's 1st Commitment Period (2008-2012) was perhaps its most successful and witnessed widespread support from most countries. During this period, 6,253 out of an eventual total of 7,844 projects were registered, CER prices reached their all-time high of 25 Euros in 2008 and approximately 1.2 billion CERs were issued. However, towards the end of 2012 (the end of the commitment period), CER prices fell to approximately 0.5 Euros, signaling a collapse of the CDM as a whole.

Subsequent years saw only 296 additional projects being registered under the CDM, and the CDM's Executive Board announced that it would not accept applications for new projects after the end of the second compliance period, which ended in 2020[xxiii]. The primary justification for this was the fact that the Kyoto Protocol had only planned for two compliance periods, both of which had ended. The collapse of the market after 2012 also resulted not only in little interest from stakeholders in the mechanism, but also extremely low prices for CERs. The Paris Agreement also introduced Nationally Determined Contributions (NDCs) as the primary means for countries to lower their emissions, leaving the status of the CDM in question. Moreover, the modalities that would enable the functioning of a new emissions trading system (and indeed if the CDM in its erstwhile form would remain) under Article 6 of the Paris Agreement had not been agreed upon by the countries before the 2nd Commitment Period had elapsed. The majority of the guidance to operationalize Article 6 was completed at COP26 in 2021. The pending guidance related to Article 6 is largely related to the issue of corresponding adjustments[3] and how voluntary carbon offsets can be accounted for. This guidance suggests that Article 6.4 of the Paris Agreement would function as an evolution of the CDM but does not state that the CDM itself will be revived.

Collapse and Criticism of the CDM

[3] A corresponding adjustment is a carbon accounting tool designed to prevent the double counting of emissions reductions in the NDCs of countries trading offsets.

The CDM has faced criticism from academics and certain stakeholders since its early days across a wide range of topics related to its design, implementation, and administration. It has also been a victim of multiple exogenous events and decisions that have hindered its success. While the failure of this program cannot be pinpointed to a single flaw, each of these factors contributed to its eventual fate. It is important to understand these criticisms while proposing any future mechanisms of this type, to ensure that similar errors are not repeated.

Exogenous Factors:

In 2011, the European Commission announced a list of wide-ranging restrictions on CERs that it would permit for use under the EU ETSs' third compliance phase from 2013-2020. Its qualitative restrictions excluded CERs from all projects related to nuclear energy, afforestation, and deforestation (including all Land Use, Land Use Change, and Forestry), destruction of industrial gases (HFC-23 and N_2O), hydroelectric projects with over 20 MW of capacity[4], and the use of projects/CERs issued after 2012 unless registered in least developed countries. It also placed quantitative restrictions on CERs by limiting the maximum number of CERs that could be used by individual entities and the EU ETS as a whole. These decisions rendered the vast majority of CERs ineligible for use in the world's most important compliance market, which was also the single largest source of their demand.

Several factors contributed to this decision. First, the EU reported that 1.058 billion CERs were used by participants during phase 2 of the EU ETS (2008-2012). The widespread availability of internationally generated CERs that were priced significantly lower than intra-regionally produced permits caused a major slump in the price for these EUR permits. As a result, member countries of the EU received far less income from these projects than initially expected. This was a matter of concern, especially among former Soviet bloc countries which lagged behind their wealthier western European counterparts in their efforts to reduce

[4] Projects above this limit would need to meet certain conditions.

emissions. By doing this, the Commission hoped to increase transfers to these countries in the hopes of driving sustainable development.

Another significant exogenous event contributing to the collapse of the CDM was Japan's retreat from its commitments to the Kyoto Protocol following the accident at the Fukushima Daiichi Nuclear Plant in 2011. Following this disaster, all nuclear plants in Japan were shut down, and the electrical grid was returned to using conventional sources of energy. A political decision was made by the government of the time to not set numerical targets for the Kyoto Protocol's 2nd Commitment Period and that the Japanese government, therefore, would not purchase any CERs.

Since a significant driving force behind the creation of the CDM was to make it easier for the EU and Japan to reduce their emissions[xxiv] in a cost-effective manner given their high costs of abatement, these decisions dealt a significant blow to the CDM as a whole. The resulting reduction in demand led to a surplus of an estimated 1.2 billion CERs, flooding the market, and was a major contributor to the crash in CER prices during 2012.

Design-related Criticisms of the CDM

Among the most significant criticisms of the CDM is the criterion of additionality that all projects were required to satisfy to be approved. Additionality is central to the environmental integrity of the CDM as it aims to ensure that its projects would not occur in the absence of the CDM (and its associated revenues). That is, if some emissions reductions can be achieved in the business-as-usual (BaU) environment (i.e., in the absence of the CDM), but the project is still approved, the CDM would effectively be paying the opportunity cost of not allowing another emissions reduction activity that would not take place in a BaU environment. Therefore, a project that creates emissions reductions through BaU could effectively claim more credits than it should be entitled to under the CDM. Establishing accurate BaU baselines for projects is therefore critical to ensuring the environmental integrity of the CDM.

However, establishing accurate BaU baselines can be extremely difficult since they are by their very nature hypothetical and therefore somewhat subjective estimates of emissions reductions. These estimates are usually prepared by project developers who have a material interest in minimizing the baseline/ estimated emissions reductions in a BaU environment as it allows them to claim the most credits for their projects. Moreover, there is also a wide range of information asymmetries between developers and those assessing additionality. To address this, the CDM's Executive Board developed a 'Tool for the demonstration and assessment of additionality'[xxv] which outlines a detailed methodology for developers to follow to demonstrate additionality. However, while this tool lays out the procedure for demonstrating additionality, the diverse nature of CDM projects and their implementation in dramatically varied contexts creates major loopholes that can be exploited. For example, a study evaluating the additionality of 1,350 wind farms in India (a context where the CDM was expected to drive significant development above the baseline) found that at least 52% of CERs were issued to projects that would likely have taken place without the CDM, making them effectively non-additional[xxvi]. These projects were claimed to be additional using a wide range of questionable assumptions ranging from an additional distance of 3 miles from the turbine to the sub-station than another non-CDM wind farm built in the same year, to claiming significantly higher installation costs than comparable projects. Other studies have also found that it is easier to demonstrate additionality, claim excess credits and exploit loopholes in CDM methodologies than others[xxvii]. Widespread coverage of this type of fraud has drawn mistrust and affected the credibility of not just the CDM, but also of offsetting more generally.

Another major criticism of the CDM is that it created perverse incentives in certain types of projects (notably HCF reduction projects)[xxviii] that encourage developers to increase emissions before proposing an emissions reduction project. By doing this, developers can state a higher baseline emissions scenario before claiming not only the ‘real’ reductions of the project but also the ‘artificial’ reductions that they created. This was particularly the case in a large number of projects aimed at reducing HCFC gases, a major class of refrigerants that have approximately 1,810 times the warming effect of carbon dioxide. An analysis of these projects found that HCFC emissions were significantly lower during periods where no emission credits could be claimed as compared to periods when emission credits could be claimed.

The CDM was designed to assist Annex I parties in achieving cost-effective emissions reductions and help with transfers to less developed countries in part because these nations were by far the biggest emitters in 1997; Non-Annex I parties, meanwhile, were not required to reduce their emissions under this mechanism as they tended to emit less and had a lower capacity to reduce their emissions. This aspect of the CDM has been problematic as, since 1997, many non-Annex 1 countries have seen rapid economic growth and industrialization (especially large countries such as China, Brazil, and India), making them some of the largest emitters of GHGs. Since the CDM does not require these countries to reduce their emissions, it is almost certain that it would not bring about the necessary decreases in GHG emissions to achieve its targets.

The manner in which the CDM is structured can create a financing gap for project developers since in many cases, they only receive credits years after the project is approved. While this gap is a result of the CDM’s verification process to ensure that the projects achieve their estimated emissions reductions, it can pose a challenge to the execution of projects since they usually require an upfront investment. This is especially the case in low-income countries where local project developers do not have access to adequately cheap credit and financing options. This has likely also contributed to the concentration of projects in the wealthier developing nations where developers have better access to financing.

The core of the CDM's process for estimating emissions reductions is the baseline and monitoring methodologies that are approved by the Secretariat and applied by project developers to estimate their emissions reductions. While at first glance, the over 250 such methodologies may appear to cover most types of potential projects, in reality, the level of detail to which the methodologies must conform with means that in many cases, approved methodologies may only apply to a specific project. This is because the methodologies provide detailed step-by-step instructions for estimating emissions reductions that are backed by evidence in the form of scientific papers. Due to this level of detail, however, many methodologies (especially those for nature-based projects) are highly specialized and only apply to specific geographies or countries. This is because of variations in factors such as soil composition, the biology of native flora, and local grid emissions factors among others which affect the estimation process. Consequently, project types and locations are constrained by the methodologies that are available to developers.

The cost of developing projects that cannot directly employ existing methodologies also varies widely depending on their nature. For example, developing projects that employ existing processes with accepted methodologies, but in new contexts (for example, in a new country), can be relatively inexpensive as they usually only require local estimates of certain parameters used in calculating the baseline and emissions reductions. Developing a methodology for a completely new process, however, can be significantly more expensive as it can often require scientific studies to be carried out (sometimes over extended periods of time) to accurately estimate these values. Developing or revising methodologies for nature-based approaches is also usually more expensive as estimating their effects is far more complex and involves far more variables than technology-based approaches which can often be simulated and tested in far more controlled environments.

A significant consequence of this methodology-based approach is that it stymies the development and adoption of new technologies for reducing or capturing emissions while encouraging the deployment of existing approaches. This approach has certainly served as a good quality-control mechanism as it favors projects that employ methodologies that are better studied and understood, however, it also discourages developers from exploring and developing projects that use new and innovative processes. This may be undesirable since carbon finance can be an effective tool to fund the development of emerging technologies that are not yet commercially or financially viable alone. This funding can also play an important role in driving down the costs of such technologies over time, perhaps making them non-additional and commercially viable.

Implementation-related Criticisms of the CDM:

In addition to the criticisms of the CDM related to its design, the manner in which it has been implemented over its many years also led to criticisms.

A concern raised a few years into the mechanism was the fact that CDM projects were very highly concentrated in only a handful of countries. For example, the five countries[5] with the most projects listed accounted for 80% of projects worldwide. In fact, China and India alone accounted for 48% and 21% respectively of the total registered projects (and account for similar proportions of issued credits). To a certain extent, this concentration of projects in these large developing countries is understandable given the size of their economies, populations, and their stages of industrialization, this level of concentration was unexpected. As a result, these few large (and relatively advanced economies) received the bulk of the benefits, while other countries, especially those in sub-Saharan Africa and Central America, gained little from the CDM in terms of financial benefits and technology transfer.

[5] China, India, Brazil, Vietnam, and Mexico

Although CDM projects are required to demonstrate how they contribute to sustainable development in their host countries, in practice, many projects not only failed to contribute to sustainable development but also caused or exacerbated a wide range of existing issue. Examples of these issues range from an encroachment on indigenous lands for a hydroelectric project in Panama[xxix], to a landfill methane-reduction in which unsegregated waste was incinerated without emissions capture technology approximately 30 meters from a residential area in India and also includes a monoculture reforestation project in the 'degraded' shrublands of Uganda (which included spraying the saplings with chemical pesticides) that destroyed the biodiversity of the local ecosystem, killing a variety of indigenous animals and plants[xxx].

In many cases, the process of determining whether a project contributes to sustainable development has been blamed for this shortcoming[xxxi]. This is because Designated National Authorities (which are governmental bodies responsible for setting the criteria that determine if a project contributes to sustainable development) have incentives to not only set weaker criteria but to also approve projects that may not fully fit these criteria as rejecting projects would likely lead to CDM funds being directed elsewhere. This issue with the CDM also increases the risk of DNAs facing captured, especially by the developers of large projects as they often stand to gain the most by having their projects approved. In a similar vein, criticism has also been leveled over the lack of formal redressal or accountability mechanisms through which stakeholders can appeal to any organization involved in the CDM to protest projects that may affect them or on other grounds.

Concerns surrounding the permanence of reductions/removals of many CDM projects have also been raised, especially for forestry (afforestation/reforestation) and LULUCF projects. This is because the reductions/removals of carbon from these projects are at the highest risk of unintentional reversal as these projects are exposed to external and environmental factors such as plant diseases or forest fires that release large amounts of emissions, effectively invalidating the credits issued for such projects. Moreover, such risks are only likely to increase with the increasing frequency of extreme weather events caused by climate change in the coming years. These projects also face a risk of partial/complete intentional reversals by stakeholders in the project in cases where a project is terminated before its minimum project term. For example, certain farmers who are part of a no-till project may decide to till their soil, thereby releasing sequestered carbon. Such reversals affect the credibility of the CDM since the credits issued for a project no longer represent the actual reductions/removals they claim to. It is also very challenging for the CDM to address such situations post facto since credits issued for a project are fungible and may be distributed across several holders, making it impossible to identify which specific credits represent the reversal. Moreover, the CDM cannot unilaterally invalidate credits that have already been issued.

Issues With Voluntary Carbon Markets:

The Clean Development Mechanism and voluntary carbon offset programs are very similar in terms of their design and implementation. In fact, the process for creating voluntary carbon offsets is largely based on the process developed by the CDM, but with different bodies responsible for the various governance and verification functions. Most voluntary offset standards also accept CDM methodologies (with some exceptions) alongside their own methodologies, which undergo a similar approval process. As a result, voluntary carbon offsets face many of the same criticisms as the CDM. These include concerns about additionality (and therefore integrity), perverse incentives for certain types of projects, the financing gap, permanence, and the aforementioned issues about methodologies. Concerns over additionality are greater for voluntary markets as several different sets of standards exist, making it difficult to monitor each of them compared to the single set of standards of the CDM.

However, there are also certain areas where the two mechanisms differ. Since the CDM is an UN-administered program that aims to encourage wealthy countries to fund emissions reduction projects in developing countries, nations (and by extension their governments) were usually involved in transactions and projects. Credits were therefore sold by non-Annex I countries to Annex 1 countries, who were obligated to purchase them to fulfill their Kyoto Protocol commitments. Voluntary markets, meanwhile, are open to individuals, corporations, governments, and most other types of entities. They are also decentralized since transactions can occur between any parties that hold an account with the relevant credit depositories/registries. Voluntary credit markets also face certain other challenges compared to the CDM.

One of the largest issues with voluntary carbon markets, ironically, is the lack of a major and centralized marketplace for transactions to occur. Virtually all transactions of voluntary credits are executed over-the-counter (OTC) between developers, brokers, and end customers. This market structure creates many inefficiencies and can severely distort the market for voluntary credits. Firstly, this creates significant information asymmetries for both buyers and sellers since they are unaware aware of market-wide transaction volumes and prices. Sellers can therefore not only quote different prices to different customers but also affect liquidity in the market by temporarily withdrawing if they believe prices are too low, which makes price discovery very difficult. This significantly reduces the efficiency of these markets since prices can be more strongly affected by the relationships between parties than by supply and demand. Large sellers can also collude to set market prices since they exert significant influence over the market. However, these distortions go further than making it more difficult to execute transactions.

The opacity of the voluntary credit markets also makes it very difficult for participants to receive the longer-term price signals or trends necessary to establish a medium-to-long term strategy for carrying out their transactions. This makes the market very volatile as participants cannot predict future price movements or even credit availability. Together, these factors create an extremely unstable 'market' for voluntary credits. This instability, when combined with doubt over the effectiveness of voluntary credits in fighting climate change, makes it difficult for buyers to trust in the system, and ultimately serves as a major barrier to their meaningful participation.

It is important to acknowledge, however, that the OTC structure of the market has not emerged on account of a lack of efforts to centralize transactions at exchanges. Many dedicated exchanges for voluntary credits have emerged around the world such as the Singapore-based AirCarbon Exchange (ACX), the U.K.-based Carbon Trade Exchange (CTX), and the US-based Toucan and Xpansiv exchanges. However, none of these have achieved sufficient scale to emerge as effective exchanges and only have a few hundred clients each[xxxii]. Several established stock exchanges (such as the SGX, HKEX, and London Stock Exchange among others) have also attempted to leverage their expertise by creating exchanges for voluntary credits but have not gained much traction.

The reason behind this failure to create an effective marketplace is the wide range of international standards for voluntary credits, the slightly different niches they serve, and the variation in the prices of credits generated by different types of projects. While the Verra and Gold Standards are by far the most widely used international standards, several other organizations also issue voluntary credits. For example, the American Carbon Registry follows its own standards which are based on the International Standards Organization's standard for quantifying GHG removals (ISO 14064-1:2018). Similarly, Planet Vivo has created its own standards for offsets that focus on forestry, agriculture, and other LULUCF projects with a special focus on sustainable development, improving rural livelihoods, and boosting ecosystem services.

In addition to these different standards, many of these organizations also issue different kinds of credits or additional certifications if projects meet certain requirements. For example, while all Verra-issued credits are denominated in VCUs (Verified Carbon Units), the VCUs generated by certain projects can gain additional Climate, Community & Biodiversity (CCB) labeling if they meet the standards set by the Climate, Community & Biodiversity Alliance[6]. Projects following Verra's standards can also gain Sustainable Development Verified Impact Standard (SD VISta) certification if they meet the requirements laid out by Verra to promote the UN's Sustainable Development Goals. These additional certifications increase the price of credits as the projects that generate them are more complex and deliver benefits beyond simply reducing emissions.

Beyond the different standards that projects follow and the additional certifications that they may obtain, several aspects of the project itself also affect the price of the credits it generates. This is because projects that create co-benefits tend to command higher prices than those simply focused on reducing/removing GHG emissions. For example, agriculture-based programs often create co-benefits for local communities and their ecosystems, and their credits commanded the highest average price of $8.81 in 2021. Meanwhile, transportation-based projects primarily aim to reduce emissions, and credits from these programs had the lowest average price of just $1.16. Certain buyers also have preferences for the types of projects from which they wish to purchase credits. For example, certain corporations have well-defined corporate social responsibility strategies or focus areas and would prefer purchasing credits from projects that affect change in similar domains, are located in regions that they operate or, other such factors. This increases the demand for certain types of projects. The table below illustrates the wide range of average prices for carbon credits that emerge from these different factors.

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[6] A partnership of many leading environmental organizations such as CARE, Conservation International, the Nature Conservancy and others

Project Type	Volume (MtCO2e)	Average Price (USD/unit)	Value (Million USD)
Forestry and Land Use	227.7	5.80	1,327.5
Renewable Projects	211.4	2.26	479.1
Chemical/ Industrial Processes	17.3	3.12	53.9
Waste Disposal	11.4	3.62	41.2
Energy Efficiency/ Fuel Switching	10.9	1.99	21.9
Household/ Community Devices	8.0	5.36	43.3
Transportation	5.4	1.16	6.3
Agriculture	1.0	8.81	8.7

Table 1. Voluntary Carbon Market Transaction Volumes, Prices and Values by Category (2020-2021)[xxxiii]

The price of credits is also affected by other factors such as the country in which the project is located, their age (or vintage), the reputation of the developer, the effectiveness of the project in communicating its effects, whether the project results in removals or reductions of GHGs, among other factors. It is clear, therefore, that despite being denominated in units of emissions reductions, that voluntary carbon credits are an extremely heterogenous commodity that commands vastly different prices. This heterogeneity makes it extremely difficult to list and trade carbon credits on exchanges like other asset classes such as equities and futures.

Operationalizing Voluntary Credit Markets:

Given the somewhat dysfunctional state of voluntary carbon markets today, it is critical that its issues are addressed so that it can achieve sustained growth in the long term and can fulfill its potential for addressing climate change. The first step in achieving this will involve improving the quality of credits and harmonizing the various standards for voluntary credits to enable their direct comparison. Next, awareness about the effects of different project types will need to be raised among all stakeholders to catalyze a change in the types of projects undertaken in the future so that they align with both, the IPCC's scenarios for limiting the warming by 1.5 degrees Celsius and the Paris Agreement's goal of achieving net zero emissions by 2050. This will involve shifting away from avoidance and reduction credits with short-term storage to carbon removal projects with long-term storage. After this, a reliable marketplace will need to be established to facilitate transparent transactions of credits. Finally, steps should be taken to bolster demand for voluntary credits to build resilience in the market and to further promote projects.

Step 1: Improving Offset Quality and Harmonizing Standards

Improving the quality of carbon offsets is perhaps the most important step toward operationalizing voluntary carbon markets since offset quality is directly linked to the trust that potential buyers have in the system. Since this system is entirely voluntary, building trust in both the effectiveness and validity of offsets as a tool to help address climate change is an indispensable element in engaging buyers. This is especially relevant in recent times due to the widespread criticism and negative perception that voluntary offsets have received in recent years from popular media, which question their integrity[xxxiv],[xxxv],[xxxvi]. Improving the quality of offsets will require several of its criticisms to be addressed.

The additionality criterion often draws widespread criticism in conversations about the quality of carbon offsets, and in many cases, rightfully so. Many studies (some of which are mentioned earlier) have highlighted the ways in which its ambiguities have been abused by developers to gain access to carbon financing. However, despite its flaws and the challenges that it may have created, additionality is a key conceptual aspect of carbon offset design. While the manner in which it is used can, and perhaps should be improved, eliminating it entirely would be akin to throwing the proverbial baby out with the bathwater.

The additionality of projects has be justified across a wide range of parameters such as financial (where the returns of a project are deemed insufficient without carbon financing), technological (where emerging technologies are deployed), and social (when new behaviors are introduced to communities) among others. These justifications are extremely diverse and are sometimes very difficult to prove as they rely heavily on theoretical counterfactuals. Moreover, evaluations of these counterfactuals can also vary significantly as they are very context specific and can rely on complicated indicators. This expansive, perhaps ill-defined, and somewhat subjective definition/criterion for additionality, however, is in fact an important feature. This is because offset projects are extremely diverse in nature and are executed in a tremendously wide range of geographies and contexts. This diversity makes it nearly impossible to establish rigid thresholds or criteria for additionality across these parameters, especially since the context of these activities constantly changes over time. For example, renewable energy projects in India and China could be considered additional in the early 2010s as there were very few such projects in these countries, their regulatory environment was ill-defined (in terms of power offtake), and their costs were very high. However, as time passed, more projects were developed, the regulatory environment became better defined and costs were driven down significantly enough for these projects to become viable, and therefore non-additional. Most renewable energy projects after 2020 in these countries were then declared ineligible for offsets by the CDM and Verra. However, these projects can still be considered additional not only in many countries in sub-Saharan Africa but also in extremely remote parts of India and China that do not have well-established electricity grids for the same reasons. Therefore, it is desirable for those assessing additionality to be granted some discretion when evaluating projects, and to leave a degree of ambiguity in the criteria for additionality.

However, granting this discretion and ambiguity necessitates measures to ensure that the assessors of additionality are as qualified to make this decision as possible and have access to the best available resources to inform their decisions. Achieving this will require experts from a wide range of disciplines to ensure that the many types of additionality claims can be reviewed effectively. Gathering and organizing such a wide range of expertise will also require a significant degree of institutional capacity to ensure that resources are used effectively. Therefore, leveraging existing institutions that possess specific domain knowledge and experts to assess additionality may be an effective strategy. For instance, experts at the Energy Sector Management Assistance Program (ESMAP) at the World Bank can be asked to assist with assessing additionality for energy-related offset projects. While these organizations may not have the capacity to evaluate each project, they can be consulted from time to time to assist with determining additionality. This is most effective in cases where temporal factors affect the context of projects since these experts are usually aware of these changing circumstances. To minimize the risk of delays due to excessive bureaucracy, rules can be put in place to ensure that only projects that require a second opinion from these organizations receive it. Records of previous applications for projects (both approved and rejected) across offset standards should also be compiled and made easy to access by assessors as they provide the most relevant comparisons for new projects. This will make it easier for assessors to evaluate the contexts of projects more effectively.

The next criticism that requires closer examination is the fact that many projects have adversely affected the local communities and environment. Although developers are required by all standards to explain how their projects do not cause social or environmental harm, in many cases, projects are carried out in a manner that leads to them. It is also nearly impossible for standard-setting organizations to directly monitor each project to ensure that this does not occur. However, one way of addressing this issue is to expand the responsibilities of the independent verification bodies beyond verifying actual emissions reduction/removals to include assessing whether projects affect their communities or the environment. However, doing so does create an incentive for developers and verification bodies to collude since the verification bodies depend on developers for business, and the termination of a project will reduce business for the verification bodies. This concern can be addressed by creating redressal mechanisms through which those affected by a project can appeal directly to the standard setting organizations, which can then investigate the claims and penalize the verification bodies and developers if necessary. Alternatively, rules can be established to mandate a rotation of verification bodies at fixed intervals to reduce collusion. Additional certifications, such as CCB for Verra credits, that increase the value of offsets are also a great tool for incentivizing developers to design responsible projects that promote sustainable development.

The issue of permanence also requires closer examination since offset standards use a wide range of methods to address it. The most common approach, used by Verra, Gold Standard, the California Air Resource Board, and the American Carbon Registry is the buffer pool. This entails setting aside a fixed percentage of offsets in a reserve account (usually held by the registry itself), which is determined by a risk assessment of the project. In some cases, the reserve offsets are held in perpetuity, while in others, some credits are returned to the developer after predetermined intervals. The Australian Carbon Farming Initiative, meanwhile, uses an account-and-replace strategy in which reversals are quantified by verification bodies, and developers are required to replace the reversals with offsets from other projects, or from the marketplace itself. The Alberta Offset System uses a discount factor (determined by the project's risk of reversal) to reduce the offsets claimed by a project. Each of these approaches has distinct advantages and disadvantages that need to be explored in a scientific manner to determine which approach is most effective.

Harmonizing the many different offset standards into a uniform standard denominated in a common set of units can also create a variety of benefits for voluntary carbon markets. First, it allows comparisons between offsets issued under different standards to be directly compared to each other, which substantially reduces the complexity of voluntary carbon markets for potential buyers. Buyers will also have more confidence when purchasing offsets since they will follow the same standards, eliminating the uncertainty over the quality between different standards. Second, establishing a uniform standard substantially reduces the cost, complexity, and difficulty of changing the process of creating offsets. This will allow the market to adapt in response to evolving demands and trends. A uniform standard also simplifies the process of creating a robust market for trading offsets as it substantially reduces the varieties of offsets traded, which is a major barrier today.

The process of harmonizing different standards, however, will be a complicated and difficult process due to the variety of standards, the large number of projects registered under each, and the privately held offsets that have been issued to date. Moreover, many projects have lifecycles that extend over multiple decades, and changing them midway can create many unexpected issues. However, the benefits that this process can create justify this undertaking, especially considering the fact that voluntary carbon markets are still in their early stages and are expected to grow considerably in the coming years.

The complicated nature of this undertaking will necessitate an organization with considerable technical expertise, experience in developing a new standard from existing standards, and substantial credibility to oversee the process. The International Organization for Standardization, for example would be one such body that can oversee this process, given its expertise in doing so. The process itself can be carried out in a variety of ways but will need to achieve two main goals. First, the methodologies used by the various standards for estimating emissions reductions/removals would need to be standardized. Next, these new methodologies would need to be applied to existing projects to re-estimate the quantity of offsets the projects will create in the future. Second, a new set of units will need to be established which to some degree account for the diversity of existing units. For example, it may be worthwhile to create special labels or unit types to account for additional certifications such as Verra's CCB as these offsets are more valuable and create many additional positive benefits. Conversion factors and mechanisms will then need to be established to convert existing units into the new standard.

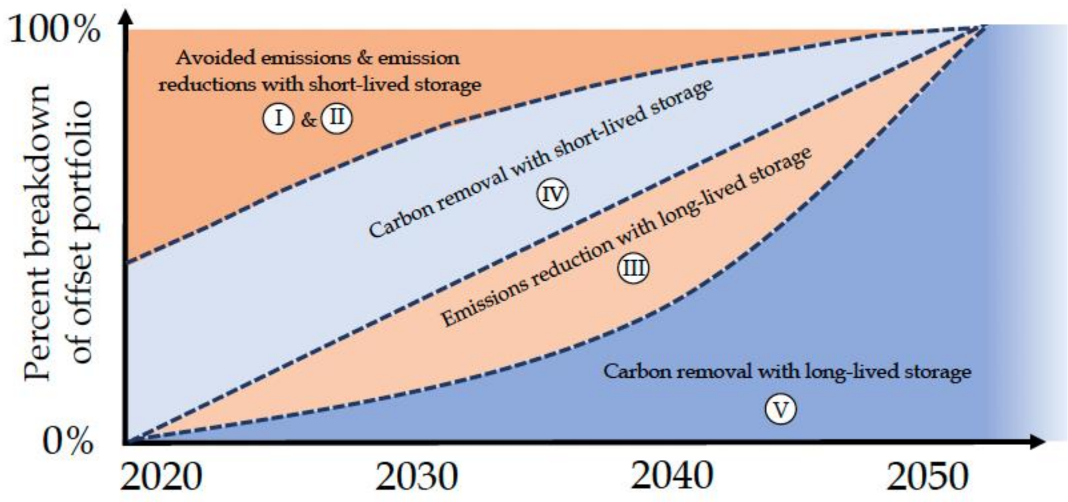
While this process will be difficult, certain aspects can be carried out in a phased manner over time. It would perhaps be most effective to first establish the new standard and finalize its methodologies to ensure that all new projects follow this standard. The process of grandfathering existing projects and offsets into the new regime can then occur during a transition period in which the conversion factors between standards can be established and applied to existing projects. This process can begin with the methodologies that are most similar such as CDM methodologies that are accepted by most standards (and therefore easiest to convert), and then gradually move on to more complicated conversions. Measures will likely also need to be taken manage opposition from existing standards since they will likely oppose the creation of a uniform standard. One way of doing this will be to recruit significant portions of their employees into the new regime. This will help preserve the specialized knowledge required to operate the standard effectively and ease their transition away from the old standards.

Step 2: Changing the nature of projects in the long run

Presently, most credits are generated from emissions reduction projects or carbon removal projects with short-term storage. But while such credits are necessary to achieve and maintain net zero in the long run, they alone are not sufficient. To achieve this goal, offsets must shift towards removal credits that reliably sequester GHGs in the long run. This can offset the ongoing residual emissions that will continue to be emitted even after deep cuts are achieved (especially for hard to abate sectors and industries) and enable the state of net zero emissions to be achieved. The switch can also enable sufficiently motivated parties to achieve negative emissions / be net absorbers of GHGs from the atmosphere.

While the nature of offsets will need to shift towards removals in the long term, emissions reductions will still be necessary for several decades. These projects involve preventing or reducing emissions that would otherwise occur by changing behaviors or introducing new technologies such as convincing farmers to switch to no-till agriculture which reduces carbon emissions compared to practices that involve tilling as it ensures that naturally occurring carbon remains stored in the soil. Meanwhile, most removal projects today adopt nature-based solutions for capturing GHGs and sequestering them in short term storage, usually within their ecosystems (often as organic matter), such as afforestation projects.

Achieving net zero in the long term, however, will require both reduction and removal credits to shift towards long term storage. This is because short-term storage methods face a constant risk of reversal through which GHGs can be released into the atmosphere, raising concerns about their permanence. Offsets that store carbon in the long term will need to be generated through projects that employ innovative technologies. For example, reduction offsets with long-term storage might take the form of projects that install carbon capture and storage devices at cement factories, thereby reducing the carbon they emit. Removal offsets with long term storage, meanwhile may come from projects that employ the direct air capture of carbon dioxide, followed by deep geological storage. The figure below illustrates a potential pathway for achieving this transition towards offsets with long-term storage.



[xxxvii]

Figure 3: Example of a net zero aligned offsetting trajectory

However, the transition towards reductions and removals at the necessary scale is not presently feasible due to the extremely high costs of these technologies today. Achieving this transition will require significant efforts and investments to develop these technologies to a point where they can be deployed at scale. The International Energy Agency estimates that half the reductions that will be necessary to achieve net zero are presently only at the prototype or demonstration phase[xxxviii].

While voluntary carbon markets are not designed to fulfill the role of mobilizing investment into these technologies, it may be worth considering mechanisms through which they may be able to. One such approach is to allow firms to participate in these projects by investing in the startups (or directly into these projects at existing companies) that are developing these technologies. If the startups succeed in developing the technologies to scale, a small percentage of the offsets generated through its deployment could be set aside to be shared among the investors in proportion to the size of their investment. While such an approach would entail a significant level of risk, the potential rewards may be sufficient for certain investors. Moreover, since such a mechanism would be entirely voluntary, it could provide an innovative source of funding for these technologies from investors willing to take the risk.

Step 3: Creating a Marketplace[7]

The next step in operationalizing an effective voluntary carbon market is to actually create a robust marketplace for transactions to occur in a transparent manner. Creating a uniform standard and converting existing offsets to it (as described in Step 1) will be the most difficult, but also the most helpful step in creating such a market. This is because reducing the number of offset types simplifies the functioning of the market to a great extent. There are also additional steps that can be taken to help the market grow.

Since the voluntary carbon market is international in nature, it might be counterproductive to have all transactions take place on a single exchange. Instead, treating offsets as a commodity listed on global commodity exchanges will make simplify the trading process for market participants across countries. Listing offsets on commodity exchanges will leverage their existing infrastructure to enable transparent and efficient trading without the need to create new infrastructure. Establishing the uniform standard for offsets will be crucial in enabling this process since it will allow standardized offsets to be traded across different markets.

Creating reference pricing benchmarks for offsets will also help transparency in markets by simplifying tracking price changes across different types of offsets. Since offsets will continue to command different prices depending on various factors (such as project type, location, etc.), creating pricing benchmarks will allow traders to track the overall price movement of offsets. These can be designed and operated in a similar manner to crude oil, which is also a heterogenous commodity that is traded using reference benchmarks such as West Texas Intermediate (WTI) or Brent. The benchmark for offsets can be set based on the market price of the simplest units under the uniform standard (i.e., those generated by projects

[7] Some of the suggestions in this section draw on the efforts of the Taskforce on Scaling Voluntary Carbon Markets

that only result in emissions reduction and do not have any additional certifications for creating other benefits). This will make voluntary carbon markets much more accessible and approachable for non-experts to track and engage with.

In addition to creating reference pricing benchmarks for the spot market, longer-term futures contracts (also based on or denominated in benchmark units) should also be established as they can add a significant degree of stability to the market. These instruments provide market participants will long-term price signals based on expected future demand and supply, which enable them to plan and develop longer-term trading strategies to secure future offset requirements.

Creating a futures market can also help address the issue of the financing gaps that project developers may face. Developers can list a portion of the expected future offsets that a project will generate (while ensuring adequate regulatory safeguards) under such futures contracts, through which buyers can support these projects as needed. Such contracts will require a robust post-trade infrastructure such as clearinghouses to mitigate the counterparty risks that may emerge to protect both buyers and sellers. Fortunately, since most commodity exchanges have these structures in place, they can also be used to enforce these contracts.

In a similar vein, steps also need to be taken to ensure governance frameworks to ensure that this market operates with integrity. This will include oversight mechanisms to enforce transaction guidelines that buyers, sellers, and intermediaries must follow to participate in the markets. The oversight should also extend to creating strict guidelines for developers who wish to sell futures contracts for their projects to protect buyers from fraud. Penalties and sanctions should also be developed and shared with participants to deter violating rules. Lastly, while a futures market can be very helpful in stabilizing voluntary carbon markets and providing financing solutions, steps should be taken to prevent excess speculation, as is often found in other commodities markets. For example, futures and derivatives contracts that are not tied to actual delivery of offsets should be banned as these instruments are primarily used for financial speculation and do not advance the stated objective of offsets, i.e., helping address climate change.

Step 4: Building Demand for Carbon Offsets:

Once a well-functioning market for offsets is established, the next step in operationalizing voluntary carbon markets will require measures to build their demand in order to ensure that they achieve the requisite scale for offsets to realize their potential. Since this market is entirely voluntary, these measures can help in building support for offsets. Large corporations are likely to be the largest buyers of offsets as part of their strategy to meet their climate commitments, which are usually driven by stakeholder demand. Efforts to encourage demand from these buyers should therefore focus on strategies that allow companies to visibly showcase their purchase of credits.

For example, sustainability reporting standards, the documents through which companies convey their sustainability efforts to stakeholders and the general public, should be modified to increase the role of offsets. Presently, the most widely used sustainability reporting standards are the Carbon Disclosure Project (CDP) which scores corporations on environmental parameters, and the Global Reporting Initiative (GRI) which outlines requirements for ESG reporting. Both standards require corporations to quantify and report their Scope 1, 2, and 3 emissions, but offsets play a minor role in both. Under the CDP, voluntary offsets can only increase companies' scores by eight points out of a total of several hundred points[xxxix]. The GRI standard, meanwhile, only allows companies to state how many offsets were purchased in the reporting period[xl]. Increasing the role of offsets in sustainability reporting will encourage companies to purchase more units. For the CDP, the points allocated to voluntary offset purchases should be increased to cover aspects such as the total number of offsets purchased, the ratio of offsets to total emissions, the quality of offsets purchased, and others. For GRI reports, this can be done by increasing the disclosure requirements to cover offsets in a more detailed manner. For example, this can be done by adding a section that allows companies to report net emissions by subtracting the offsets purchased from total emissions. This incentivizes companies to purchase more offsets as they can report lower net emissions, which can enhance their reputation for climate action. Similarly, the GRI should also permit co-benefits produced through offset projects to be included in some capacity under the corporate social responsibility section of their reports, as this encourages companies to purchase higher-quality offsets.

Integrating Carbon Pricing Approaches:

Each of the approaches to carbon pricing has distinct advantages and limitations in terms of what they can achieve. These approaches have largely been implemented in isolation in jurisdictions and have yielded mixed to somewhat positive results. However, integrating these approaches in a manner where the advantages of one approach are used to counteract a limitation of another may help these approaches complement each other and yield very positive results in addressing climate change.

Carbon taxes can be effective and relatively straightforward tools for governments to implement for placing a price on emissions. They raise substantial revenues for governments that can be used for a variety of purposes while creating incentives for reducing emissions. Carbon taxes also provide very stable price signals for emitters since they are changed infrequently and with adequate notice, which allows them to create long-term plans to reduce their emissions. Since they levy a price on every unit of emissions without permitting a level of unpriced emissions (as cap-and-trade systems do), they encourage firms to minimize their absolute level of emissions

Carbon taxes also have limitations that reduce their effectiveness in reducing emissions. For example, they cannot reliably a achieve nation's emissions reduction targets as they only create incentives to reduce emissions, but do not explicitly set limits for them. Carbon taxes can also be regressive in nature if not implemented appropriately, placing unfair burdens on poorer communities. The discretion that governments have in spending carbon tax revenues can also be used in ways that do not help address climate change, or the issues it will create. Carbon taxes revenues will also be generated predominantly in wealthy and industrialized countries as they produce the majority of emissions and can also tolerate the highest tax rates. This makes transfers to developing nations politically difficult, creating climate justice issues, and denying the developing nations the critical climate finance they will need to reduce their emissions and deal with the effects of climate change.

Compliance markets (i.e., cap and trade systems) can be very effective at reducing emissions in a structured manner since they explicitly place limits on emission levels. This allows nations to determine and enforce the trajectory of their emissions reductions as desired. Furthermore, since these targets are set and enforced by governments, they have a very high probability of being met. The dynamic price of emission permits also creates flexibility for emitters to reduce emissions in a cost-effective manner as they can choose to buy permits if the marginal cost of reducing emissions is more than the price of permits and vice versa. Compliance markets also place strong incentives for firms within sectors or industries to pursue ambitious targets as they can gain monetary benefits for doing so, sometimes at the cost of their competitors.

However, compliance markets can be extremely complicated to design, implement, and enforce. Governments require significant amounts of institutional capacity to monitor emissions and effectively police firms. Setting realistic, but sufficiently ambitious emission reduction trajectories is also an extremely challenging exercise as governments require large amounts of industry-specific technical information and an understanding of prevailing trends to set. Determining the method of permit allocation is a major determinant of the system's success and also requires deep domain knowledge. Compliance markets can also place unfair costs on medium and small firms as it can be extremely challenging and expensive for them to participate in the market, especially compared to large corporations that can distribute these costs more easily. Compliance regimes are also limited in their ability to bring economies to net zero as they can only reduce emissions to a certain extent in most cases (particularly for hard to abate industries such as concrete and steel), without eliminating them. They also cannot incentivize GHG removals as they function as permits to emit. Compliance markets also prevent transfers from wealthier nations to developing nations as the revenues they produce are kept either by the governments supervising these markets or by the firms who sell excess allowances.

Voluntary credits also have distinct advantages which can help address some of the shortcomings of carbon taxes and compliance regimes. First, voluntary credits can enable large and targeted transfers to developing nations since funds are directly used in projects that fight climate change and promote sustainable development. Voluntary markets can also play a role in enabling the GHG removals that will be necessary to achieve and maintain net zero emissions targets in the long run.

The largest problem with voluntary credits is that they are voluntary in nature and rely on support from private industry to function. This issue has been compounded by their negative perception in recent years, due to which they have had mixed success. Voluntary markets are also quite dysfunctional and will need to be organized effectively to deliver on their potential.

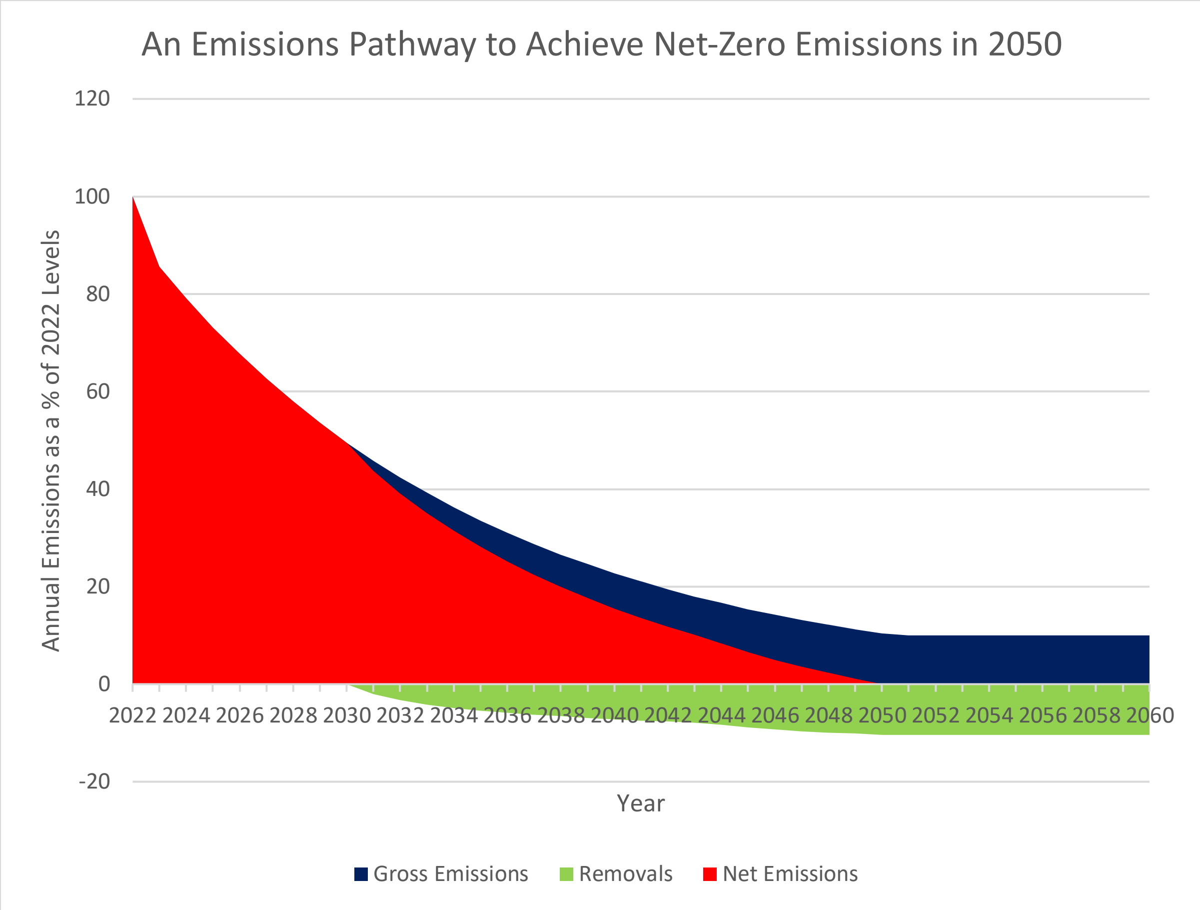


Figure 4: An illustrative emissions pathway for achieving net-zero emissions by 2050.

To better understand how carbon pricing mechanisms can be integrated to achieve net zero emissions in 2050, it is helpful to refer to the plot shown in Figure 5. This pathway is not representative of the magnitude of emissions reductions needed to achieve the 1.5-degree goal of the Paris Agreement but represents the broad shape that trends will need to follow. The blue section of the chart represents gross emissions from all sources over time and assumes (representationally) that 10% of emissions will continue to be emitted by hard-to-abate sectors even after 2050. The green section represents GHG removals over time. This model assumes that removals will occur at scale in a few years from the present as scalable removal technologies are still in their early stages. The red section represents net emissions, which are calculated by subtracting removals from gross emissions. To achieve this pathway, I propose employing all three major carbon pricing mechanisms, but using them in different ways to achieve different targets. Each of the mechanisms will need to be continuously evaluated and modified as necessary to improve their likelihood of succeeding.

Compliance markets should be employed to bring about the bulk of reductions in gross emissions for the largest emitters and corporations. These groups are responsible for the most emissions globally and reducing their emissions in a timely manner will be crucial for achieving net zero. Since compliance markets can reduce emissions in a structured manner most reliably, they will be most effective for reducing the emissions of the largest emitters. The actual pace of reductions under such a regime can be decided by national governments based on feasibility and the nation's nationally determined contributions under the Paris Agreement. Enforcing this regime only on the largest emitters and corporations is also likely to be politically acceptable since these groups will be large enough to deal with the higher regulatory burdens and complexities that compliance markets create. Governments should set thresholds for firms based on metrics of their size (for example, market capitalization) and total emissions for them to be regulated under compliance regimes. Governments must also carefully determine how they allocate allowances as this is a key determinant of the results a compliance regime will produce. Ideally, allocation methods should shift towards reducing the number of free allocations over time to maximize emissions reductions.

Carbon taxes, meanwhile, should be used to incentivize small and medium sized businesses to reduce their emissions. While members of this group do not individually produce large quantities of emissions, they account for a significant proportion of emissions when aggregated. Placing them under a carbon tax regime preserves their incentives to reduce emissions without placing undue administrative and regulatory burdens. Since it may be difficult for small businesses to measure their actual emissions every year, an estimate can be calculated somewhat easily by multiplying their output by the average emissions per unit of output for the industry, calculated by the government. This creates a fairly straightforward and easy to apply system for calculating the carbon tax each firm must pay. Instituting a carbon tax will also allow governments to raise additional revenues, which ideally should be used for climate mitigation and adaptation efforts.

Voluntary offsets should also be encouraged for firms of all sizes as a way to achieve more ambitious targets than mandated. They should especially be used as an interim way for organizations to achieve their net zero targets since creating such deep cuts in emissions can take many years. They will also help address climate justice issues since they can enable transfers to developing countries.

Voluntary markets are also the only carbon pricing instrument that can achieve emission removals. They present a compelling business model for emissions removal projects to earn revenues for their activities. However, voluntary markets must gradually shift away from emission reductions and move towards removals (as outlined in Step 2 of Operationalizing Voluntary Carbon Markets) to achieve net zero targets in the long run.

Conclusion:

The goal of this thesis has been to identify the role that carbon pricing mechanisms can play in addressing global climate change, and how they may need to change to achieve this goal. Although many such mechanisms have been implemented across several nations and regions, their results have been mixed. As a result, these mechanisms have attracted a significant amount of criticism which has affected their credibility as tools to reduce emissions. Restoring their credibility is a critical step in ensuring their effectiveness since winning the support and cooperation of people and institutions will likely be the biggest determinant of their success.

This thesis outlines many of the criticisms of each of the three major carbon pricing instruments in operation today: compliance markets, carbon taxes, and voluntary markets, and provides some suggestions that can help address them. These mechanisms have largely been implemented and studied in isolation from each other, which may have contributed to their mixed results. I outline one possible strategy to integrate these approaches in a manner that takes advantage of the strengths of each mechanism while using others to address their individual shortcomings.

It is important to note, however, that despite their tremendous potential, carbon pricing strategies alone will not be adequate to address the issue of global climate change. Organizations will need to achieve deep cuts in their emissions that go well beyond the government mandates, especially to achieve the goal of limiting warming to 1.5 degrees by 2050.

While creating structures and standards to improve how these mechanisms operate today will be helpful, they must be flexible are frequently reviewed and adapted as necessary. Past mechanisms have often been rigid and have suffered as a result. The design and implementation mechanisms also need to be constantly studied to ensure that they achieve their climate and sustainable development-related goals.

References:

[i] McKinsey Global Institute. (2022, January). *The Net-zero transition: What it would cost, what it could bring*. McKinsey & Company. Retrieved December 4, 2022, from https://www.mckinsey.com/capabilities/sustainability/our-insights/the-net-zero-transition-what-it-would-cost-what-it-could-bring

[ii] "Global Warming of 1.5 ºC: Summary for Policymakers." *Summary for Policymakers*, IPCC, 2015, https://www.ipcc.ch/sr15/chapter/spm/.

[iii] "Climate Change Vulnerability Index." *Verisk Maplecroft*, 2021, https://www.maplecroft.com/risk-indices/climate-change-vulnerability-index/.

[iv] "United Nations Framework Convention on Climate Change." *UNFCCC*, United Nations, 1994, https://unfccc.int/resource/docs/convkp/conveng.pdf.

[v] "Parties & Observers | United Nations Framework Convention on Climate Change." *Unfccc.int*, United Nations, https://unfccc.int/parties-observers.

[vi] Staff, Science X. "Limiting Warming to 2 C Requires Emissions Reductions 80% above Paris Agreement Targets." *Phys.org*, Phys.org, 9 Feb. 2021, https://phys.org/news/2021-02-limiting-requires-emissions-reductions-paris.html.

[vii] IEA (2021), World Energy Investment 2021, IEA, Paris https://www.iea.org/reports/world-energy-investment-2021,

[viii] "Nationally Determined Contributions Registry." *Unfccc.int*, United Nations, https://unfccc.int/NDCREG.

[ix] "Paris Agreement ." *UNFCCC*, United Nations, 2015, https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

[x] "Carbon Pricing Dashboard." *ETS & Carbon Pricing*, The World Bank | IBRD IDA, https://carbonpricingdashboard.worldbank.org/map_data.

[xi] *World Bank. 2022. State and Trends of Carbon Pricing 2022. State and Trends of Carbon Pricing;. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/37455 License: CC BY 3.0 IGO.*

[xii] "Carbon Markets: The Beginning of the Big Carbon Age." *Treeprint*, Credit Suisse, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiVlLjVheL7AhUPEUQIHWUjCVsQFnoECA8QAQ&url=https%3A%2F%2Fwww.credit-suisse.com%2Fmedia%2Fassets%2Fsustainability%2Ftreeprint-carbon-markets.pdf&usg=AOvVaw1HFHoLKRej260-Iu5wBkTD.

[xiii] Marron, Donald. "How to Use Carbon Tax Revenues." *Brooking Tax Policy Center*, Brookings Institution, Feb. 2016, https://www.brookings.edu/wp-content/uploads/2016/07/howtousecarbontaxrevenuemarronmorris.pdf.

[xiv] Morris, Adele C. 2013. "The Many Benefits of a Carbon Tax." Washington, DC: Hamilton Project, Brookings Institution.

[xv] "Carbon Border Adjustment Mechanism: Questions and Answers." *European Commission*, 14 July 2021, https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661.

[xvi] Ibikunle, Gbenga, et al. "Liquidity and Market Efficiency in the World's Largest Carbon Market." *The British Accounting Review*, vol. 48, no. 4, Dec. 2016, pp. 431–447., https://doi.org/10.1016/j.bar.2015.11.001.

[xvii] "Step 5: Distribute Allowances." *Emissions Trading in Practice: A Handbook on Design and Implementation (2nd Edition)*, International Carbon Action Partnership, Washington D.C., 2021, pp. 110–115.

[xviii] "VCS Guidance Guidance for Standardized Methods." *Verra*, 2013, https://verra.org/wp-content/uploads/2018/03/VCS-Guidance-Standardized-Methods-v3.3_0.pdf.

[xix] "Article 3.4, Kyoto Protocol to the United Nations Framework Convention on Climate Change." *UNFCC*, United Nations, 1998, https://unfccc.int/resource/docs/convkp/kpeng.pdf.

[xx] United Nations Framework Convention on Climate Change. "CDM: CDM Insights - Intelligence about the CDM." *Clean Development Mechanism*, UNFCCC, https://cdm.unfccc.int/sunsetcms/Statistics/Public/CDMinsights/index.html.

[xxi] "Achievements of the Clean Development Mechanism: Harnessing Incentive for Climate Action." *UNFCCC*, United Nations, 2019, https://unfccc.int/sites/default/files/resource/UNFCCC_CDM_report_2018.pdf.

[xxii] "Deals Questioned in Carbon Credit Rush." *The Sydney Morning Herald*, 24 Oct. 2006, https://amp.smh.com.au/world/deals-questioned-in-carbon-credit-rush-20061024-gdoo44.html.

[xxiii] "The CDM Executive Board Considers CDM Beyond 2020." *Unfccc.int*, 6 Oct. 2020, https://unfccc.int/news/the-cdm-executive-board-considers-cdm-beyond-2020.

[xxiv] Kazunari, Kainou. "Column: Collapse of the CDM Scheme under the Kyoto Protocol and Its Spillover: Consequences of 'Carbon Panic.'" *RIETI*, 7 Sept. 2021, https://www.rieti.go.jp/en/columns/a01_0659.html#note1.

[xxv] United Nations Framework Convention on Climate Change. "Methodological Tool: 'Tool for the Demonstration and Assessment of Additionality.'" *Clean Development Mechanism- Executive Board*, UNFCCC, https://cdm.unfccc.int/methodologies/index.html.

[xxvi] Calel R, Colmer J, Dechezleprêtre A, Glachant M (2021) *Do carbon offsets offset carbon?* Centre for Climate Change Economics and Policy Working Paper 398/Grantham Research Institute on Climate Change and the Environment Working Paper 371. London: London School of Economics and Political Science

[xxvii] Cames, Martin & Harthan, Ralph & Füssler, Jürg & Lazarus, Michael & Lee, Carrie & Erickson, Peter & Spalding-Fecher, Randall. (2016). How additional is the Clean Development Mechanism? Analysis of the application of current tools and proposed alternatives. Study prepared for DG CLIMA.. 10.13140/RG.2.2.23258.54728.

[xxviii] SCHNEIDER, LAMBERT RICHARD. "Perverse Incentives under the CDM: An Evaluation of HFC-23 Destruction Projects." *Climate Policy*, vol. 11, no. 2, 2011, pp. 851–864., https://doi.org/10.3763/cpol.2010.0096.

[xxix] Marcos, Miriam. "The CDM Project Barro Blanco – an Obstacle to Peace." *Carbon Market Watch*, 25 Apr. 2012, https://carbonmarketwatch.org/2012/04/25/the-cdm-project-barro-blanco-an-obstacle-to-peace-watch-this-1/.

[xxx] "The CDM: Local Impacts of a Global System." *Carbon Market Watch*, 2018, https://carbonmarketwatch.org/wp/wp-content/uploads/2018/10/CMW-THE-CLEAN-DEVELOPMENT-MECHANISM-LOCAL-IMPACTS-OF-A-GLOBAL-SYSTEM-FINAL-SPREAD-WEB.pdf.

[xxxi] Boyd, Emily, et al. "Reforming the CDM for Sustainable Development: Lessons Learned and Policy Futures." *Environmental Science & Policy*, vol. 12, no. 7, 2009, pp. 820–831., https://doi.org/10.1016/j.envsci.2009.06.007.

[xxxii] L, Jennifer. "The Top 4 Carbon Exchanges for 2022." *Carbon Credits*, 20 May 2022, https://carboncredits.com/the-top-4-carbon-exchanges-for-2022/.

[xxxiii] "State of the Voluntary Carbon Markets 2022 Q3." *Ecosystem Marketplace Insights Brief*, Ecosystem Marketplace, Aug. 2022, https://www.ecosystemmarketplace.com/publications/state-of-the-voluntary-carbon-markets-2022/.

[xxxiv] Bloomberg, Akshat Rathi |. "Analysis | What Are Carbon Offsets and How Many Really Work?" *The Washington Post*, WP Company, 22 June 2022, https://www.washingtonpost.com/business/energy/what-are-carbon-offsets-and-how-many-really-work/2022/06/14/1741863c-ebdd-11ec-9f90-79df1fb28296_story.html.

[xxxv] Niiler, Eric. "Do Carbon Offsets Really Work? It Depends on the Details." *Wired*, Conde Nast, 14 Jan. 2020, https://www.wired.com/story/do-carbon-offsets-really-work-it-depends-on-the-details/.

[xxxvi] Peach, Sara. "'Are Carbon Offsets a Scam?' " Yale Climate Connections." *Yale Climate Connections*, 18 Oct. 2022, https://yaleclimateconnections.org/2019/05/are-carbon-offsets-a-scam/.

[xxxvii] Hepburn, Cameron, et al. "The Oxford Principles for Net Zero Aligned Carbon Offsetting." *Smith School of Enterprise and the Environment*, Oxford University, 30 Sept. 2020, https://www.smithschool.ox.ac.uk/.

[xxxviii] "Pathway to Critical and Formidable Goal of Net-Zero Emissions by 2050 Is Narrow but Brings Huge Benefits, According to IEA Special Report - News." *IEA*, 1 May 2021,

https://www.iea.org/news/pathway-to-critical-and-formidable-goal-of-net-zero-emissions-by-2050-is-narrow-but-brings-huge-benefits.

[xxxix]"CDP Climate Change 2018 Scoring Methodology." *CDP*, Carbon Disclosure Project, 2018, https://guidance.cdp.net/en/guidance?cid=2&ctype=theme&idtype=ThemeID&incchild=1µsite=+1&otype=ScoringMethodology&tags=TAG-646%2CTAG-605%2CTAG-600.

[xl]"GRI 305: Emissions 2016 ." *Global Reporting Initiative*, 2016, https://www.globalreporting.org/standards/media/1012/gri-305-emissions-2016.pdf.