



# RE-ENGINEERING THE CARBON SUPPLY CHAIN WITH BLOCKCHAIN TECHNOLOGY

## Abstract

The effect of greenhouse gas emissions across the globe is forcing countries as well as companies to redesign their manufacturing processes and reduce their carbon footprint. However, despite international agreements, there is a lack of global and standardized system to measure carbon emissions and track where it is generated across the supply chain. Without such a system, sustainable strategies will have only a limited impact. This paper explains how blockchain technology can be used to measure carbon, calculate carbon credit, standardize emissions, and ensure fair carbon credit pricing through an integrated and standardized platform. It also discusses the current challenges in the carbon supply chain and how blockchain can address these.

## Introduction

Across the globe, citizens are becoming increasingly aware of and concerned about the impact of human activities on the environment. Recently, there have been numerous initiatives that encourage companies as well as countries to reduce the emission of carbon and greenhouse gases across the entire supply chain. One such key initiative accepted by 197 countries is the Paris Agreement.

The Paris Agreement or the Paris Climate Accord has established a mechanism of measuring and controlling carbon emissions by setting emission standards for every country or nationally determined. The Paris accord by its framework establishes every country to have its own nationally determined contributions aligned to their national growth objective. The Kyoto Protocol of 1997 ratified the carbon credit system<sup>1</sup>. Both Kyoto protocol and Paris accord paves way for a global acceptance and transaction of carbon credit system. The carbon credit systems awards credits to countries or companies (entities, in case of Group Company) that exceed the nationally determined emission quota standards by reducing their carbon emissions<sup>2</sup>. Currently, 1 carbon credit is awarded to any group/ company that reduces their carbon emission by equivalent of 10 tons of carbon di oxide or its equivalent gases. The carbon credit system has paved way for the carbon trade

across the globe which is similar to any financial transaction. This carbon trade allows parties that emit higher amounts of carbon than permissible limits to purchase or exchange credits from parties that have lowered their carbon emissions than the permissible limits, thereby balancing out the amount of greenhouse gases emitted into the atmosphere. The World Bank estimates that the carbon credit market, which is valued at less than US \$50 billion today, will grow to US \$185 billion by 2030<sup>3</sup>.

The effort for carbon credit system or carbon trade has two fold values, first it makes the planet a better place to live (and for future generations) and second it brings value to customers. The value of such systems is driven more for individual customers than just countries or companies. Today customers desirous of purchasing eco-friendly products have limited access to emission labels. This brings the focus on having relevant information about the carbon footprint of each product through the means of carbon emission label. The carbon emission label or carbon label provides information on the amount of carbon dioxide produced during the process of manufacturing, transporting, stocking, and delivering a product to the consumer. The lower the value on the carbon label, the more eco-friendly is the product. In fact, there

are several companies/authorities such as CarbonNeutral<sup>®</sup>, Bonsucro, carboNZero, Climate Registered, EarthCheck, etc., that inform customers about the carbon footprint of various products<sup>4</sup>.

Fuelled by the need to spread awareness of eco-friendly practices, many manufacturers and retailers are taking active steps to reduce their carbon emissions and inform customers of the same. For instance, Coca-Cola is implementing a strategy to drive sustainability throughout its supply chain and reduce the carbon footprint of 'the drink in your hand' by 25% by 2020<sup>5</sup>. Casino, a French retail chain, displays the carbon labels of all its own products. Another French retailer, E. Leclerc, displays carbon labels on store shelves indicating the carbon emissions per kilogram of produce along with the price tag<sup>6</sup>.

It is important to note that the carbon trading system and carbon emission label are two independent initiatives. While they each have their own challenges, manufacturers and governments seeking to amplify impact need a unified system that integrates the advantages of both these systems. Here, blockchain technology can be a useful tool to unify these systems while reengineering supply chain processes to effectively reduce carbon emissions.

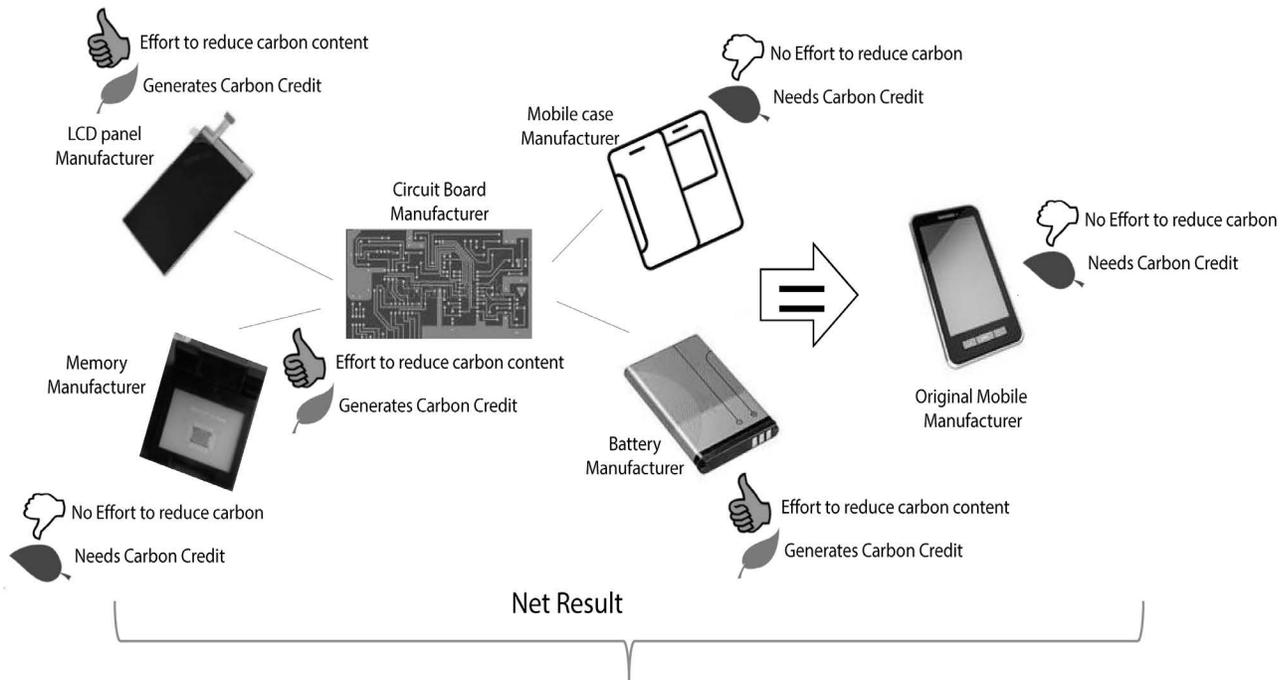
## II. Example: Reducing the carbon footprint of every phone

Usually, smartphones have 5 main components namely, the circuit board, LCD panel, battery, memory chip, and the mobile case<sup>7</sup>. Each component is produced using raw materials. Often, components are produced by independent manufacturers (known as component manufacturers) who then supply these to a final equipment manufacturer like Samsung or LG. This manufacturer then assembles the components, adds its unique value, loads the requisite software, and ships it to distributors. The product may then travel to various international, national, regional, and local distributors or service providers before being bought by a consumer.

Now, this entire cycle involves multiple parties and processes and at each step there is a certain amount of carbon dioxide being produced. However, without a centralized system, there is no way for manufacturers to identify and measure these different sources of carbon emissions in order to calculate the total carbon footprint of the final product. Further, third parties such as component manufacturers, suppliers, distributors, and retailers may not have a sustainable strategy in place to reduce their carbon footprint by re-engineering their manufacturing and business processes or regulating sourcing. Such insight is crucial for manufacturers

who embark on initiatives to reduce their carbon footprint.

Let us say the circuit board, LCD panel and battery manufacturers were able to reduce their carbon emissions beyond the preset standard earning them carbon credits. However, the memory, mobile case and final manufacturers were unable to do so. The second set of manufacturers can buy the carbon credit generated and sold by the first set to offset their emissions, thereby reducing the overall carbon footprint of the product.



### Overall reduction in the carbon footprint of Mobile

Fig 1: How the carbon credit system works for a mobile manufacturer

Thus, it becomes important to build synergies across the supply chain and create a unified process whereby manufacturers share information across all their partners and vendors. This visibility will help manufacturers leverage the carbon trading system to share carbon credits and lower their carbon label. For example, in 2014, Nestlé replaced 92% of its industrial refrigerants with eco-friendly natural refrigerants, sourced 85% of the

electricity used in its Mexican factories from wind farms and used spent coffee grounds as a supplementary fuel in more than 22 of its factories<sup>5</sup>. According to the Paris Agreement, each of these measures generates a higher number of carbon credits, which can then be sold or exchanged with other partners who are unable to reduce their carbon emissions, thereby lowering the carbon footprint of Nestlé's products.

Clearly, carbon labeling and carbon credit are two sides of the same coin. While accurate carbon measurement and labeling will encourage companies to make use of carbon credits, standardization will change the way carbon credits are used across the supply chain. As it becomes more institutionalized the carbon credits can change the way we perceive things.

### III. Challenges in implementing low-carbon supply chains

Carbon measurement and carbon credit sharing and usage face certain challenges such as:

- **Effort spent in tracking carbon emissions** – Calculating the carbon label of a product is complex and costly. Besides needing product provenance, it also requires tracing each ingredient or component of the product from the beginning of their respective supply chains and across their manufacturing processes to calculate the associated emissions. It requires various methods, technologies, personnel and is extremely time consuming
- **High cost of measuring carbon emissions** – According to 3M, an American industrial giant that makes over 55,000 different products, the cost of calculating the carbon footprint of a single product can be as high as US \$30,000. Further, this may be a recurring cost<sup>6</sup>. The cost arises from the effort spent in coordinating with various parties to glean specific information which may need to be paid to get access as well as not readily available
- **Lack of standardization in calculating emissions** – The lack of carbon labeling standards and a single globally recognized methodology to calculate the carbon footprint is a significant challenge<sup>7,8,9</sup>. As each country grapples with creating their own methodology, the market becomes flooded leading to non-standardized calculation processes. Thus, companies are unable to reliably compare the footprint of a similar category of products across countries, creating further challenges when sharing carbon credits
- **International differences in measuring and pricing of carbon credits** – While the carbon credit system attributes a monetary value to pollution, its measurement and pricing varies across countries as seen in the carbon credit pricing of the Kyoto Protocol. For example, the price of a carbon credit earned for 1 megawatt of power

generated by wind farms in India can vary significantly from the price of carbon credits earned from afforested land in Denmark or the reduction of carbon dioxide emissions from a chemical plant in China. Thus, pricing standardization becomes critical to achieve international acceptance of carbon credit and its price

- **Need for a single regulatory body** – The success of the carbon credit system depends on the establishment of a single regulatory body that can standardize measure, price and accordingly issue credits to companies and projects that require these to succeed. Additionally, the verification process for carbon offsetting and granting must also be accepted and standardized. Currently, the challenge lies in the lack of standards for credit verification and grants<sup>10</sup>. Thus, there is a need for better measurement, reporting and verification to drive effective carbon credit trading
- **Lack of buy-in or awareness among consumers about green products** – A study by Vanlay et al. (2011)<sup>11</sup> showed that the overall change in purchasing behavior for eco-friendly products with green product labels was small<sup>12</sup>. However, when green label products were the cheapest, the shift was substantial. This indicates that product price is still a key driver for purchasing behavior compared to lower carbon emissions or green products. An experiment by the Carbon Trust with carbon labels also indicates that carbon labels are yet to inspire customers to change their buying habits. According to the survey, while a brand may use carbon labels to increase its green credentials, consumers still fail to understand the significance of the information<sup>13</sup>
- **Limited governmental regulation and involvement** – Limited transparency among governments for carbon credit measurement and carbon credits is a key challenge. This leads to minimal

investments and poor visibility, compromising widespread adoption by companies

The above challenges are universal across countries as well products. For instance, Tesco shelved a proposed project to label all in-store products with their carbon footprints owing to the need for extensive effort as well as lack of support from other supermarkets. However, such challenges are outside the scope of this paper. Thus, the lack of transparency among partners, the absence of a universal ledger and the inability to track carbon credits among peers are some of the key hurdles for global adoption of the carbon measurement and credit systems.



## IV. The blockchain solution

Blockchain is one of the most compelling and befitting tool to help companies meet the demand for accurate, reliable, standardized, and readily available information for carbon emission calculation. The design and architecture of blockchain technology promotes instant authentication, immutable data records and smart contracts. These features make it a fitting solution to integrate suppliers, manufacturers, logistics service providers, and stocking locations into a single network for rule-based interactions and value generation. The blockchain technology can readily transform the individual efforts of the companies into a network of effort with the primarily goal of overall carbon footprint reduction of the final product.

In a blockchain network, each party will be able to report the carbon emissions across their individual value chains based on standardized metrics, thereby creating a single platform for carbon measurement. Blockchain will provide standardized and accepted algorithm to calculate carbon emissions. This is going to be one of the key benefits of integrated platform. This will help get the idea accepted across parties and around the world. The World Economic Forum has already stated that carbon credits are the perfect candidates for crypto currency as these are data-driven, rely on multiple approval steps and are independent from the physical impact to which they correlate<sup>11</sup>. As blockchain addresses all of the concerns and challenges associated with lack of

standardization through smart contracts and verifiable transactions. Further, connecting blockchain to various source systems such as ERP and SCADA will simplify data gathering across the supply chain, thereby improving visibility at lower cost, time and effort. This will be an answer to the high cost and huge effort of calculating the carbon emissions across supply chain entities.

Thus, blockchain provides a platform where every partner across the supply chain, i.e., manufacturers, suppliers and distributors can work together in a transparent and accountable manner with the original equipment manufacturer (OEM) or retailer to drive a unified carbon ecosystem with accurate measurement and credits.



## V. Blockchain –: Architecture and details

Blockchain offers two solution architectures to help companies achieve an integrated carbon emission calculation process. These are:

**Open blockchain architecture** – Here, all channel partners and manufacturers can join the open architecture blockchain network as members and must be verified before they can conduct trades. These members can be generators as well as consumers of carbon credits. The carbon emission calculations are authenticated by independent authenticators and these results are then used to determine carbon credits. The calculation process has to follow the blockchain network accepted algorithm in order to standardize verification and sharing of carbon credits.

In this architecture, authenticators play a crucial role as they must be technically competent consultants who can onboard members, verify emissions and calculate credits. The authenticators must also ensure that calculation standards are consistent across generators and

consumers within the blockchain network. Some examples of open source blockchain systems that can be used in this scenario are Bitcoin, Ethereum and Multichain.

In the previous mobile manufacturing example, the open architecture system will act as an application platform that onboards all interested parties. Independent authenticators will verify the suppliers' and manufacturers' emissions and issue carbon credits. It is important to note that all suppliers and manufacturers must agree to the credit system designed by the open blockchain before they agree to join. However, this solution architecture requires significant computational power to maintain a large-scale distributed ledger and standardize calculations among numerous participants and authenticators. Due to this challenge, open blockchain architecture may not be suitable for all manufacturers.

**Private blockchain network** – This is a permission-controlled business-specific blockchain with controlled participants

and smart contracts. Standards for emission calculation, acceptable terms for the carbon credit system and well-defined criteria for memberships are the cornerstone of the permissioned blockchain. Participant entry is decided by existing members, a regulatory authority or a consortium. In the previous mobile manufacturing example, the mobile OEM may initiate the blockchain and invite all its suppliers, contract manufacturers, logistics service providers, warehouse operators, distributors, and retailers to join the permissioned blockchain network. The blockchain will define its own emissions calculation standards, carbon credit system and credit sharing mechanism, all of which are driven through smart contracts. Smart contracts are the key here as permissioned blockchains do not involve independent authenticators. Some examples of private blockchain networks are Hyperledger Fabric and Oracle Blockchain Cloud Services.

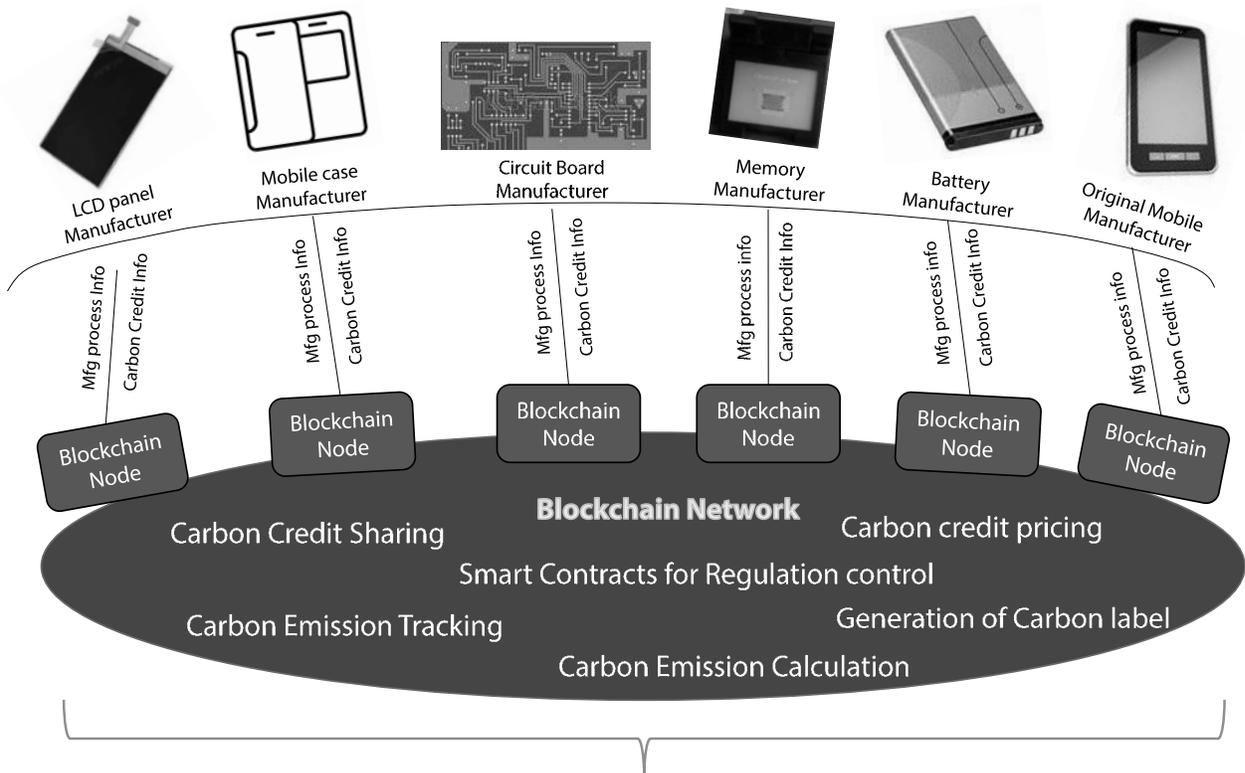


Fig 2 – High- level view of how private blockchains provide a platform to reduce carbon footprint of products across the supply chain.

## VI. Conclusion

Accurately measuring carbon emissions is the key to driving the success of international agreements such as the Paris Accord that aims to reduce the carbon footprint within the manufacturing industry. However, different countries use different approaches to measure carbon and calculate carbon credits, leading to challenges such as high effort and cost, inaccurate pricing, poor regulation, and low adoption. Thus, while the carbon credit system is a step in the right direction, the lack of standardization limits its effectiveness. Blockchain technology leverages distributed ledger systems, auditable trades and smart contracts, making it a fitting solution to address these issues. Depending on the type of supply chain and channel partners, open blockchain architecture or private blockchain networks can be used. Its unique features make blockchain the best vehicle to enable standardization across carbon measurement and calculation, thereby driving the carbon credit system to reduce the carbon footprint of products across the entire supply chain.



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