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Bringing Technological Transparency to Tenebrous Markets: The Case for Using Blockchain to Validate Carbon Credit Trading Markets

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BRINGING TECHNOLOGICAL TRANSPARENCY TO TENEBROUS MARKETS: THE CASE FOR USING BLOCKCHAIN TO VALIDATE CARBON CREDIT TRADING MARKETS

ABSTRACT

Carbon reductions have become a priority as companies and other entities emitting greenhouse gases seek to comply with regulatory requirements and commit to voluntary goals that are consistent with their sustainability pledges. These carbon reductions are accounted for by carbon credits, which are tradeable units of carbon reduction that can be used to comply with regulatory or voluntary carbon reduction credits. Many companies are making such carbon reduction promises, and are frequently relying on credits generated by non-traditional mitigation sources such as agriculture or forestry to achieve those reductions and credits. However, the credibility and reliance on such carbon credit markets is seriously undermined by the reality and perception of double counting, lack of transparency, and greenwashing. Blockchains and smart contracts can address many of the monitoring and transparency shortcomings of current carbon credit markets, and hence provide greater trust and veracity to carbon reduction claims to meet regulatory or voluntary commitments. This article describes the growing role of carbon credit markets, their current shortcomings, and describes existing and proposed mechanisms for using blockchain and smart contracts to overcome those existing problems.

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INTRODUCTION

In a time of rising global temperatures and atmospheric carbon levels, melting ice caps, and an ever-expanding flood of new technologies, it is not surprising that emerging technologies are playing a growing role in the global fight against climate change. What may be surprising to some, however, is the key role that distributed ledger technology, and specifically blockchain, can play in that fight. Though blockchain is best known as the technology enabling Bitcoin and as a notorious consumer of large amounts of electricity which results in significant greenhouse gas emissions,[1] blockchain's value and use cases are far broader, including for promoting sustainability.[2] One of those use cases, the focus of this article, is taking advantage of the technology's monitoring and accounting functions to bring trust and accountability to carbon credit trading markets.

Blockchain is an emerging technology rapidly reaching technological maturity and producing practical applications in a variety of industries.[3] Advances in blockchain technology promise to repurpose existing networking, cryptographic, and recordkeeping technologies for new purposes,[4] and players within the carbon economy are already strategizing and using blockchain.[5] While many of these existing implementations hinge on cryptocurrency applications of blockchain in funding decarbonization projects,[6] other future applications focused on flaws in the current carbon credit market could also provide new means and credibility to enhance the global community's ability to mitigate climate change through a trusted carbon market.

Part I of this article describes the growing regulatory and non-regulatory markets for carbon credits. Part II describes some problems with those carbon markets affecting the credibility, validity, and effectiveness of some carbon credits. Part III defines and describes blockchain and related smart contract technologies. Finally, Part IV explores potential applications of blockchain technology for making carbon credit markets more robust, trusted, and reliable.

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1. Christian Stoll et al., *The Carbon Footprint of Bitcoin*, 3 JOULE 1647, 1648 (2019) (estimating carbon emissions associated with Bitcoin mining in 2018 at 22.0 to 22.9 MtCO2 per year, which is between the levels emitted by Jordan and Sri Lanka, and is approximately the same as all emissions from Kansas City).

2. Some major use cases for blockchain beyond cryptocurrencies include sharing medical information, tracking financial transactions, managing supply chains, coordinating energy trading, and enabling smart contracts. *See* Wulf A. Kaal, *Blockchain Technology for Good*, 17 U. ST. THOMAS L. J. 878 (2022).

3. *See* DYLAN YAGA ET AL., U.S. NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, NISTIR 8202, BLOCKCHAIN TECHNOLOGY OVERVIEW (2018), https://csrc.nist.gov/publications/detail/nistir/8202/final [hereinafter NIST Report].

4. *Id.* at 46.

5. Paul Gambill, *Why a Carbon Removal Market Belongs on the Blockchain*, MEDIUM (Nov. 15, 2018), https://medium.com/nori-carbon-removal/why-a-carbon-removal-market-belongs-on-the-blockchain-91da31127228.

6. *See, e.g.*, Ross Kenyon, *Why Nori Needs Its Own Cryptocurrency Token*, MEDIUM (Sep. 21, 2018), https://medium.com/nori-carbon-removal/why-nori-needs-its-own-cryptocurrency-token-b2f1eef885c7.

I. THE DEMAND FOR CARBON CREDITS

Carbon markets emerged from the United Nations Framework Convention on Climate Change (UNFCCC) as a market mechanism to incentivize decarbonization of the global economy and mitigate climate change.[7] Adopted on May 9, 1992 by the United Nations, the UNFCCC currently has 197 parties and entered into force on March 21, 1994.[8] Article 4 of the UNFCCC commits parties to track and limit "anthropogenic emissions" at the national level, establishing Jointly Implemented (JI) mitigation efforts to incentivize collective projects to reduce greenhouse gas releases.[9] Such recognition sought to address disparities in the mitigation capabilities between industrialized and industrializing economies.[10] In theory, this separates financing from emission reduction success and provides alternate means of reaching emission reduction targets.[11]

At the first Conference of the Parties in Berlin, disagreements over the efficacy of market approaches as an emission reduction strategy led to the adoption of a pilot phase studying Activities Implemented Jointly (AIJ) as mitigation efforts.[12] The initial Conference of Parties rejected carbon credits, but later Conferences of the Parties removed this limitation.[13] While this rule encouraged successful projects aimed at reducing emissions in some industrializing countries,[14] other projects exceeded expected costs while still failing to reduce emissions.[15] Seizing on the potential of market mechanisms to incentivize decarbonization, the global community further refined its approach to the carbon market with the adoption of the first explicit emission limits and reduction timetables in the Kyoto Protocol of 1997.[16]

The Kyoto Protocol aimed to stabilize greenhouse gas concentrations by committing industrialized countries to reduce emissions of six types of gases[17] by at least 5% from 1990 levels by 2008-2012.[18] These commitments were reaffirmed under the Doha Amendment to the Kyoto Protocol through, at least, 2020. Emission reduction targets were defined by emission allowances or assigned amount units

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7. Axel Michaelowa et al., *Evolution of International Carbon Markets: Lessons for the Paris Agreement*, 10 WILEY INTERDISC. REV. CLIMATE CHANGE, 2019, at 1, 2 (2019).

8. United Nations Framework Convention on Climate Change, May 9, 1992, 1771 U.N.T.S. 107.

9. *Id.* at art. 4.

10. Axel Michaelowa & Holger Schmidt, *A Dynamic Crediting Regime for Joint Implementation to Foster Innovation in the Long Term*, 2 MITIGATION & ADAPTATION STRATEGIES FOR GLOB. CHANGE 45, 46 (1997).

11. *Id.*

12. Michaelowa et al., *supra* note 7, at 2.

13. Michaelowa & Schmidt, *supra* note 10, at 46.

14. *See* Michael Dutschke & Alex Michaelowa, *Joint Implementation as Development Policy- The Case of Costa Rica*, 3 INT'L J. OF SUSTAINABLE DEV. 63 (2000).

15. *See* Urs Springer, *Can the Risks of the Kyoto Mechanisms Be Reduced Through Portfolio Diversification? Evidence from the Swedish AIJ Program,* 25 ENV'T. RES. ECON. 501 (2003).

16. *See* Kyoto Protocol to the United Nations Framework Convention on Climate Change, annex B, Dec. 10, 1997, 2303 U.N.T.S. 162 [hereinafter Kyoto Protocol].

17. *Id.* at art. 2.

18. *Id.* at art. 3.

(AAUs).[19] These allowances enabled three emission reduction mechanisms to emerge from the Kyoto Protocol: International Emissions Trading (IET), JI, and the Clean Development Mechanism (CDM).[20] By providing three separate mechanisms, the international community sought to ensure flexibility in achieving greenhouse gas reduction commitments and recognized resource disparities between industrialized and industrializing nations.[21]

Article 16 enables IET by granting the parties in Annex B the right to engage in emissions trading—so long as such trading is aimed at fulfilling emission reduction commitments and is supplemental to other domestic action.[22] Article 6 authorizes offsetting emissions by permitting the transfer and acquisition of emission reduction units between parties involved in joint projects that reduce emissions.[23] Reductions under JI must be "additional to any that would otherwise occur" and JI derived reductions must only supplement other domestic emission reduction activity.[24] Furthermore, industrializing countries have access to the CDM.[25] The CDM allows industrialized nations, the so-called Annex I parties, to fund emission reduction projects in non-Annex I countries and use the resulting emission reductions to offset emissions as part of their own compliance commitments.[26] The treaty indicates that projects falling under the CDM face stricter scrutiny as to their efficacy, as certification requires, "real measurable, and long-term benefits to the mitigation of climate change."[27] These measures and the emission regulatory regime introduced under the Kyoto Protocol incentivized the emergence of the original carbon market by creating demand for carbon credits in Annex B countries.[28]

It should also be noted that the Paris Agreement, the most recent international agreement under the UNFCCC addressing climate change, provides for new market mechanisms that may reshape carbon markets.[29] Article 6 defines Cooperative Approaches and establishes the Sustainable Development Mechanism (SDM) as new market mechanisms for addressing climate mitigation efforts at the international stage.[30] Although adopting rules to implement this provision for international carbon markets proved to be one of the most difficult and last sections of the Paris Agreement to be implemented, the 26th Conference of the Parties held in Glasgow in November 2021 finally reached agreements on rules and mechanisms to implement Section 6.[31] This agreement is expected to "jump start" international

19. Michaelowa et al., *supra* note 7, at 2.

20. Springer, *supra* note 15, at 502.

21. Springer, *supra* note 15, at 502.

22. Kyoto Protocol, *supra* note 16, at art. 17.

23. Kyoto Protocol, *supra* note 16, at art. 6.

24. Kyoto Protocol, *supra* note 16, at art. 6(1)(b).

25. Kyoto Protocol, *supra* note 16, at art. 12.

26. Kyoto Protocol, *supra* note 16, at art. 12.

27. Kyoto Protocol, *supra* note 16, at art. 12(5)(b).

28. Michaelowa et al., *supra* note 7, at 2.

29. Michaelowa et al., *supra* note 7, at 12−13.

30. Paris Agreement to the United Nations Framework Convention on Climate Change, art. 6, Dec. 12, 2015, T.I.A.S. No. 16-1104. *See generally* Michaelowa et al., *supra* note 7, at 12-13.

31. U.N. President of the G.A., Proposal for Guidance on Cooperative Approaches Referred to in Article 6, Paragraph 2, of the Paris Agreement (Nov. 13, 2021), https://unfccc.int/sites/default/files/resource/cma2021_L18E.pdf.; U.N. President of the G.A., Proposal for Rules, Modalities,

markets for voluntary carbon credits.[32] Two types of carbon credits arose from this original market: allowances and offsets.[33] Allowances arise under cap-and-trade systems like IET, where participants are assigned a finite set of tradeable emission allowances based on a reduction target.[34] The finite supply further drives up both demand and price.[35] Offsets result from baseline-and-credit systems, like CDM or JI, only generating credits for new emission reduction efforts if a project brings additionality, or greater emissions reductions than would have occurred but for the project.[36] The key difference is that allowance credits result from reducing an entity's own carbon emissions directly, whereas offset credits involve reducing, avoiding or removing carbon emissions elsewhere (either within or outside the same entity).

A carbon offset credit is defined as one unit of carbon removed from the atmosphere or prevented from entering the atmosphere, but for the action of the party generating the offset credit. These credits can be bought or sold by an entity or individual for purposes of reducing their carbon footprint, taking credit for atmospheric reduction of carbon or prevention of carbon emissions. As an industry standard, one carbon offset credit is typically equivalent to removing or avoiding one ton of carbon that would have otherwise been added to the atmosphere.[37]

Carbon credit trading markets can be broadly segregated into two distinct markets: (i) regulatory or compliance markets and (ii) voluntary markets.[38] Though both markets share a commonality in that they permit market participants to buy and sell certain credits related to reducing carbon in the atmosphere, they differ significantly in how that end is achieved. Voluntary markets operate outside the regulation and bureaucracy of compliance markets, and are more open to experimentation with new technology and innovative projects.[39] Credits on the voluntary market may be the product of CDM projects or Verified/Voluntary Emissions Reductions (VERs).[40] Some compliance schemes have even implemented credits originating under voluntary schemes into their regulatory framework.[41]

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and Procedures for the Mechanism Established by Article 6, Paragraph 4, of the Paris Agreement (Nov. 13, 2021),https://unfccc.int/sites/default/files/resource/cma3_auv_12b_PA_6.4.pdf.

32. Silvia Favasuli, *Paris accord Article 6 approval set to jump-start evolution of voluntary carbon market*, S&P GLOB. COMMODITY INSIGHTS (Nov. 17, 2021), https://www.spglobal.com/platts/en/market-insights/latest-news/energy-transition/111721-paris-accord-article-6-approval-set-to-jump-start-evolution-of-voluntary-carbon-market.

33. Anja Kollmuss et al., *Making Sense of the Voluntary Carbon Market: A Comparison of Carbon Offset Standards*, WWF GER. (Mar. 2008), https://www.globalcarbonproject.org/global/pdf/WWF_2008_A%20comparison%20of%20C%20offset%20Standards.pdf.

34. *Id.*

35. *Id.*

36. *Id.*

37. NORI, A BLOCKCHAIN-BASED MARKETPLACE FOR REMOVING CARBON DIOXIDE FROM THE ATMOSPHERE 8, (Feb. 8, 2019), https://nori.com/resources/white-paper.

38. *Id.* at 17; Esteve Corbera et al., *How Do Regulated and Voluntary Carbon-Offset Schemes Compare?*, 6 J. INTEGRATIVE ENV'T. SCI. 25 (2009); Heather C. Lovell, *Governing the Carbon Offset Market*, 1 WILEY INTERDISC. REV. CLIMATE CHANGE 353, 354 (2010).

39. Kollmuss et al., *supra* note 33, at 6.

40. Kollmuss et al., *supra* note 33, at 6.

41. Greenhouse Gas Management Institute, *Mandatory and Voluntary Offset Markets*, CARBON OFFSET GUIDE, https://www.offsetguide.org/understanding-carbon-offsets/carbon-offset-programs/mandatory-voluntary-offset-markets/ (last visited Apr. 16, 2022).

Regulatory or compliance markets operate around carbon emission standards set by a regulatory body, applying to market participants under the jurisdiction of that regulatory body. In practice, the regulatory body issues carbon credits, which permit credit holders to emit an amount of carbon into the atmosphere. When credit holders have or can achieve excess credits, they may sell those credits to purchasers in need of additional carbon emission allowances. Depending on the jurisdiction, additional carbon emission allowances can also be gained by purchasing a unit of atmospheric carbon removal.[42] Although the U.S. does not have a national regulatory program requiring purchase of carbon credits by emitters, two regional programs, the Regional Greenhouse Gas Initiative in which eleven Northeast states participate and the California cap and trade program, create a market for regulatory carbon credits.[43]

Voluntary markets, however, operate independent of any set of carbon emission standards and focus on either removing carbon from the atmosphere or on avoiding or reducing emissions in the first place.[44] These carbon offset reductions are often adopted by companies voluntarily as part of their sustainability and "zero net carbon" pledges. There has recently been a flurry of companies pledging to achieve zero net carbon emissions, and at least a fifth of the world's largest public companies have now made some sort of "net zero" carbon pledge.[45] For example, Microsoft pledged to be "carbon negative" by 2030, Apple claims its products and supply chains will be carbon neutral by 2030, and Google has committed to using only renewable energy by 2030.[46]

The carbon offset credit market contains many firms that facilitate credit trading and sales that represent a growing industry with over $5.5 billion worth of carbon offset credits transacted in 2019, reportedly removing over 1.3 billion tons of carbon from the atmosphere.[47] Though each firm operates slightly differently than the next, the critical mass are for-profit businesses that operate as credit trading markets linking credit sellers with credit buyers.[48] A representative example of carbon offset credit trading markets generally is Carbon Trade Xchange ("CTX"). For the sake of this article, CTX is used as an example to discuss problems and trends in the broader carbon offset credit trading market industry. CTX, just like many other credit trading markets, operates as a for-profit business that serves as an intermediary

42. U.N. CLIMATE CHANGE CONFERENCE, Mechanisms Under the Kyoto Protocol: Emissions Trading, https://unfccc.int/process/the-kyoto-protocol/mechanisms/emissions-trading (last visited Apr. 16, 2022).

43. JOHN REILLY & STEPHANIE MERCIER, HOW U.S. AGRICULTURE CAN BE PART OF THE CLIMATE CHANGE SOLUTION: OPPORTUNITIES AND INCENTIVES FOR FARMERS TO REDUCE THEIR EMISSIONS AND TURN THE INDUSTRY INTO A NET CARBON SINK 12 (2021), https://www.farmjournalfoundation.org/post/new-report-shows-how-u-s-agriculture-can-fight-climate-change.

44. *See* Corbera et al., *supra* note 38, at 8.

45. Jocelyn Timperley, *The Truth Behind Corporate Climate Pledges*, THE GUARDIAN (July 26, 2021), https://www.theguardian.com/environment/2021/jul/26/climate-crisis-green-light.

46. *Id.*

47. STEPHEN DONOFRIO, ET AL., VOLUNTARY CARBON AND THE POST-PANDEMIC RECOVERY 2 (2020), https://www.forest-trends.org/publications/state-of-the-voluntary-carbon-markets-2020-2/.

48. *Id.*

linking buyers and sellers of carbon offset credits.[49] Based in the United Kingdom, CTX serves the European market for customers operating within European regulatory markets, as well as international markets for voluntary credit buyers.[50] Notably, under this model, sellers place the credits they have for sale into an escrow account, and those credits are either transferred to a purchaser on sale, or transferred back to the seller if the credits are de-listed by CTX or a seller. The contractual relationship amongst the parties exists between CTX and the buyer or seller, respectively, not directly between the buyer and seller. One of the key problems that such exchanges face is that more than one party may take credit for a carbon offset. CTX attempts to combat this double counting problem by contractually dictating, "[credit purchasers] are required to retire or cancel the [credits] purchased on the CTX Trading Platform from the market."[51] Other firms in the industry use similar terms and contractual approaches.[52]

To date, carbon offsets have primarily focused on reducing conventional carbon sources such as industrial emissions, resource extraction, and transportation sources. However, there is great interest and need to expand carbon offset sources to include activities such as agriculture, forestry, and other land use decisions.[53] While these types of land management activities are currently one of the largest contributors to climate change, "[a]griculture is the ONE sector that has the ability to transform from a net emitter of CO_2 to a net sequester of CO_2—there is no other human managed realm with this potential."[54] Farmers could reduce carbon emissions by a variety of actions including carbon sequestration in soils, emission reductions from fuel choice or reduced fuel use, livestock emissions reductions, reduced fertilizer use, and reforestation or restoration of wetlands and grasslands.[55] The use of these approaches to increase carbon sequestration using agricultural practices has been referred to as "carbon farming."[56] A number of private companies have begun contracting or negotiating with farmers to create carbon offsets, but these initiatives are impeded by uncertainty and disagreement about the value, quantification, and validity of such offsets.[57]

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49. *Carbon Trade Exchange: A History*, CARBON TRADE XCHANGE, https://ctxglobal.com/history/ (last visited Apr. 16, 2022).

50. *Id.*

51. *Carbon Trade Exchange Rules and Regulations for the Voluntary Carbon Market 22 May 2018*, CARBON TRADE XCHANGE 13 (May 22, 2018), https://ctxglobal.com/wp-content/uploads/2018/05/CarbonTradeExchangeRules_20180522.pdf (last visited Apr. 16, 2022).

52. *See generally What We Do*, AMERICAN CARBON REGISTRY, https://americancarbonregistry.org/how-it-works/what-we-do (last visited Apr. 16, 2022).

53. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE AND LAND 10 (2020); John M. Crespi & Kristine A. Tidgren, *The First Legal Step for an Agricultural Carbon Market is In the Growing Climate Solutions Act of 2021*, CTR. FOR AGRIC. & RURAL DEV. 2 (May 2021).

54. *Carbon Farming*, CARBON CYCLE INST., https://www.carboncycle.org/wp-content/uploads/2018/09/carbon-farming-brochure-Sept2018-CCI-5.pdf (last visited Apr. 16, 2022).

55. REILLY & MERCIER, *supra* note 43, at 7-12; Crespi & Tidgren, *supra* note 53, at 3-4; *see What is Carbon Farming?*, CARBON CYCLE INSTITUTE (2021), https://www.carboncycle.org/carbon-farming/ (stating that over 30 on-farm practices have been identified for sequestering carbon).

56. Alexia Brunet Marks, *(Carbon) Farming Our Way Out of Climate Change*, 97 DENV. L. REV. 497, 503 (2020).

57. *Id.* at 511-13; ENVIRONMENTAL DEFENSE FUND & WOODWELL CLIMATE RESEARCH CENTER, AGRICULTURAL SOIL CARBON CREDITS: MAKING SENSE OF PROTOCOLS FOR CARBON SEQUESTRATION

At the federal level, the Secretary of the United States Department of Agriculture (USDA) announced in the spring of 2021 that he was exploring creating a "carbon bank" for agriculture potentially using the Commodity Credit Corporation to finance such efforts.[58] A "Carbon Bank" could subsidize or purchase carbon credits from voluntary, non-regulatory agricultural practices that result in quantifiable and verifiable reductions in carbon emissions.[59]

In March 2021, the USDA published a notice in the Federal Register seeking comment on approaches the agency might take to foster carbon mitigation in agriculture.[60] The agency specifically asked, "How can USDA help support emerging markets for carbon and greenhouse gases where agriculture and forestry can supply carbon benefits?"[61] Not to be outdone, a month later Congress introduced the bipartisan Growing Climate Solutions Act of 2021, intended to reduce entry barriers for farmers, ranchers, and private forest landowners to take carbon mitigation efforts and participate in voluntary carbon credit markets.[62] This legislation was passed by a strong bipartisan majority in the Senate in July 2021, and if passed by the House, is expected to significantly increase agricultural participation in voluntary carbon credit markets.[63]

II. CONCERNS ABOUT CARBON CREDIT COMMITMENTS

As increased interest and reliance on carbon credits accelerates in both the regulatory and voluntary markets, growing concerns have risen about transparency, fraud, and the fundamental long-term environmental efficacy of the carbon credit market.[64] While global carbon markets have evolved significantly from their origin

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AND NEW GREENHOUSE GAS REMOVALS 13-20 (2021), https://www.edf.org/sites/default/files/content/agricultural-soil-carbon-credits-protocol-synthesis.pdf [hereinafter ENVIRONMENTAL DEFENSE FUND]; Peggy Kirk Hall, *Here's What is Known About Carbon Markets*, OHIO FARMER (May 21, 2021), https://www.farmprogress.com/carbon/heres-what-known-about-carbon-markets (stating Bayer Crop Sciences has launched its Carbon Initiative which pays farmers up to $9 per acre per year for practices that create carbon reduction credits, to help meet the company's goal of reducing its greenhouse gas emissions 30 percent by 2030); *see also* BAYER , *Earn Rewards for the Way You Farm* , https://www.cropscience.bayer.com/who-we-are/farmer-partner-resources/carbon-program/united-states (last visited Apr. 16, 2022); Several companies (such as General Mills, McDonalds and Cargill) along with other entities have formed the Ecosystem Services Market Consortium (ESMC) which plans to launch a voluntary carbon offset market from agricultural sources in 2022. ESMC, *About Us*, https://ecosystemservicesmarket.org/about-us/ (last visited Apr. 16, 2022).

58. Chuck Abbott, *Vilsack Says a Carbon Bank Fits into USDA Portfolio*, SUCCESSFUL FARMING (Mar. 23, 2021), https://www.agriculture.com/news/business/vilsack-says-a-carbon-bank-fits-into-usda-s-portfolio. The Commodity Credit Corporation is an institution created during the Depression to enable the USDA to pay farm subsidies and support land stewardship programs. *Id.*

59. Climate, Food & Agriculture, *USDA National Climate Bank – Concept Note* (2021), https://climatefoodag.org/wp-content/uploads/sites/9/2021/04/Climate-Bank-Concept-Note.pdf.

60. Notice of Request for Public Comment on the Executive Order on Tackling the Climate Crisis at Home and Abroad, 86 Fed. Reg. 14403 (Mar. 16, 2021).

61. *Id.*

62. S. 1251, 117th Cong. (2021).

63. Crespi & Tidgren, *supra* note 53, at 3. The equivalent bill was introduced in the House in April 2021, H.R. 2820, 117th Cong. (2021).

64. Arthur Neslen, *Kyoto Protocol's Carbon Credit Scheme 'Increased Emissions by 600m Tonnes'*, THE GUARDIAN (Aug. 24, 2015), https://www.theguardian.com/environment/2015/aug/24/kyoto-

under Kyoto, questions of their fundamental efficacy as a mitigation tool remain.[65] Considering the mixed track record of CDM and JI projects,[66] tracking and ensuring that future emission reducing activity actually achieves additionality is especially important in ensuring the environmental efficacy of mitigation efforts.[67]

Various analyses indicate that many companies are not complying with their "net zero" carbon pledges, especially those relying on carbon offsets from agricultural and other activities.[68] However it is very difficult to determine whether a particular entity is complying with its pledge—"[a]nalyzing what companies are actually doing, however, can be painstakingly difficult when there is no requirement to disclose all key climate information and little consistency in corporate pledges making it all but impossible to benchmark progress."[69] Moreover, many of the offset projects that companies rely on "have been plagued by allegations of flawed accounting, greenwash and sometimes even of actively fueling climate change."[70] Given these problems with ensuring the accuracy and validity of carbon offset credits, there is a shortage of verified carbon emission credits. For example, a Microsoft official stated in the summer of 2020 that there are not enough "verified" carbon offset credits in the world today to satisfy Microsoft's needs for just this year.[71]

One major concern with the lack of transparency associated with emissions reduction credits is the potential for double counting, where a single greenhouse gas reduction project is accounted multiple times towards mitigation pledges.[72] According to one analysis, "there is rampant double counting and fraud [as purchasers] routinely count emissions reductions against their carbon emissions after someone in their supply chain has done the same thing."[73] Double counting can result from double issuance, double claiming, and double use.[74] Otherwise stated, entities will purchase a credit, claim the resulting atmospheric carbon reduction for regulatory or other purposes, and sell that credit to a new purchaser who later claims the same atmospheric carbon reduction as the original purchaser. The result of this

protocols-carbon-credit-scheme-increased-emissions-by-600m-tonnes; ENVIRONMENTAL DEFENSE FUND, *supra* note 57, at 13-14; Lovell, *supra* note 38, at 357.

65. *See generally* Benjamin K. Sovacool, *Four Problems with Global Carbon Markets: A Critical Review*, 22 ENERGY AND ENV'T 681 (2011).

66. Heleen de Coninck & Nico van der Linden, *Characteristics of Carbon Transactions. Joint Implementation, Clean Development Mechanisms, and Emission Trading in Perspective,* 14 ENERGY & ENV'T 557, 557 (2003).

67. ENVIRONMENTAL DEFENSE FUND ET AL., WHAT MAKES A HIGH-QUALITY CARBON CREDIT? 9 (2020), https://www.greenfinanceplatform.org/sites/default/files/downloads/resource/What_Makes_a_High-quality_Carbon_Credit.pdf.

68. Timperley, *supra* note 45.

69. Timperley, *supra* note 45.

70. Timperley, *supra* note 45.

71. Ian Allison, *Carbon Credits Have a Double-Spend Problem. This Microsoft-Backed Project is Trying to Fix It*, COINDESK (July 29, 2020, 7:00 AM), https://www.coindesk.com/business/2020/07/29/carbon-credits-have-a-double-spend-problem-this-microsoft-backed-project-is-trying-to-fix-it/.

72. Lambert Schneider et al., *Addressing the Risk of Double Counting Emission Reductions Under the UNFCCC*, 131 CLIMATIC CHANGE 473, 473 (2015).

73. Gambill, *supra* note 5.

74. Schneider et al., *supra* note 72, at 475.

double counting problem is that multiple entities will take credit, in a regulatory or voluntary market context, for the same unit of carbon removed from the atmosphere. As a result, more atmospheric carbon reduction is reflected in the marketplace than has actually been removed from the atmosphere and traded as a carbon offset credit.

Current carbon offset credit trading markets have made various efforts to negate the double counting problem, but the issue persists. For example, double counting continues to be an issue despite the UNFCCC maintaining an International Transaction Log[75], and this is particularly relevant in the voluntary market where standards vary drastically.[76] Some stakeholders have recommended a universal mandatory registry for all types of carbon offsets to alleviate these concerns, especially with various independently operating registries in the voluntary market.[77]

As an industry standard, carbon offset credit trading markets use contractual terms such as mandatory retirement conditions, representations, warranties, and covenants, to combat the double counting problem. Conditions are contractual terms that, if breached, give an aggrieved party the right to either terminate a contract or enforce it.[78] Representations are statements of truth pertaining to something already in existence, made prior to or at the time of the bargain, and made to induce one or both parties to contract.[79] By contrast, warranties are a guarantee of the truth of a matter at the time of the contract, and its truth in the future, made to induce one or both parties to contract.[80] As applied to carbon offset credits, warranties can be used as a Credit purchaser's guarantee, and statement of understanding, that credits are non-transferrable or are to be retired upon the close of the transaction. Differing slightly, covenants are a promise to do, or not do, a particular act as part of a contract.[81] Applied to carbon offset credits, covenants are a credit purchaser's promise to refrain from reselling purchased credits, or a promise to retire those credits at a particular time.

In a world of good actors, mandating that purchasers of carbon offset credits retire their credits would be sufficient, but in reality, it falls short. Several problems arise with contractual efforts to curb the double counting problem, making the efforts ineffective: insufficient enforcement incentives, insufficient monitoring after the close of a transaction, lack of standing, and more.

One of the biggest pitfalls of the current contract regime against the double counting problem is that it lacks sufficient incentive to make rigorous enforcement economically feasible. It is no secret that litigation is expensive. Similarly, the costs

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75. *See* U.N. CLIMATE CHANGE CONFERENCE, Mechanisms under the Kyoto Protocol: International Transaction Log, https://unfccc.int/process/the-kyoto-protocol/registry-systems/international-transaction-log (last visited Apr. 16, 2022).

76. Heather C. Lovell, *Governing the Carbon Offset Market,* 1 WILEY INTERDISC. REV. CLIMATE CHANGE 353, 354 (2010).

77. Kollmuss et al., *supra* note 33, at 40-41.

78. *Back to Basics - Terms of a Contract*, FORTUNE LAW (Feb. 7, 2012), https://www.fortunelaw.com/back-to-basics-terms-of-a-contract/.

79. Marc A. Primack*, Representations, Warranties and Covenants: Back to the Basics in Contracts*, THE NAT'L L. REV., Vol. XI, No. 185 (Dec. 1, 2009), https://www.natlawreview.com/article/representations-warranties-and-covenants-back-to-basics-contracts#.

80. *Id.*

81. *Covenant*, CORNELL L. SCH. LEGAL INFO. INST. , https://www.law.cornell.edu/wex/covenant (last visited Apr. 16, 2022).

of pursuing alternative dispute resolution, such as arbitration, can be significant.[82] However, absent alternative measures contemplated by the contract itself, enforcement action in this context likely requires either the non-violating party or a non-party third party to being a lawsuit. Though it is conceivable that enforcing a contract against a carbon offset credit purchaser who breaches their contract by reselling or failing to retire their credits would be financially feasible in some cases, if the transaction was large enough, the converse is probably more likely. The cost of litigating non-compliance is likely not worth the value of ensuring that carbon credits are properly retired, especially if the number of credits involved is modest. Because of the significant cost of enforcing a contract against a breaching credit purchaser, and the notable doubts about offsetting damage awards (if any), contractual terms aimed at solving the double counting problem are ineffective, and as a result, they are unlikely to be enforced.

Assuming, for arguments sake, that enforcement costs are not an issue and contract parties are sufficiently incentivized to enforce the agreement when it is breached, there is still a significant barrier to enforcement: a lack of monitoring. Insufficient monitoring means that entities breaching credit agreements are unlikely to be caught. CTX, just like other carbon offset credit trading markets, requires credit purchasers to retire their credits. Though the form that retirement takes varies between credit trading markets, CTX is again representative by placing the retirement burden on the credit purchaser.[83] Though, theoretically, CTX could monitor credit purchasers' retirement of credits by maintaining communication with the purchasers, monitoring carbon offset credit regulatory bodies, and more, in practice, CTX and other private trading markets fail to effectively police the retirement of credits. As a matter of practicality, it is not feasible or scalable for them to keep tabs on the status of every credit that passes through their trading platform; CTX and other markets are not able to monitor whether and when credits are resold. Because of a lack of monitoring, CTX and other markets fail to become aware of double count contract breaches when they occur. Accordingly, they cannot effectively enforce the underlying contract.

Standing is another barrier to effective enforcement. Standing refers to an individual's ability to take legal action in a particular scenario. Generally, it requires that a potential plaintiff has been, or will be, injured, and that the injury is redressable.[84] As it relates to CTX and other similarly organized trading markets, standing may become an issue for carbon offset credit sellers that wish to enforce a contract, because the contractual relationship exists between the market and the buyer or seller, not directly between the buyer and seller. Without a contract made directly between the buyer and seller, the seller cannot bring an action for enforcement against the buyer for a double count breach, because they lack standing. Notably, it is plausible that courts could hold that credit sellers, in this situation, have

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82. *See Costs of Arbitration*, AM. ARB. ASS'N, https://www.adr.org/sites/default/files/document_repository/AAA228_Costs_of_Arbitration.pdf (last visited Apr. 16, 2022).

83. *See Carbon Trade Exchange,* Rules And Regulations For the Voluntary Carbon Market, Rule 21 (May 22, 2018), https://ctxglobal.com/wp-content/uploads/2018/05/CarbonTradeExchangeRules_20180522.pdf (last visited May 14, 2022).

84. *Standing*, CORNELL L. SCH. LEGAL INFO. INST., https://www.law.cornell.edu/wex/standing (last visited Apr. 16, 2022).

standing as *third-party beneficiaries*.[85] However, given the relative immaturity of the carbon offset credit market as a whole, as of this writing, the effect of this plausible argument cannot yet be verified, and moreover, it may not be universally applied by all courts, so the standing problem remains an issue, none-the-less.

Given these problems with enforcing against double-counting, more robust protections are necessary for carbon offset credits to reach their full potential, as it pertains to their effectiveness and trust in the global fight against climate change. Credit trading markets have already attempted to solve the double counting problem through traditional contract law, but that remedy depends on certain information being known to the credit seller or trading market. Specifically, credit sellers or trading markets must know when a credit purchaser resells the credit after claiming it for regulatory or other purposes. Integrating blockchain into carbon offset credit trading markets enables a level of traceability, or monitoring, after the transaction has been completed, that is not otherwise available. Simply stated, blockchain can mitigate the double counting problem by giving credit sellers and trading markets the information they need to enforce contractual provisions aimed at solving the double counting problem. Moreover, the integration of blockchain and smart contracts into the market may even make the double counting problem a non-issue by automatically retiring a credit once purchased, or later claimed for a regulatory or other purpose.

The double-counting problem is not the only challenge for credible carbon offset trading markets. Additional challenges include ensuring that carbon offsets are permanent and additional to actions and reductions that would occur without the credits ("additionality"), and more broadly the need for monitoring, reporting and verification ("MRV") of the offsets more generally.[86] These challenges result in significant part from the lack of consensus definitions, methodologies, and standards for carbon reductions from non-industrial processes, such as agriculture and forestry. While the USDA has developed a tool known as the COMET Farm to account for CO_2 emissions reductions from agricultural practices,[87] there are concerns that this tool does not provide enough specificity and assurance to be used for verifiable accounting of carbon sequestration at specific sites.[88]

Farmers, ranchers, and other landowners who could provide carbon reductions from adopting new carbon sequestration and reduction methods are therefore deterred from doing so by the lack of standards for measuring such reductions, and the absence of any verification mechanism.[89] The situation is

85. Schlam Stone & Dolan LLP, *Plaintiff That Did Not Sign Contract Lacked Standing to Bring Breach of Contract Claim*, COM. DIV. BLOG (Aug. 27, 2019), https://www.schlamstone.com/plaintiff-that-did-not-sign-contract-lacked-standing-to-bring-breach-of-contract-claim/.

86. Climate, Food & Agricultural, *supra* note 59, at 3.

87. *COMET Farm: Whole Farm and Ranch Carbon and Greenhouse Gas Accounting System*, USDA, http://comet-farm.com/ (last visited Apr.16, 2022).

88. Crespi & Tidgren, *supra* note 53, at 4 ("The unease over carbon markets that has been expressed by policy makers, researchers, farmers and agribusiness can boil down to one question, 'How can we trust the markets?' ").

89. Crespi & Tidgren, *supra* note 53, at 3. *See, e.g.*, J. GORDON ARBUCKLE, IOWA ST. UNIV. *2020 Summary Report - Iowa Farm and Rural Life Poll*, (2020) https://store.extension.iastate.edu/product/16071 (finding that 47% of farmers were uncertain about earning money for carbon credits and 17% were opposed).

analogous to the confusion over the term "organic" food in the 1980s, where multiple criteria, standards, and certifications existed causing confusion in the marketplace, until Congress and the USDA stepped in and created a national "USDA Organic" certification program which created a national standard and criteria for using the term "organic" on food labels.[90]

The bipartisan Growing Climate Solutions Act passed by the U.S. Senate in July 2021[91] is intended to address these problems. It would, among other things, require the USDA to establish a third-party verifier certification program in which the USDA would certify the certifiers, as well as establish an online website with information for producers. Further, it would require the USDA to report regularly to Congress on performance of the offset market performance, challenges for producers, and barriers to market entry.[92] The legislation does not specify how the USDA should certify and track carbon offsets, which opens the door to a blockchain-based system to provide the consistency and transparency the market requires.

III. BLOCKCHAIN AND SMART CONTRACTS

This section provides relevant background on blockchains and smart contracts, which are contractual agreements automatically executed by computers often administered on a blockchain. Both technologies have relevant applications for making carbon offset credits more credible and transparent, as discussed in the following section.

A. What is Blockchain?

In essence, a blockchain is an electronic database that retains certain immutable data by tying that stored data to encrypted blocks, publicly displayed on a shared ledger, that can be tracked through its lifecycle and any transactions it is involved in. Blockchain is a cryptographic database in which a distributed electronic ledger is "built around a [peer to peer] system that can be openly shared among disparate users to create an unchangeable record of transactions, each time stamped and linked to the previous one."[93]

Blockchains are a secure method of enabling the transfer and recording of digital assets without the need for a central authority.[94] Distributed ledgers operate off independent computers, called nodes, to record, transmit, and harmonize transactions across multiple electronic ledgers, instead of a centralized database.[95] Data entered into a blockchain is cryptographically sealed, permanent, and visible in

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90. Crespi & Tidgren, *supra* note 53, at 5.

91. S. 1251, 117th Cong. (2021).

92. *See id.*

93. *Blockchain: The Complete Guide - Computerworld*, BUS. TEL. (Jan. 29, 2019), https://www.businesstelegraph.co.uk/blockchain-the-complete-guide-computerworld/.

94. U.S. GOV'T ACCOUNTABILITY OFF., GAO-19-704SP, SCIENCE & TECH SPOTLIGHT: BLOCKCHAIN & DISTRIBUTED LEDGER TECHNOLOGIES (2019) [hereinafter GAO].

95. *Blockchain & Distributed Ledger Technology (DLT)*, The WORLD BANK, (Apr. 12, 2018), https://www.worldbank.org/en/topic/financialsector/brief/blockchain-dlt.

real time to other nodes on the network.[96] Blockchain is particularly useful in recording ownership of assets, such as currency, securities, and specific information like health information or personal data.[97] Blockchain also supports the potential use of smart contracts, or self-executing code, enabling future automation of processes executing transactions.[98] Practical applications for blockchains are rapidly being adopted throughout the financial, manufacturing, and clean energy industries.[99]

While popularized in the public imagination through cryptocurrencies like Bitcoin,[100] at its most basic the underlying technology of blockchain involves connecting blocks of data that have been encrypted into a unique alphanumeric code of a standardized length. Blockchains use a special software that "hashes" any source of information, whether it be a single word or an entire library, into a unique code.[101] The same information will always produce the same code when hashed, but it is not possible to reverse the process and identify the original information from the output code. A group of such hashed codes are then added to the blockchain as a block, with each block referencing the block before it. Any change to a single entry in one block on one computer (or "node") in the distributed network will change every subsequent block on that copy of the blockchain. This will show that the altered copy of the blockchain is now inconsistent with every other copy of the blockchain on the network, and thus can be identified and rejected as fraudulent. This system allows independent users to input and hash new data and derive the same result, ensuring that no changes occurred within the dataset, as even small variations in input data lead to drastically different outputs.[102] In theory, this makes blockchains functionally immutable (i.e., unalterable without detection).[103] These cryptographically secured blocks of data are then merged onto a ledger chronologically, allowing network users to review and validate all added "blocks" of data up to the original input.[104]

Blockchain networks maintaining such ledgers can be further classified based on their permission model. Permission models determine who can publish new blocks to the chain. Networks where anyone with access can publish are called permissionless, while networks with restrictions on publishers are permissioned.[105] Both types of networks rely on methods of multiparty agreement, or method of finding consensus, but permissionless networks rely more heavily on resource-

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96. GAO, *supra* note 94, at 1.

97. *Blockchain & Distributed Ledger Technology (DLT)*, *supra* note 95.

98. DEPOSITORY TRUST AND CLEARING CORPORATION GUIDING PRINCIPLES FOR THE POST-TRADE PROCESSING OF TOKENIZED SECURITIES 8 (2019), https://www.dtcc.com/~/media/Files/Downloads/WhitePapers/Crypto-Asset-Whitepaper-2019.pdf.

99. WORLD BANK GROUP, DISTRIBUTED LEDGER TECHNOLOGY (DLT) AND BLOCKCHAIN 21 (2017), https://olc.worldbank.org/system/files/122140-WP-PUBLIC-Distributed-Ledger-Technology-and-Blockchain-Fintech-Notes.pdf.

100. *See generally* Satoshi Nakamoto, *Bitcoin: A Peer-to-Peer Electronic Cash System*, https://bitcoin.org/bitcoin.pdf (last visited Apr. 16, 2022).

101. NIST Report, *supra* note 3, at 7.

102. NIST Report, *supra* note 3, at 7.

103. Gideon Greenspan, *The Blockchain Immutability Myth*, COINDESK (May 9, 2017, 7:18 AM), https://www.coindesk.com/blockchain-immutability-myth.

104. Xiwei Xu et al., *A Taxonomy of Blockchain-Based Systems for Architecture Design*, 2017 IEEE INT'L CONF. ON SOFTWARE ARCHITECTURE 243, 244 (2017).

105. NIST Report, *supra* note 3, at 5-6.

intensive consensus methods to disincentivize malicious behavior in publishing new blocks.[106]

Current implementations of blockchain rely on a variety of consensus methods, but commonly use proof-of-work and proof-of-stake. Proof-of-work consensus mechanisms, such as used for Bitcoin, incentivize digital "miners" to compete to solve a cryptographic puzzle to add new transactions to the ledger through computing power, and thus large consumption of electricity.[107] Proof-of-stake instead selects the next mining node based on their holding of digital currency native to that blockchain network, incentivizing good behavior among nodes on the network and also limiting resources expended adding new blocks.[108] A variety of other consensus models are available, depending on which aspects of blockchain an application is attempting to capitalize on.[109]

Notably, implementing changes to a blockchain network's protocol and data structure is difficult, as these changes divide the network into separate forks. In blockchains, soft forks occur when changes made are backwards compatible with unchanged nodes, while hard forks cause the unchanged nodes to reject blocks following new protocols.[110] This is particularly relevant in permissionless blockchain networks, where the lack of controlling central authority ensures user support is necessary to significantly alter a blockchain network's characteristics. Permissioned blockchains do not face this issue, as the governing entity or consortium can determine who joins the network, what members are removed, and have dominance over network protocol and structure.[111]

Another significant risk facing permissionless networks is a majority attack, also commonly referred to as a 51% attack. In a majority attack, a malicious actor attempts to use overwhelming computational power to privately mine a fork in the blockchain before a merchant can confirm the transaction across the network, enabling the malicious actor to complete a double-spending transaction in the new fork.[112] While rare under current circumstances, new specialized mining hardware, like application-specific integrated circuits, indicates majority attacks could become more prevalent as the base computing capabilities of mining technology increases.[113]

New applications of blockchains utilizing proof-of-work consensus models must also be wary that the high energy costs and power consumption intrinsic to some applications are fundamentally counter to the goals of sustainable development.[114] As such, entities desiring to mitigate emissions should not use

106. NIST Report, *supra* note 3, at 5-6.

107. Xu et al., *supra* note 104, at 249.

108. Xu et al., *supra* note 104, at 249.

109. NIST Report, *supra* note 3, at 18-24.

110. NIST Report, *supra* note 3, at 29-30.

111. NIST Report, *supra* note 3, at 35.

112. Griffin Mcshane, *What is a 51% Attack?*, COINDESK (Oct. 12, 2021), https://www.coindesk.com/learn/what-is-a-51-attack/#:~:text=A%2051%25%20attack%2C%20also%20known,power%20from%20a%20third%20party.

113. *Blockchain Attacks and the Fight for Immutability*, PERKINS COIE (Feb. 19, 2019), https://www.perkinscoie.com/en/news-insights/blockchain-attacks-and-the-fight-for-immutability.html.

114. Kevin Hotchkiss, *With Great Power Comes Great (Eco) Responsibility—How Blockchain is Bad for the Environment*, GEO. ENV'T L. REV. (Apr. 6, 2019), https://www.law.georgetown.edu

blockchain applications relying on resource exhaustive consensus mechanisms such as the proof-of-work model underlying Bitcoin.

B. What Are Smart Contracts?

Whereas blockchain lends itself to preserving immutable data in a transparent way, smart contract technology serves a different purpose. At its core, a smart contract is a set of coded self-executing computer functions that take specified actions based on the occurrence or non-occurrence of specified events.[115] Smart contracts are often implemented on a blockchain. The easiest way to think of smart contracts are a set of computerized "if/then" conditions. If some condition is met, then the computerized code will automatically implement some function of the underlying contract.

A good example of smart contract technology being implemented would be in the context of insurance. An insurance company could implement a smart contract that automatically disperses claim money based on the occurrence of some event that is sure to cause loss such as hurricanes, floods, or other natural disasters.[116] Smart contracts can also be integrated into a blockchain and used based on the information contained in that blockchain.[117] As discussed previously, smart contracts could be implemented to ensure that carbon offset credits tracked on a blockchain are automatically retired upon the completion of preset requirements.

IV. BLOCKCHAIN SOLUTIONS APPLIED TO CARBON OFFSET CREDIT TRADING MARKETS.

Despite significant hype and misconceptions about what blockchain is and can do, practical applications are emerging that could improve society's ability to respond to challenges in a variety of contexts.[118] Within the carbon market, stakeholders are already conceptualizing new projects seeking to apply blockchain to meet the unique challenges players face in addressing climate mitigation through market mechanisms. For example, a recent OECD report recommended the use of a blockchain registry to transform the current fragmented carbon credit market into a decentralized but synchronized network.[119]

Applied to carbon offset credit trading markets, an integrated blockchain would enable individuals and entities to trace the chain of ownership of a particular credit, provide heightened accounting standards, and generally lend itself to solving trust and accountability issues prevalent in current markets. There are now many

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/environmental-law-review/blog/with-great-power-comes-great-eco-responsibility-how-blockchain-is-bad-for-the-environment/.

115. *A Primer on Smart Contracts*, COMMODITY FUTURES TRADING COMM'N (Nov. 27, 2018), https://www.cftc.gov/sites/default/files/2018-11/LabCFTC_PrimerSmartContracts112718.pdf.

116. Lucas Mearian, *What's a Smart Contract (And How Does It Work)?*, COMPUTERWORLD (July 29, 2019), https://www.computerworld.com/article/3412140/whats-a-smart-contract-and-how-does-it-work.html.

117. *Id.*

118. Cathy Mulligan, *Blockchain and Sustainable Growth*, 55 U.N. CHRON. 47, 48 (2019).

119. OECD, BLOCKCHAIN TECHNOLOGIES AS A DIGITAL ENABLER FOR SUSTAINABLE INFRASTRUCTURE 38 (2019), https://www.oecd.org/finance/blockchain-technologies-as-as-digital-enabler-for-sustainable-infrastructure.htm.

hundreds of companies and non-governmental organizations generating and selling carbon credits in a wide variety of contexts,[120] but a blockchain would facilitate all the data from these diverse sources to consolidated into a consistent and verifiable record on a common platform. The verifiability of records on a blockchain that cannot be altered or tampered will help reduce the double counting and fraud that undermine the credibility of current carbon markets.[121]

This section first surveys some existing applications of blockchain to verify carbon offset credits, then explores some possible future applications in making more transparent and credible carbon offset credit markets, and then finally discusses the potential use of smart contracts run on blockchains for further validating carbon offset credit trading.

A. Existing Blockchain Applications for Carbon Offset Credits

One such blockchain venture operating in the carbon market is Nori, who seek to develop a cryptocurrency token, the Nori Carbon Removal Tonne (NRT), exchangeable for one Carbon Removal Certificate (CRC).[122] CRCs are a non-fungible secondary digital asset representing the removal of one metric ton of carbon dioxide from Earth's atmosphere. This venture hopes to develop an exchange where NRT can act as a market-driven, universal price for the mitigation efforts represented by a CRC, in order to develop a signal price for carbon.[123] Nori plans to "mint" 500,000,000 NRTs, setting aside an insurance pool of tokens to replace invalid CRCs. CRC sellers utilizing the Nori market receive a payment of restricted and unrestricted tokens, with the restricted tokens held back as collateral until emission reduction activity can be verified. Should the CRC seller break the contract and release carbon, the restricted tokens are used to purchase new CRCs. This mechanism ensures that CRCs on the Nori market are actually beneficial in climate change mitigation efforts. [124]

To fund and launch this venture, Nori plans to launch the NRT with an ICO to seed a market and incentivize adoption of NRT in carbon removal markets. Nori considers funding itself through an ICO as preferable to selling off equity in the company itself to investors, hoping to link financial decisions with the goal of mitigating greenhouse gas emissions instead of solely investor expectations.[125] The ICO relies on a SAFT Regulation D offering to comply with securities regulation.[126]

For its projects, Nori relies on Carbon Quantification Tools (CQTs) to develop carbon removal methodologies verifiable by independent parties and in line with International Organization for Standardization principles for emission estimations, monitoring, reporting, and verification.[127] The Nori Methodology relies

120. Lovell, *supra* note 38, at 357.
121. Gambill, *supra* note 5.
122. Gambill, *supra* note 5.
123. Gambill, *supra* note 5.
124. Gambill, *supra* note 5.
125. *See* Kenyon, *supra* note 6, at 4.
126. NORI, *supra* note 37, at 51-53.
127. NORI, PILOT CROPLANDS METHODOLOGY 5 (Dec. 15, 2021) https://nori.com/resources/croplands-methodology.

on a Greenhouse Gas Implementation Tool model ("GGIT") that complies with the United States Department of Agriculture greenhouse gas and carbon stock and flux estimation guidance.[128] Carbon sequestration through adoption of regenerative soil treatment and cropping practices are eligible for credits under the Nori methodology.[129] Nori's premier CRC supplier under this program has already committed to soil carbon retention projects worth 14,010.6 NRT tokens, and nearly all of these tokens have already been sold on the Nori marketplace.[130]

A different project backed by Microsoft and the InterWork Alliance (IWA) plans to adopt a different tokenization standard to bring transparency in emission calculations. In particular, this project seeks to address issues of verifiability and double spending of carbon credits.[131] The partners have drafted a sustainability working group plan attempting to create a standardized framework for tokenization of securities in the voluntary carbon market, and eventually moving into compliance markets.[132] The overall goal of the project is to establish for the global community what constitutes a carbon credit, the proper way to tokenize such an asset, and how to make carbon accounting more rigorous through blockchains.[133] The results of this project, if successful, are likely to incentivize more blockchain-focused ventures to enter the carbon market as climate change mitigation efforts.

In December 2020, the Universal Protocol Alliance, a coalition of blockchain companies including Uphold, Bittrex Global, Ledger, Certik, and Infinigold announced the Universal Carbon token.[134] Each carbon token will be, "a tradable certificate confirming that one tonne of CO_2 (or equivalent greenhouse gas) has been averted in a given year by an environmental project or company, as verified by an international standards agency such as Verra."[135] The tokens are available for purchase now, both by companies that are seeking to meet zero carbon pledges or individuals wishing to offset their carbon footprints by buying and "burning" (i.e., permanently disabling) carbon credits.[136] A major purpose for developing this blockchain-based carbon credit was to prevent the "double counting" problem.[137]

Finally, Global Carbon Holding recently announced it is tokenizing carbon credits on the Algorand public blockchain.[138] The project will focus on making carbon credits more accessible and transparent in Asian nations as part of a global

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128. *Id.* at 3-5.

129. *Id.* at 3.

130. NORI, *Harborview Farms*, https://nori.com/supplier/1 (last visited Apr. 16, 2022).

131. Allison, *supra* note 71.

132. Allison, *supra* note 71.

133. Allison, *supra* note 71.

134. Ian Allison, *Blockchain Coalition Launches Tradable Carbon Credit Token*, COINDESK (Dec. 1, 2020 6:40AM), https://www.coindesk.com/business/2020/12/01/blockchain-coalition-launches-tradable-carbon-credit-token/.

135. *Frequently Asked Questions: What Is A Carbon Credit?*, UPCO2, https://universalcarbon.com/faq.html (last visited Apr. 16, 2022).

136. *Id.*; *Frequently Asked Questions: What Can I Do with my UPCO2 Token?*, UPCO2, https://universalcarbon.com/faq.html (last visited Apr. 16, 2022).

137. Allison, *supra* note 134.

138. *Global Carbon Holding Partners with the Algorand Foundation to Leverage Blockchain Technology and Bring Greater Transparency and Trust to the Global Carbon Credits Ecosystem*, ALGORAND FOUND. (Jan. 13, 2021), https://algorand.foundation/news/global-carbon-grant-award.

carbon credit marketplace.[139] As with the other blockchain initiatives for facilitating carbon credit trading, the objective of this project is to enhance the transparency and trust in carbon trading in order to accelerate the use of this mechanism to more rapidly reduce atmospheric carbon levels.[140]

B. Future Applications of Blockchain for Carbon Credit Offsets

Turning away from existing projects applying blockchain to carbon credits, researchers and academics are discussing future applications of blockchain in the carbon market. Macinante proposes a conceptual model for networking and harmonizing different emission trading schemes across blockchains to facilitate development of global carbon markets.[141] Given the scale and diversity of carbon removal options and needs, it will not be possible for any one system or program to track and credit all carbon offsets.[142] A blockchain could provide a "bridge" that connects various carbon credit regulatory schemes and platforms into a unified system that would reduce transaction costs and barriers to the development of an effective global carbon price.[143] Entities involved in regulating emissions trading should consider the benefits of synchronized transactions across the global carbon market that could be facilitated by such a blockchain solution.

Implementing blockchain into carbon offset credit trading markets offers a uniquely effective solution to the double counting problem. By way of form, such a system would likely use a blockchain application as the platform on which carbon offset credits are traded. Using a blockchain credit trading platform would bring two main benefits to the industry: monitoring capabilities and transparency. Carbon offset credits could be effectively tracked from creation to retirement.

Integrating blockchain into carbon offset credit trading markets would enable credits to be monitored throughout their lifecycle. Functionally, blockchain integration would mean that any carbon offset credits being traded through the system would need to be tokenized and then turned into a *block* on the chain. Once listed and sold, a new block would be created reflecting a particular credit that is transferred from one owner to another (from the original seller to the original buyer). An additional block could be created to reflect a credit's retirement. This also means that a new block would be created when a credit purchaser resells their credits and causes the double counting problem. By tying particular credits to blocks on the chain, which are followed by subsequent blocks whenever there is a transfer, every credit traded comes with a log that is immutable and follows it throughout its lifecycle.

Assuming the blockchain platform is public, anyone could trace the ownership of a particular credit through its chain of ownership, reflected by blocks in the system. Curious members of the public and NGOs could verify claims made

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139. *Id.*

140. *Id.*

141. *See generally* Justin D. Macinante, *A Conceptual Model for Networking of Carbon Markets on Distributed Ledger Technology Architecture*, 11 CARBON & CLIMATE L. REV. 243 (2017).

142. Jan C. Minx et al., *Negative Emissions—Part 1: Research Landscape and Synthesis*, 13 ENV'T RSCH. LETTERS, May 2018, at 1, 17.

143. Macinante, *supra* note 141, at 258-59.

by credit owners. Potential purchasers could investigate the chain of ownership of a particular credit before buying it, to avoid the double counting problem. And regulatory bodies could verify the legitimacy of any related claims made by individuals and entities under its jurisdiction. In turn, the double counting problem would be mitigated. Carbon offset credit trading markets would have the information they need to more effectively police credit purchasers and enforce their contracts against those who breach and cause the double counting problem.

Integrating blockchain into carbon offset credit trading markets would provide a level of transparency and trust that is not currently available. Under the current system, the only parties that can view a particular transaction are those that are involved in it. Blockchain, however, is inherently transparent. Anyone with access to the public blockchain can view the information on it, as well as any transactions occurring on it. Accordingly, credit purchasers would be incentivized to avoid reselling their credits and causing the double count problem, because doing so would now be publicly visible. Moreover, individuals and regulators would have an ability to hold credit purchasers accountable for the accuracy of any related claims they make, because those claims would be verifiable through the blockchain.

The effectiveness of blockchain integration into carbon offset credit trading markets, as it relates to solving the double counting problem, can be verified by observing Nori, discussed above as an early adopter of blockchain in the carbon offset credit industry. Nori uses blockchain to monitor credits traded through its system, providing transparency in the process, and in turn ensuring "easy auditability of the lifecycle of the Carbon [offset credit]."[144] Nori proves blockchain's use case in the carbon offset credit industry, and has taken a crucial first step towards using technology to solve the double counting problem. However, more widespread adoption is necessary to fully eradicate the double counting problem.

Aside from significant potential to help solve the double counting problem, blockchains can provide additional value to the carbon offset credit industry. If each carbon credit is given a unique identification code and placed on a blockchain, additional functionalities for ensuring the validity of carbon offset credits can be further enhanced. For instance, once problem that has hampered existing carbon market is the lack of transparency, where potential carbon credit buyers cannot easily locate prospective carbon credit sellers.[145] With a blockchain that lists all available carbon credits, buyers and sellers can easily and inexpensively find each other, resulting in much more efficient and dynamic carbon credit markets.[146]

Another problem with certain sequestration programs is the permanence of the carbon offsets.[147] For example, an entity may earn carbon credits by dedicating a parcel of land to reforestation that generates a specified level of credits for the increased carbon sequestration. But what if something happens to that forested land, such as being sold for residential development, or loss through a forest fire?[148] By enabling easy tracking of carbon credits on a public blockchain, the credits assigned

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144. *See* NORI, *supra* note 37, at 41.

145. OECD, *supra* note 119, at 34.

146. *Id.* at 35.

147. REILLY & MERCIER, *supra* note 43, at 8.

148. *See, e.g.*, Daniel Wolfe & Tal Yellin, *Bootleg Fire is Burning Up Carbon Offsets*, CNN (July 22, 2021), https://www.cnn.com/2021/07/22/weather/bootleg-oregon-fire-carbon-offsets/index.html.

to that now disrupted forest can be identified and their value appropriately discounted. For example, Nori "self-insures" against such unanticipated events by setting aside twenty percent of Nori tokens to cover incidents such as a fire that destroy the value of Nori tokens on the blockchain.[149]

C. Smart Contracts Applied to Carbon Offset Credit Trading Markets

Integrating the use of smart contracts into the carbon offset credit trading industry would also be valuable in the fight against the double counting problem. In application, smart contracts could be used to automatically retire credits when certain conditions are met, void credits when a purchaser resells them and causes the double counting problem, ensure firms are held to carbon reduction claims, or even to simply automate the transfer of credits and exchanged money between buyers and sellers. No matter their use, smart contracts could add value to the carbon offset credit trading industry, but if used properly, they also are an effective tool in combating the double counting problem.

Smart contracts can be deployed to automatically retire carbon offset credits when certain conditions are met. A key feature of smart contracts is that they can be made dependent on outside, or third-party, information that is monitored by third party or independent sites known as "oracles."[150] Oracles are essentially a piece of hardware or software that feed real time data to the smart contract for purposes of its execution.[151] Applied here, oracles could be used to monitor carbon emission and credit regulatory bodies, to determine when credits are "claimed" by a purchaser, and then subsequently retire those credits automatically. Using smart contracts to retire credits when they are claimed for regulatory or other purposes, offers a distinct advantage over automatic retirement on purchase (which can be implemented without the use of technology), because it enables credit buyers to resell excess credits without causing the double counting problem. Credit buyers would only be able to resell those credits that have not already been claimed for a regulatory or other purpose and have been automatically retired by smart contracts as a result. Moreover, outside monitors would be able to observe which credits have been retired or used.

Smart contracts can also be used to automatically void carbon offset credits when a buyer sells previously used credits to a third-party purchaser, causing the double counting problem. Smart contracts are often implemented on a blockchain. To this end, smart contracts can be developed in a way that uses information on that same blockchain to inform the intended function of the smart contract. Applied to the carbon offset credit industry, the sale and purchase of credits can be conducted on a blockchain, also including a smart contract, which voids carbon offset credits when they are sold to a third-party purchaser but have already been "claimed." To monitor the transfer of particular credits and whether they have been claimed, one of the smart contract's inputs would be the creation of new blocks on the chain, and another would be whether or not a particular credit has been claimed (informed by oracles as discussed above). By combining the monitoring functions of blockchain

149. Gambill, *supra* note 5.

150. *See generally* Mearian, *supra* note 116.

151. Mearian, *supra* note 116.

with the enforcement functions of smart contracts, to help solve the double counting problem, credit purchasers would again be incentivized to avoid a transfer resulting in the double counting problem, for fear of their credits becoming void.

More generally, through the use of smart contracts, parties who make a commitment to remove an amount of carbon from the atmosphere, or pledge to be carbon neutral, can be held to their claims. These claims of carbon reduction or neutrality can be enforced by implementing a smart contract, where a number of carbon offset credits are automatically purchased on behalf of the individual or entity making the claim. Moreover, the number of credits purchased can either be specified, or vary depending on actual carbon emissions, and monitored through the use of oracles. In today's environmentally conscious society, businesses often make claims that they are carbon neutral or low carbon emitters, but there is really no way to verify their claims.[152] However, by using smart contracts to fulfill their claims, especially when operating on a blockchain, businesses can be more transparent and give credibility to their word. Where a carbon reduction claim is made by a business, a presumption of credibility is warranted where it is fulfilled through a smart contract because the process is automated. Even more so, if that smart contract is on a blockchain, so individuals could verify the claimed action by accessing the public ledger for the blockchain.

At the most basic level, smart contracts can also be used to automate the sale and purchase of carbon offset credits conducted on a credit trading market. From serving the most basic function of facilitating transactions for a carbon offset credit trading market, to enforcing carbon reduction claims, and automatically retiring or voiding credits to fight against the double counting problem, smart contracts can provide significant value to the carbon offset credit industry and should be adopted as an industry standard.

V. CONCLUSION

Carbon offset credits have become a major commodity, but the credibility and veracity of offset claims are undermined by non-transparent and non-verified accounting, leading to actual and perceived double-counting. Without more robust protections and active measures taken to solve the double counting problem, the potential for credits to make an impact on climate change will be significantly limited. Credit trading markets do not currently make sufficient effort to effectively combat the double counting problem or enforce the basic underpinnings of the contracts they use. Proven technologies like blockchain and smart contracts need to be adopted to better fight the double counting problem. The use of blockchain would provide the monitoring capabilities that credit trading markets need to enforce their contracts. Moreover, it would bring transparency to the market and build greater trust. The use of smart contracts would help credit trading markets enforce their contracts, and may even help to avoid some the issues currently plaguing the industry.

Aside from the significant business case for integrating blockchain and smart contracts into the carbon offset credit trading industry, the technologies should

152. *See, e.g.*, Sustainability Commitments, GOOGLE, https://sustainability.google/commitments/ (last visited Apr. 16, 2022).

be adopted because they have the potential to strengthen trust in the industry, enable greater transparency, and most importantly, they are the clearest solution to solving the double counting problem. Whether the purpose is business related or humanitarian, blockchain and smart contract technologies should be used for the sale and purchase of carbon offset credits because they help solve the double counting problem and make credits more effective at serving their intended purpose of combating climate change.

As carbon markets continue to globalize, Blockchain's characteristics of immutability and transparency could provide unique tools in the fight against climate change. However, Blockchain is not a panacea- applications of Blockchain will not solely solve the climate crisis. The full scope of what Blockchain will be able to eventually accomplish is still to be determined, but players in the carbon market should be ready and open to experimentation with these new applications to ensure climate change mitigation efforts are successful.