Blockchain Decentralized Clearing of Environmental Credits

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The focus of this research is commoditizing environmental credits into standardized units by guaranteeing the provenance of the credit through the application of blockchain technology. The commoditization occurs by creating a decentralized clearing process using blockchain for the environmental credit market. The cleared standardized commodity units can then potentially be traded without the risk of rejection by the U.S. Environmental Protection Agency (EPA) because of production fraud or errors. The removal of the rejection risk would allow for small farmers, municipal wastewater plants and landfills to enhance their profitability by producing green electricity from biogas and receiving market tradable environmental credits. The complexity of the pathway requires blockchain, which creates an immutable ledger holding production and distribution data for the environmental credit. This immutable ledger supplies provenance that can eliminate counterparty risk when combined with the concept of decentralized clearing of the credits.

Introduction

The United States is currently planning to transition to electric vehicles (EVs) while trying to reduce the production of greenhouse gases (GhGs) for electricity generation. To date, twelve states have adopted legislation requiring increased sales of EVs over the next decade. The increase in green baseload electricity generation will be necessary to achieve this dual goal.

The Energy Policy Act of 2005 created the Renewable Fuel Standard Program in the United States. The U.S. EPA uses Renewable Volume Obligations (RVOs) to express the percentage of renewable fuels that refiners and fuel importers must blend into motor fuel per the law. Renewable Identification Numbers (RINs) are tradable securities representing a standardized renewable unit. Obligated parties deliver RINs to the Environmental Protection Agency (EPA) to fulfill their RVO requirements. eRINs are RINs that complete the energy pathway by powering EVs for transportation.

The biogas for the RIN can come from many feedstocks including manure. The process from manure to natural gas or electricity relies on self-regulation with independent process audits leading to the opportunity for fraud or unacceptable documentation that creates a failure to deliver (FTD) risk.

In this paper, we detail the application of blockchain to remove risk of rejection by the EPA, which is effectively a FTD risk in commodities and, by extension, the creation of an alternative clearing structure. This alternative clearing structure can be applied to the production of all environmental credits to remove

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the FTD risk and ensure the provenance of the credit from creation to destruction, allowing for multiple non-traditional products to be commoditized.

Blockchain

Blockchain stores information about transactions in an immutable ledger. The objective of a blockchain is to create a distributed platform focused on efficiency, quality, speed, flexibility and risk reduction (Kshetri, 2018). A private blockchain can reduce operational costs, and reduce/eliminate counterparty risk (Kamble *et al*., 2019). The proposed solution in this paper uses Hyperfabric Ledger, which eliminates the lack of privacy common in most public blockchain (Cong and He, 2019).

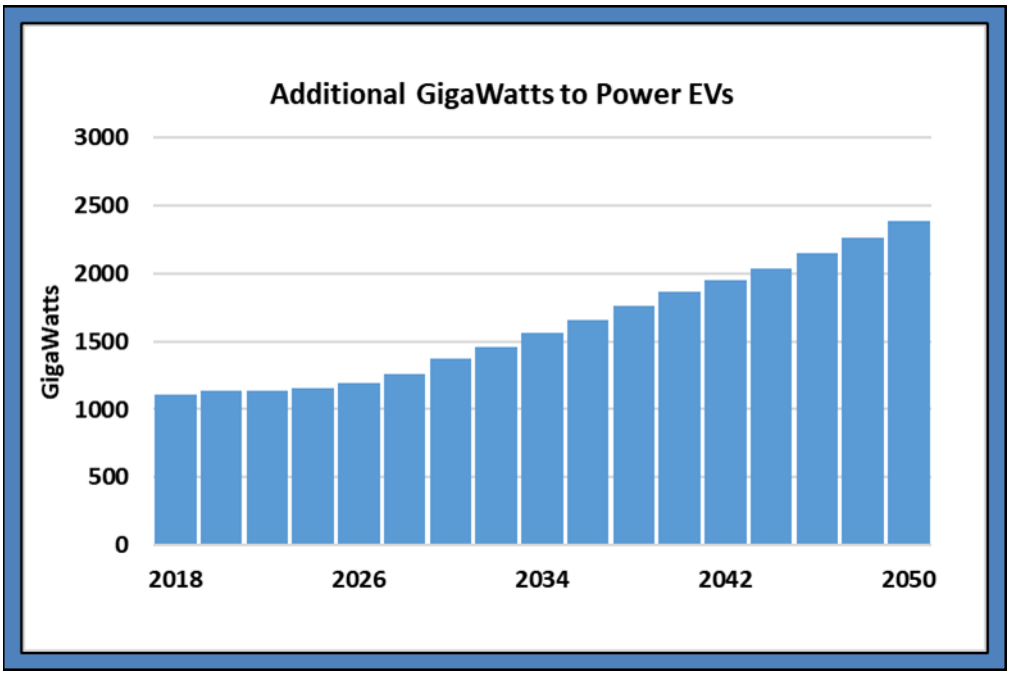
Embedded smart contracts are programmed to provide assurance to one party that the counterparty will fulfill the promise (Allen *et al*., 2021). The FoodTrust organization has successfully applied blockchain to certify food commodities such as grain, fruits, and even orange juice which is a listed commodity (Mendi, 2022). FoodTrust mainly focuses on immediate transactions so the FoodTrust blockchain structure is not proper for exchange-traded commodity products for various reasons including holding periods.

A unique benefit of applying blockchain technology to the environmental credits space is the standardization of the process across multiple producers and users. The standardization of production can revolutionize how an industry functions (Davenport, 2005). The standardization of issuing environmental credits through a Blockchain Clearing System (BCS) will commoditize the digital asset (Markus and Loebbecke, 2013). Using this standardized process will allow a producer to claim multiple credits using one set of data. A producer could legally reap the known benefits from investing in a California Carbon Allowances project (Johnson and Thuerbach, 2022) along with obtaining RINs.

Importance of Environmental Credits

Twelve states have adopted the Zero Emission Vehicle (ZEV) Program (California, Colorado, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Vermont and Washington), which requires increasing sales of ZEVs over the next decade (Vermont DEC, 2022). A U.S. Department of Energy study found that increased electrification across all sectors of the economy could boost national consumption by as much as 38 percent by 2050, largely because of EVs. The environmental benefit of EVs depends on the electricity being generated by renewables (Brown, 2020). Figure 1 on the next page provides an estimate of the new gigawatts of electricity needed by year including increases for space and water heating, and industrial power needs by 2050 with vehicle electrification dominating incremental demand growth (Murphy *et al*., 2021).

Figure 1
Additional Gigawatts Needed Mainly to Power EVs

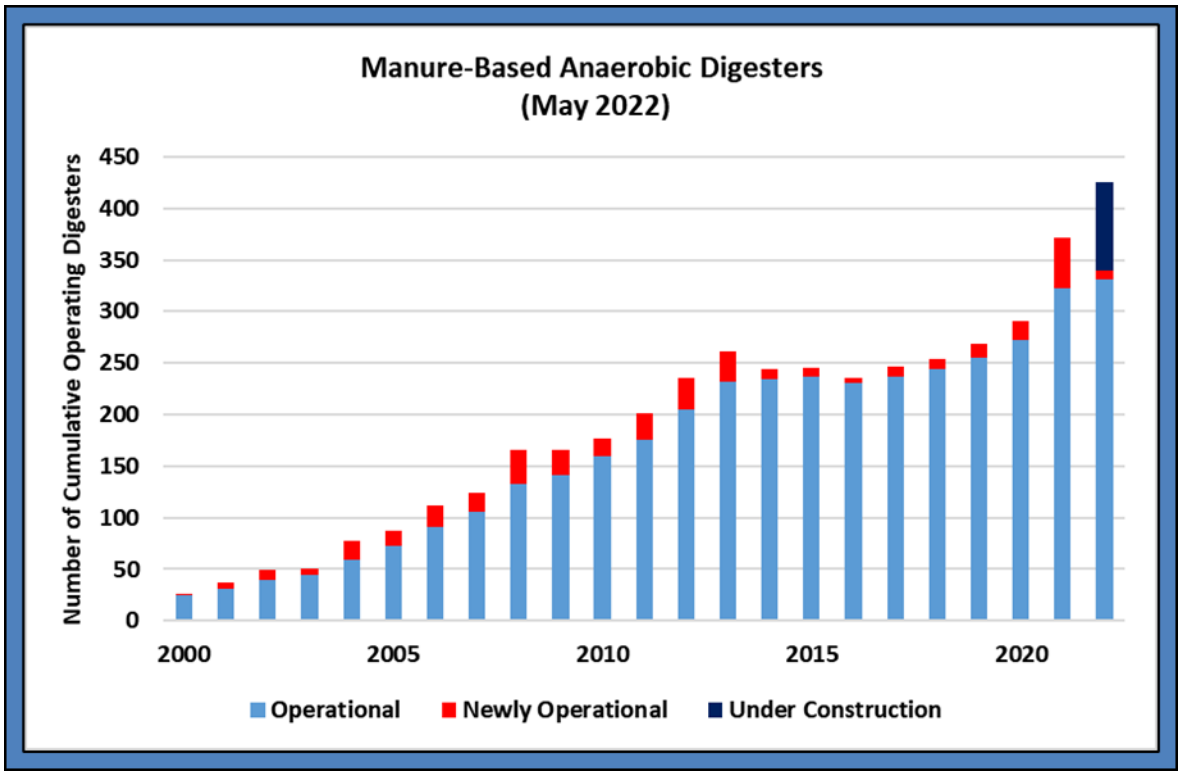


Sources: *Reuters Graphics* (2021) and Murphy *et al.* (2021).

Baseload green electricity will be needed to power the increasing number of EVs, which will reduce GhG from both the vehicles and the electricity production. Bioelectricity is produced from waste products (livestock manure and food waste) that generate biogas through anaerobic digestion and is then turned into electricity. This electricity is a potential source of baseload electricity that can power EV's.

Large dairy farms have been using anaerobic digesters to produce natural gas and electricity for years. In 2021, energy generation from manure-based anaerobic digesters was around 1.76 million megawatt-hours (MWh) equivalent. In calendar-year 2021, manure-based anaerobic digesters reduced Green House Gas (GhG) emissions by 6.09 million metric tons of CO2 equivalent (MMTCO2e) (U.S. EPA, 2022d).

Figure 2
Manure Digesters



Source: U.S. EPA (2022d).

The main obstacle to increasing the production of green energy through the application of anaerobic digestion is profitability due to infrastructure costs for small to mid-sized farms. The initial capital expenditures to build a digester is prohibitively expensive for small and mid-sized farms (Cernauskas *et al*., 2022). Another obstacle to funding a digester product is that the dairy business has profitability volatility due to government regulation of agricultural production (Almering *et al*., 2021). The added revenue from the creation of RINs credits can make the investment in the pollution reduction facilities due to government regulations profitable. A hurdle for the eRIN pathway is the complexity of the audit process that spans from the creation of the biogas to the electricity to miles driving by EVs.

FTD Risk from Fraud or Poor Record Keeping

One of the key hurdles in all RIN pathways is the potential of fraud. History includes cases of large-scale fraud in the renewable energy space. An illustrative list of RIN fraud using the D4 pathway is listed below in Table 1 on the next page.

Table 1 Fraudulent RIN Examples

Company	QTY of Invalid RINs	Fuel Code	Year
Elliot Global Partners	5,800,000	D4	2021
NGL Crude Logistics, LLC	36,000,000	D4	2018
Triton	39,000,000	D4	2017
Western Dubuque Biodiesel, LLC	36,000,000	D4	2016
Chemoil Corporation	72,700,000	D4	2016
Montgomery Recycling Corporation	12,500,000	D4	2016
Gen-X Energy Group, Inc. or Southern Resources and Commodities	7,700,000	D4	2015
New Energy Fuels Inc	10,200,000	D4	2015
Chieftain Biofuels LLC	4,800,000	D4	2015
Washakie Renewable Energy, LLC	7,200,000	D4	2015
Global E Marketing, LLC	6,000,000	D4	2014
Green Diesel, LLC	60,000,000	D4	2014
Imperial Petroleum, Inc. and e-Biofuels, LLC	33,500,000	D4	2013
Absolute Fuels, LLC	48,100,000	D4	2013
Clean Green Fuels	6,800,000	D4	2013
Total	386,300,000		

Source: U.S. EPA (2022c).

The examples in Table 1 illustrate fraud involving the largest number of biodiesel D4 RINs. Fraud is perpetrated by those creating and selling invalid RINS deliberately. The Quality Assurance Plan (QAP) is a voluntary program administered by the EPA where independent third parties may audit and verify that RINs have been properly generated and are valid for compliance. Only RINs verified under a QAP can submitted by obligated parties to meet their renewable fuel obligations. A voluntary program based on periodic site visits will reduce fraud but cannot eliminate fraud due to the periodic nature of the audits (U.S. House of Representatives, 2012).

The EPA requires the RIN production facilities to be audited by third-party auditors to ensure the data presented to the EPA for the RIN was valid (U.S. EPA, 2022a). The EPA has effectively ruled that if the producer of the RIN is insolvent and fraud is identified later that the auditor of the facility can be held responsible for the fraud (U.S. EPA, 2022b). However, this EPA ruling does not mitigate the FTD risk since the auditor must be proven negligent in the performance of the audit. As discussed in the next section, applying blockchain technology to RINs captures production data in an immutable ledger used to provide provenance, standardization and a financial guarantee.

The current EPA process of issuing RINs to the producers of biogas relies on a traditional audit structure. Farmers are generally the producers of the RIN and obtain a RIN by submitting data through an online EPA form. The EPA audit review may result in the invalidation of the credit several years after its issuance due to fraud or improper documentation which has led to FTD risk for the purchasers of the RINs. The EPA prosecution of a RIN auditor (Genscape) for replacement of invalid RINs has established that an audit firm has clearing agent responsibilities. The EPA and Greenspace settlement also established a negligent

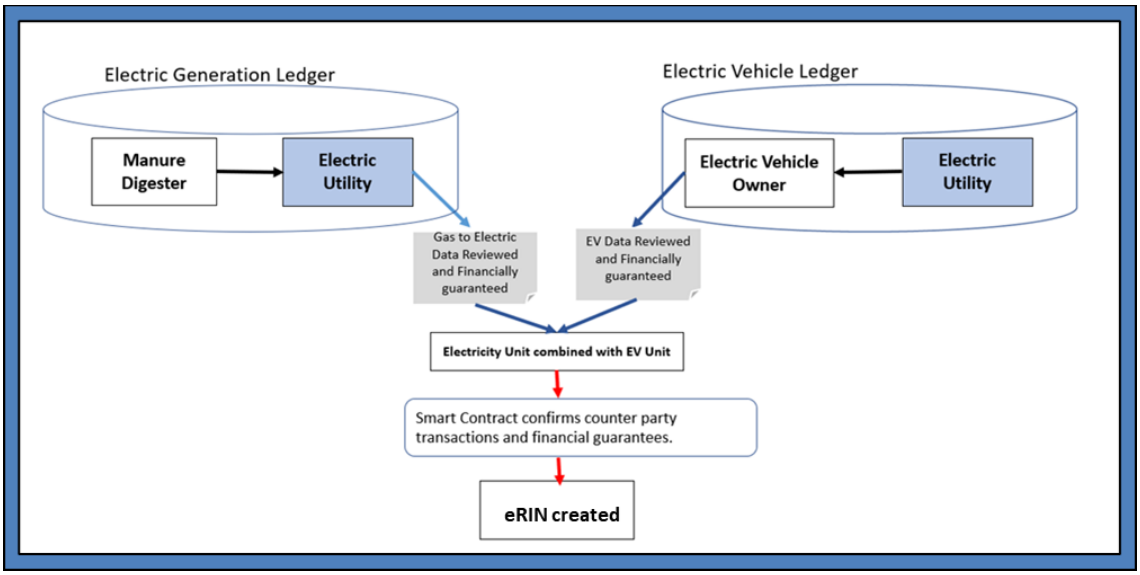
auditor has FTD risk if the producer is insolvent. In this precedent setting case, the auditor was negligent and ordered to replace 24,000,000 RINs (U.S. EPA, 2022b). The assignment of this risk to the auditor has created the need for a formal clearing structure.

Unlike traditional exchange-traded commodities, in which a clearing firm guarantees delivery, environmental credits not certified by an auditor do not have a guarantor. The EPA's right to invalidate the credit does not have a time limit and can occur many years after delivery, subjecting both the producer and the user of the credit to the risk of FTD.

Decentralized Guaranteeing (Clearing) of RINs via Blockchain

The Blockchain Clearing System (BCS) creates the financial guarantees to the eRIN purchaser that protects against the risk that the EPA invalidates the eRIN due to fraud or record keeping. The concept of using a BCS mechanism to financially guarantee a security for its life using a decentralized clearing mechanism is a new financial structure for commodities. As shown in Figure 3, the biogas/electricity producer, and the block EV operators counterparty risk to each other for fraud or errors has been eliminated.

Figure 3
eRIN Creation From Ledger Data and Smart Contracts



The unique decentralized framework where the provenance of the commodity is guaranteed based on immutable data will allow insurance firms, banks and other high credit firms to provide the financial guarantees to their customers that own small farms. The price of the financial guarantee is the price of a knockout option calculated by using the immutable data stored in the BCS. The immutable data is available both to the guarantor and the current owners of the eRIN so the risk can be calculated by all parties that own, trade or create an eRIN. Additionally, the BCS structure restricts the access of data to only approved participants for agreed upon data sets. This anonymization of the production data protects all network participants privacy along with all production data (Dunn, 2020). The application of a BCS to

this product will create a structure like traditional clearing since all parties are covered by insurance, the insurance is active, and the insurance will cover the eRINs total life until the eRIN is considered valid by the EPA after a formal audit.

The BCS directly addresses the veracity and the harmonization of production/market data. The BCS ensures that standardized units of the commodity are produced. The BCS ensures that counterparty risk and FTD risk is eliminated. These features are required for all commodity markets to grow and eventually evolve into exchange-traded products listed on derivative exchanges.

Conclusion

All commodities are a tangible product with standardized delivery features. It is the standardization of the product along with guarantee of a product for delivery that allows a product to become a liquid commodity that can be efficiently traded. As shown in this paper, a private blockchain can be used to both guarantee the provenance and to standardize the product. The application discussed in the paper was eRINs; however, the concept in this paper could be applied to a wide range of products.

The process to convert a tangible product into a commodity using blockchain is straightforward. First, the blockchain needs to document the provenance of the product. The environmental credit space requires that key production data is captured continually during the time of production and is available for review by all parties. The immutableness of the data allows for semi-real time quality inspection of the process to document potential fraud or an out-of-specification process such as adding too much alternative waste being placed into the manure process.

The smart contracts embedded in the blockchain will only allow product that passes the continuous quality inspection to be converted into standardized units. The standardized units are then guaranteed by a third-party against FTD risk. The role of the guarantor is like a clearing firm in futures where the counter party risk between buyers and the sellers is replaced by a AAA credit rated firm with the ability to make either party whole in the unlikely case that the EPA revokes this credit.

The blockchain process detailed in this paper expands the concept of commoditization into multiple non-traditional products through the ability to standardize and guarantee non-traditional products such as environmental credits. The commoditization of these products could allow for practical derivatives markets in these products since the FTD risk has been removed. Finally, the example used for the application of blockchain can create a new source of green baseload of electricity that can power EVs.

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Steve Josephs is a consultant who specializes in renewable and alternative energy projects. He is currently providing engineering and business advice to several biogas-to-transportation-fuel projects at farms and landfills. Prior to these projects, Josephs was a co-founder of AMP Americas and served as V.P. of Engineering. In this role, he led engineering for construction and operation of multiple farm Renewable Natural Gas (RNG) Facilities and Compressed Natural Gas (CNG) Stations. Before AMP, Josephs was the Chief Technology Officer at Infinium Capital Management, a Chicago-based proprietary trading firm.

Steve Josephs received his Bachelor of Science degree in Engineering from Princeton University and his M.B.A. from the University of Chicago. He is a licensed Professional Engineer (PE) in the State of Illinois and was Licensed by the Texas Railroad Commission to Manage CNG Station Operations.

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