TITLE OF INVENTION: AUTOMATED METHOD AND SYSTEM FOR IMMUTABLE END-TO-END SUSTAINABILITY MANAGEMENT

Technical Field

[1] Embodiments of the invention relate to automated or computer-implemented, tamperproof sustainability management system that is a node in a Blockchain network, delivering end-to-end immutability as the emergence, and methods thereof.

Background

[2] Massive investment in time, money and effort to commoditise carbon and create a carbon trading system following the 1997 Kyoto Climate Accord have met at best with mixed results. Main challenges carbon cap & trade face include fragmented implementations and lack of transparency, leading to double-counting of GHG reduction as well as conflicts of interest when it comes to so-called third party validation or verification. Furthermore, many governments as well as corporations are reluctant participants in the complicated Kyoto Protocol. These complications are exacerbated and even exploited because of the lack of a proper validation system. A lack of a standardised, transparent and verifiable validation system is a serious impediment to the carbon market making a real dent in the dangerous growth of green house gas emissions (GHG).

[3] Blockchain technology provides decentralized, distributed and immutable ledgers that record the provenance of a digital asset. By inherent design, the data on a blockchain is unable to be modified, which makes it a legitimate disruptor of carbon markets. Blockchain would eliminate the double counting that plagues carbon markets. Certain blockchain may allow users to trade their digital tokens on the blockchain without high-cost middle men. In theory, blockchain provides the infrastructure required to create a digital carbon credit ecosystem and engage all the stakeholders. Blockchain also provides a traceable and auditable record of emission reduction projects. These projects, however, need to be physically validated before being entered into the blockchain. A number of ways to validate projects have been proposed, including using Global Position System (GPS) and satellites, or using a network of professionals who are accredited, globally distributed, and technically

competent. However, these solutions are technically complex, non-transparent and expensive.

Summary

[4] Embodiments of the invention provide a cloud-native, blockchain-native platform that creates an immutable data chain from remote carbon footprints through a Sustainability Management System to deliver analytics to authorised recipients without human intervention. Its unique, salient features include ability to handle a large number of sensors, receive data over proprietary protocols that is standardised for analytics, to then be made available to authorised recipients via Blockchain smart contracts either through authorised (e.g., password enabled) access to the relevant smart contracts, or via a Blockchain bridge.

[5] According to a first aspect, a computer-implemented sustainability management method comprises:

automatically receiving, by a node in a blockchain network and over proprietary protocols, sensor-measured energy data provided by sensors installed at energy assets associated with owner entities;

standardising the sensor-measured energy data by converting the sensor-measured energy data into comma-separated values (CSV) format for analytics;

for each owner entity:

generating, by the node, a carbon emission report based on a first subset of the sensor-measured energy data of a first subset of the energy assets which is associated with the each owner entity;

providing a verification node in the blockchain network with access to the first subset of the sensor-measured energy data and the carbon emission report for verification of the carbon emission report; and

ascertaining a presence of a successful verification of the carbon emission report in the blockchain network.

[6] Various embodiments of the first aspect may be provided in claims 2 to 9.

[7] According to a second aspect, a computer-implemented sustainability management system comprising:

a node of a blockchain network, wherein the node comprises:

a processing server configured to automatically receive, over proprietary protocols, sensor-measured energy data provided by sensors installed at energy assets associated with owner entities and further configured to standardise the sensor-measured energy data by converting the sensor-measured energy data into comma-separated values (CSV) format for analytics;

a report server configured to generate a carbon emission report of each owner entity based on a first subset of the sensor-measured energy data of a first subset of energy assets which is associated with the each owner entity, and provide a verification node in the blockchain network with access to the first subset of the sensor-measured energy data and the carbon emission report;

an access interface configured to provide a verification node in the blockchain network with access to the first subset of the sensor-measured energy data and the carbon emission report for verification of the carbon emission report, and

wherein the processing server is further configured to ascertain a presence of a successful verification of the carbon emission report in the blockchain network.

[8] Various embodiments of the first aspect may be provided in claims 13 to 15.

[9] Notwithstanding the above, an embodiment of the invention may include the following features/characteristics:

- Being native-cloud and native-blockchain.
- Its ability to handle a large variety of Internet of Things (IoT) sensors, and standardizing different proprietary protocols of a wide variety of IoT sensors, for calculations, analysis, as well as discovering, interpreting, and communicating significant patterns effortlessly on real time or periodic basis. This is particularly useful when carbon credits are earned based on forecast against a baseline — requiring ongoing monitoring of actuals against the forecast and against the baseline.
- Application Programming Interfaces (APIs).
- Flexibility allowing for a variety of digital Monitoring, Verification, Reporting (dMVR) features to be quickly coded into a Software as a Service (SaaS)

platform. The analytics may continually be changed to accommodate changes to standard and methodologies.

- Disallowing manually entered data from the Blockchain.
- Allowing a registry to retrieve immutable information on a carbon credit's provenance either through authorised (e.g., password enabled) access to the relevant smart contracts, or via a Blockchain Bridge.

[10] Specifically, the above embodiment connects commercial facilities immutably to Blockchain and registries in a transparently verifiable manner that, besides allowing for tamperproof dMVR (digital Monitoring, Verification, Reporting) also allows them to monetise carbon savings from their carbon footprints from carbon credits certified by connected registries, and/or from digitized carbon credit equivalents, including fractional portions thereof through the Blockchain's Automated Market Maker (AMM). The uniqueness of this embodiment, allowing large and small commercial facilities to earn carbon credits, is worth emphasising. Today's supply side of carbon credits is largely from reforestation and agricultural/carbon sequestration projects because of their ability to scale, compared to commercial facilities. By connecting large and small commercial facilities in an automated manner without the need for expensive human verifications, and the ability to then allow them to earn fractionalized credits commensurate to their relatively modest carbon savings, this invention gives large commercial buildings as well as small homeowners, an incentive to reduce their carbon footprints.

[11] Generally, the above embodiment connects remote carbon footprints (commercial facilities, reforestation & agricultural projects, renewable energy producers, other carbon sequestration projects) over an immutable data chain to authorised recipients like ESG auditors, registries and their authorised verifiers, offset purchasers, and carbon exchanges.

[12] The tamperproof, immutable nature of the data collected at source using IoT sensors, and transferred to the cloud based Sustainability Management System where all data received from different proprietary IoT sensors is standardised for analytics that then are made available either directly, or immutably from a Blockchain is particularly advantageous. The ability of the invention and its emergence through the

Sustainability Management System that connects to any and all IoT sensors at one end and to the Blockchain at the other, creating this unique and immutable end-to-end data chain, is also particularly advantageous. Other advantages will be apparent from the following drawings and description.

Brief Description of Drawings

[13] Figure 1 shows a flowchart describing a computer-implemented sustainability management method according to embodiments of the invention;

[14] Figure 2A shows a schematic logical diagram of entities connected to the sustainability management system according to embodiments of the invention;

[15] Figure 2B is an embodiment of Figure 2A;

[16] Figure 3A shows a schematic diagram of the sustainability management system; and

[17] Figure 3B is an exemplary actual depiction of the sustainability management system in a working environment.

Detailed Description

[18] In the following description, numerous specific details are set forth in order to provide a thorough understanding of various illustrative embodiments of the invention. It will be understood, however, to one skilled in the art, that embodiments of the invention may be practiced without some or all of these specific details. In other instances, well known process operations have not been described in detail in order not to unnecessarily obscure pertinent aspects of embodiments being described. In the drawings, like reference numerals refer to same or similar functionalities or features throughout the several views.

[19] Embodiments described in the context of one of the methods, devices, systems may be analogously valid for the other methods, devices, systems. Similarly, embodiments described in the context of a method are analogously valid for a device or system, and vice versa. Similarly, features and their additions, combinations and/or

alternatives that are described in the context of an embodiment may correspondingly be applicable to the same or similar features in the other embodiments even if not explicitly described in these other embodiments.

[20] In the context of various embodiments, including examples and claims, the articles “a”, “an” and “the” as used with regard to a feature or element include a reference to one or more of the features or elements. The terms “comprising,” “including,” and “having” are intended to be open-ended and mean that there may be additional features or elements other than the listed ones. The term “and/or” includes any and all combinations of one or more of the associated listed items. Identifiers such as "first", "second" and so on, are used merely as labels, and are not intended to impose numerical requirements on their objects, nor construed in a manner imposing any relative position or time sequence between limitations. The term “coupled” and related terms are used in an operational sense and are not necessarily limited to a direct physical connection or coupling. Thus, for example, two devices may be coupled directly, or via one or more intermediary devices. Based on the present disclosure, a person of ordinary skill in the art will appreciate a variety of ways in which coupling exists in accordance with the aforementioned definition.

[21] The term “blockchain” may include all forms of electronic, computer-based, distributed ledgers. These may include, but are not limited to consensus-based blockchain and transaction-chain technologies, permissioned and un-permissioned ledgers, shared ledgers and variations thereof. The term “node” may refer to an electronic device, such as a computer, tablet computer, mobile communication device, computer server, computer terminal, etc. The phrase “carbon reduction” and related phrases may refer to carbon avoidance and/or carbon removal. The terms “verification”, “validation”, and “certification” and their related terms may be used interchangeably.

[22] Figure 1 shows a flowchart describing a computer-implemented sustainability management method according to embodiments of the invention.

[23] In **block 102**, sensors or Internet of Things (IoT) devices are installed at energy assets of owner entities. Energy assets may refer to energy-production and/or energy-

consumption equipment which are emission sources and/or emission reduction sources which may have been identified as part of the project design and development document for measurement statistics and may be located at various different sites. Examples of energy assets include, but are not limited to, commercial buildings, data centres, power utility facility (thermal or renewable), manufacturing facility, sustainable forestry program facility, agriculture facility, aquaculture facility. Owner entities may refer to organisations, enterprises, individuals, etc. The sensors may be configured to measure energy data, e.g., power, heat, and/or energy consumption and/or production. The sensors may be off-chain.

[24] The sensors are communicably coupled, by wired and/or wireless connections, to a sustainability management system which connects to a blockchain network. The sustainability management system may be a node in the blockchain network and may be referred to as sustainability management node. The sustainability management system or node may be provided as a cloud computing platform and service, e.g. built over Amazon Web Services. Suitably connectivity protocols may include Modbus, Bacnet, WiFi, LONWorks, LoRaWAN, etc. Wide Area Network (WAN) may use a variety of secure connectivity solutions for connecting to the cloud platform and service.

[25] In **block 104**, the sensors automatically transmit or stream energy data, which are measured by the sensors, to the sustainability management node, via the wired and/or wireless connections, over a plurality of proprietary protocols. Such data may be referred to as sensor-measured energy data. The data streaming and/or receipt may be real-time, substantially real-time, or delayed by a predetermined or non-determined duration. The data streaming and/or receipt may be continuous and/or periodic. Such information received over proprietary protocols may be standardised for analytics on the sustainability management system. In different examples, energy data may be automatically fed to the sustainability management node via interfacing APIs, or manually entered into the sustainability management node, or both.

[26] In **block 106**, the sustainability management node receives or aggregates the sensor-measured energy data of various proprietary protocols. The sustainability management node has a translator on the access side which will convert and

standardise into comma-separated values (CSV) format for analytics (measurement, reporting and validation), all sensor-measured energy data received over proprietary protocols including but not limited to the following:

- BACnet IP
- Modbus IP
- Modbus RTU (requires a converter)
- OPC
- JSON/Rest
- SOAP/XML
- SNMP traps
- Import of CSV files.

[27] In **block 108**, for an owner entity, the sustainability management node generates a carbon emission report of the particular owner entity based on a first subset of the received sensor-measured data (or the standardised data) which corresponds to a first subset of energy assets, e.g., carbon emitting energy assets, associated with the particular owner entity. In particular, the carbon emission report includes carbon footprint data which is calculated based on the GHG protocol framework. The carbon emission report may include an identifier of the energy asset, sensor-measured energy data for generating the report, mechanism for performing online verification of the collected sensor-measured energy data, and/or carbon footprint data calculations.

[28] Access to the carbon emission report may be provided to at least a verification node and optionally a carbon registry and/or blockchain smart contracts in the blockchain network. The verification node may be a carbon registry and/or audit entity which is independent of the owner entity.

[29] In this disclosure where access to report and/or data is described, it is understood to be provided via an access interface, by posting in the blockchain network, and/or by direct or indirect transmission to the identified receiving node(s). It is to be further understood that the identified receiving node(s) are to receive access to the report and/or data, and/or receive the report and/or data. It is to be further understood that providing access may refer to submitting the report and/or data as part of carbon reporting and validation process.

[30] In **block 110**, the verification node, receives the first subset of the received sensor-measured data, e.g., via the access interface, and verifies the carbon emission report based on this first subset of the received sensor-measured data. If a successful or failed verification of the carbon emission report is ascertained, access to the respective successful or failed verification of the carbon emission report is provided to a carbon registry node in the blockchain network, the sustainability management node, and optionally some other nodes in the blockchain network and/or blockchain smart contracts. Furthermore, for the generated carbon emission report, the verification node may perform a variance analysis between the first subset of the received sensor-measured data and a second subset of the received sensor-measured data as outlined in Figure 1. The variance analysis may be performed in respect of overall critical operation information such as power usage efficiency, cooling, energy efficiency, coefficient of performance, carbon usage efficiency, carbon footprint, etc.

[31] In this disclosure, a successful verification of a report or ascertained data may include ascertaining that the generated report or ascertained data is valid or certified true, e.g., by ascertaining that the generated report or ascertained data is identical or substantially identical to an independently generated report or ascertained data; while a failed or unsuccessful verification may include ascertaining that both reports or data are non-identical or non-substantially identical. In this disclosure, substantially identical may refer to having a difference within a predetermined allowance; accordingly, non-substantially identical may refer to having a difference exceeding the predetermined allowance.

[32] In an example, an electricity meter that can provide source data for GHG protocol's Scope 2 emission of an owner entity of a commercial building is installed at the building. The electricity meter may be provided with a smart sensor which transmits or streams actual consumption data (sensor-measured energy data) from the meter to the sustainability management node on a real-time basis for generating a carbon emission report. On the other hand, the utility company also provides a bill for the consumed electricity and may also provide a portal where users may check their usage. The verification node may refer to the sensor-measured energy data, compare

it with the uploaded bill and/or usage data, and verifies the accuracy of the carbon emission report, e.g. reported Scope 2 figures.

[33] The sustainability management node may ascertain a presence of a successful verification of the carbon emission report in the blockchain network. Thus, the carbon emission report (carbon footprint of the particular owner entity) has been ascertained and verified by different or independent entities or nodes.

[34] In **block 112**, for an owner entity, the sustainability management node generates a carbon reduction report based on a second subset of the received sensor-measured data which corresponds to a second subset of energy assets, e.g., carbon reducing energy assets, associated with the particular owner entity. The first and second subset of energy assets may be mutually exclusive or non-exclusive, i.e., includes at least some common energy assets.

[35] In an example, for the purpose of generation a carbon reduction report, similar type of sensor-measured data may be transmitted or streamed to the sustainability management node from a solar power plant, e.g., total hourly power produced by the plant. This may be converted to the carbon reduction as per standards. The power produced fed through the sustainability management node from the grid software may be validated through an independent sensor.

[36] Access to the carbon reduction report may be provided to at least the verification node and optionally the carbon registry and/or blockchain smart contracts.

[37] In **block 114**, the verification node receives the second subset of the received sensor-measured data, and verifies the carbon reduction report based on this second subset of the received sensor-measured data. If a successful or failed verification of the carbon reduction report is ascertained, access to the respective successful or failed verification of the carbon reduction report is provided to the carbon registry node, the sustainability management node, and optionally some other nodes in the blockchain network and/or blockchain smart contracts. This feature manages carbon credits earned based on a forecast against the first subset as described in Figure 1 —

requiring ongoing monitoring of actuals or the second subset against the baseline or the first subset.

[38] The sustainability management node may ascertain a presence of a successful verification of the carbon reduction report in the blockchain network. Thus, the carbon emission report has been ascertained and verified by different or independent entities or nodes.

[39] In **block 116**, for an owner entity, the sustainability management node ascertains a carbon offset required to achieve carbon neutrality or ascertains a carbon credit available for sale, based on the carbon emission report and the carbon reduction report or based on a carbon neutrality status. This may include ascertaining the carbon neutrality status based on the carbon emission report and the carbon reduction report. In this disclosure, carbon offset may refer to the required removal of GHGs from the atmosphere to achieve carbon neutrality by the particular owner entity; carbon credit may refer to a reduction in GHGs released into the atmosphere.

[40] Access to the carbon neutrality status, the carbon offset and/or credit may be provided to at least the verification node and optionally the carbon registry and/or a carbon exchange node in the blockchain network and/or blockchain smart contracts.

[41] In **block 118**, the verification node receives and verifies at least the carbon offset or the carbon credit, and optionally the carbon neutrality status, based on the carbon emission report and the carbon reduction report. If a successful or failed verification of the carbon neutrality status, the carbon offset and/or credit is ascertained, access to the respective successful or failed verification of the carbon neutrality status, the carbon offset and/or credit is provided to the carbon exchange node, the sustainability management node, and optionally the carbon registry node and some other nodes in the blockchain network and/or blockchain smart contracts.

[42] The sustainability management node may ascertain a presence of a successful verification of the carbon neutrality status, the carbon offset and/or credit in the blockchain network. Thus, carbon neutrality status, the carbon offset and/or credit have been ascertained and verified by different or independent entities or nodes.

[43] In **block 120**, upon successful verification of the carbon emission report, the carbon reduction report and the carbon offset or credit, the sustainability management node may instruct the carbon exchange node to transact the carbon offset or the carbon credit. In particular, the instruction may include a purchase of a carbon credit, which is equivalent to the carbon offset, from at least one carbon credit seller, or an offer for purchase. Alternatively, the instruction may include a sale of the carbon credit to at least one carbon offset buyer, or an offer for sale.

[44] After the purchase or sale transaction, the sustainability management node may update the carbon neutrality status. Access to the updated carbon neutrality status, the updated carbon offset and/or credit may be provided to at least the verification node and optionally the carbon registry and/or a carbon exchange node in the blockchain network.

[45] It is to be appreciated that the aforesaid steps may be performed in the aforesaid sequence or interchanged. In an embodiment, all generating steps in relation to various reports and ascertaining steps of carbon offset or credit may be performed, before any verifying step is performed. In another embodiment, some of the generating steps in relation to various reports and ascertaining steps of carbon offset or credit may be performed before any verifying step is performed.

[46] Furthermore, certain step(s) may be omitted or modified, e.g., ascertaining carbon neutrality status may be omitted, provision of access may extend to other nodes in the blockchain network. In an example, the method may require generation and verification of carbon emission report only. In another example, the method may additionally require generation and verification of carbon reduction report. In yet another example, the method may additionally require generation and verification of carbon neutrality status, carbon offset required for carbon neutrality and/or excess carbon credits for sale.

[47] Furthermore, the generating and ascertaining steps may occur periodically or upon demand. For example, the periodic intervals may be fixed or varied according to user requirements.

[48] Furthermore, the aforesaid steps may be performed for some of the owner entities.

[49] Furthermore, block 120 may include tokenisation of the carbon offset or credits prior to transaction. Furthermore, the Blockchain may be connected to carbon registries. By doing so, a certifying registry can be ensured the data, reports and analytics it receives is clean and untampered. This is done by having the registries connect to the Blockchain as nodes, or over a Blockchain bridge and become muti-sigs on that smart contract where certification is done. Alternatively, a registry can simply be provided a password to access the relevant smart contract in the Blockchain to access the pertinent data, reports, and analytics. Optionally, should the sell-side wish to digitise its carbon offset credits, the Blockchain may create a digital version of the certified carbon credit — a certified carbon credit equivalent. Once a carbon credit is digitised, it may not be reverted back to the original carbon credit. Once a carbon credit is sold/offset, it is 'burnt' and a non-fungible token (NFT) may be issued.

[50] In an example from the supply side, the carbon footprint of an owner entity may be ascertained or measured using the GHG framework. Based on the ascertained or measured carbon footprint, an owner entity may decide on a plan to monetise the reduction in emissions by applying for and selling certified carbon credits. The sustainability management node on a blockchain network may assist such owner entities by validating their claim in a Carbon Reduction Report as outlined in Figure 1, and depending on the compliance specifications of the certifying registry. Once certified by said registry, the sustainability management node may then move the certified carbon credit to a carbon exchange connected directly to the sustainability management node or via the blockchain network, or to the Automatic Market Maker (AMM) in the blockchain network, for sale to an offset purchaser.

[51] In an example on the demand side, the carbon footprint of an owner entity is ascertained or measured using the GHG framework. Based on the ascertained or measured carbon footprint, an owner entity may decide on a plan to reduce carbon footprint by purchasing carbon offset. The sustainability management node on a

blockchain network may assist the owner entity purchase various offsets depending on the compliance specifications of the offsets that they can use.

[52] Figure 2A shows a schematic logical diagram of entities connected to the sustainability management system. Connected entities may include at least a carbon exchange entity which provides a trading floor for carbon offset credits and tokens, offset buyers which purchase carbon offset credits and tokens, owner entities / enterprises which may send data to the sustainability management systems, verification or certification entities which may be carbon registries and/or independent consultants or auditors, credit sellers and/or developers which earn carbon offset credits and offers them for sale.

[53] Figure 2B is an embodiment of Figure 2A. The embodiment comprises at least three interconnected systems: Cloud Based SaaS System (i.e., sustainability management node), Blockchain System, and System Application which may be downloadable to a smart device and/or accessed from a website.

[54] The Cloud Based SaaS System enables authorised users to manage remote carbon footprints — access data, view analytics, and generate GHG reports for corporate and third party stakeholders. The SaaS System may connect to carbon registries and carbon exchanges directly and/or through the Blockchain to which the SaaS system, carbon registries & carbon exchanges connect as nodes. The SaaS system may also enable the credit holders to list their carbon offset credits certified by standards on the platform marketplace as well as users to buy those from the marketplace to retire their carbon emissions without going through the attached blockchain network. However, this entire transaction, if entirely over the SaaS system without going through the blockchain network, may be conducted by the users using their own discretion as the platform just provides a marketplace.

[55] On the other hand, Credit Holders (credit sellers) may also have the option of converting their certified carbon offset credits to digital token equivalent (via the blockchain network). The blockchain tokenizes the carbon offset credits into digitized equivalent of a Carbon Offset Credit (hereinafter “VCC Tokens”) to enable trade

through digital coin exchanges. Offset credits once tokenised cannot be detokenized and have to be traded only through coin exchanges.

[56] To participate in the operation of Figure 2B via the block-chained SaaS Platform, the Credit Holder/ Project Developer and the Buyer, may have to download the System Application on a smart device or access the System Application via a website, and to register on a carbon registry as well as a carbon exchange that connects to the block-chained SaaS platform so they may get certified and trade in their carbon offset credits either over the paperless smart contract mechanism or the token equivalents being traded over the exchanges both being enabled by the Blockchain.

[57] Figure 3A shows a schematic diagram of the sustainability management system (blockchain connectivity not shown).

[58] The sustainability management system comprises a plurality of sensors or sensor feeds, a processing server, a report server, and an access interface.

[59] The sensors are installed at various energy assets, e.g. equipment, associated with various owner entities. The sensors are communicably coupled to the processing server via wireless and/or wired connections.

[60] The processing server, e.g. web server, may comprise at least one computer processor, at least one memory storage communicably coupled thereto for storing computer-executable instructions, and a communication module communicably coupled to the computer processor for receiving and/or transmitting data. The processing server may provide communication protocols or interface, e.g. application programming interface (API), for facilitating communication between the sensors and the processing server. The processing server may be configured to receive data from the sensors, directly or indirectly, and provide the received data to a memory storage for storage and/or the report server. The processing server may be configured to standardise the received data prior to providing the data to the memory storage and/or the report server. The processing server may be configured to provide, via the access interface, other entities or nodes with access to generated reports and/or computed

data via the access interface. The processing server may be configured to post blockchain data into a blockchain network. The processing server may be configured to ascertain presence of successful or failed verification. The processing server may be configured to instruct a carbon exchange to transact on carbon offset or credit.

[61] The report server may be communicably coupled to the processing server and/or memory storage. The report server may be configured to generate carbon emission reports, carbon reduction reports, ascertain carbon offset or credit and/or carbon neutrality status.

[62] The memory storage may be communicably coupled to the processing server and/or report server, and configured to store instructions, e.g., computer-executable instructions, and/or data, e.g., sensor-measured energy data.

[63] The access interface may be communicably coupled to the processing server and/or memory storage, and configured to provide at least some nodes in the blockchain network with interface for accessing data stored in the memory storage.

[64] In an embodiment, the processing server may perform operations in block 106, e.g., receiving or aggregating the sensor-measured energy data, operations in blocks 108, 112, 116, e.g., providing access of generated reports and ascertained data to nodes in the blockchain network, operations in blocks 110, 114, 118, e.g., ascertaining presence of successful verifications, and operations in block 120, e.g., instructing the carbon exchange node to transact carbon offset or credit, updating the carbon neutrality status.

[65] The report server may perform operations in blocks 108, 112, 116, e.g. generating carbon emission report and carbon reduction report, ascertaining carbon neutrality status, carbon offset and/or carbon credit).

[66] The access interface may perform operations in blocks 108, 112, 116, e.g., providing access of generated reports and ascertained data to nodes in the blockchain network, and operations in blocks 120, e.g., providing access of updated carbon neutrality status to nodes in the blockchain network.

[67] Figure 3B is an exemplary actual depiction of the sustainability management system in a working environment.

[68] Embodiments of the invention provide at least the following features and/or technical advantages:

[69] The sustainability management system accepts data from a vast range of IoT sensors and converts it into standard formats for calculation and analytics. This is significant and warrants elaboration. This ability along with the ability to quickly add new dMVR features and compliances, makes the invention functional across all verticals — commercial facilities, agricultural, reforestation, renewables, etc.

[70] The sustainability management system is connectable to various carbon registries, carbon credit exchanges (carbon markets) and carbon credit token blockchains for certification purposes. This overcomes the problem of carbon related certifications currently faced by the carbon industry where, blockchain or not, validation of remote and dispersed carbon footprints continues to be a significant challenge. This allows users of the sustainability management system to access the carbon registries and carbon markets directly or through blockchain.

[71] The sustainability management system provides an automated or computer-implemented platform for third-party validation or verification, and together with blockchain network, provides an elegant solution which overcomes the issues of non-standardisation, non-transparency, un-verifiable validation, as well as double counting and conflict of interest which are all prevalent in existing carbon industry. Hence, the need for a network of human validators or verifiers for in-person site inspections, validations or otherwise is minimised or obviated.

[72] Automated streaming of sensor-measured data, at continuous or periodic intervals, real-time or substantially real-time, to the sustainability management system allows generation and verification of carbon reports and data to be performed continuously or periodically. Automated generation and verification also allow sustainability management to be performed and scaled up conveniently, and

submission of validation or verification to be performed securely and transparent. Providing the sustainability management as a cloud application further allows it to be accessible globally. Hence, sustainability management may be performed anywhere in the world, 24 hours per day, and 365 days per year. This feature is critical when carbon credits are earned based on a forecast against base line — requiring ongoing monitoring of actuals against the forecast and the baseline.

[73] The invention provides an immutable data chain from remote carbon footprints to authorised recipients without human intervention. While the platform also provisions for manual data entry through its web portal, reports and analytics based on manually entered data are not allowed into the Blockchain, and may be accessed as soft copies directly from the sustainability management system. In this way, the end-to-end immutable nature of the data chain through the Blockchain and to the authorised recipient(s) is maintained. Furthermore, the Blockchain resolves issues with double counting and multiple carbon offsets; enables users to view the provenance of a carbon credit to facilitate trade between parties, who do not know or may not have transacted with each other, and also without intermediary.

[74] Other embodiments will be apparent to those skilled in the art from consideration of the specification and practice of the disclosure. Furthermore, certain terminology has been used for the purposes of descriptive clarity, and not to limit the disclosed embodiments. The embodiments and features described above should be considered exemplary.

Claims

1. A computer-implemented sustainability management method comprising:

automatically receiving, by a node in a blockchain network and over proprietary protocols, sensor-measured energy data provided by sensors installed at energy assets associated with owner entities;

standardising the sensor-measured energy data by converting the sensor-measured energy data into comma-separated values (CSV) format for analytics;

for each owner entity:

generating, by the node, a carbon emission report based on a first subset of the sensor-measured energy data of a first subset of the energy assets which is associated with the each owner entity;

providing a verification node in the blockchain network with access to the first subset of the sensor-measured energy data and the carbon emission report for verification of the carbon emission report; and

ascertaining a presence of a successful verification of the carbon emission report in the blockchain network.

2. The method according to claim 1, further comprising:

for each owner entity:

verifying the carbon emission report; and

providing a carbon registry node in the blockchain network with access to the successful verification of the carbon emission report.

3. The method according to claim 2, further comprising:

for each owner entity:

for the carbon emission report, performing variance analysis between the first subset of the sensor-measured energy data and a second subset of the sensor-measured energy data of a second subset of the energy assets which is associated with the each owner entity.

4. The method according to claim 1 or claim 2, further comprising:

for each owner entity:

generating, by the node, a carbon reduction report based on a second subset of the sensor-measured energy data of a second subset of the energy assets which is associated with the each owner entity;

providing the verification node with access to the second subset of the sensor-measured energy data and the carbon reduction report for verification of the carbon reduction report; and

ascertaining a presence of a successful verification of the carbon reduction report in the blockchain network.

5. The method according to claim 4, further comprising:

for each owner entity:

verifying the carbon reduction report;

providing the carbon registry node with access to the successful verification of the carbon reduction report.

6. The method according to any one of claim 1 to claim 5, further comprising:

for each owner entity:

ascertaining, by the node, a carbon offset required to achieve carbon neutrality or ascertaining a carbon credit available for sale based on the carbon emission report and the carbon reduction report;

providing the verification node with access to the carbon offset or the carbon credit for verification thereof; and

ascertaining a successful verification of the carbon offset or the carbon credit.

7. The method according to claim 6, further comprising:

for each owner entity:

verifying the carbon offset or the carbon credit; and

providing a carbon exchange node in the blockchain network with access to the successful verification of the carbon offset or the carbon credit.

8. The method according to claim 7, further comprising:

instructing the carbon exchange node to transact the carbon offset or the carbon credit.

9. The method according to any one of claim 1 to claim 8, wherein the sensor-measured energy data is received in real-time, substantially real-time, and/or on an ongoing or periodic basis when carbon credits are earned based on forecast against baseline.

10. A computer-implemented sustainability management system comprising:

at least one computer processor, at least one memory storage communicably coupled thereto, wherein the at least one memory storage stores computer-executable instructions that, when executed by the at least one computer processor, cause the at least one computer processor to perform the method according to any one of claim 1 to claim 9.

11. At least one non-transitory computer-readable medium comprising instructions stored thereon that, in response to execution of the instructions by at least one or more computer processors, cause the at least one or more computer processors to perform the method according to any one of claim 1 to claim 9.

12. A computer-implemented sustainability management system comprising:

a node of a blockchain network, wherein the node comprises:

a processing server configured to automatically receive, over proprietary protocols, sensor-measured energy data provided by sensors installed at energy assets associated with owner entities and further configured to standardise the sensor-measured energy data by converting the sensor-measured energy data into comma-separate values (CSV) format for analytics;

a report server configured to generate a carbon emission report of each owner entity based on a first subset of the sensor-measured energy data of a first subset of energy assets which is associated with the each owner entity, and provide a verification node in the blockchain network with access to the first subset of the sensor-measured energy data and the carbon emission report;

an access interface configured to provide a verification node in the blockchain network with access to the first subset of the sensor-measured energy data and the carbon emission report for verification of the carbon emission report, and

wherein the processing server is further configured to ascertain a presence of a successful verification of the carbon emission report in the blockchain network.

13. The system according to claim 11, wherein the report server is further configured to generate a carbon reduction report of the each owner entity based on a second subset of the sensor-measured energy data of a second subset of energy assets which is associated with the each owner entity,

wherein the access interface is configured to provide the verification node with access to the second subset of the sensor-measured energy data and the carbon reduction report for verification of the carbon reduction report,

wherein the processing server is further configured to ascertain a presence of a successful verification of the carbon reduction report in the blockchain network.

14. The system according to claim 12, wherein the report server is further configured to ascertain a carbon offset required to achieve carbon neutrality or ascertaining a carbon credit available for sale based on the carbon emission report and the carbon reduction report,

wherein the access interface is further configured to provide the verification node with access to the carbon offset or the carbon credit for verification thereof,

wherein the processing server is further configured to ascertain a successful verification of the carbon offset or the carbon credit.

The system according to claim 13, wherein the processing server is further configured to instruct the carbon exchange node to transact the carbon offset or the carbon credit.

15. The system according to any one of claim 11 to claim 14, wherein the processing server is further configured to receive the sensor-measured energy data in real-time, substantially real-time and/or on an ongoing or periodic basis when carbon credits are earned based on forecast against baseline.