

ENERGY MANAGEMENT OVER A BLOCKCHAIN NETWORK

TECHNICAL FIELD

[0001] The present invention generally relates to energy management techniques, and more particularly relates to a system and a method for energy management over a blockchain network.

BACKGROUND

[0002] Due to the rise in global warming and increased public awareness, people nowadays are more inclined to adopt green initiatives to withstand the impact of natural calamities caused by climate change. Further, governance initiatives in many countries have encouraged citizens to live and work in ways that reduce the burden on our planet by lowering carbon emissions. Accordingly, it is perceived that in the future, power plants in most countries may transition from coal powered plants to greener energy resources powered plants, for example, hydrogen, which is also a safer alternative to nuclear power. It is further perceived that electric vehicles (EVs) and hydrogen fuel cell vehicles (HFCVs) may be widely adopted, resulting in a steep reduction in internal combustion engine (ICE) vehicles.

[0003] Further, in the current era of advanced green technology, sophisticated conventional devices that use renewable energy, for example, solar photovoltaic (PV) panels, battery energy storage systems (BESS), and electric vehicle supply equipment (EVSE) are being utilized to create smaller versions of virtual power plants (VPP) for residential and commercial sectors. This advanced green technology is helping in attain energy self-sustainability and contributing to a collective societal effort to reduce carbon emissions and protect our planet.

[0004] However, management of the energy may still remain an issue that needs to be addressed to better utilize the available renewable resources and to reduce the dependency on the grid supply which is powered by burning coal or nuclear fuel.

[0005] Furthermore, there is a need for encouragement to continue to embrace the green initiatives, where residential and commercial developer corporations, as green initiators, may implement systems that facilitate the acquisition of Renewable Energy Certificates (RECs) for participation in the green initiatives.

[0006] Therefore, it is essential to define a system for predicting energy generation, consumption, along with detailed and secure energy traceability. Thus, due to the rise of

green initiatives, there is a need for equipping the current energy management techniques in view of energy generation, consumption, along with detailed and secure energy traceability. By acknowledging the challenges associated with energy usage profiles that cannot be met with the conventional techniques, there is a requirement for developing a robust system and
5 method for energy management over a blockchain network.

SUMMARY

[0007] This summary is provided to introduce a selection of concepts, in a simplified format, that are further described in the detailed description of the invention. This summary is neither
10 intended to identify essential inventive concepts of the invention nor is it intended for determining the scope of the invention.

[0008] According to one embodiment of the present disclosure, a method for energy management over a blockchain network is disclosed. The method includes obtaining real-time energy data from one or more energy sources associated with each of one or more
15 entities. Further, the method includes predicting energy data for a predefined subsequent period corresponding to each of the one or more entities based on the obtained real-time energy data, using an Artificial Intelligence (AI) model. Furthermore, the method includes encrypting the obtained real-time energy data and the predicted energy data corresponding to each of the one or more entities. Furthermore, the method includes tracking a trend profile
20 associated with each of the one or more entities based on the encrypted data. The trend profile may indicate energy generation pattern and energy consumption pattern for each of the one more entities. Furthermore, the method includes determining whether an amount of energy generated from the one or more energy sources associated with each of the one or more entities falls within a predefined threshold range based on the tracked trend profile.
25 Furthermore, the method includes generating energy exchanging recommendations for each of the one or more entities based on determining that the amount of energy generated falls out of the predefined threshold range.

[0009] According to one embodiment of the present disclosure, a system for energy management over a blockchain network is disclosed. The system includes a data acquisition
30 module, a prediction module, an energy management module, and an energy-exchange module. The data acquisition module is configured to obtain real-time energy data from one or more energy sources associated with each of one or more entities. The prediction module is configured to predict energy data for a predefined subsequent period corresponding to

each of the one or more entities based on the obtained real-time energy data, using an Artificial Intelligence (AI) model. The prediction module is further configured to encrypt the obtained real-time energy data and the predicted energy data corresponding to each of the one or more entities. The energy management module is configured to track a trend profile associated with each of the one or more entities based on the encrypted data. The trend profile may indicate energy generation pattern and energy consumption pattern for each of the one more entities. The energy management module is further configured to determine whether an amount of energy generated from the one or more energy sources associated with each of the one or more entities falls within a predefined threshold range based on the tracked trend profile. The energy-exchange module is configured to generate energy exchanging recommendations for each of the one or more entities based on determining that the amount of energy generated falls out of the predefined threshold range.

[0010] To further clarify the advantages and features of the present invention, a more particular description of the invention will be rendered by reference to specific embodiments thereof, which are illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail in the accompanying drawings.

20 **BRIEF DESCRIPTION OF THE FIGURES**

[0011] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

25 [0012] **FIG. 1** illustrates a schematic block diagram depicting an environment for the implementation of a system for energy management over a blockchain network, in accordance with an embodiment of the present disclosure;

FIG. 2 illustrates a schematic block diagram of components of the system for energy management over a blockchain network, in accordance with an embodiment of the present disclosure;

30 **FIG. 3** illustrates a schematic block diagram depicting the one or more modules, in accordance with an embodiment of the present disclosure;

FIG. 4 illustrates an operation flow diagram illustrating the recording of the predicted available energy data and aggregating of the real-time energy generation data on the corresponding distributed ledger, in accordance with an embodiment of the present disclosure;

5 **FIG. 5** illustrates an operation flow block diagram of the energy management module for prediction of personalized energy management steps based on the status of each of the one or more entities, in accordance with an embodiment of the present disclosure;

FIG. 6 illustrates an operation flow block diagram for the aggregation operation performed by the aggregation module, in accordance with an embodiment of the present disclosure;

10 **FIG. 7** illustrates an operation flow block diagram for the energy exchange operation performed by the energy exchange module, in accordance with an embodiment of the present disclosure;

FIG. 8 illustrates a schematic block diagram depicting the implementation of the first contract and the second contract, in accordance with an embodiment of the present disclosure; and

15 **FIG. 9** illustrates a flow chart of a method for energy management over a blockchain network, in accordance with an embodiment of the present disclosure.

[0013] Further, skilled artisans will appreciate that elements in the drawings are illustrated for simplicity and may not have necessarily been drawn to scale. For example, the flow charts illustrate the method in terms of the most prominent steps involved to help improve understanding of aspects of the present invention. Furthermore, in terms of the construction of the device, one or more components of the device may have been represented in the drawings by conventional symbols, and the drawings may show only those specific details that are pertinent to understanding the embodiments of the present invention so as not to obscure the drawings with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

DETAILED DESCRIPTION OF THE FIGURES

30 [0014] For the purpose of promoting an understanding of the principles of the invention, reference will now be made to the various embodiments and specific language will be used to describe the same. It should be understood at the outset that although illustrative implementations of the embodiments of the present disclosure are illustrated below, the present invention may be implemented using any number of techniques, whether currently

known or in existence. The present disclosure is not necessarily limited to the illustrative implementations, drawings, and techniques illustrated below, including the exemplary design and implementation illustrated and described herein, but may be modified within the scope of the present disclosure.

5 **[0015]** It will be understood by those skilled in the art that the foregoing general description and the following detailed description are explanatory of the invention and are not intended to be restrictive thereof.

10 **[0016]** Reference throughout this specification to “an aspect”, “another aspect” or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrase “in an embodiment”, “in another embodiment” and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

15 **[0017]** It is to be understood that as used herein, terms such as, “includes,” “comprises,” “has,” etc. are intended to mean that the one or more features or elements listed are within the element being defined, but the element is not necessarily limited to the listed features and elements, and that additional features and elements may be within the meaning of the element being defined. In contrast, terms such as, “consisting of” are intended to exclude features and elements that have not been listed.

20 **[0018]** The embodiments herein and the various features and advantageous details thereof are explained more fully with reference to the non-limiting embodiments that are illustrated in the accompanying drawings and detailed in the following description. Descriptions of well-known components and processing techniques are omitted to not unnecessarily obscure the embodiments herein. Also, the various embodiments described herein are not necessarily
25 mutually exclusive, as some embodiments can be combined with one or more other embodiments to form new embodiments. The term “or” as used herein, refers to a non-exclusive or unless otherwise indicated. The examples used herein are intended merely to facilitate an understanding of ways in which the embodiments herein can be practiced and to further enable those skilled in the art to practice the embodiments herein. Accordingly,
30 the examples should not be construed as limiting the scope of the embodiments herein.

[0019] As is traditional in the field, embodiments may be described and illustrated in terms of blocks that carry out a described function or functions. These blocks, which may be referred to herein as units or modules or the like, are physically implemented by analog or

digital circuits such as logic gates, integrated circuits, microprocessors, microcontrollers, memory circuits, passive electronic components, active electronic components, optical components, hardwired circuits, or the like, and may optionally be driven by firmware and software. The circuits may, for example, be embodied in one or more semiconductor chips, or on substrate supports such as printed circuit boards and the like. The circuits constituting a block may be implemented by dedicated hardware, by a processor (e.g., one or more programmed microprocessors and associated circuitry), or by a combination of dedicated hardware to perform some functions of the block and a processor to perform other functions of the block. Each block of the embodiments may be physically separated into two or more interacting and discrete blocks without departing from the scope of the invention. Likewise, the blocks of the embodiments may be physically combined into more complex blocks without departing from the scope of the invention.

[0020] The accompanying drawings are used to help easily understand various technical features and it should be understood that the embodiments presented herein are not limited by the accompanying drawings. As such, the present disclosure should be construed to extend to any alterations, equivalents, and substitutes in addition to those which are particularly set out in the accompanying drawings. Although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are generally only used to distinguish one element from another.

[0021] FIG. 1 illustrates a schematic block diagram depicting an environment for the implementation of a system for energy management over a blockchain network, according to an embodiment of the present disclosure.

[0022] The environment may include a plurality of entities 102, in particular one or more entities 102a-102n, connected to one another over a network 104. In an embodiment, the one or more entities 102a-102n may be located at either a residential site or at a commercial site. In a non-limiting example, one or more entities 102a-102n may include a prosumer of energy. In an embodiment, there may be an entity group 110 that may include one or more entities 102a-102n. For example, the entity group 110 may be a developer corporation including one or more entities 102a-102n. In a non-limiting example, as shown in the **FIG. 1**, the entity group 110 includes a first entity 102a and a second entity 102b, however, the entity group 110 may also include the plurality of entities 102 within the scope of the present disclosure. The one or more entities 102a-102n as the prosumer may be configured to consume energy, and as well as be configured to generate their own energy.

[0023] In one embodiment, the one or more entities 102a-102n may include one or more energy generating sources 106a-106n, respectively, (interchangeably referred to herein as “energy generating sources 106”) for generating their own renewable energy. In a non-limiting example, the one or more energy generating sources 106 may include at least one of solar photovoltaics (PV) panels, battery energy storage system (BESS), and electric vehicle supply equipment (EVSE), and the like. The renewable energy generated may be utilized to supplement the energy received from the grid via a power line for consumption.

[0024] In an embodiment, the one or more entities 102a-102n may include smart energy measuring devices installed therein for measuring real-time energy data. Herein, the real-time energy data includes energy consumption data and renewable energy generation data. The smart energy measuring devices may include, for example, energy meters. The one or more entities 102a-102n may further be connected to a blockchain server 108, preferably referred to as blockchain 108, via the network 104. In an embodiment, the blockchain 108 may further be in communication with a power regulatory blockchain server (not shown) associated with a power regulatory authority.

[0025] In an embodiment, the one or more entities 102a-102n may be associated with a status selected by an owner of each of the one or more entities 102a-102n, where the status may indicate a preferred target for pattern of energy consumption and generation.

[0026] Accordingly, the real-time energy data from each one or more entities 102a-102n may be acquired. Further, the acquired real-time energy data may be utilized in prediction of the future energy generation and consumption data. Further, all the acquired and predicted data may be uploaded to the blockchain 108. Furthermore, to ensure security, the real-time energy data may be encrypted with blockchain keys at the one or more entities 102a-102n. In an embodiment, a trend profile based on the acquired encrypted real-time energy data may be tracked. The trend profile may help in determining an energy surplus in case of energy generation by the one or more energy generating sources 106 is more than the consumption.

[0027] Further, a determination may be made if the selected status and the acquired encrypted real-time energy data fall within a predetermined threshold. Accordingly, recommendations for each of the one or more entities may be generated to help the one or more entities 102a-102n achieve their preferred target according to the selected status.

[0028] In an embodiment, a profile of one or more entities 102a-102n may be created based on the acquired encrypted real-time energy data, in particular, based on the predicted future energy generation data.

[0029] In an embodiment, interactions between at least two entities among the one or more entities 102a-102n may be facilitated for peer-to-peer (P2P) energy exchange, based on the determination of the generation of renewable energy surplus based on the trend profile associated with the corresponding entity. Accordingly, a first contract may be generated on the blockchain 108 among the least two entities participating in the peer-to-peer (P2P) energy exchange.

[0030] In an embodiment, the entity group 110 may participate in a green initiative for reducing the dependence on the grid imports, and accordingly may seek to acquire renewable energy certificates (RECs) issued by, for example, the power regulatory authority or the like. Accordingly, the entity group 110 may acquire and aggregate the renewable energy generation data from each of the renewable energy producing plurality of entities 102 associated with the entity group 110. In a non-limiting embodiment, the acquisition and aggregation of the generated renewable energy data may be initiated after the end of a predetermined duration. In a non-limiting example, the predetermined duration may either be monthly, quarterly, half-yearly, or annually. In an embodiment, a second contract may be generated on the blockchain 108 between the entity group 110 and the plurality of entities 102 associated with the entity group 110 based on the acquired and aggregated renewable energy generation data associated with the corresponding each of the plurality of entities 102. The second contract may be evident of the possession of the acquired renewable energy generation data by the entity group 110. In an embodiment, the second contract may facilitate interactions between the entity group 110 and the power regulatory authority or the like, for carbon credit exchange based on the generated second contract. In a non-limiting embodiment, the carbon credit exchange may facilitate the acquisition of the renewable energy certificates (RECs) for participation in the green initiative for reducing the dependence on the grid imports on the determination of generated energy being above a predetermined threshold, for example, more than 1MWh.

[0031] FIG. 2 illustrates a schematic block diagram of components of a system 200 for energy management over a blockchain network, according to an embodiment of the present disclosure.

[0032] The system 200 may include, but is not limited to, one or more processors 202, a memory 204, database 206, I/O interface 208, and one or more modules 220. The one or more modules 220 and the memory 204 may be coupled to the one or more processors 202.

[0033] In an embodiment, the one or more processors 202 may be located at one of, the one or more entities 102a-102n, the blockchain 108, or distributed across the entities 102a-102n and the blockchain 108. As a non-limiting example, the one or more processors 202 can be a single processing unit or several units, all of which could include multiple computing units.

5 The one or more processors 202 may be implemented as one or more microprocessors, microcomputers, microcontrollers, digital signal processors, central processing units, state machines, logic circuitries, and/or any devices that manipulate signals based on operational instructions. Among other capabilities, the one or more processors 202 are adapted to fetch and execute computer-readable instructions and data stored in the memory 204. Among other

10 capabilities, the one or more processors 202 may be configured to fetch and execute computer-readable instructions and data stored in the memory 204. The one or more processors 202 may include one or a plurality of processors. The plurality of processors is further implemented as a general-purpose processor, such as a central processing unit (CPU), an application processor (AP), or the like, a graphics-only processing unit, such as a graphics

15 processing unit (GPU), a visual processing unit (VPU), and/or an AI-dedicated processor such as a neural processing unit (NPU). The plurality of processors controls the processing of the input data in accordance with a predefined operating rule or an artificial intelligence (AI) model stored in the memory 204. The predefined operating rule or the AI model is provided through training or learning.

20 **[0034]** The one or more processors 202 may be disposed in communication with one or more input/output (I/O) devices via an Input/Output (I/O) interface 208. The I/O interface 208 employs communication code-division multiple access (CDMA), high-speed packet access (HSPA+), global system for mobile communications (GSM), long-term evolution (LTE), WiFi, and the like, etc. In another embodiment of the present disclosure, the I/O interface

25 208 employs ethernet, industrial wireless Local Area Network (LAN), Process Field Bus (PROFIBUS), Actuator Sensor (AS) Interface, and the like.

[0035] The memory 204 is configured to store instructions executable by the one or more processors 202. In one embodiment, the memory 204 communicates via a bus within the system 200. The memory 204 includes, but is not limited to, a non-transitory computer-

30 readable storage media, such as various types of volatile and non-volatile storage media including, but not limited to, random access memory, read-only memory, programmable read-only memory, electrically programmable read-only memory, electrically erasable read-only memory, flash memory, magnetic tape or disk, optical media and the like. In one

example, the memory includes a cache or random-access memory (RAM) for the one or more processors 202. In alternative examples, the memory 204 is separate from the one or more processors 202 such as a cache memory of a processor, the system memory, or other memory. The memory 204 is an external storage device or the database 206 for storing data.

5 The memory 204 is operable to store instructions executable by the one or more processors 202. The functions, acts, or tasks illustrated in the figures or described are performed by the programmed processor for executing the instructions stored in the memory 204. The functions, acts, or tasks are independent of the particular type of instruction set, storage media, processor, or processing strategy and may be performed by software, hardware,

10 integrated circuits, firmware, micro-code, and the like, operating alone or in combination. Likewise, processing strategies include multiprocessing, multitasking, parallel processing, and the like.

[0036] The one or more modules 220, amongst other things, include routines, programs, objects, components, data structures, etc., which perform particular tasks or implement data

15 types. The modules 220 may also be implemented as, signal processor(s), state machine(s), logic circuitries, and/or any other device or component that manipulates signals based on operational instructions.

[0037] Further, the one or more modules 220 can be implemented in hardware, instructions executed by a processing unit, or by a combination thereof. The processing unit can comprise

20 a computer, a processor, such as the one or more processors 202, a state machine, a logic array, or any other suitable devices capable of processing instructions. The processing unit can be a general-purpose processor which executes instructions to cause the general-purpose processor to perform the required tasks or, the processing unit can be dedicated to performing the required functions. In another embodiment of the present disclosure, the one or more

25 modules 220 may be machine-readable instructions (software) which, when executed by the one or more processors/processing unit 202, perform any of the described functionalities.

[0038] FIG. 3 illustrates a schematic block diagram depicting the one or more modules 220, in accordance with an embodiment of the present disclosure. The one or more modules 220 may include the one or more instructions that may be executed to cause the system 200, in

30 particular, the processor 202 of the system 200, to execute the one or more instructions.

[0039] In an embodiment, the one or more modules 220 may include a data acquisition module 222, a prediction module 224, an energy-management module 226, an energy-exchange module 228, an aggregation module 230, and a carbon-exchange module 232, and

a digital token transceiver module 236. The data acquisition module 222, the prediction module 224, the energy-management module 226, the energy-exchange module 228, the aggregation module 230, the carbon-exchange module 232, and the digital token transceiver module 236 may be in communication with each other.

5 **[0040]** The data acquisition module 222 may obtain real-time energy data from one or more energy sources associated with each of one or more entities 102a-102n. In an embodiment, the obtained real-time energy data may include at least one of, energy generation data and energy consumption data.

10 **[0041]** The prediction module 224 may predict energy data for a predefined subsequent period corresponding to each of the one or more entities 102a-102n based on the obtained real-time energy data, using an Artificial Intelligence (AI) model.

[0042] The digital token transceiver module 236 may be configured to encrypt the obtained real-time energy data and the predicted energy data corresponding to each of the one or more entities 102a-102n.

15 **[0043]** The energy-management module 226 may be configured to track a trend profile associated with each of the one or more entities 102a-102n based on the encrypted data. The trend profile indicates energy generation pattern and energy consumption pattern for each of the one or more entities 102a-102n. The energy-management module 226 may further be configured to determine whether an amount of energy generated from the one or more energy
20 sources associated with each of the one or more entities 102a-102n falls within a predefined threshold range based on the tracked trend profile.

[0044] In an embodiment, the energy-exchange module 228 may be configured to generate energy exchanging recommendations for each of the one or more entities 102a-102n based on determining that the amount of energy generated falls out of the predefined threshold
25 range.

[0045] The aggregation module 230 may be configured to request, from the acquisition module 222, the real-time energy data associated with the energy generation data from each of the one or more entities 102a-102n belonging to the entity group 110. Accordingly, the aggregation module 230 may obtain, via the digital token transceiver module 236, encrypted
30 real-time energy data associated with the energy generation data for each of the one or more entities 102a-102n belonging to the entity group 110. Further, the aggregation module 230 may be configured to aggregate the obtained encrypted real-time data associated with the energy generation by the one or more entities 102a-102n. The aggregation module 230 may

further be configured to store the aggregated data associated with each of the one or more entities 102a-102n to a corresponding distributed ledger of each of the one or more entities 102a-102n.

[0046] The carbon-exchange module 232 may be configured to facilitate the exchange of carbon credit. The carbon credit exchange may facilitate the acquisition of the renewable energy certificates (RECs) for participation in the green initiative for reducing the dependence on the grid imports.

[0047] FIG. 4 illustrates an operation flow diagram illustrating the recording of the predicted available energy data and aggregating of the real-time energy generation data on the corresponding distributed ledger, in accordance with an embodiment of the present disclosure.

[0048] In an embodiment, the acquisition module 222, may obtain the real-time energy data from one or more energy generation sources 106a-106n associated with one or more entities 102a-102n. The real-time energy data may include at least one of energy generation data and energy consumption data. In an embodiment, each of the one or more entities 102a-102n may further include blockchain nodes for performing the energy exchange among at least two entities 102a-102n.

[0049] The data acquisition module 222 may encapsulate the obtained real-time energy data into a single binary file. Further, the data acquisition module 222 may split the encapsulated files into multiple chunks.

[0050] The prediction module 224 may predict energy data for the predefined subsequent period corresponding to each of the one or more entities 102a-102n based on the obtained real-time energy data, using an Artificial Intelligence (AI) model. The predicted energy data may include future energy production from the energy generation sources 106a-106n and consumption from the future energy produced and the grid supply imports.

[0051] Further, the digital token transceiver module 236 may encrypt the obtained real-time energy data and the predicted energy data corresponding to each of the one or more entities 102a-102n.

[0052] In an embodiment, the energy-exchange module 228 may be in communication with the prediction module 224 via the digital token transceiver module 236. The energy-exchange module 228 may receive the encrypted real-time energy data and the predicted energy data through the digital token transceiver module 236 for further processing. The encrypted real-time energy data and the predicted energy data may preferably be referred to

as encrypted data. In an embodiment, the energy-exchange module 228 may be configured to obtain one or more conditions for generation of a first contract associated with at least two or more entities 102a-102n based on the trend profile associated with each of the one or more entities 102a-102n. The energy-exchange module 228 may generate the first contract associated with the at least two or more entities 102a-102n when the one or more conditions are met. Furthermore, the energy-exchange module 228 may be configured to facilitate interaction between the at least two or more entities 102a-102n for peer-to-peer (P2P) energy exchange based on the generation of the first contract and the generated energy exchanging recommendations.

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10 **[0053]** In an embodiment, the energy-exchange module 228 may further be configured to predict available energy for exchange corresponding to at least one supplier entity among the one or more entities 102a-102n. The supplier entity corresponds to the one or more entities 102a-102n having generated surplus energy and which may participate in the peer-to-peer (P2P) energy exchange for supplying the generated surplus energy to another one or

15 more entities 102a-102n. The one or more entities 102a-102n receiving the generated surplus energy from the supplier entity may be referred to as a consumer entity. The energy-exchange module 228 may be configured to record predicted available energy data on a corresponding distributed ledger 402a-402n associated with the at least one supplier entity. Furthermore, the energy-exchange module 228 may be configured to record a data address

20 based on the blockchain network 108.

[0054] In an embodiment, the energy-exchange module 228 may further be configured to receive a transform key issued by the digital token transceiver module 236 to decrypt the encrypted data associated with the least one supplier entity. The energy-exchange module 228 may further be configured to retrieve the predicted available energy data from the

25 corresponding distributed ledger 402a-402n of at least one supplier entity. The energy-exchange module 228 may further be configured to validate the available energy for exchange based on the retrieved predicted available energy data. Furthermore, the energy-exchange module 228 may be configured to update, on the blockchain network 108, a profile of at least one consumer entity receiving the predicted available energy based on the

30 validation.

[0055] In an embodiment, the entity group 110 may interact with the power regulatory authority or the like for carbon credit exchange. The carbon credit exchange may be utilized to acquire renewable energy certificates (RECs) issued by, for example, the power regulatory

authority or the like, on the determination of generated energy being above a predetermined threshold, for example, more than 1MWh. Accordingly, the entity group 110 may execute the second contract with one or more entities 102a-102n to acquire the generated energy data, such that the aggregated generated energy data associated with the combined one or more entities 102a-102n is beyond the predetermined threshold. As shown in the **FIG. 4**, the entity group 110 may include the first entity 102a and the second entity 102b, and accordingly, entity group 110 may initiate the second contract between the entity group 110 and the first and the second entities 102a and 102b.

[0056] In an embodiment, the aggregation module 230 may be in communication with the data acquisition module 222 via the digital token transceiver module 236. The aggregation module 230 may request real time energy generation data from the data acquisition module 222. Accordingly, the digital token transceiver module 236 may encrypt the real time energy generation data and transmit the same to the acquisition module 222. In an embodiment, the acquisition module 222 may further be configured to receive a transform key issued by the digital token transceiver module 236 to decrypt the encrypted real time energy generation data associated with the first and the second entities 102a and 102b. Accordingly, the aggregation module 230 may obtain the encrypted real-time energy generation data pertaining to each of the first and second entities 102a and 102b for further processing. The aggregation module 230 may aggregate the obtained encrypted real-time energy generation data associated with the first and second entities 102a and 102b. The aggregation module 230 may further store the aggregated data to a corresponding distributed ledger 402a and 402b of the first and second entities 102a and 102b.

[0057] In an embodiment, the aggregated encrypted data may include one or more of the following information:

- a) Energy source from the grid supply import.
- b) Energy sources harvested from the photovoltaic (PV) panel.
- c) Energy source discharged from the battery energy storage system (BESS).
- d) Energy source from an EV charging station via vehicle to grid (V2G).
- e) Energy consumed by household load (Lightings, Appliances, etc.) of the one or more entities 102a-102n.
 - i. The amount of energy used from the PV harvest.
 - ii. The amount of energy used from the BESS.
 - iii. The amount of energy used from the grid imports.

- f) Energy consumed by the BESS for charging purposes.
 - i. The amount of energy used from the PV harvest.
 - ii. The amount of energy used from the grid imports.
- g) Energy consumed by the EV charging station.
 - i. The amount of energy used from the PV harvest.
 - ii. The amount of energy used from the BESS.
 - iii. The amount of energy used from the grid imports.

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[0058] In an embodiment, the aggregation module 230 may further generate the second contract between the entity group 110 and the one or more entities 102a-102n based on the aggregation of the encrypted real-time energy generation data associated with the energy generation by the one or more entities 102a-102n associated with the entity group 110. For example, referring to Fig. 4, the aggregation module 230 may generate the second contract between the entity group 110 and the first and second entities 102a and 102b.

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[0059] Further, based on the generated second contract, the carbon credit exchanging module 232 may facilitate the exchange of carbon credits with the power regulatory blockchain server of the power regulatory authority or the like third party blockchain, that supports carbon credit exchange facility. In particular, the second contract may be evident of the possession of the acquired renewable energy generation data by the entity group 110. Accordingly, the second contract may ease out the acquisition of renewable energy certificates (RECs) on the determination of the aggregate of the energy generated by the one or more entities 102a-102n associated with the entity group 110, i.e., the first and second entities 102a and 102b, being above a predetermined threshold, for example, more than 1MWh.

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[0060] In an embodiment, the encrypted data associated with each of the one or more entities 102a-102n may be stored at the one or more distributed ledgers 402a-402n. In another embodiment, the encrypted data associated with each of the one or more entities 102a-102n may be stored at the blockchain 108, and a portion of the encrypted data may be stored and distributed among the one or more distributed ledgers 402a-402n. In another embodiment, each of the one or more distributed ledgers 402a-402n may also include a combination of data associated with the encrypted data associated with each of the one or more entities 102a-102n. In another embodiment, the one or more distributed ledgers 402a-402n may reside in at least one of, the blockchain 108, or in the corresponding one or more entities 102a-102n.

[0061] FIG. 5 illustrates an operation flow block diagram of the energy management module 226 for the prediction of personalized energy management steps based on the status of each of the one or more entities 102a-102n, in accordance with an embodiment of the present disclosure. The energy-management module 226 may be configured to determine a status for each of the one or more entities based on the trend profile. The status may include at least one of a green priority mode status 502, a reward priority mode status 504, and a comfort priority mode status 506. Accordingly, the energy-management module 226 may determine a target for each of the one or more entities based on the determined status.

[0062] Accordingly, the energy-exchange module 228 may be configured to generate energy exchanging recommendations for each of the one or more entities 102a-102n based on determining that the amount of energy generated falls out of the predefined threshold range.

[0063] In an embodiment, the energy-management module 226, for the first entities having the green priority mode status 502, may be configured to compute a self-sustainable efficiency based on the trend profile associated with the corresponding entity. The first entities may correspond to the one or more entities 102a-102n with the green priority mode status 502 as the determined status. The self-sustainable efficiency may help in the determination of how far away the first entities are from the target. The same is illustrated in equation (1):

$$\text{Self - Sustainable efficiency (\%)} = \frac{X - Y}{Z} \times 100 \dots (1)$$

wherein, X = Current potential yield; Photovoltaic (PV) panel harvested; Battery Discharging; Vehicle to Grid (V2G);

Y = Current Grid import;

Z = Current total consumption; Household load, battery charging and EV charging.

[0064] In an embodiment, the energy-management module 226 may determine a Net-zero target for green priority mode status 502. Accordingly, the energy-management module 226 may be configured to compare the self-sustainable efficiency with a predefined threshold self-sustainable efficiency. In order to achieve the Net-zero target, the predefined threshold self-sustainable efficiency may turn out to be a 100% self-sustainable efficiency, where X=Z and Y = 0. Accordingly, the energy-management module 226 may be configured to obtain a difference based on the comparison. The difference may indicate a gap between the

computed self-sustainable efficiency and the 100% self-sustainable efficiency. The same is illustrated in equation (2):

$$\text{Difference (Gap)} = 100 - \text{Computed Self-Sustainable Efficiency} \quad \dots(2)$$

5 [0065] The energy-management module 226 may further be configured to predict one or more personalized energy management steps 508 for the first entities based on the obtained difference. Furthermore, the energy-management module 226 may be configured to provide the one or more personalized energy management steps 508 for the corresponding entity to be followed to achieve the target. Accordingly, the energy-management module 226 may understand the behaviour of each of the first entities, and may provide one or more
10 personalized energy management steps 508 that may help to increase the current potential yield (X) and decrease the current grid import (Y). In a non-limiting example, there may be a situation where the photovoltaic (PV) panel has harvested surplus energy and has fully charged the batteries, and as per weather prediction, tomorrow it may rain. Here, the energy-management module 226 may predict one or more personalized energy management steps
15 508 suggesting charging EV, where the suggestion may recite, *“please charge your EV if you can. Tomorrow it is a rainy day so PV will not harvest too much energy, and other household consumption will depend on the battery energy, it is not advisable to charge your EV”*.

[0066] In an embodiment, energy-management module 226, to help the first entities having
20 the green priority mode status 502 to achieve the target, may further supplement the provided the one or more personalized energy management steps 508 with a graphic representation of a Net-zero target profile.

[0067] In a non-limiting example, the graphic representation may provide data pertaining to the photovoltaic (PV) energy harvested and the predicted energy data for the next 12 hours,
25 based on the trend profile pertaining to energy generation patterns of the first entities.

[0068] In a non-limiting example, the graphic representation may provide data pertaining to the current grid import (Y) data and the predicted import data for the next 12 hours, based on the trend profile pertaining to the energy consumption pattern of the first entities.

[0069] In another non-limiting example, the graphic representation may provide data
30 pertaining to the current total consumption energy data and the predicted consumption energy data for the next 12 hours, based on the trend profile pertaining to the energy consumption pattern of the first entities. The predicted consumption energy data may indicate a prediction of how much energy usage from photovoltaic (PV) panels, battery

energy storage systems (BESS), grid imports (Y), and the like. This graphic representation may further provide an average representation based on a comparison of the respective first entities with the one or more entities 102a-102n belonging to the green priority mode status 502.

5 **[0070]** In another non-limiting example, the graphic representation may provide data pertaining to the one or more energy sources charging the one or more batteries, based on the trend profile pertaining to energy generation and energy consumption patterns of the first entities. The one or more energy sources may include the photovoltaic (PV) panels, the grid, and the like. This graphic representation may further provide an average representation based
10 on a comparison of the respective first entities with the one or more entities 102a-102n belonging to the green priority mode status 502.

[0071] In another non-limiting example, the graphic representation may provide data pertaining to the one or more energy sources at the EV charger, based on the trend profile pertaining to energy generation and energy consumption patterns of the first entities. The
15 one or more energy sources may include the photovoltaic (PV) panels, the battery energy storage systems (BESS), the grid, and the like. This graphic representation may further provide an average representation based on a comparison of the respective first entities with the one or more entities 102a-102n belonging to the green priority mode status 502.

[0072] In another non-limiting example, the graphic representation may provide data
20 pertaining to the self-sustainable efficiency based on the computation by the energy-management module 226 for the first entities having the green priority mode status 502. This graphic representation may further provide an average representation based on a comparison of the respective first entities with the one or more entities 102a-102n belonging to the green priority mode status 502.

25 **[0073]** In another non-limiting example, the graphic representation may provide data pertaining to the gap or the difference between the computed self-sustainable efficiency and the 100% self-sustainable efficiency for the first entities having the green priority mode status 502.

[0074] In an embodiment, the energy-management module 226, for second entities with the
30 reward priority mode status, may be configured to determine a value for an energy surplus based on the trend profile associated with the corresponding entity. The second entities may correspond to the one or more entities 102a-102n with the reward priority mode status 504

as the determined status. The value of the energy surplus may help in the determination of how far away the second entities are from the target. The same is illustrated in equation (3):

$$\text{Energy Surplus (\%)} = \frac{(X + Y) - Z}{Z} \times 100 \dots (3)$$

wherein, X = Current potential yield; Photovoltaic (PV) panel harvested, Electric Vehicle (EV) discharging, and battery discharging

Y = Current Grid import;

Z = Current total consumption; Household load, battery charging, and EV charging.

[0075] In an embodiment, the energy-management module 226, for determination of the energy surplus for reward priority mode status 504, evaluates if the following condition is fulfilled:

$$\frac{X - Y}{Z} > 0$$

[0076] Accordingly, the energy surplus in Kilowatt hours (KWh) is determined using the below equation (4):

$$\text{Energy Surplus (kWh)} = (X+Y) - Z \dots (4)$$

[0077] The energy-management module 226 may further be configured to predict the one or more personalized energy management steps 510 for the second entities based on the determined energy surplus to achieve the target. Furthermore, the energy-management module 226 may be configured to provide the one or more personalized energy management steps 510 for the corresponding entity to be followed to achieve the target. Accordingly, the energy-management module 226 may understand the behaviour of each of the second entities, and may provide one or more personalized energy management steps that may help in achieving the green impact reward.

[0078] In an embodiment, energy-management module 226, to help the second entities having the reward priority mode status 504 to achieve the target, may further supplement the provided the one or more personalized energy management steps 510 with a graphic representation of an energy surplus profile.

[0079] In a non-limiting example, the graphic representation may provide data pertaining to the photovoltaic (PV) energy harvested and the predicted energy data for the next 12 hours, based on the trend profile pertaining to energy generation patterns of the second entities.

[0080] In another non-limiting example, the graphic representation may provide data pertaining to the current total consumption energy data and the predicted consumption energy data for the next 12 hours, based on the trend profile pertaining to the energy consumption pattern of the second entities. The predicted consumption energy data may indicate prediction of energy usage from photovoltaic (PV) panels, battery energy storage systems (BESS), grid imports (Y), and the like. This graphic representation may further provide an average representation based on a comparison of the respective second entities with the one or more entities 102a-102n belonging to the reward priority mode status 504.

[0081] In another non-limiting example, the graphic representation may provide data pertaining to the one or more energy sources charging the one or more batteries, based on the trend profile pertaining to energy generation and energy consumption patterns of the second entities. The one or more energy sources may include the photovoltaic (PV) panels, the grid, and the like. This graphic representation may further provide an average representation based on a comparison of the respective second entities with the one or more entities 102a-102n belonging to the reward priority mode status 504.

[0082] In another non-limiting example, the graphic representation may provide data pertaining to the one or more energy sources at the EV charger, based on the trend profile pertaining to energy generation and energy consumption patterns of the second entities. The one or more energy sources may include the photovoltaic (PV) panels, the battery energy storage systems (BESS), the grid, and the like. This graphic representation may further provide an average representation based on a comparison of the respective second entities with the one or more entities 102a-102n belonging to the reward priority mode status 504.

[0083] In another non-limiting example, the graphic representation may provide data pertaining to the energy surplus (%) based on the determination by the energy-management module 226 for the second entities having the reward priority mode status 504. This graphic representation may further provide an average representation based on a comparison of the respective second entities with the one or more entities 102a-102n belonging to the reward priority mode status 504.

[0084] In another non-limiting example, the graphic representation may further provide one or more categorizations based on an impact of the achieved target. The one or more categorizations may include a diamond category, a platinum category, a gold category, a silver category, and a bronze category. The diamond category may indicate achieving the target of energy surplus value being above 500%. The platinum category may indicate

achieving the target of energy surplus value being above 400%. The gold category may indicate achieving the target of energy surplus value being above 300%. The silver category may indicate achieving the target of energy surplus value being above 200%. The bronze category may indicate achieving the target of energy surplus value being above 100%.

5 **[0085]** In another non-limiting example, the graphic representation may further provide an offset from the grid import (Y) consumption due to peer-to-peer (P2P) energy exchange.

[0086] In an embodiment, the energy-management module 226, for third entities with the comfort priority mode status 506, may be configured to compare the energy consumption of the third entities with the energy consumption of the first entities and the second entities.

10 The third entities may correspond to the one or more entities 102a-102n with the comfort priority mode status 506 as the determined status. The comfort priority mode status 506 may indicate that the third entities care for personal comfort but willing to reduce the consumption from the grid imports (y) by producing the energy from the one or more energy sources available in possession of the third entities. In an embodiment, the energy-
15 management module 226, for comfort priority mode status 506, may compute the self-sustainable efficiency based on the trend profile associated with the corresponding entity, similar to the computation performed for the first entities. The self-sustainable efficiency may help in the determination of how far away the third entities are from the target, i.e., achieving the reducing the grid imports (y) to their level of comfort. The equation for
20 computation of the self-sustainable efficiency is illustrated in equation (1). Accordingly, a gap between the computed self-sustainable efficiency and the 100% self-sustainable efficiency is determined for the third entities. The equation for computation of the gap is illustrated in the equation (2).

[0087] The energy-management module 226 may be configured to determine a difference
25 in the energy consumption based on the comparison of the energy consumption. The energy-management module 226 may further be configured to predict the one or more personalized energy management steps 512 based on the obtained difference. Furthermore, the energy-management module 226 may be configured to provide the one or more personalized energy management steps 512 to the corresponding entity to be followed to achieve the target.
30 Accordingly, the energy-management module 226 may understand the behaviour of each of the third entities, and may provide one or more personalized energy management steps 512 that may help to increase the current potential yield (X) and decrease the current grid import (Y).

[0088] In a non-limiting example, there may be a situation where the photovoltaic (PV) panel has harvested surplus energy and has fully charged the batteries, and as per weather prediction, tomorrow it may rain. Here, the energy-management module 226 may predict one or more personalized energy management steps 512 suggesting charging EV, where the
5 suggestion may recite, *“please charge your EV if you can. Tomorrow it is a rainy day so PV will not harvest too much energy, and other household consumption will depend on the battery energy, it is not advisable to charge your EV”*.

[0089] In an embodiment, energy-management module 226, to help the third entities having the comfort priority mode status 506 to achieve the target, may further supplement the
10 provided the one or more personalized energy management steps 512 with a graphic representation of an energy surplus profile.

[0090] In a non-limiting example, the graphic representation may provide data pertaining to the increased energy consumption by the third entities as compared to the energy consumption of the first entities and the second entities.

15 [0091] In another non-limiting example, the graphic representation may provide data pertaining to one or more achievements of the first entities and the second entities, along with proposed rewards from the peer-to-peer (P2P) energy exchange.

[0092] In another non-limiting example, the graphic representation may provide data pertaining to the current grid import (Y) data and the predicted import data for the next 12
20 hours, based on the trend profile pertaining to the energy consumption pattern of the third entities.

[0093] In another non-limiting example, the graphic representation may provide data pertaining to the current total consumption energy data and the predicted consumption energy data for the next 12 hours, based on the trend profile pertaining to the energy
25 consumption pattern of the third entities. The predicted consumption energy data may indicate a prediction of energy usage from photovoltaic (PV) panels, battery energy storage systems (BESS), grid imports (Y), and the like.

[0094] In another non-limiting example, the graphic representation may provide data pertaining to the self-sustainable efficiency based on the computation by the energy-
30 management module 226 for the third entities having the comfort priority mode status 506. This graphic representation may further provide an average representation based on a comparison of the respective third entities with at least one of, the with the first entities

belonging to the green priority mode status 502, and the second entities belonging to the reward priority mode status 504.

[0095] In another non-limiting example, the graphic representation may provide data pertaining to the gap or the difference between the computed self-sustainable efficiency and the 100% self-sustainable efficiency for the third entities having the comfort priority mode status 506.

[0096] FIG. 6 illustrates an operation flow block diagram for the aggregation operation performed by the aggregation module 230, in accordance with an embodiment of the present disclosure.

[0097] At block 602, the aggregation module 230 may be configured to obtain one or more conditions for the generation of the second contract between the entity group 110 and the one or more entities 102a-102n based on the energy generation associated with each of the one or more entities. In a non-limiting embodiment, at least one condition may be met on detection of the generation of the renewable energy for consumption by the one or more entities 102a-102n.

[0098] At block 604, the aggregation module 230 may be configured to generate the second contract between the entity group 110 and the one or more entities 102a-102n when the one or more conditions are met.

[0099] At block 606, the aggregation module 230 may be configured to measure the renewable energy generated by the one or more energy generation sources 106 for the respective one or more entities 102a-102n.

[0100] At block 608, the aggregation module 230 may be configured to record the measured renewable energy generated data on storage providers, such as a corresponding distributed ledger 402a-402n associated with the one or more entities 102a-102n.

[0101] At block 610, the aggregation module 230 may be configured to generate renewable energy data in real-time for a predetermined period of time. The renewable energy data may be encapsulated into a single binary file.

[0102] At block 612, aggregation module 230 may be configured to record the generated renewable energy data on the blockchain 108.

[0103] At block 614, the aggregation module 230, for retrieving the generated renewable energy data by the entity group 110, may be configured to request the energy data from the blockchain 108.

[0104] At block 616 the aggregation module 230 may be configured to request a transform key to access the generated renewable energy data. Accordingly, a digital token transceiver module 236 may issue the transform key to a proxy server. In an embodiment, the proxy server may reside in the blockchain 108.

5 [0105] At block 618, the proxy server may re-encrypt the encrypted encryption key string with the transform key and may issue the re-encrypted encryption key string.

[0106] At block 620, the aggregation module 230 retrieves the generated renewable energy data from the corresponding distributed ledger 402a-402n associated with the one or more entities 102a-102n.

10 [0107] At block 622, the aggregation module 230 may be configured to validate the retrieved generated renewable energy data by decrypting the encryption key string, and accordingly, decrypting the received energy data.

[0108] At block 624, the aggregation module 230 may be configured to update, on the blockchain 108, a profile of entity group 110 based on the validation. The update profile of

15 the entity group 110 may indicate ownership of the generated renewable energy data on blockchain 108 corresponding to energy aggregation based on the second contract associated between the entity group 110 and each of the one or more entities 102a-102n.

[0109] FIG. 7 illustrates an operation flow block diagram for the energy exchange operation performed by the energy-exchange module 228, in accordance with an embodiment of the

20 present disclosure.

[0110] At block 702, the energy-exchange module 228 may be configured to obtain one or more conditions for the generation of the first contract associated with each of the one or more entities 102a-102n based on the trend profile associated with each of the one or more entities. In a non-limiting embodiment, at least one condition may be met on detection of the

25 generation of the energy surplus by the one or more entities 102a-102n.

[0111] At block 704, the energy-exchange module 228 may be configured to generate the first contract associated with at least two or more entities 102a-102n when the one or more conditions are met.

[0112] At block 706, the prediction module 224 may be configured to predict data for the

30 available surplus energy to be exchanged corresponding to at least one supplier entity.

[0113] At block 708, the energy-exchange module 228 may be configured to retrieve all the available surplus energy allowable for energy exchange data from one or more supplier entities.

[0114] At block 710, the energy-exchange module 228 may be configured to record predicted available surplus energy data on the corresponding distributed ledger 402a-402n associated with the at least one supplier entity.

[0115] At block 712, the energy-exchange module 228 may be configured to record a data address based on the recorded predicted available surplus energy data on the blockchain 108.

[0116] At block 714, the energy-exchange module 228 may comprise a P2P exchanging sub-module 238, which may be configured to request the energy data for a consumer entity from the blockchain 108, for energy exchange matching with the least one supplier entity.

[0117] At block 716 the energy-exchange module 228 may be configured to request a transform key to access the energy data. Accordingly, the digital token transceiver module 236 may issue the transform key to the proxy server.

[0118] At block 718, the proxy server may re-encrypt the encrypted encryption key string with the transform key and may issue the re-encrypted encryption key string.

[0119] At block 720, the energy-exchange module 228 may be configured to retrieve the predicted available surplus energy data from the corresponding distributed ledger of at least one supplier entity.

[0120] At block 722, the energy-exchange module 228 may be configured to validate the available surplus energy for exchange based on the retrieved predicted available surplus energy data.

[0121] At block 724, the energy-exchange module 228 may be configured to update, on the blockchain 108, a profile of at least one consumer entity receiving the predicted available energy data based on the validation.

[0122] FIG. 8 illustrates a schematic block diagram depicting the implementation of the first contract and the second contract, in accordance with an embodiment of the present disclosure. The energy data pertaining to each of the one or more entities 102a-102n may be collected into the blockchain 108. The real-time energy data prior to being collected may first be authenticated and validated to check whether the one or more entities 102a-102n have met the requirement of one or more conditions for generating at least one of the first and second contracts. The at least one of the first and second contracts can be generated securely on the blockchain 108 and become trusted not to have the chance of tampering.

[0123] In an embodiment, the system 200, including the hardware, software, and networking, may comply with the security standard, for example, ISO/IEC 27001:2022.

[0124] As shown, the first entity 102a may be configured to import an energy supply from the grid 802 for consumption of energy from the electricity regulator authority. The first entity 102a may further include the energy generation sources 106a, for example photovoltaic (PV) panels to harvest energy. In example embodiment, the first entity 102a is a supplier entity.

[0125] In an embodiment, the acquisition module 222 may obtain real-time energy data from energy generation sources 106a associated with the entity 102a. In an embodiment, the entity 102a may further include blockchain nodes for performing the energy exchange among at least two entities.

[0126] The data acquisition module 222 may encapsulate the obtained real-time energy data into a single binary file. The data acquisition module 222 may further split the encapsulated files into multiple chunks. In an embodiment, the digital token transceiver module 236 may generate the encryption key string and may encrypt the multiple chunks.

[0127] In an embodiment, the entity 102a may include a local ledger to store the data chunks. The local ledger may generate an address as a hash value of the each of the multiple chunks. In an embodiment, the digital token transceiver module 236 may further consolidate the storage provider and hash address into an energy data list. The digital token transceiver module 236 may further encrypt the energy data list using the encryption key string. The digital token transceiver module 236 may further encrypt the encryption key with a public key. Further, the encrypted energy data list in the form of a data block may be transmitted to the blockchain 108.

[0128] In an embodiment, the data block may be stored with the encrypted energy data in the local ledger associated with the entity 102a, and with the encrypted encryption key string in the blockchain 108.

[0129] In an embodiment, when the second entity 102b is a consumer entity, a first contract may be initiated between the first entity 102a, i.e., the supplier entity, and the second entity 102b, i.e., the consumer entity for peer-to-peer (P2P) energy exchange.

[0130] In an embodiment, the energy exchange module 228, for generating the first contract, may request the data block comprising the encrypted energy data from the blockchain 108 pertaining to the supplier entity. The data block may contain real-time energy data pertaining to renewable energy data for a predefined period from the energy source 106 associated with the supplier entity.

[0131] Accordingly, the digital token transceiver module 236 may issue the transform key to the proxy server. The encrypted encryption key string may be re-encrypted with the transform key by the proxy server. The energy exchange module 228 may retrieve the re-encrypted encryption key string and may decrypt the encryption key string. Accordingly, the energy exchange module 228 may decrypt the encrypted energy data using the encryption key string. Thereafter, the energy exchange module 228 may validate and retrieve the real-time energy data of the entity 102a from blockchain 108. The energy-exchange module 228 may generate and/or update on the blockchain 108, the first contract of the owner of the renewable energy, i.e., the first entity 102a, based on the validation.

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[0132] In an embodiment, the first contract may be implemented for peer-to-peer (P2P) energy exchange between two entities, i.e., first entity 102a as the supplier entity, and the second entity 102b as the consumer entity. The peer-to-peer (P2P) energy exchange advantageously reduces the reliance of the consumer entity on the current grid import (Y), while allowing energy surplus generated by the supplier entity to be exchanged between the two entities 102a and 102b.

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[0133] In an embodiment, the energy-exchange module 228 facilitates the second entity 102b, being a consumer entity, to perform energy exchange according to a predetermined energy demand and may request energy exchange from the first entity 102a, i.e., the supplier entity. Accordingly, the second entity 102b may request the data block comprising the encrypted energy data from the blockchain 108.

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[0134] Accordingly, the digital token transceiver module 236 may issue the transform key from the first entity 102a to the proxy server. The encrypted encryption key string may be re-encrypted with the transform key by the proxy server.

[0135] Further, the second entity 102b, via the energy-exchange module 228, may retrieve the re-encrypted encryption key string and may decrypt the encryption key string. Further, the energy-exchange module 228 may decrypt the encrypted energy data using the encryption key string. Accordingly, the energy-exchange module 228 may retrieve the energy data from the blockchain 108 to a local ledger associated with the second entity 102b. The energy-exchange module 228 may validate the encrypted energy data in the local ledger associated with the second entity 102b. Accordingly, the energy exchange contract may update the ownership of the supplier entity's energy data to the purchaser entity on the blockchain 108.

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- 5 **[0136]** In an embodiment, the assignment of the energy exchange contract may be implemented by an AI module configured to execute automatic energy exchange based on the status of the one or more entities 102a-102b. In an embodiment, the assignment of the energy exchange contract may be implemented by an energy exchange platform where the consumer entity may bid or choose the supplier entity.
- 10 **[0137]** In an embodiment, there may be one or more electricity regulatory blockchain servers in connection with the blockchain 108, where the one or more electricity regulatory blockchain servers may be associated with the power regulatory authority. In an embodiment, the aggregation module 230 may generate the second contract between the entity group 110 and the one or more entities 102a-102n, for example, the first entity 102a and the second entity 102b. In an embodiment, the aggregation module 230, for generating the second contract, may request the data block comprising the encrypted energy data from the blockchain 108. The data block may contain real-time energy data pertaining to renewable energy data for a predefined period from the energy source 106.
- 15 **[0138]** In an embodiment, the Renewable Energy Certificates (RECs) may be issued by the electricity regulatory authority.
- [0139]** In an embodiment, the second contract as required to be provided to the Renewable Energy Certificates (RECs) issuer for validation purposes may contain installation information namely as follows:
- 20 a) Name of Installation.
- b) Unique Installation Group ID, license number or permit number assigned by a regulator, regulator-appointed party or grid operator.
- c) Renewable energy source/technology/fuel type.
- d) Type of Installation: Installation group.
- 25 e) Name-plate rating of each installation (and total name-plate rating of installation group) – where applicable, both the direct current and alternating current output capacities of the installation shall be provided (e.g. solar PV installations; provide output capacities in kWp and kWac).
- f) Supporting documents showing the generation measurement methods and procedures.
- 30 g) Generation data tolerance level.
- h) Metering set-up of each installation.

- i) Connections to grid, on-site loads, and any other devices drawing electricity from the installation.
 - j) Location of installation(s) – unique street address of each installation or set of GPS coordinates – this also applies to individual installations within an installation group.
 - 5 k) Commenced operation data of installation(s).
 - l) Records of previous registration(s) with other registries and corresponding records of issuance of RECs and any other instruments that convey environmental attributes.
 - m) Whether the installation is participating in a national support scheme or labeling and certification scheme.
- 10 **[0140]** In an embodiment, the carbon-exchange module 232 may facilitate the exchange of carbon credits based on the generated second contract. The second contract being associated with the carbon credit exchange may facilitate the acquisition of renewable energy certificates (RECs) for participation in a green initiative for reducing the dependence on the grid imports on the determination of generated energy being above a predetermined
- 15 threshold, for example, more than 1MWh.
- [0141]** FIG. 9 illustrates a flow chart of a method 900 for energy management over a blockchain network, according to one or more embodiments disclosed herein. The method 900 may be a computer-implemented method executed, for example, by the one or more processors 202 and the one or more modules 220. For the sake of brevity, constructional and
- 20 operational features of the system 200 that are already explained in the description of FIG. 1, FIG. 2, FIG. 3, FIG. 4, FIG. 5, FIG. 6, FIG. 7 and FIG. 8 are not explained in detail in the description of FIG. 9.
- [0142]** At step 902, the method 900 may include obtaining real-time energy data from one or more energy sources associated with each of one or more entities 102a-102n. In an
- 25 embodiment, the obtained real-time energy data comprises at least one of energy generation data and energy consumption data.
- [0143]** At step 904, the method 900 may include predicting energy data for a predefined subsequent period corresponding to each of the one or more entities 102a-102n based on the obtained real-time energy data, using an Artificial Intelligence (AI) model.
- 30 **[0144]** At step 906, the method 900 may include encrypting the obtained real-time energy data and the predicted energy data corresponding to each of the one or more entities 102a-102n.

[0145] At step 908, the method 900 may include tracking a trend profile associated with each of the one or more entities 102a-102n based on the encrypted data. The trend profile indicates the energy generation pattern and energy consumption pattern for each of the one or more entities 102a-102n.

5 [0146] At step 910, the method 900 may include determining whether an amount of energy generated from the one or more energy sources associated with each of the one or more entities falls within a predefined threshold range based on the tracked trend profile.

[0147] At step 912, the method 900 may include generating energy exchanging recommendations for each of the one or more entities 102a-102n based on determining that

10 the amount of energy generated falls out of the predefined threshold range.

[0148] In an embodiment, the method 900 may further include determining a status for each of the one or more entities 102a-102n based on the trend profile. The status comprises at least one of a green priority mode status, a reward priority mode status and a comfort priority mode status. Further, the method 900 may include determining a target for each of the one

15 or more entities 102a-102n based on the determined status.

[0149] In an embodiment, for the first entities among the one or more entities 102a-102n with the determined green priority mode status, the method 900 may include computing a self-sustainable efficiency based on the trend profile associated with the corresponding entity. Further, the method 900 may include comparing the self-sustainable efficiency with

20 a predefined threshold self-sustainable efficiency. Further, the method 900 may include obtaining a difference based on the comparison. Further, the method 900 may include predicting the one or more personalized energy management steps for the first entities based on the obtained difference. Furthermore, the method 900 may include providing the one or more personalized energy management steps to the corresponding entity to be followed to

25 achieve the target.

[0150] In an embodiment, for second entities among the one or more entities 102a-102n with the reward priority mode status, the method 900 may include determining an energy surplus based on the trend profile associated with the corresponding entity. Further, the method 900 may include predicting the one or more personalized energy management steps for the

30 second entities based on the determined energy surplus to achieve the target. Furthermore, the method 900 may include providing the one or more personalized energy management steps to the corresponding entity to be followed to achieve the target.

[0151] In an embodiment, for third entities among the one or more entities 102a-102n with the comfort priority mode status the method 900 may include comparing energy consumption of the third entities with the energy consumption of the first entities and the second entities. Further, the method 900 may include determining a difference in the energy consumption based on the comparison. Further, the method 900 may include predicting the one or more personalized energy management steps based on the obtained difference. Furthermore, the method 900 may include providing the one or more personalized energy management steps to the corresponding entity to be followed to achieve the target.

[0152] In an embodiment, the method 900 may further include obtaining one or more conditions for a generation of a first contract between at least two or more entities 102a-102n based on the trend profile associated with each of the one or more entities 102a-102n. Further, the method 900 may include generating the first contract between the at least two or more entities 102a-102n when the one or more conditions are met. Furthermore, the method 900 may include facilitating interaction between the at least two or more entities (102a-102n) for peer-to-peer (P2P) energy exchange based on the generation of the first contract and the generated energy exchanging recommendations.

[0153] In an embodiment, the method 900 may further include predicting available energy for exchange corresponding to at least one supplier entity among the one or more entities 102a-102n. Further, the method 900 may include recording predicted available energy data on the corresponding distributed ledger associated with the at least one supplier entity. Furthermore, the method 900 may include recording a data address based on the blockchain network 108.

[0154] In an embodiment, the method 900 may further include receiving a transform key issued to decrypt the encrypted data associated with the least one supplier entity. Further, the method 900 may include retrieving the predicted available energy data from the corresponding distributed ledger of at least one supplier entity. Further, the method 900 may include validating the available energy for exchange based on the retrieved predicted available energy data. Furthermore, the method 900 may include updating, on the blockchain network 108, a profile of at least one consumer entity receiving the predicted available energy based on the validation.

[0155] In an embodiment, the method 900 may further include obtaining, for an entity group 110, the encrypted real-time energy data associated with the energy generation by the one or more entities 102a-102n. The entity group 110 comprises one or more entities 102a-102n.

The method 900 further includes aggregating the obtained encrypted real-time energy data associated with the energy generation by the one or more entities 102a-102n. Further, the method 900 may include storing the aggregated data associated with each of the one or more entities 102a-102n to a corresponding distributed ledger of each of the one or more entities 102a-102n.

[0156] In an embodiment, the method 900 may further include generating a second contract between the entity group 110 and the one or more entities 102a-102n based on the aggregation of the encrypted data associated with the energy generation by the one or more entities 102a-102n associated with the entity group 110.

[0157] In an embodiment, the method 900 may further include facilitating exchange of carbon credits based on the generated second contract.

[0158] The present disclosure provides various advantages:

- a) The system 200 and the method 900 of the present disclosure may track all energy information, i.e., the real-time energy data from one or more energy sources, from one or more entities n102a-102n, where each one or more entities n102a-102n may include a prosumer of energy, or a group of prosumers, where a group of prosumers may include a plurality of prosumers, as in developer corporations.
- b) The system 200 and the method 900 of the present disclosure may use the energy surplus, i.e., the amount of excess energy generated from the one or more energy sources, for the peer-to-peer (P2P) energy exchange, therefore, reducing the reliance on the current grid import (Y). For example, exporting the energy surplus to the at least one consumer entity, or back to the grid.
- c) The system 200 and the method 900 of the present disclosure may aggregate the amount of energy generated from the one or more energy sources which may be used to make renewable energy claims in the form of carbon credit. For example, an aggregate of the amount of energy generated above 1MWh may be used to make renewable energy claims in the form of carbon credits.
- d) The system 200 and the method 900 of the present disclosure may advantageously provide one or more personalized energy management steps to the first, second, and the third entities of the one or more entities 102a-102n, based on the determined status for each of the one or more entities 102a-102n.
- e) The system 200 and the method 900 of the present disclosure advantageously ensure that the at least one of the first and second contracts can be generated securely on the

blockchain 108 and become trusted not to have the chance of tampering. Thereby, eliminating any possibility of counterfeiting of the contracts.

[0159] The embodiments disclosed herein can be implemented through at least one software program running on at least one hardware device and performing network management functions to control the elements. The elements can be at least one of a hardware device or a combination of hardware devices and software modules.

[0160] It is understood that terms including “unit” or “module” at the end may refer to the unit for processing at least one function or operation and may be implemented in hardware, software, or a combination of hardware and software.

[0161] While specific language has been used to describe the disclosure, any limitations arising on account of the same are not intended. As would be apparent to a person in the art, various working modifications may be made to the method in order to implement the inventive concept as taught herein.

[0162] The drawings and the forgoing description give examples of embodiments. Those skilled in the art will appreciate that one or more of the described elements may well be combined into a single functional element. Alternatively, certain elements may be split into multiple functional elements. Elements from one embodiment may be added to another embodiment. For example, orders of processes described herein may be changed and are not limited to the manner described herein.

[0163] Moreover, the actions of any flow diagram need not be implemented in the order shown; nor do all of the acts necessarily need to be performed. Also, those acts that are not dependent on other acts may be performed in parallel with the other acts. The scope of embodiments is by no means limited by these specific examples. Numerous variations, whether explicitly given in the specification or not, such as differences in structure, dimension, and use of material, are possible. The scope of embodiments is at least as broad as given by the following claims.

[0164] Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems, and any component(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature or component of any or all the claims.

[0165] The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications
5 should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of at least one embodiment, those skilled in the art will recognize that the embodiments herein can be practiced with modification
10 within the spirit and scope of the embodiments as described herein.

WE CLAIM

1. An energy management system (200) over a blockchain network (108), the system comprising:

a data acquisition module (222) configured to obtain real-time energy data from one or more energy sources associated with each of one or more entities (102a-102n), wherein the obtained real-time energy data comprises at least one of energy generation data and energy consumption data;

a prediction module (224) configured to predict energy data for a predefined subsequent period corresponding to each of the one or more entities (102a-102n) based on the obtained real-time energy data, using an Artificial Intelligence (AI) model, and

a digital token transceiver module (236) configured to encrypt the obtained real-time energy data and the predicted energy data corresponding to each of the one or more entities (102a-102n);

an energy management module (226) configured to:
track a trend profile associated with each of the one or more entities (102a-102n) based on the encrypted data, wherein the trend profile indicates energy generation pattern and energy consumption pattern for each of the one more entities (102a-102n); and

determine whether an amount of energy generated from the one or more energy sources associated with each of the one or more entities (102a-102n) falls within a predefined threshold range based on the tracked trend profile; and

an energy-exchange module (228) configured to:
generate energy exchanging recommendations for each of the one or more entities (102a-102n) based on determining that the amount of energy generated falls out of the predefined threshold range.

2. The system (200) as claimed in claim 1, wherein the energy management module (226) is further configured to:

determine a status for each of the one or more entities (102a-102n) based on the trend profile, wherein the status comprises at least one of a green priority mode status, a reward priority mode status, and a comfort priority mode status; and

determine a target for each of the one or more entities (102a-102n) based on the determined status.

3. The system (200) as claimed in claim 2, wherein for first entities among the one or more entities (102a-102n) with the green priority mode status, the energy management module (226) is further configured to:
 - compute a self-sustainable efficiency based on the trend profile associated with the corresponding entity;
 - compare the self-sustainable efficiency with a predefined threshold self-sustainable efficiency;
 - obtain a difference based on the comparison;
 - predict one or more personalized energy management steps for the first entities based on the obtained difference; and
 - provide the one or more personalized energy management steps to the corresponding entity to be followed to achieve the target.
4. The system (200) as claimed in claim 2, wherein for second entities among the one or more entities (102a-102n) with the reward priority mode status, the energy management module (226) is further configured to:
 - determine an energy surplus based on the trend profile associated with the corresponding entity;
 - predict the one or more personalized energy management steps for the second entities based on the determined energy surplus to achieve the target; and
 - provide the one or more personalized energy management steps to the corresponding entity to be followed to achieve the target.
5. The system (200) as claimed in claim 2, wherein for third entities among the one or more entities (102a-102n) with the comfort priority mode status, the energy management module (226) is further configured to:
 - compare energy consumption of the third entities with the energy consumption of the first entities and the second entities;
 - determine a difference in the energy consumption based on the comparison;

predict the one or more personalized energy management steps based on the obtained difference; and

provide the one or more personalized energy management steps to the corresponding entity to be followed to achieve the target.

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6. The system (200) as claimed in claim 1, wherein the energy-exchange module (228) is further configured to:

obtain one or more conditions for generation of a first contract associated with at least two or more entities (102a-102n) based on the trend profile associated with each of the at least two or more entities (102a-102n);

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generate the first contract associated with the at least two or more entities (102a-102n) when the one or more conditions are met; and

facilitate interaction between the at least two or more entities (102a-102n) for peer-to-peer (P2P) energy exchange based on the generation of the first contract and the generated energy exchanging recommendations.

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7. The system (200) as claimed in claim 6, wherein the energy-exchange module (228) is further configured to:

predict available energy for exchange corresponding to at least one supplier entity among the one or more entities (102a-102n);

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record predicted available energy data on the corresponding distributed ledger associated with the at least one supplier entity; and

record a data address based on the blockchain network (108).

8. The system (200) as claimed in claim 7, wherein the energy-exchange module (228) is further configured to:

receive a transform key issued to decrypt the encrypted data associated with the least one supplier entity;

retrieve the predicted available energy data from the corresponding distributed ledger of at least one supplier entity;

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validate the available energy for exchange based on the retrieved predicted available energy data; and

update, on the blockchain network (108), a profile of at least one consumer entity receiving the predicted available energy based on the validation.

9. The system (200) as claimed in claim 1, further comprising:

5 an aggregation module (230) configured to:
 obtain the encrypted real-time energy data associated with the energy generation data for an entity group (110), wherein the entity group (110) comprises one or more entities (102a-102n);
 aggregate the obtained encrypted real-time energy data associated with the energy generation data by the one or more entities (102a-102n); and
10 store the aggregated data associated with each of the one or more entities (102a-102n) to a corresponding distributed ledger of each of the one or more entities (102a-102n).

15 10. The system (200) as claimed in claim 9, wherein the aggregation module (230) is further configured to:

 generate a second contract between the entity group (110) and the one or more entities (102a-102n) based on the aggregation of the encrypted data associated with the energy generation by the one or more entities (102a-102n) associated with the entity group (110).
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11. The system (200) as claimed in claim 10, comprising a carbon credit exchanging module (232) configured to facilitate the exchange of carbon credits based on the generated second contract.
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12. A method (900) for energy management over a blockchain network (108), the method (900) comprising:

 obtaining (902) real-time energy data from one or more energy sources associated with each of one or more entities (102a-102n), wherein the obtained real-time energy data comprises at least one of energy generation data and energy consumption data;
30

predicting (904) energy data for a predefined subsequent period corresponding
 to each of the one or more entities (102a-102n) based on the obtained real-time energy
 data, using an Artificial Intelligence (AI) model;

5 encrypting (906) the obtained real-time energy data and the predicted energy
 data corresponding to each of the one or more entities (102a-102n);

tracking (908) a trend profile associated with each of the one or more entities
 (102a-102n) based on the encrypted data, wherein the trend profile indicates energy
 generation pattern and energy consumption pattern for each of the one more entities
 (102a-102n);

10 determining (910) whether an amount of energy generated from the one or more
 energy sources associated with each of the one or more entities (102a-102n) falls
 within a predefined threshold range based on the tracked trend profile; and

generating (912) energy exchanging recommendations for each of the one or
 more entities (102a-102n) based on determining that the amount of energy generated
 15 falls out of the predefined threshold range.

13. The method (900) as claimed in claim 12, further comprising:

determining a status for each of the one or more entities (102a-102n) based on
 the trend profile, wherein the status comprises at least one of a green priority mode
 20 status, a reward priority mode status and a comfort priority mode status; and

determining a target for each of the one or more entities (102a-102n) based on
 the determined status.

14. The method (900) as claimed in claim 13, wherein for first entities among the one or
 25 more entities (102a-102n) with the green priority mode status, the method (900)
 further comprises:

computing a self-sustainable efficiency based on the trend profile associated
 with the corresponding entity;

comparing the self-sustainable efficiency with a predefined threshold self-
 30 sustainable efficiency;

obtaining a difference based on the comparison;

predicting the one or more personalized energy management steps for the first
 entities based on the obtained difference; and

providing the one or more personalized energy management steps to the corresponding entity to be followed to achieve the target.

5 15. The method (900) as claimed in claim 13, wherein for second entities among the one or more entities (102a-102n) with the reward priority mode status, the method (900) further comprises:

determining an energy surplus based on the trend profile associated with the corresponding entity;

10 predicting the one or more personalized energy management steps for the second entities based on the determined energy surplus to achieve the target; and

providing the one or more personalized energy management steps to the corresponding entity to be followed to achieve the target.

15 16. The method (900) as claimed in claim 13, wherein for third entities among the one or more entities (102a-102n) with the comfort priority mode status, the method (900) further comprises:

comparing energy consumption of the third entities with the energy consumption of the first entities and the second entities;

determining a difference in the energy consumption based on the comparison;

20 predicting the one or more personalized energy management steps based on the obtained difference; and

providing the one or more personalized energy management steps to the corresponding entity to be followed to achieve the target.

25 17. The method (900) as claimed in claim 12, further comprising:

obtaining one or more conditions for a generation of a first contract between at least two or more entities (102a-102n) based on the trend profile associated with each of the one or more entities (102a-102n);

30 generating the first contract between the at least two or more entities (102a-102n) when the one or more conditions are met; and

facilitating interaction between the at least two or more entities (102a-102n) for peer-to-peer (P2P) energy exchange based on the generation of the first contract and the generated energy exchanging recommendations.

18. The method (900) as claimed in claim 17, further comprising:
- predicting available energy for exchange corresponding to at least one supplier entity among the one or more entities (102a-102n);
 - 5 recording predicted available energy data on the corresponding distributed ledger associated with the at least one supplier entity; and
 - recording a data address based on the blockchain network (108).
19. The method (900) as claimed in claim 18, further comprising:
- 10 receiving a transform key issued to decrypt the encrypted data associated with the least one supplier entity;
 - retrieving the predicted available energy data from the corresponding distributed ledger of at least one supplier entity;
 - validating the available energy for exchange based on the retrieved predicted
 - 15 available energy data; and
 - updating, on the blockchain network (108), a profile of at least one consumer entity receiving the predicted available energy based on the validation.
20. The method (900) as claimed in claim 11, further comprising:
- 20 obtaining the encrypted real-time energy data associated with the energy generation data for an entity group (110), wherein the entity group (110) comprises one or more entities (102a-102n);
 - aggregating the obtained encrypted real-time energy data associated with the energy generation data by the one or more entities (102a-102n); and
 - 25 storing the aggregated data associated with each of the one or more entities (102a-102n) to a corresponding distributed ledger of each of the one or more entities (102a-102n).
21. The method (900) as claimed in claim 20, further comprising:
- 30 generating a second contract between the entity group (110) and the one or more entities (102a-102n) based on the aggregation of the encrypted data associated with the energy generation by the one or more entities (102a-102n) associated with the entity group (110).

22. The method (900) as claimed in claim 21, further comprising facilitating the exchange of carbon credits based on the generated second contract.