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Networked lighting control system with lighting value tracking protocol

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Abstract

A lighting system includes a plurality of lighting system elements. The lighting system elements include a luminaire and a reporting device. The luminaire includes a light source to emit illumination light. The reporting device includes a reporting device network communication interface system for network communication, a reporting device processor, a reporting device memory, and reporting device programming in the reporting device memory. Execution of the reporting device programming causes the respective reporting device to collect a respective performance metric of a respective luminaire and submits a respective claim including the respective performance metric to one or more storage devices. A respective storage device validates a plurality of claims, including the respective claim. The storage device stores the subset or all of the plurality of claims in a block in at least one storage device of the one or more storage devices. The block includes a lighting value token.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) The present application is a continuation of U.S. patent application Ser. No. 17/864,130 filed Jul. 13, 2022 entitled "Networked Lighting Control System with Lighting Value Tracking Protocol," now allowed, the entire contents of which are incorporated herein by reference.

BACKGROUND

(1) Conventionally, lighting equipment is often designed to maximize light produced per watt, or to maximize light produced over the lifetime of the lighting equipment. This optimization is often built into the light, by designing a light source that lasts a certain number of hours while producing a certain number of lumens. A light source therefore can be designed to balance wattage, luminosity, and lifespan. Alternatively, optimization can be achieved by adjusting the amount of power or wattage provided to the light source. Lowering the wattage provided to a light source implicitly lowers the wattage used by the light source, and can often extend the lifespan of the light source—at the expense of producing fewer lumens.

(2) However, existing wireless lighting control systems do not address a responsive strategy directed to promoting honest reporting of light source compliance with owner or regulatory requirements, and do not address promoting encouraging compliance with light source owner requirements. The owners of lighting equipment have a long felt but unresolved need to have light sources meet performance requirements beyond efficient wattage or efficient lifespan of their light sources. These requirements are often driven by national or regional government regulations or by utility incentive programs which can be very specific and evolving. For example, lighting equipment owners may need to have their light sources operate efficiently not with respect to watts consumed, or light source lifespan, but with respect to available ambient sunlight: lights in sunny areas should need to produce less lumens than lights in shaded or dark areas. Lighting equipment owners may also require or prefer a certain lighting configuration, independent of the actual results of that configuration. A light source set to be energy-efficient by utilizing occupancy sensors may be considered preferable to a light source that is constantly powered—even if the occupancy sensors of the energy-efficient light ultimately cause that light source to be constantly powered due to constant, twenty-four-hour occupation. Both light sources consume the same number of watts, and experience the same wear-and-tear, but the light source with the occupancy sensor may be considered superior by the owner due to being configured to only operate when the space of the light source is occupied.

(3) Some organizational systems currently exist to promote energy efficiency. For example, many building codes include specific efficiency requirements and corporations and governments often issue rebates for devices that are designed to be energy efficient. Electrical companies often have tiered rate plans, rewarding those who use fewer kilowatt hours than the electrical company considers reasonable or efficient. However, these systems are blunt tools attempting to solve a nuanced problem. Equipment that is designed to be energy efficient may not ultimately be used in an energy-efficient manner—even still, the rebate is nevertheless still issued on the equipment. Electrical metering is usually done at a building or business entity level, and is not performed at the level of individual devices: an office worker may judiciously turn off their lights when they leave their office, but not receive a lower-tier electrical bill due to another office worker leaving their air conditioning running constantly. Building-level metering also makes it difficult to incentivize efficient behavior in the proper individuals: the electric bill becomes a tragedy of the commons, and no one behaves conscientiously.

(4) Users of equipment may also be dishonest, and may falsely report the settings selected, light sources used, and ultimately how much wattage was utilized by a light source in order to maximize rebates and minimize electrical bills.

(5) Accordingly, a system for deploying evolving and specific requirements for electrical systems, promoting compliance with those requirements, and enforcing faithful reporting of that compliance is desired to overcome these and other limitations in the art.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) The drawing figures depict one or more implementations in accord with the present teachings, by way of example only, not by way of limitation. In the figures, like reference numerals refer to the same or similar elements.

(2) FIG. **1** is a high-level functional block diagram of an example of a lighting system including a plurality of luminaires and reporting devices.

(3) FIG. **2** is a block diagram of a reporting device that is in the lighting system that communicates via the lighting control network of FIG. **1**.

(4) FIG. **3** is a block diagram of a luminaire of the lighting system that communicates via the lighting control network of FIG. **1**.

(5) FIG. **4**A is a block diagram of a storage device implemented as a database device that is in the lighting system that communicates via the lighting control network of FIG. **1**.

(6) FIG. **4**B is a block diagram of a storage device implemented as a validator device that is in the lighting system that communicates via the lighting control network of FIG. **1**.

(7) FIG. **5** is a high-level functional block diagram of an example of a heating, venting, and air cooling (HVAC) system including a plurality of HVAC devices and reporting devices, similar to the lighting system of FIG. **1**.

(8) FIG. **6** is a block diagram of an HVAC device of the HVAC system that communicates via the HVAC control network of FIG. **4**.

(9) FIG. **7** is a high-level functional block diagram of an example of an electrical load system including a plurality of luminaires, HVAC devices, appliances, reporting devices, and validators divided between two vicinities or connected to a wide-area network (WAN), and able to communicate via the WAN.

(10) FIG. **8** depicts an electrical load value tokenization protocol for recording performance metrics for luminaires, HVAC devices, and other appliances coupled to a reporting device.

DETAILED DESCRIPTION

(11) In the following detailed description, numerous specific details are set forth by way of examples in order to provide a thorough understanding of the relevant teachings. However, it should be apparent to those skilled in the art that the present teachings may be practiced without such details. In other instances, well known methods, procedures, components, and/or circuitry have been described at a relatively high-level, without detail, in order to avoid unnecessarily obscuring aspects of the present teachings.

(12) Although the discussion herein is focused on light fixture type luminaires that have a fixed position in a space, it should be understood that other types of luminaires can be used/sensed in lieu of light fixtures, such as lamps. The term "luminaire" as used herein, is intended to encompass essentially any type of device, e.g., a light fixture or a lamp, that processes energy to generate or supply artificial light, for example, for general illumination of a space intended for use of or occupancy or observation, typically by a living organism that can take advantage of or be affected in some desired manner by the light emitted from the device. However, a luminaire may provide light for use by automated equipment, such as sensors/monitors, robots, etc. that may occupy or

observe the illuminated space, instead of or in addition to light provided for an organism. However, it is also possible that one or more luminaries in or on a particular premises have other lighting purposes, such as signage for an entrance or to indicate an exit. In most examples, the luminaire(s) illuminate a space of a premises to a level useful for a human in or passing through the space, e.g. general illumination of a room or corridor in a building or of an outdoor space such as a street, sidewalk, parking lot or performance venue. The actual source of illumination light in or supplying the light for a luminaire may be any type of artificial light emitting device, several examples of which are included in the discussions below.

(13) The "luminaire" can include other elements such as electronics and/or support structure, to operate and/or install the particular luminaire implementation. Such electronics hardware, for example, may include some or all of the appropriate driver(s) for the illumination light source, any associated control processor, sensor(s), or alternative higher-level control circuitry, and/or data communication interface(s). As noted, the lighting component(s) are located into an integral unit, such as a light fixture or lamp implementation of the luminaire. The electronics for driving and/or controlling the lighting component(s) may be incorporated within the luminaire or located separately and coupled by appropriate means to the light source component(s).

(14) The term "lighting control system" or "lighting system" as used herein, is intended to encompass essentially any type of system that either includes a number of such luminaires coupled together for data communication and/or luminaire(s) coupled together for data communication with one or more control devices, such as wall switches, sensors, control panels, remote controls, central lighting or building control systems, servers, etc.

(15) The illumination light output of a luminaire, for example, may have an intensity and/or other characteristic(s) that satisfy an industry acceptable performance standard for a general lighting application. The performance standard may vary for different uses or applications of the illuminated space, for example, as between residential, office, manufacturing, warehouse, or retail spaces. Any luminaire, however, may be controlled in response to commands received with the network technology of the lighting system, e.g. to turn the source ON/OFF, to dim the light intensity of the output, to adjust or tune color of the light output (for a luminaire having a variable color source), etc.

(16) Terms such as "artificial lighting" or "illumination lighting" as used herein, are intended to encompass essentially any type of lighting in which a luminaire produces light by processing of electrical power to generate the light. A luminaire for artificial lighting or illumination lighting, for example, may take the form of a lamp, light fixture, or other luminaire that incorporates a light source, where the light source by itself contains no intelligence or communication capability, such as one or more LEDs or the like, or a lamp (e.g. "regular light bulbs") of any suitable type.

(17) Illumination light output from the light source of the luminaire may carry information, such as a code (e.g. to identify the luminaire or its location) or downstream transmission of communication signaling and/or user data. The light-based data transmission may involve modulation or otherwise adjusting parameters (e.g. intensity, color characteristic or distribution) of the illumination light output of the light source of the light source of the luminaire.

(18) Terms such as "lighting device" or "lighting apparatus," as used herein, are intended to encompass essentially any combination of an example of a luminaire discussed herein with other elements such as electronics and/or support structure, to operate and/or install the particular luminaire implementation. Such electronics hardware, for example, may include some or all of the appropriate driver(s) for the illumination light source, any associated control processor or alternative higher-level control circuitry, and/or data communication interface(s). The electronics for driving and/or controlling the lighting component(s) may be incorporated within the luminaire or located separately and coupled by appropriate means to the light source component(s).

(19) The term "coupled" as used herein refers to any logical, optical, RF, physical, or electrical connection, link or the like by which signals or light produced or supplied by one system element

are imparted to another coupled element. Unless described otherwise, coupled elements or devices are not necessarily directly connected to one another and may be separated by intermediate components, elements or communication media that may modify, manipulate, or carry the light or signals.

(20) Reference now is made in detail to the examples illustrated in the accompanying drawings and discussed below.

(21) FIG. **1** is a high-level functional block diagram of an example of a lighting system **1** that includes a plurality of lighting system elements **3**A-N. The plurality of lighting system elements **3**A-N includes a plurality of luminaires **10**A-N, a plurality of reporting devices **20**A-N, and a plurality of storage devices **40**A-B. The lighting system **1** in particular includes a reporting device **20**D acting as a gateway **50**. The lighting system **1** supports an electrical load value tokenization protocol **800** (see FIG. **8**) for reporting performance metrics **240**A-Z (see FIG. **2**) of the luminaires **10**A-N, HVAC devices **510**A-N(see FIG. **5**), or appliances **710**A-C (see FIG. **7**) by the reporting devices **20**A-N, and recording those same performance metrics **240**A-N utilizing the storage devices **40**A-N. The numbers of elements within the lighting control system **1** are for illustrative purposes only: any number of luminaires **10**A-N, reporting devices **20**A-N, lighting control device(s) **30**, sensor device(s) **31**, storage devices **40**A-B, gateways **50**A-N, and other networked devices can be included in the lighting system **1**. The components in off-premises location **60**, including a wide-area network (WAN) **55**, cloud computing device **65**, and storage devices **40**C-N may be fully integrated components of lighting system **1** or part of a 3.sup.rd-party system used for validation. Lighting system **1** provides a variety of lighting controls of a lighting control group over lighting control network **5**, and may support light commissioning/maintenance network communication over the lighting control network **5**. Lighting control communication includes communications in support of turning lights on/off, dimming, set scene, and sensor trip events. Communication between lighting system elements **3**A-N can occur in the form of control messages **170**A-N.

(22) Storage devices **40**A-B reside on the lighting control network, but storage devices **40**C-N can reside beyond the gateway reporting device **20**D, on a validator network for inter-communication between storage devices **40**C-N. Further, the lighting control network **5** can allow the storage devices **40**A-N implemented as validator devices **42** to maintain and add to a blockchain **444** (see FIG. **4**B) implemented within the lighting control network **5**.

(23) Referring now to FIG. **2**, the lighting system **1** observes the performance of the luminaires **10**A-N during a running period of time **238**A, and records the performance of the luminaires **10**A-N as performance metrics **240**A-Z associated with that running period of time **238**A as a record **242**A. The pairing of a particular luminaire **10**A, a particular running period of time **238**A, and a particular performance metric **240**A is unique: duplicate records **242**A for the same luminaire **10**A, running period of time **238**A, and performance metric **240**A should be prohibited or ignored to avoid incorrect recordation. To assist in avoiding incorrect recordation, records **242**A can be signed with a signature **264**A, the signature **264**A utilizing a public key **254**, a private key **256**, and/or a shared key **262**.

(24) The performance metrics **240**A-Z are quantifiable representations of the performance of the luminaires **10**A-N, which can be weighed and compared. In some examples, the performance metrics **240**A-Z are normalized, such that a comparison between one performance metric **240**A and another performance metric **240**B can be validly performed—even if the two compared performance metrics **240**A-B quantify different behavior. For example, a first performance metric **240**A measuring electricity usage of a first luminaire **10**A, and a second performance metric **240**B measuring lighting produced by a second luminaire **10**B—by normalizing the two performance metrics **240**A-B, one can determine which luminaire **10**A-B provided superior performance, even though both luminaires **10**A-B were judged on different criteria. In systems like the electrical load system **701** of FIG. **7**, normalization of performance metrics **240**A-Z allows for comparison of

performance between different types of electrical load system elements **703**A-N, e.g. between a luminaire **10**E and an HVAC device **510**D, or between a luminaire **10**F and an appliance **710**A. Performance metrics **240**A-Z can be further divided into fixed attributes and dynamic metrics. Generally, fixed attributes are performance metrics **240**A-Z which do not vary during operation of a luminaire **10**A; some examples of fixed attributes include an active image firmware designation, physical attributes of the luminaire **10**A, and default configurations. Alternatively, dynamic metrics are performance metrics **240**A-Z which do vary during operation of the luminaire **10**A; some examples of dynamic metrics include the physical state of emitted lighting, the state of a lighting control algorithm, or modifications made to the default configurations. The distinction between fixed attributes and dynamic metrics can be arbitrary, and in some examples a performance metric **240**A may be identified as a fixed attribute, while in another example that same performance metric **240**A may be identified as a dynamic metric.

(25) As further detailed in FIGS. **4**A-B, the luminaires **10**A-N, reporting devices **20**A-N, and storage devices **40**A-N can store ideal performance metrics **258**A-Z in memory **235**, **335**, **435**, **485**. Ideal performance metrics **258**A-Z can be compared to performance metrics **240**A-Z to determine how well or poorly a luminaire **10**A performed in satisfying the performance goals of the owner of the luminaire **10**A. As the ideal performance metrics **258**A-Z can be set at a reporting device **20**A or luminaire **10**A level, in some implementations the ideal performance metrics **258**A-Z are stored in the reporting device **20**A or luminaire **10**A, and sent along with the related performance metrics **240**A-Z to the storage devices **40**A-N for storage. In other implementations, the storage devices **40**A-N store the ideal performance metrics **258**A-Z, and the reporting device **20**A is not required or permitted to store the ideal performance metrics **258**A-Z. Maintaining the ideal performance metrics **258**A-Z can allow the owner of the lighting control network **5** to enforce governance rules more effectively, as the performance can be weighed and rated at the storage devices **40**A-N: in some examples, the owner of the lighting control network **5** may have physical possession and physical control over the storage devices **40**A-N, but not over the reporting devices **20**A-N or luminaires **10**A-N: by weighing and rating performance at the storage devices **40**A-N in the physical possession and control of the owner of the lighting control network **5**, errors and fraud can often be more easily detected, and corrected or ignored.

(26) Referring now to FIG. **4**A, the lighting system **1** can maintain a database **494**A within one or more storage devices **40**A-N configured as database devices **41** for the secure storage of performance metrics **240**A-Z of the luminaires **10**A-N, the accurate tokenization of those performance metrics **240**A-Z, and the transaction of the tokenized performance metrics **240**A-Z. The database **494** can be a traditional database, accessed by a database management system (DBMS) implementing atomicity, consistency, isolation, and durability to store blocks **450**A-B or database records. The database **494** can reside in a single storage device **40**A, or can be shared across a cluster of storage devices **40**A-N. The database blocks **450**A-B can track records **242**A-F, **458**A; lighting value tokens **452**A-F, and wallet addresses **456**A-B in the database **494** associated with lighting value tokens **452**A-F.

(27) The database device memory **485** can include: a whitelist of public keys **254** or shared keys **258** associated with validated luminaires **10**A-N and reporting devices **20**A-N with a controlled chain of custody; a blacklist of public keys **254** or shared keys **258** that have been deemed invalid to ensure they are never added to the whitelist; a history of all validated records **242**A containing the public key **254** or shared key **258** of each respective luminaire **10**A-N, and the running period of time **238**A recorded. The database device programming **486** can also include a service to validate records **254**, and can verify record signatures **264**A based on whitelist of public keys **254** or shared keys **258**, verify the running period of time **238**A recorded for the device has not already been allocated in the history, and verify the running period of time **238**A does not start before the known creation of the luminaire **10**A, or that the running period of time **238**A does not occur in the future. Records **242**A may be made based on a running period of time **238**A when exact

timekeeping is difficult. The sum of running periods of time **238**A-N in records **242**A-N for a given luminaire **10**A should not exceed the time available in the window of time for those records **242**A-N. For example, no more than 24 hours of a running period of time **238**A should assigned to a given day in a record **242**A (except when the clocks change).

(28) The database device programming **486** can also include a service to convert validated records **242**A, and validated records **242**A can be converted based on the needs of the organization or owner. For example, records **242**A may be treated like a traditional rebate application: the amount of the rebate would be determined by the conversion rules published and implemented by the organization or owner. Rebates may be fulfilled through traditional means such as a paper check being issued to the individual or company specified as the claimant or user. The organization or owner may implement various auditing procedures to ensure the validity of records **242**A, associated luminaires **10**A-N, reporting devices **20**A-N, storage devices **40**A-N, manufacturers, or claimants.

(29) Referring now to FIG. **4**B, the lighting system **1** can alternatively or additionally maintains a blockchain **444** within the validator devices **42** for the secure storage of performance metrics **240**A-Z of the luminaires **10**A-N, the accurate tokenization of those performance metrics **240**A-Z, and the transaction of the tokenized performance metrics **240**A-Z. The blockchain **444** in this example is a ledger, distributed among the validator devices **42**, maintaining transactions which create light value tokens **452**A and transfer those light value tokens **452**A between traders. The reporting devices **20**A-N fill the role somewhat analogous to miners in a conventional blockchain. However, conventional blockchains often operate on a proof-of-work model, where miners create value by solving increasingly complicated math problems. In this example, the lighting system **1** operates on a proof of lighting value model, e.g., a proof of performance value model, where reporting devices **20**A-N create value by determining how effectively the luminaires **10**A-N of the lighting system **1** follow their performance metrics **240**A-Z

(30) In FIGS. **4**A-B, users or operators of the luminaires **10**A-N earn lighting value tokens **452**A by controlling their luminaires **10**A-N in such a manner that the luminaires **10**A-N produce high quality performance metrics **240**A-Z. The reporting devices **20**A-N, often under the control of the owner of the lighting system **1**, record this behavior. Then, the reporting devices **20**A-N bundle the performance metrics **240**A-Z into records **242**A-N, and transmit the records **242**A-N to the storage devices **40**A-N. The storage devices **40**A-N cryptographically validate the records **242**A-N, store the records **242**A-N, and allocate lighting value tokens **452**A to the digital wallet addresses **456**A-B of the users or operators. Validating the records **242**A-N can include verifying that a single record **242**A is being validated for a specific running period of time **238**A and luminaire **10**A pairing. Some luminaires **10**A-N may not have a clock implemented, but may have a timer. In such examples, the storage devices **40**A-N ultimately ensure that records **242**A-N are not double counted.

(31) Double counting can occur if a luminaire **10**A or reporting device **20**A submits a performance metric **240**A which overlaps with another performance metric **240**B for the same running period of time **238**A. In one example, this would occur if the luminaire **10**A submits a performance metric **240**A which covers a 25-hour span of time every 24-hour period: those submitted performance metrics **240**A overcount an hour of performance every 24 hours. Requiring a running period of time **238**A to be specified allows basic limits to be enforced: such as a luminaire **10**A not being able to claim more than 100% of the available time within a given period (no more than 365 days claimed in a year.) In this example, the storage devices **40**A-N ensure that performance metrics **240**A are only submitted for a running period of time **238**A equal to the span of time covered, to prevent double counting. This type of double counting can be further prevented if the reporting device **20**A-N (which can implement a clock) appends the relevant time (the current time, the time the time span started, and/or the time the time span concluded) to the performance metric **240**A as part of the running period of time **238**A when preparing the bundling record **242**A to send to the storage

devices **40**A-N. In some example, only a single record **242**A may be applied to a luminaire **10**A for any given running period of time **238**A. Records **242**A-N can be segmented into blocks of time. Some performance metrics **240**A-N may be reported with percentage compliance within the time of a given record **242**A. For example, a 30% occupancy enabled during a 120-minute record **242**A running period of time **238**A. The exact time for a given record **242**A is not particularly important, but rather the avoidance of records **242**A involving the same luminaire **10**A during the same running period of time **238**A.

(32) In another example of potential double counting, a luminaire **10**A transmits a performance metric **240**A to a first reporting device **20**A, and then transmits that same performance metric **240**A to a second reporting device **20**B. Both reporting devices **20**A-B transmit the same performance metric **240**A to the storage devices **40**A-N. The storage devices **40**A-N can discern that the same performance metric **240**A, representing the performance of a given luminaire **10**A for a given running period of time **238**A in a given performance metric **240**A, was submitted twice, and can reject one of the two submissions. Alternatively, the storage devices **40**A-N can request that the reporting devices **20**A-B and the luminaire **10**A re-convene and determine which performance metric **240**A should be validated and stored by the storage devices **40**A-N.

(33) After validation, at a later time, the users or operators can transact with other users, operators, owners, or third parties (such as rebate sponsor, building owners, environmental compliance auditors, or governments) for any earned lighting value tokens **452**A. Such transactions are also recorded in the database **494** or on the blockchain **444**, although examples where separate blockchains and databases exist for recording performance metrics and transferring lighting value tokens **452**A are considered: such examples may be implemented if the quantity of transactions, timing of transactions, or cost of transacting are materially different between the recordation of performance transactions, and the transference transactions.

(34) The depicted example utilizes a blockchain **444**, but any form of ledger or database **494** can be utilized, whether centralized or decentralized. If a centralized ledger is used, such as a database device **41**, a single storage device **40**A may be used rather than a plurality of storage devices **40**A-N. In such an example the storage device **40**A reaches a consensus of one, i.e., with itself, and stores the records **242**A-F in the database **494** or ledger. If a blockchain is used, the blockchain **444** can be a blockchain specifically implemented to store light value tokens **452**A-F, or it can be an existing blockchain, preferably one which allows for smart contract transactions within the blockchain ledger. Later figures disclose an HVAC value token **552**A (see FIG. **5**) and an electrical load value token **752**A (see FIG. **7**). The HVAC value token **552**A or electrical load value token **752**A can be stored in separate blockchains which do not share consensus with the blockchain **444** storing the lighting value token **452**A; or, the HVAC value token **552**A or electrical load value token **752**A can be stored in a database **494**. Alternatively, any or all of the described tokens (lighting value token **452**A, HVAC value token **552**A, or electrical load value token **752**A) can be stored in the same blockchain **444** or database **494**. In such an example, the structure of the lighting value token **452**A, HVAC value token **552**A, and electrical load value token **752**A may vary, or the structure can be the same, and any distinction between the lighting value token **452**A, HVAC value token **552**A, and electrical load value token **752**A is in name and not in function.

(35) Returning to FIG. **1**, the lighting system **1** can further include a sensor device **31**, or multiple sensor device(s) **31** which can monitor any physical or occupant condition or phenomenon in the space (e.g., occupancy, motion, ozone, daylight, audio, temperature, or fastener detector(s) **260**) on behalf of any of the luminaires **10**A-N, reporting devices **20**A-N, or other lighting system elements. Sensor device(s) **31** can monitor luminaire **10**A-N performance and/or conditions in the space, without being directly integrated into either a luminaire **10**A-N or a reporting device **20**A-N. Instead, the sensor device **31** can report the performance of a luminaire **10**A-N and/or conditions in the space to a reporting device **20**A-N, and the reporting device can use that in determining performance metrics **240**A-N.

(36) A lighting control device **30** or multiple lighting control devices **30** may also be present, and can include user interface elements to allow an operator or user to configure the lighting system **1** and lighting system elements **3**A-N and ultimately energize the luminaires **10**A-N in order to emit illumination lighting. A lighting control device **30** may also provide information to the reporting devices **20**A-N, for example that a user attempted to powered off a luminaire **10**A, even if the luminaire programming (see FIG. **3**) would not allow the luminaire **10**A to be powered off at that time: as performance metrics **240**A-N can track users' good faith efforts to efficiently use the lighting system elements **3**A-N, good-faith but ineffective use a lighting control device **30** to increase the performance of the lighting control network **5** may be behavior the owner of the lighting system elements **3**A-N would like to record and potentially reward. Good-faith attempts by the occupants to control their lights manually, whether effective or not, may also be used to manually or automatically (i.e., through artificial intelligence or machine learning techniques) optimize the lighting system programming.

(37) Each of the lighting system elements **3**A-N is physically connected to the lighting control network **5**, which can be a wired network via communication wires or cables (ex: CAT5 cable) or enabled for wireless network communication (ex: BLUETOOTH® Low Energy (BLE), Wi-Fi, near field communication (NFC), optical communication, Sub-GHz RF communication, etc.). Therefore, the lighting system **1** may comprise of all wired connected control devices, wireless only connected devices, or hybrid combination of both wired and wireless control devices. Sensor device(s) **31** or sensors **260** (see FIG. **2**) can include a traditional passive infrared motion sensor (PIR) enhanced with microphonics, or an audio detector circuit, for improved reliability of motion and occupancy sensing. In other embodiments, the motion sensors of sensor device(s) **31** or the sensors **260** may be based on ultrasonic, UWB, radar, or other motion sensing technologies. In a similar manner, each of the HVAC system elements **503**A-N of FIG. **5** are physically connected to the HVAC control network **505**, and each of the electrical load system elements **703**A-N of FIG. **7** are physically connected to the electrical load control network **705**—even if that connected is solely through a metered electrical socket, like the appliance **710**C of FIG. **7**.

(38) As shown, each of the reporting devices **20**A-N include an on-board reporting device processor **230**, which is shown in more detail in FIG. **2**. The reporting device processor **230** is connected to a reporting device memory **235** (volatile and non-volatile). As shown, the reporting device processor **230** is coupled to drive/sense circuitry **247** operable to control detectors **260**. The luminaire devices **10**A-N have a luminaire driver circuit **310** that controls light source operation of a light source **315**.

(39) Reporting devices **20**A-N, storage devices **40**A-B, and luminaires **10**A-B, D-N can communicate control signal(s) **170**A-N for the luminaire light source(s) **315** over a wireless lighting control network **5** (e.g., 900 MHz) and accordingly can each include an RF transceiver **246**A in the sub-GHz range. A variety of control signals **170**A-N for the luminaire light source(s) **315** are transmitted over wireless lighting control network **5**, including, for example, to turn the luminaire light source **315** on/off and sensor trip events. Messages **170**A-B related to records **242**A-N (see FIG. **2**) may be sent from reporting devices **20**A-N to record performance metrics **240**A-Z, and can be sent between storage devices **40**A-N to maintain the blockchain **444** or database **494**. These claims control messages **170**A-B may be forwarded between storage devices **40**A-N by other lighting system elements **3**A-N, such as the luminaires **10**A-B, D, N.

(40) Alternatively, the lighting control network **5** may be partially or completely wired, and the reporting devices **20**A-N, storage devices **40**A-N, and the luminaires **20**A-B, D-N communicate over wired data connections. Furthermore, some control signals **170**A-N can be communicated over energy-providing wired connections, for example in the presence or absence of voltage or current, or in the timing of the presence or absence of voltage or current.

(41) The lighting control system **1** can be provisioned with set dynamic metrics, fixed attributes, ideal dynamic metrics, and ideal fixed attributes. The fixed attributes, ideal dynamic metrics, and

ideal fixed attributes can be factory-programmed, or can be presented in a user-programmable configuration so that the lighting system **1**, via a control station or other interface device, behavior can be optimized for the specific physical space **2** and owner or user requirements of the lighting system **1**.

(42) The lighting control system **1** can further include a gateway **50**. The gateway **50** is a computing device that provides access between a WAN **55** and a local communication network, such as the lighting control network **5**. The WAN **55** (e.g., Internet) can be a cellular network, optical fiber, cable network, or satellite network that can be connected to via Ethernet, for example. The gateway **50** may provide routing, access, and other services for the reporting devices **20**A-N and the luminaires **10**A-B, D-N residing at the physical space **2**, for example. In implementations where the luminaires **10**A-N and reporting devices **20**A-N are not aware of the time or their physical space **2**, the gateway **50** can append that information to claims messages **170**A. The gateway **50** can be a reporting device **20**D.

(43) The lighting control system **1** can still further include a cloud computing device **65**, and the cloud computing device **65** resides off-premises **60** (e.g., cloud) meaning the cloud computing device **65** is a remote computing device or server hosted on the Internet to store, manage, and process data, rather than the local gateway **50**. The gateway **50**, cloud computing device **65**, or mobile device can also be used to monitor and control (e.g., switch on/off) the luminaire light source(s) **315** of the luminaires **10**A-N and other components of the lighting system **1**, such as reporting devices **20**A-N and storage devices **40**A-N. Gateway **50**, cloud computing device **65**, or a mobile device can receive and process data from the luminaires **10**A-N and the reporting devices **20**A-N. In particular, gateway **50**, cloud computing device **65**, or a mobile device can maintain the database **494**, or copies of the database **494**. Gateway **50**, cloud computing device **65**, or a mobile device can also maintain the blockchain **444** if utilized, act as or integrate validator devices **42**, and assist in validating claims and achieving consensus, in particular for transfer claims **201-202**A (see FIG. **4**).

(44) The instructions, programming, or application(s) implementing the performance tracking programming **236**, reporting device programming **236**, database device programming **486**, or validator device programming **436** described herein may be software or firmware used to implement any other device functions associated with luminaires **10**A-N, reporting devices **20**A-N, storage devices **40**A-N, network controller (e.g., gateway **50**), and cloud computing device **65**. Program aspects of the technology may be thought of as "products" or "articles of manufacture" typically in the form of executable code or process instructions and/or associated data that is stored on or embodied in a type of machine or processor readable medium (e.g., transitory or non-transitory), such as memory **235**, **335**, **435**, **485**, **635** and/or another computer used to download or otherwise install such programming into the with luminaires **10**A-N, reporting devices **20**A-N, storage devices **40**A-N, network controller (e.g., gateway **50**), cloud computing device **65**, or a transportable storage device or a communications medium for carrying program for installation in the luminaires **10**A-N, reporting devices **20**A-N, storage devices **40**A-N, network controller (e.g., gateway **50**), and/or cloud computing device **65**.

(45) Returning to FIG. **2**, shown is a block diagram of a reporting device **20**A of the lighting system **1**. As shown, the reporting device **20**A includes a power supply **205** that is driven by a line power source **201** or optionally a non-line power source **202**. The power supply **205** may include a magnetic transformer, electronic transformer, switching converter, rectifier, or any other similar type of circuit to convert an input power signal into a power signal suitable for operation of the reporting device **20**A. Reporting device **20**A includes power distribution circuitry **225** driven by the line power source **201** or non-line power source **202**. The power distribution circuitry **225** distributes power and ground voltages to the reporting device processor **230**; reporting device memory **235**; reporting device network communication interface system **255** (e.g., wireless transceivers, wired interface); and optional on-board occupancy, motion, ozone, daylight, or audio

sensor as detectors **260** to reliably record and report operation of luminaires **10**A-N. The optional detectors **260** function similarly to a sensor device **31**, and a sensor device **31** can be integrated as part of the reporting device **20**A and utilize the physical components of the reporting device **20**A. In this example, the detectors **260** detect occupancy, daylight, audio, temperature, and fastener status (e.g., whether a window or door in the physical space **2** is open or closed). A reporting device **20**A-N monitoring a luminaire **10**A may only need to implement some of these detectors **260**, whereas a reporting device **260** monitoring an HVAC device **510**A or appliance **710**A may implement other of these detectors **260**. Reporting devices **20**A-N may be manufactured with a plethora of, or all reasonable detectors **260**, if it is not known at the time of manufacture what type of luminaire **10**A-N, HVAC device **510**A-N, or appliance **710**A-C (see FIG. **7**) the reporting device **20**A will be monitoring. Reporting device processor **230** includes a central processing unit (CPU) that controls the operation of the reporting device **20**A. Reporting device memory **235** can include volatile and/or non-volatile storage.

(46) As shown, reporting device processor **230** is coupled to a reporting device communication interface system **255** for receiving and transmitting various control signals **170**A-N. Reporting device communication interface system **255** of FIG. **2**, luminaire communication interface system **355** of FIG. **3**, database device communication interface **495** of FIG. **4**A, validator device communication interface **455** of FIG. **4**B, and HVAC device communication interface system **655** of FIG. **6** allow for data communication (e.g., wired or wireless) over various networks, including the lighting control network **5** of FIG. **1**, HVAC control network **505** of FIG. **5**, or electrical load control network **705** of FIG. **7**. Communication interface systems **255**, **355**, **455**, **495**, **655** include at least one radio frequency (RF) transceiver **246**A (XCVR), for example, a single-band, dual-band, or tri-band chipset of RF transceiver(s) **246**A-B configured for wireless communication via separate radios that operate at three different frequencies, such as sub-GHz (e.g., 900 MHz), Bluetooth Low Energy (BLE) (2.4 GHz), and 5 GHz, for example. Communication interface systems **255**, **355**, **455**, **495**, **655** can include a first RF transceiver **246**A configured for wireless communication (e.g., unicast and multicast) via a wireless lighting control network **5** over a first wireless lighting control network communication band (e.g., sub-GHz) for lighting control and systems operations (or information), such as control signals **170**A-N, with lighting system elements **3**A-N. Communication interface systems **255**, **355**, **455**, **495**, **655** can include a second wireless RF transceiver **246**B for communication (e.g., point-to-point) via a commissioning network (not shown) with lighting system elements **3**A-N (e.g., mobile device) over a second different wireless commissioning network communication band, such as 1 GHz or above communications (e.g., 2.4 GHz for Bluetooth) for commissioning, configuration, or maintenance operations.

(47) In some examples, the lighting system **1** can further include an optional secondary network (e.g., wired or wireless LAN) for communications involving the electrical load value tokenization protocol **800** (e.g., see FIG. **8**) described herein. The optional secondary network may be separate and distinct from the lighting control network **5** and carries light value token communications. Reporting device **20**A can communicate over the optional secondary network (via the second wireless RF transceiver **246**B, such as a backhaul network for communication between the luminaires **10**A-N, reporting devices **20**A-N, storage devices **40**A-N, and a network controller (e.g., gateway) **50**. Transport layer methods ride on the network layer function of the RF transceivers **246**A-B. The second RF transceiver **246**B is optional. Communication interface systems **255**, **355**, **455**, **495**, **655** can include an optional wired network communication interface for communication over a wired lighting control network **5**.

(48) Reporting device processor **230**, luminaire processor **330** of FIG. **3**, database device processor **480** of FIG. **4**, validator device processor **430** of FIG. **4**B, and HVAC device processor **630** of FIG. **6** serve to perform various operations, for example, in accordance with instructions or programming executable by processors **230**, **330**, **430**, **480**, **630**. For example, such operations may include operations related to communications with various lighting control system **1** elements, such

as luminaires **10**A-N, reporting devices **20**A-N, and storage devices **40**A-N to implement the electrical load value tokenization protocol **800**. Although a processor **230**, **330**, **430**, **480**, **630** may be configured by use of hardwired logic, typical processors are general processing circuits configured by execution of programming Processors **230**, **330**, **430**, **480**, **630** include elements structured and arranged to perform one or more processing functions, typically various data processing functions. Although discrete logic components could be used, the examples utilize components forming a programmable CPU. A processor **230**, **330**, **430**, **480**, **630** for example includes one or more integrated circuit (IC) chips incorporating the electronic elements to perform the functions of the CPU. The processors **230**, **330**, **430**, **480**, **630** for example, may be based on any known or available microprocessor architecture, such as a Reduced Instruction Set Computing (RISC) using an ARM architecture, as commonly used today in mobile devices and other portable electronic devices. Of course, other processor circuitry may be used to form the CPU or processor hardware in. Although the illustrated examples of the processors **230**, **330**, **430**, **480**, **630** include only one microprocessor, for convenience, a multi-processor architecture can also be used. A digital signal processor (DSP) or field-programmable gate array (FPGA) could be suitable replacements for the processors **230**, **330**, **430**, **480**, **630** but may consume more power with added complexity.

(49) Reporting device memory **235**, luminaire memory **335** of FIG. **3**, database device memory **485**, validator device memory **435**, and HVAC device memory **635** of FIG. **6** are for storing data and programming. In the example, the main memory systems **235**, **335**, **435**, **485**, **635** may include a flash memory (non-volatile or persistent storage) and/or a random-access memory (RAM) (volatile storage). The RAM serves as short term storage for instructions and data being handled by the processors **230**, **330**, **430**, **480**, **630** e.g., as a working data processing memory. The flash memory typically provides longer term storage.

(50) Of course, other storage devices or configurations may be added to or substituted for those in the example. Such other storage devices may be implemented using any type of storage medium having computer or processor readable instructions or programming stored therein and may include, for example, any or all of the tangible memory of the computers, processors or the like, or associated modules.

(51) FIG. **3** is a block diagram of a luminaire **10**A of the lighting control system **1**. As shown, the luminaire **10**A includes a luminaire light source **315** to emit illumination lighting, to improve visibility for occupants of the physical space **2**. The luminaire **10**A may have additional luminaire light sources, which can be operated independently from each other: For example, the luminaire light source **315** can be one while the additional luminaire light source is off, or the luminaire light source **315** can be set to 50% intensity while the additional luminaire light source **315** is set to 100% intensity.

(52) As shown, MCU **329** includes power switch processor **330** and power switch memory **331** to implement luminaire programming **336** described herein. The circuitry, hardware, and software of the luminaire **10**A is similar to the reporting device **20**A of FIG. **2**, including the line power source **201**, non-line power source **202**, power supply **205**, power distribution **225**, and the optional luminaire processor **330**, luminaire memory **335**, and luminaire communication interface system **355**.

(53) The luminaire light source **315** is configured to emit illumination lighting in the physical space **2**. The physical space **2** can include an office, hospital, medical facility, classroom, restaurant, retail store, restroom, and other private or public facilities. However, the light source **315** may also emit non-visible light, such as ultraviolet light.

(54) The luminaire **10**A includes a driver circuit **310** coupled to control the light source **315**. The driver circuit **310** can drive the light source **315** by regulating the power to the light source **315** by providing a constant quantity or power to the light source(s) **315** as their electrical properties change with temperature as detected by the detectors **260**, for example. The driver circuit **310** can include an electrical circuit that pulses a high voltage to ignite or strike an arc of the luminaire light

source **315**, after which the discharge of the luminaire light source(s) **315** can be maintained at a lower voltage.

(55) Luminaire driver circuit **310** can further include an AC or DC current source or voltage source, a regulator, an amplifier (such as a linear amplifier or switching amplifier), a buck, boost, or buck/boost converter, or any other similar type of circuit or component. Luminaire driver circuit **310** may output a variable voltage or current to the luminaire **10**C that may include a DC offset, such that its average value is nonzero, and/or an AC voltage.

(56) The driver circuit **310** of the luminaire **10**A is coupled to control the luminaire light source **315**. The luminaire driver circuit **310** can include an electrical circuit that pulses a high voltage to ignite or strike an arc of the luminaire light source **315**, after which the discharge of the luminaire light source **315** can be maintained at a lower voltage.

(57) The luminaire light source **315** may include electrical-to-optical transducers, such as various light emitters. The emitted illumination lighting may be in the visible spectrum, or in other wavelength ranges. Suitable light generation sources include various conventional lamps, such as incandescent, fluorescent or halide lamps; one or more light emitting diodes (LEDs) of various types, such as planar LEDs, micro LEDs, micro organic LEDs, LEDs on gallium nitride (GaN) substrates, micro nanowire or nanorod LEDs, nanoscale LEDs, photo pumped quantum dot (QD) LEDs, micro plasmonic LED, micro resonant-cavity (RC) LEDs, and micro photonic crystal LEDs; as well as other sources such as micro super luminescent Diodes (SLD) and micro laser diodes. A luminaire **10**A that includes a laser diode as luminaire light source **315** can include a light frequency up-converter.

(58) A lamp or "light bulb" is an example of a single light source. An LED light engine may use a single output for a single source but typically combines light from multiple LED type emitters within the single light engine. The luminaire light source **315** can include light emitting diodes (LEDs) that emit red, green, and blue (RGB) light or tunable white light to emit the illumination lighting. Many types of light sources provide uniform light output, although there may be some intensity striations. For purposes of the present examples, however, the light source output may not be strictly uniform across the output area or aperture of the source. For example, although the source may use individual emitters or groups of individual emitters to produce the light generated by the overall source; depending on the arrangement of the emitters and any associated mixer or diffuser, the light output may be relatively uniform across the aperture. The individual emitters or groups of emitters may be separately controllable, for example to control intensity of the source output.

(59) Luminaire driver circuit **310** can drive the luminaire light source **315** by regulating the power to the luminaire light source **315** by providing a constant quantity or power to the luminaire light source **315** as their electrical properties change with temperature, for example. The luminaire driver circuit **310** provides power to the luminaire light source(s) **315**. The luminaire driver circuit **310** may include a ballast and an igniter for an arc gaslamp type of luminaire light source **315**. Alternatively or additionally, the luminaire driver circuit **310** can include a constant-voltage driver, constant-current driver, or AC LED driver type circuit that provides dimming through a pulse width modulation (PWM) circuit and may have many channels for separate control of different LEDs or LED arrays that comprise the luminaire light source **315**. An example of a commercially available luminaire driver circuit **310** is manufactured by EldoLED®. In the case of luminaire **10**A, the luminaire driver circuit **310** is coupled to the luminaire light source **315** to control light source operation of the luminaire light source(s) **315**. In particular, the luminaire **10**A can include a luminaire optical wireless communication interface to transmit data over a VLC communication band. A VLC communication band is a data communications network variant, which uses visible light between 400 and 800 THz (780-375 nm), and is a subset of optical wireless communications technologies. VLC can be done by having the luminaire **10**A output oscillating visible light or illumination lighting (e.g., projection of a barcode) in combination with the luminaire light

source(s) **315**. A common method of VLC modulation or oscillation is to rapidly vary luminaire **10** brightness too quickly for a human eye to detect.

(60) Luminaire driver circuit **310** can further include an AC or DC current source or voltage source, a regulator, an amplifier (such as a linear amplifier or switching amplifier), a buck, boost, or buck/boost converter, or any other similar type of circuit or component. Luminaire driver circuit **310** may output a variable voltage or current to the luminaire light source(s) **315** that may include a DC offset, such that its average value is nonzero, and/or an AC voltage.

(61) The luminaire **10**A can include a luminaire communication interface system **355** like the reporting device communication interface system **255** of FIG. **2**. This example luminaire **10**A is configured to communicate with the reporting device **20**A, as the luminaire **10**A does not utilize the power source via the reporting device **20**A and cannot transmit control signals **170**A-N merely by current or voltage interruption to the reporting device driver circuit **310**. Alternatively, if a luminaire **10**C is not capable of connecting to the lighting control network **5**, the circuitry of a luminaire **10**C can be simple, potentially providing illumination lighting from the light source **315** when the power supply **205** received power. In such an example that luminaire **10**C is recorded by a reporting device **20**C connected to the lighting control network **5**.

(62) The luminaire **10**A can also include some or all of the reporting device programming **236**: if the luminaire **10**A is trusted, the luminaire can generate its own performance metrics **240**A based upon the performance of the light source **315**, and even bundle its own records **242**A, either of which the reporting device **20**A then submits to the storage devices **40**A-N.

(63) FIG. **4**A is a block diagram of a storage device **40**A implemented as a database device **41** of the lighting control group that communicates via the lighting control network **5** of FIG. **1**. The circuitry, hardware, and software of the database device **41** shown is similar to the reporting devices **20**A-N of FIG. **2**. The hardware of a database device **41** can be largely conventional. The database device **41** is configured to receive claim messages **170**A containing records **242**A-N of performance metrics **240**A-N. A database device **41**, possibly in conjunction with other storage devices **40**B-N implemented as database devices **41**, is configured to cryptographically confirm the validity of the records **242**A-N transmitted by the reporting devices **20**A-N. The validator **40**A is configured to next add the valid records **242**A-F to a block **450**A or database record, and add that block **450**A to the database **494**.

(64) A database device **41** can be within the physical space **2**, or the database device **41** can be off-premises. So long as the database device **41** can receive claims messages **170**A from the reporting devices **20**A-N, the database device **41** is sufficiently connected to the lighting control network **5**.

(65) FIG. **4**B is a block diagram of a storage device **40**A implemented as a validator device **42** of the lighting control group that communicates via the lighting control network **5** of FIG. **1**. The circuitry, hardware, and software of the validator device **42** shown is similar to the database device **41** of FIG. **4**A. The hardware of a validator device **42** can be largely conventional. A validator device **42** is configured to receive claim messages **170**A containing records **242**A-N of performance metrics **240**A-N. A validator device **42**, in conjunction with other storage devices **40**A-N implemented as validator devices **42**, is configured to cryptographically confirm the validity of the records **242**A-N transmitted by the reporting devices **20**A-N. The validator device **42** is configured to next add the valid records **242**A-F to a block **450**A. This block **450**A is then shared between other storage devices **40**B-N implemented as validators **42** via a block message **170**C. The storage devices **40**A-N implemented as validators **42** then verify that the blocks **450**A received via block messages **170**C are valid, and once a certain number of storage devices **40**A-N implemented as validators **42** agree regarding a certain block **450**A then consensus is reached, and the storage devices **40**A-N implemented as validators **42** add that block **450**A to the blockchain **444**.

(66) A validator device **42** can be within the physical space **2**, or a validator device **42** can be off-premises. So long as the validator device **42** can communicate with other validator devices **42** to effectively form consensus, and so long as the validator device **42** can receive claims messages

170A from the reporting devices **20**A-N, the validator device **42** is sufficiently connected to the lighting control network **5**.

(67) Therefore, FIGS. **1-4** depict a lighting system **1**, including a plurality of lighting system elements **3**A-N located in a space **2**, where the lighting system elements **3**A-N include a plurality of luminaires **10**A-N, a plurality of reporting devices **20**A-N, and a plurality of storage devices **40**A-N. A respective luminaire **10**A includes a light source **315** to emit illumination lighting and a driver circuit **310** coupled to the luminaire **10**A light source **315** to control light source operation of the luminaire light source **315**. A respective reporting device **20**A includes a transceiver **246**A-B configured for communication via a lighting control network **5** over a lighting control network communication channel for lighting control and systems operations. The respective reporting device **20**A further includes a reporting device processor **230** coupled to the reporting device network communication interface system **255**. The respective reporting device **20**A further includes a reporting device memory **235** accessible to the reporting device processor **230**. The respective reporting device **20**A further includes reporting device programming **236** in the reporting device memory **235**, wherein execution of the reporting device programming **236** by the reporting device processor **230** configures the reporting device **20**A to implement functions. First, the reporting device **20**A collects a respective performance metric **240**A of the respective luminaire **10**A. Second, the reporting device **20**A submits a respective record **242**A including the respective performance metric **240**A from the respective luminaire **10**A to some or all of the storage devices **40**A-N.

(68) Additionally, the lighting system **1** further includes a plurality of performance metrics **240**A-Z, including the respective performance metric **240**A. The plurality of performance metrics **240**A-Z bundle one or more dynamic metrics **240**B, one or more fixed attributes **240**A, or a combination thereof. A dynamic metric **240**B is generally a recorded performance value of a luminaire **10**A, whereas a fixed attribute **240**A is a set value, configured either at production, installation, or by a user of the luminaire **10**A.

(69) Fixed attributes **240**A can include the following settings. A daylight harvesting setting of the respective luminaire **10**A, which determines whether or how much daylight a detector **260** or sensor device **31** must detect before a driver circuit **310** turns the light source **315** off. The daylight harvesting setting can be set to inhibit production of illumination lighting when any daylight is detected by detectors **260** or sensor device(s) **31**, to completely ignore any daylight detectors **260** and sensor device(s) **31**, and to inhibit production of illumination lighting when a specific amount of daylight is detected by the detectors **260**.

(70) An occupancy sensing setting of the respective luminaire **10**A, which determines whether or how many occupants a detector **260** or sensor device **31** must detect before a driver circuit **310** turns the light source **315** on. The occupancy sensing setting can be set to induce production of illumination lighting when any occupant is sensed by detectors **260** or sensor device(s) **31**, to inhibit production of illumination lighting when no occupant is sensed by detectors **260** or sensor device(s) **31**, or to completely ignore any occupants sensed by detectors **260** and sensor device(s) **31**.

(71) Fixed attributes **240**A can include the following properties. A wattage-controlled property of the respective luminaire **10**A, which determines the maximum amount of wattage the luminaire **10**A is able to control. This setting can limit the power supply **205**, preventing more than, for example ninety watts from being available to the luminaire **10**A, even if more wattage is available from a line power source **201** or a non-line power source **202**. Alternatively, this setting can limit the driver circuit **310**, preventing more than, for example, eighty watts from being available to the light source **315** of the luminaire **10**A, or to the luminaire **10**C if that luminaire **10**C is coupled to a driver circuit **310** of a reporting device **20**A-N.

(72) A square footage of light coverage property of the respective luminaire **10**A, which determines the square footage services by a given luminaire **10**A. Generally, a luminaire **10**A which services a

higher square footage area is more efficient than a luminaire **10**B which services a small square footage area. This setting will often be set at installation, as a skilled technician is often proficient at determining how much area is serviced by a given luminaire **10**A, and for determining how to handle two or more luminaires **10**D-Z with overlapping lit square footage.

(73) A lumens per watt property of the respective luminaire **10**A, which determines the range of brightness available to a given luminaires **10**A. Many light source(s) **315** have a preferred efficiency range (ignoring the light source **315** being off, which has zero lumens per zero watts, resulting in undefined efficiency) within which the optimal amount of lumens per watt can be achieved. For example, a light source **315** with a perfect range of efficiency can produce ten lumens per one watt: increasing the wattage linearly will increase the lumens linearly on the same slope. However, most light source(s) **315** are designed to target an ideal wattage, in an example eighty watts. Increasing the wattage by twenty percent will not result in a proportionate increase in lumens—the lumens will increase by a lower percentage. Furthermore, some light source(s) **315** cannot produce light at certain low wattages, for example ten watts or less: running such a light source **315** at 9.9 watts would be infinitely inefficient, as zero lumens are being produced per watt. Doing so may also still induce wear-and-tear on the light source **315**, reducing lifespan. Additionally, extremely high wattages, such as five thousand watts, can destroy the light source **315**, again resulting in zero lumens per watt, and obviously reducing the remaining lifespan of the light source **315** to zero. Therefore, limiting the acceptable range of lumens to watts, primarily by limiting the acceptable watt values, can improve light source **315** efficiency.

(74) A light color temperature property of the light source **315** of the respective luminaire **10**A, which determines the light color temperature of a given luminaire **10**A. Different light color temperatures can have different perceptual brightness and energy efficiency, and so it may be valuable to limit the light temperatures available to the end user. Similarly, a color rendering index (CRI) property of the light source **315** of the respective luminaire **10**A can also improve efficiency by limiting the color of the light source **315** to colors with high perceptual brightness and energy efficiency.

(75) Fixed attributes **240**A are not limited to the above, and may encompass any fixed or discrete value, configurable by either user or owner, and may encompass settings, properties, and measurements.

(76) Dynamic metrics **240**B can include the following records. A daylight harvesting inhibition over a period of time of the light source **315** of the respective luminaire **10**A, which records how often the light source **315** is inhibited from producing illumination light based upon daylight sensed by the detectors **260** or sensor device(s) **31**. This record works in tandem with the daylight harvesting setting: the more liberal the daylight harvesting setting, the more often the light source **315** will be inhibited when some amount of daylight is sensed by the detectors **260** or sensor device(s) **31**. Knowing why the light source **315** does not produce illumination lighting can be relevant to the owner of the luminaire **10**A: sunlight is usually free, but varies with time of day and seasonality: prediction of future energy usage can be improved by knowing the reason illumination lighting was inhibited. The owner of the luminaire **10**A may want to reward the users of the luminaire **10**A for utilizing sunlight rather than illumination lighting, but may not want to reward, or want to reward to a lesser extent, merely setting the luminaire **10**A to a daylight harvesting mode: if the luminaire **10**A is installed in a basement or subfloor, a user setting the luminaire **10**A to harvest daylight is likely aware that daylight will never be harvested in a physical space **2** with no source of natural light: an owner might determine such a user should neither be rewarded nor punished for setting a luminaire **10**A to pointlessly attempt to harvest sunlight.

(77) An occupancy sensor inhibition over the period of time of the light source **315** of the respective luminaire **10**A, which records how often the light source **315** is activated to produce illumination light based upon the presence of occupants. This record works in tandem with the occupancy sensing setting. Much like the daylight harvesting inhibition over a period of time of the

light source **315**, owners of the luminaire **10**A may want to know if the light source **315** is activated due to sensed occupancy, and may want to reward users which have set the occupancy sensing setting judiciously, resulting in higher efficiency than either having the light source **315** provide illumination lighting constantly, or manually turning the light source **315** on and off as occupants enter and leave the physical space **2**.

(78) A user override percentage over the period of time of the respective luminaire **10**A, which records how often a user overrides efficiency settings of the luminaire **10**A. This record can track when individual settings are overridden, such as if a user turns on the light source **315** during a time period when the physical space is scheduled to be closed to occupants, or when a user sets the luminaire **10**A to produce illumination lighting regardless of the presence of occupants in the physical space **2**. The record can also track overall override time, independent of what rule or setting is being overridden; or, the record can convert the override results into a measurable quantity, such as the increase in wattage due to overrides during the period of time, or the duplicative or excess lumens requested due to overrides during the period of time. The record can also track overrides of illumination light temperature, brightness, and color.

(79) An online percentage over a period of time of the respective luminaire **10**A, which records how often the light source **315** of the luminaire **10**A is activated and producing illumination light. This record can also track the percentage of time the luminaire **10**A is connected to the lighting control network **5**, or the percentage of time the luminaire **10**C is connected to a reporting device **20**A-N. An owner may want to presume that, if a luminaire **10**A is not connected to the lighting control network **5**, and the efficiency of the luminaire **10**A cannot be monitored, then the luminaire **10**A is being operated in an inefficient manner.

(80) A high-output percentage over a period of time of the light source **315** of the respective luminaire **10**A, which records how often the light source **315** is set to produce high-output illumination lighting. In some circumstances, light source(s) **315** can be configured to be able to produce-high output illumination: some examples include emergency egress lighting, disinfection lighting, or user-requested high-output lighting. High-output lighting is often less energy efficient than typical-output lighting, and so owners of the luminaire **10**A may want to know how often high-output lighting is used, or may want to discourage the frivolous use of high-output lighting.

(81) Dynamic metrics **240**B are not limited to the above, and may encompass any variable or continuous value or range of values, configurable by either user or owner, and may encompass settings and measurements.

(82) Furthermore, in some examples the submitted respective record **242**A is encrypted using a shared public key **254** by the reporting devices **20**A-N before transmitting to the validator devices **42**. The storage devices **40**A-N have access to this same public key **254** to assist in decryption of the encrypted respective record **242**A. The shared public key **254** can be implemented with a secure firmware image placed on the reporting devices **20**A-N or luminaires **10**A-N which report their own performance metrics **240**A-N. Secure firmware images, coupled with trusted manufacturers, can improve trust and security, allowing the owner of the lighting control network **5** to trust the reported performance metrics **240**A-N and potentially reward the users of the luminaires **10**A-N for proper performance. Encryption may also involve private keys **256**, and additionally or alternatively to a public key **254**, a shared key **262**.

(83) The keys **254**, **256**, **262** may be an identifier, and the storage device **40**A-N may maintain a whitelist or blacklist of reporting devices **20**A-N or luminaires **10**A-N with keys **254**, **256**, **262** permitted to submit performance metrics **240**A-N for validation and storage. Devices may be added or removed from a trusted devices list as needed. A certification process and audits may be involved. Individual devices, sets of devices, whole sites, entire device models, or manufacturers of devices can be whitelisted or blacklisted. Claims history from reporting devices **20**A-N or luminaires **10**A-N can be inspected for suspicious behavior—Records **242**A-N and performance metrics **240**A-N need not be anonymous.

(84) In some examples, the reporting device **20**B is integrated as part of the luminaire **10**B. In other examples, the reporting devices **20**B is integrated as part of a storage device **40**B. Although shown as standalone devices, the reporting device **20**B and storage device **40**B can be integrated with any of the lighting system elements **3**A-N. Particularly, the luminaire **10**B, reporting device **20**B, and storage device **40**B can all be integrated in some examples. In FIG. **1**, this integration is represented with the reporting device **20**B within the luminaire **10**B. Any of combination of integrations among luminaires **10**A-N, reporting devices **20**A-N, and storage devices **40**A-N are acceptable, and the distinction can be largely arbitrary: in some examples a single device is capable of performing the functionality of the reporting device **20**B as well as the functionality of the luminaire **10**B and the storage device **40**B, in particular if the storage device **40**B is a validator device **42**. When integrated, the reporting device **20**B, luminaire **10**B, and storage device **40**B may share some components, such as a processor **230**, **330**, **430**, **480** or a network communication interface system **255**, **355**, **455**, **495**. Alternatively, these components may remain segregated, such that a reporting device **20**B integrated as part of the luminaire **10**B may include a separate physical reporting device processor **230** and luminaire processor **330**, or a separate reporting device memory **235** and luminaire memory **335**, for example. Luminaires **10**A-N with integrated smart devices such as the reporting device programming **236** which allow for the creation of performance metrics **240**A-N should be assigned to lighting control devices such as reporting devices **20**A-N in the factory to ensure the validity of those performance metrics **240**A-N.

(85) Further, in certain examples the respective performance metric **240**A of the respective luminaire **10**A is certified by an operator of the lighting control network **5**. This operator can be the owner of the network, and the certification is often performed by a reporting device **20**A-N. At issue in conventional solutions which interact with physical, non-purely-mathematical worlds like the lighting system **1**, is that while the records **242**A-N submitted to a blockchain **444** or database **494** can have the veracity of those records **242**A-N verified, the contents of the record **242**A-N cannot be verified to the same extent. Meaning, the lighting control network **5** can cryptographically verify via the storage devices **40**A-N that a valid reporting device **20**A-N submitted a record **242**A in a valid format—a rogue device connected to the lighting control network **5** has not submitted a false record **242**A-N to the validators **40**A-N. However, cryptographic verification is not applied to the contents of a record **242**A related to actions or phenomena within the physical world: a record **242**B can be verified to have been transmitted by a valid reporting device **20**B, but if that claim states that luminaire **10**B utilized 2.5 kilowatt hours in a month as a performance metric **240**B, that fact cannot be cryptographically verified by the validator devices **20**A-N: if the reporting device **20**B has been physically tampered with, such that the reporting device **20**B cannot properly detect wattage used by the luminaire **10**A, then conventionally that tampering cannot be discerned in a cryptographic manner.

(86) One solution to this problem is for the hardware of the reporting devices **20**A-N to be designed in a tamper-proof, tamper-resistant, or tamper-evident manner: if tampering has occurred, then the lighting control network **5** is notified of that tampering by some behavior or non-behavior of the tampered reporting device **20**B. Similarly, if an incidental error has occurred, for example that the sensor **260** which records wattage used by the luminaire **10**B has become damaged and constantly reports zero watts used, the damage to the sensor can be noted by the lighting control network **5**. The reporting devices **20**A-N, validator devices **42**, and the luminaires **10**A-N can be manufactured by trusted manufacturers, which have an economic incentive to prevent fraud and tampering: if the devices **20**A-N, **40**A-N or luminaires **10**A-N are audited and produce invalid performance metrics **240**A-N, then the manufacturer may lose their trusted status, and their contract or permission to produce devices **20**A-N, **40**A-N or luminaires **10**A-N. Therefore, approved manufacturers have a vested interest in ensuring their devices **20**A-N, **40**A-N and luminaires **10**A-N are considered valid sources of records **242**A. The reporting devices **20**A-N, validator devices **42**, and the luminaires **10**A-N can also have secure firmware images installed, with the image security key held by the

owner of the lighting control network **5**: even trusted manufacturers in such an example are less likely to be able to tamper with or adjust the firmware, and thereby the reporting device programming **236**, database device programming **486**, or validator device programming **436** installed on the device **20**A-N or luminaries **10**A-N.

(87) Once the reporting device **20**B is reasonably assured to not fail or be tampered with, or the reporting devices **20**B fails and reports tampering in a predictable manner, the reporting device **20**B can be certified, and the performance metrics **240**A-Z reported within records **242**A-N sent by the reporting device **20**B are presumed to be reliable—so long as the reporting device **20**B indicates no tampering or failure. In these examples, execution of the reporting device programming **236** by the reporting device processor **230** configures the reporting device **20**A to enable the operator of the lighting control network **5** to certify the respective performance metric **240**A of the respective luminaire **10**A.

(88) An alternative implementation to certifying reporting devices **20**B is a physical installation where reporting devices **20**A-N audit and report on each other. For example, a group of reporting devices **20**A-F may each be wired to each luminaire **10**A-F: to falsify performance metrics **240**A-Z in such a setting would require effecting tampering with all six reporting devices **20**A-F: if the performance metrics **240**A-Z recorded by the reporting devices **20**A-F for a given luminaire **10**A did not agree or substantially agree, then tampering or hardware failure is evident. Alternatively or additionally, a standalone reporting device **20**G can be installed to audit all of the luminaires **10**A-F collectively. Meaning, if reporting devices **20**A-F each report 80.0 watts used by each luminaire **10**A-F, but the standalone reporting device **20**G reports 240.0 watts used collectively by the luminaires **10**A-F, then the deviation between the summed individual usage (6×80.0=480.0 watts) and the collective usage (240.0 watts) indicates a failure or tampering of either the six reporting devices **20**A-F or the standalone reporting device **20**G. The standalone reporting device **20**G may be installed remotely from the other reporting devices **20**A-F, for example in a locked room. The standalone reporting device **20**G could also be installed by the owner without the knowledge of the users, in order to more effectively detect attempted tampering of the reporting devices **20**A-F known to the users.

(89) These same issues and solutions apply whether the reporting devices **20**A-N directly record usage and physical phenomena using detectors **260** of the reporting devices **20**A-N, or if the luminaires **10**A-N report to the reporting devices **20**A-N their usage and physical phenomena over the lighting control network **5** or another network protocol, or if the luminaires **10**A-N implement some or all of the reporting device programming **236** and send performance metrics **240**A-N to the reporting devices **20**A-N directly—the link between the physical phenomena and the record of the physical phenomena should be secured and observed, to ensure that the cryptographically secured records in the database **494** or blockchain **444** are representative of the physical phenomena (such as illumination lighting) generated, used, or experienced by the luminaires **10**A-N.

(90) FIGS. **1**-**4** also depict a lighting system including a plurality of lighting system elements **3**A-N located in a space **2**, where the lighting system elements **3**A-N include a plurality of luminaires **10**A-N, a plurality of reporting devices **20**A-N, and a plurality of storage devices **40**A-N. A respective luminaire **10**A includes a light source **315** to emit illumination lighting and a driver circuit **310** coupled to the luminaire **10**A light source **315** to control light source operation of the luminaire light source **315**. A respective reporting device **20**A includes a transceiver **246**A-B configured for communication via a lighting control network **5** over a lighting control network communication channel for lighting control and systems operations. The respective luminaire **10**A further includes a reporting device processor **230** coupled to the reporting device network communication interface system **255**. The respective luminaire **10**A further includes a reporting device memory **235** accessible to the reporting device processor **230**. The respective luminaire **10**A further includes reporting device programming **236** in the reporting device memory **235**, wherein execution of the reporting device programming **236** by the reporting device processor **230**

configures the reporting device **20**A to implement functions. First, the reporting device **20**A collects a respective performance metric **240**A of the respective luminaire **10**A. Second, the reporting device **20**A submits a respective record **242**A including the respective performance metric **240**A from the respective luminaire **10**A to some or all of the storage devices **20**A-N.

(91) Additionally, a respective storage device **40**A of the lighting system **1** comprises a validator device **42**, which includes a validator device network communication interface system **455** including at least one transceiver **246**A-B configured for communication via a lighting control network **5** over a lighting control network communication channel for lighting control and systems operations. The validator device **42** further includes a validator device processor **430** coupled to the validator device network communication interface system **455**. The validator device **42** further includes validator device memory **435** accessible to the validator device processor **430**. The validator device **42** further includes validator device programming **436** in the reporting device memory **435**, wherein execution of the validator device programming **436** by the validator device processor **430** configures the validator device **42** to implement functions. First, the validator device **42** validates a plurality of records **242**A-N, including the respective record **242**A. Second, the validator device **42** achieves a consensus within a plurality of storage devices **40**A-N comprising validator devices **42** for a subset **242**A-F or all of the plurality of records **242**A-N. Third, the validator device **42** stores the subset or all of the plurality of records **242**A-F in a block **450**A in at least one storage device **40**A-N of the lighting control network **5**, wherein the block **450**A includes a lighting value token **452**A.

(92) Further, the function in the validator device programming **436** to achieve the consensus includes to decrypt the subset or all of the plurality of records **242**A-F by a pre-determined number **464** of some or all of the storage devices **40**A-N comprising a validator device **42**. In many implementations of blockchain **444**, the blockchain **444** itself is used in the encryption and decryption of these respective records **242**A. However, in some blockchain implementations, only a certain number of recent blocks **450**A in the blockchain **444** are used in encryption and decryption, and consequently devices like the validator device **42** may only maintain a partial blockchain **448** of recent blocks **450**A in order to achieve consensus and add new blocks **450**B to the blockchain **444** and partial blockchain **448**. In some examples, the blockchain **444** or partial blockchain **448** is not used in the hashing process of encryption and decryption when validating records **242**A-N. Some devices, where users can view the number and quality of their lighting value tokens **452**A, may need to maintain the complete blockchain **444**, while validator devices **42**, which in these examples do not display the wallet addresses **456**A-B or the lighting value tokens **452**A associated with those wallet addresses, may only need to maintain a partial blockchain **448**.

(93) In some examples, the lighting system **1** further includes a respective luminaire benefactor wallet address **456**A associated with an owner of the respective luminaire **10**A, where the block **450**A in the at least one lighting system element, in this example storage device **40**A, of the lighting control network **5** makes a controlling association between the respective appliance benefactor wallet address **456**A and the lighting value token **452**A. In examples where the owner of the lighting system **1** desires to reward luminaires **10**A-N responsible for high-quality performance metrics **240**A-Z, the owner can quantify that reward within the lighting value tokens **452**A-F. However, the value of the reward can only be utilized by a user if that value can be converted into some kind of real-world value, outside of the lighting control network **5**. Even if that real-world value simply manifests as the enjoyment or pleasure of a user in receiving a reward, whether that enjoyment be based upon the recognition of their altruistic efforts, or their comparative superiority over their peers, that value should nevertheless be associated with that user in order to induce a material and personal emotional effect. Therefore, the value within a lighting value token **452**A, representing the improved performance beyond a baseline of the luminaire **10**A, must be somehow assigned, transferred, or associated with the user who brought about that improved efficient performance. By first provisioning that user with a wallet address, here the benefactor wallet

address **456**A, it enables the lighting control network **5** to, when the lighting value token **452**A is created, assign that lighting value token **452**A to that benefactor wallet address **456**A, and consequently assign that lighting value token **452**A to the user for whom the benefactor wallet address **456**A was provisioned, as a reward.

(94) For the value within a lighting value token **452**A-F to be remunerative, the reward should be transferrable, in order to be exchanged for goods or services. Therefore, in some examples the lighting system **1** further includes a buyer wallet address **456**B associated with a buyer of lighting value token, where a transfer claim **458**A is stored in a claim block **450**B in the lighting control network **5,** and the transfer claim **458**A represents assigning the lighting value token **452**A from the respective luminaire benefactor wallet address **456**A to the buyer wallet address **456**B. A transfer claim **458**A is transactional in nature, and can be distinguished from a record **242**A-F related to reporting of performance metrics **240**A-Z. Transfer claims **458**A, unlike records **242**A-F can have their contents validated by the validator devices **42** of the lighting control network **5**: the transfer of a lighting value token **452**A from a benefactor wallet address **456**A to a buyer wallet address **456**B can be cryptographically verified. The protocol for verifying and deriving consensus for transfer claims **458**A can be different than the protocol for verifying and deriving consensus for records **242**A-F regarding recording performance metrics **240**A-Z. Alternatively, the blockchain **444** may not represent or understand there to be any difference between records **242**A-F regarding recording performance metrics **240**A-Z and transfer claims **458**A.

(95) In examples where the value of a lighting value token **452**A is remunerative in nature, that value can be represented as a quantity, or number. An example method for calculating that quantity is by creating ideal performance metrics **258**A-Z. Ideal performance metrics **258**A-Z includes ideal fixed attribute values and ideal dynamic metric values. Ideal performance metrics **258**A-Z can be created network-wide, for example indicating that the ideal percentage that an occupancy sensor should be active is 100% of the time: any time period less than that arguably results in illumination lighting being generated in the physical space **2** that does not serve occupants, and is therefore wasteful. Alternatively, ideal performance metrics **258**A-Z can be assigned at an individual luminaire **10**A level: the luminaire **10**A could be in an entryway, while the rest of the luminaires **10**B-N reside further into a physical space **2**: in such an example, that luminaire **10**A may have an ideal performance metric **258**A indicating that the percentage that an occupancy sensor should be active is 0%: the entryway in this example has been designated as always lit as a safety protocol, and the owner may not want to incentivize users to operate that luminaire **10**A more efficiently at the expense of safety. In some examples, therefore, the lighting value token **452**A includes a reward **466**A, which may be burned or transferred. In further examples, that reward **466**A may include or constitute a reward amount **462**A. That reward amount **462**A, being a quantitative value, which may be utilized for transactional purposes, is a rational number, and can in some examples be limited to positive rational numbers. The reward amount **462**A can be calculated by the luminaire **10**A, the reporting device **20**A, or the storage device **40**A; however, calculating the reward amount **462**A at the storage device **40**A may be more secure than calculating the reward amount **462**A at the reporting device **20**A, and calculating the reward amount at the reporting device may be more secure than calculating the reward amount at the luminaire **10**A. The reward amount **462**A may be calculated at any time, and the valuation process may change between the recording of a performance metric **240**A at the luminaire **10**A and the assignment of the reward amount **462**A. Valuation of performance metrics **240**A-N may depress or lower the weight of performance metrics **240**A-N which are based upon user inputs, as opposed to performance metrics **240**A-N which are based upon manufacturer inputs: A user may miscalculate how much square footage a particular luminaire **10**A services, whereas a manufacturer is less likely to improperly configure a wattmeter within a luminaire **10**A or reporting device **20**A which records wattage used by the light source **315** of the luminaire **10**A. In the square footage example, appropriate square footage is the responsibility of the lighting designers, specifiers and installers. Overpacking of fixtures to

leverage rewards can be considered gaming Records **242**A-N and luminaires **10**A-N can be voided if insufficient square footage is covered and discovered based on audits or other means. A correlation to square footage known to be owned by the user can limit the square footage claimed in a performance metric **240**A-N. To further avoid erroneous or fraudulent performance metrics **240**A reported by users, a reporting device **20**A can impose limits based on the maximum load ratings of the luminaire **10**A, or the luminaire **10**A can impose limits based on direct load measurement: these values are from the manufacturer, who again is less likely to erroneously or fraudulently assert these values. Rewards may be adjusted based on user entered power controlled versus directly measured.

(96) The value of reward amount **462**A can be calculated based on comparing the ideal performance metric **258**A, either an ideal fixed attribute value or an ideal dynamic metric value, associated with a respective performance metric **240**A. In particular, this can include taking the inverse absolute value of the difference between the ideal performance metric **258**A and the performance metric **240**, and additionally dividing by a basis to generate a percentage difference, or alternatively multiplying by a constant or variable value. For example, if the ideal performance metric **258**A is 100% daylight harvesting, and the recorded performance metric **240**A recorded 40% daylight harvesting, then the reward could be calculated as ((ideal performance metric—recorded performance metric)/(ideal performance metric))*constant factor, or ((1.0−0.4)/(1.0))*100, resulting in a reward amount **462**A of 40.0. This calculation can be performed at the reporting device **20**A-N, with the results placed within the claims message **170**A, or the underlying performance metrics **240**A-Z and ideal performance metrics **258**A-N can be placed within the claims message **170**A: in such an example, the validators **40**A-N perform the reward amount **462**A calculation in the process of verifying results and deriving consensus. However, the reward amount **462**A may not require an ideal performance metric **258**A-Z in order to calculate the reward amount **462**A: the reward amount **462**A may be calculated based solely upon the performance metric **240**A.

(97) The reward amount **462**A, or a partial portion thereof, can be transaction and transferred from the recipient benefactor wallet address **456**A to a buyer wallet address **456**B. That buyer can exchange other goods and services in exchange for the transferred reward amount **462**A, thereby imbuing the reward amount with economic value. The buyer can be the owner of the lighting control network **5** itself, or of the luminaires **10**A, and in buying reward amounts **462**A with fiat currency, can effectuate a rebate system, rewarding users and operators who use and operate the luminaires **10**A-N within the ideal parameters and requirements of the owner. Alternatively, the owner, a regulator, or a government can institute a cap-and-trade system, wherein which fines are levied which can be paid in the reward amount **462**A of light value tokens **452**A. Users which choose to generate illumination lighting inefficiently or in low-performance manners can choose to purchase reward amounts **462**A with fiat currency, instead of choosing to be efficient and highly-performant with their use of illumination lighting. The reward amounts **462**A of the lighting value tokens **452**A may take on economic value to other parties, and may be bought, held, exchanged, or sold by any number of parties, who may not and may have no plans to utilize or own luminaires **10**A on the lighting system **1**. The only requirement for ownership of the reward amount **462**A of a lighting value token **452**A is that the potential owner control a wallet address **456**A-B on the blockchain **444**. In some examples, wallet addresses can be spontaneously generated based upon a seed value, and therefore the wallet address does not need to be recorded on the blockchain **444** before that address can receive lighting value tokens **452**A.

(98) The previous example discloses a lighting value token **452**A which contains a reward amount **462**A. An equivalent example would include a lighting value token **452**A which is an atomic unit of value: one which cannot be subdivided. The equivalent concept in physical American currency would be the penny. In such an example, the creation of a lighting value token **452**A would not necessarily create a single token, but enough tokens to represent a rational number. For example, above the lighting value token **452**A held a reward amount **462**A of 40.0. If the smallest unit a

lighting value token **452**A could represent is 0.001, then the prior example of generating a single lighting value token **452**A containing a reward amount **462**A of 40.0, would instead generate 40,000 lighting value tokens **452**, each with the atomic value of 0.001, resulting in a reward amount of 40.0. Both examples are functionally equivalent, interchangeable, and disclosed. The reward amount **462**A as an abstract value can also be obviated by implementing a direct conversion of records **242**A-N to currency via smart contracts which provide offers for claims, or offers of claims on a marketplace for a seller determined price.

(99) FIG. **3** depicts a luminaire **10**A including a light source **315** to emit lighting, a luminaire network communication interface system **355** for network communication, a luminaire processor **330** coupled to the luminaire network communication interface system **355**, a driver circuit **310** coupled to the luminaire light source **315** to control light source operation of the luminaire light source, a luminaire memory **335** accessible to the luminaire processor **330**, and performance tracking programming **236** in the luminaire memory **330**. Execution of the performance tracking programming **236** by the luminaire processor causes the luminaire **10**A to perform the following functions. First, the luminaire **10**A measures a first running period of time **238**A of the luminaire **10**A of a plurality of running periods of time **238**A-N. Second, the luminaire **10**A forms a respective record **242**A based on the first running period of time **238**A. Third, the luminaire **10**A submits the respective record **242**A via the luminaire network communication interface system **355**. The first running period of time **238**A is distinct from each other running period of time **238**B-N of the plurality of running periods of time **238**A-N.

(100) In some examples, measuring the first running period of time **238**A further includes measuring one or more fixed attributes **240**A of the luminaire **10**A associated with the first running period of time **238**A, one or more dynamic metrics **240**B of the luminaire **10**A associated with the first running period of time **238**A, or a combination thereof. Forming the respective record **242**A based on the first running period of time **238**A can further include forming the respective record **242**A with the measured one or more fixed attributes **240**A, the one or more dynamic attributes **240**B, or a combination thereof.

(101) The fixed attributes **240**A can include: an image firmware designation of a firmware image active in the luminaire memory **335**, a physical attribute of the luminaire **10**A, a default lighting control configuration of the luminaire **10**A, or a combination thereof. The dynamic metrics **240**B can include a physical state metric based on a physical state of the emitted lighting, a lighting control algorithm metric based on the state of a lighting control algorithm, a modification metric based on a modification to a default lighting control configuration, or a combination thereof.

(102) In some examples, the fixed attributes **240**A are factory-programmed, and include: a wattage-controlled property of the luminaire **10**A, a lumens per watt property of the luminaire **10**A, a light temperature property of the light source **315** of the luminaire **10**A, a color rendering index (CRI) property of the light source **315** of the luminaire **10**A, or a combination thereof. The dynamic metrics **240**B may include one or more of the following: a high-output percentage over the first running period of time **238**A of the light source **315** metric of the luminaire **10**A, an occupancy metric based on occupancy detection, a daylight harvesting metric based on daylight harvesting, a user adjustment metric based on a manual user adjustment, a configuration change metric based on a scheduled configuration change, or a combination thereof. In other examples, the fixed attributes **240**A are user programmed, and can include a square footage of light coverage attribute based on a square footage of light coverage of the luminaire **10**A, a physical location attributed based on a physical location **2** where the luminaire **10**A is installed, an installation date attribute based on an installation date of the luminaire **10**A, a site information attribute based on site information of the physical location **2**, a device operator attribute based on the device operator, or a combination thereof.

(103) The submitted respective record **242**A can be signed with a signature **260**A using a private key **256** held within the luminaire memory **335**. A public key **254** can be used to validate the

signature of the private key **256**, or a shared key **262** can be used to validate the signature **260**A of the respective record **242**A. The submitted respective record **242**A can be signed with a signature **260**A using a shared key **262** held within the luminaire memory **335**.

(104) FIG. **2** depicts a reporting device **20**A, including a reporting device network communication interface system **255** for network communication, a reporting device processor **230** coupled to the reporting device network communication interface system **255**, a reporting device memory **235** accessible to the reporting device processor **230**, and performance tracking programming **236** in the reporting device memory **235**. Execution of the performance tracking programming **236** by the reporting device processor **230** causes the reporting device **20**A to implement the following functions. First, the reporting device **20**A measures a first running period of time **238**A of a respective electrical load (i.e. electrical load system element **703**A of FIG. **7**) of a plurality of running periods of time **238**A-N and a fixed attribute **240**A of the respective electrical load **703**A, a dynamic metric **240**B of the respective electrical load **703**B, or a combination thereof. Second, the reporting device **20**A forms a respective record **242**A based on the first running period of time **238**A of the electrical load **703**A and the fixed attribute **240**A, the dynamic metric **240**B, or a combination thereof. Third, the reporting device **20**A submits the respective record **242**A via the reporting device network communication interface system **255**. The first running period of time **238**A is distinct from each other running period of time **238**B-N of the plurality of running periods of time **238**A-N. The reporting device **20**A can further include a luminaire **10**A, or an HVAC device **510**A (see FIG. **5**).

(105) FIGS. **1**-**4** still further depict a lighting system **1**, including a plurality of lighting system elements **3**A-N located in a space **2**, wherein the lighting system elements **3**A-N include a luminaire **10**A and a reporting device **20**A. A respective luminaire **10**A includes a light source **315** to emit illumination lighting and a driver circuit **310** coupled to the luminaire **10**A light source **315** to control light source operation of the luminaire light source **315**. A respective reporting device **20**A includes a reporting device network communication interface system **255** for network communication. The respective reporting device **20**A further includes a reporting device processor **230** coupled to the reporting device network communication interface system **255**. The respective reporting device **20**A further includes a reporting device memory **235** accessible to the reporting device processor **230**. The respective reporting device **20**A further includes performance tracking programming **236** in the reporting device **235** memory, wherein execution of the performance tracking programming **236** by the reporting device processor **230** causes the respective reporting device **20**A to implement the following functions. First, the respective reporting device **20**A measures a first running period of time **238**A of the respective luminaire **10**A of a plurality of running periods of time **238**A-N and: a fixed attribute **240**A of the respective luminaire **10**A, a dynamic metric **240**B of the respective luminaire **10**A, or a combination thereof. Second, the respective reporting device **20**A forms a respective record **242**A based on the first running period of time **238**A and: the fixed attribute **240**A, the dynamic metric **240**B, or a combination thereof. Third, the respective reporting device **20**A submits the respective record **242**A via the reporting device network communication interface system **255**. The first running period of time **238**A is distinct from each other running period of time **238**B-N of the plurality of running periods of time **238**A-N.

(106) The lighting system elements **3**A-N can further include a lighting control device **30**; an occupancy, light level, motion sensor or audio sensor **31**; or a combination thereof. Each record **242**A-N from the respective reporting device **20**A contains a unique identifier or signature **260**A-N. The respective record **242**A of the respective luminaire **10**A can be certified by an owner of the lighting control network **5**.

(107) The lighting system **1** can further include at least one or more storage devices **40**A-N. A respective storage device **40**B of the one or more storage devices **40**A-N includes a validator device **42**, which includes a validator device network communication interface system **455** for

network communication. The respective storage device **40**B further includes a validator device processor **430** coupled to the validator device network communication interface system **455**. The respective storage device **40**B further includes a validator device memory **435** accessible to the validator device processor **430**. The respective storage device **40**B further includes validator device programming **436** in the validator device memory **435**, wherein execution of the validator device programming **436** by the validator device processor **430** causes the respective validator device **42** to implement the following functions. First, the validator device **42** validates a plurality of records **242**A-F, including the respective record **242**A. Second, the validator device **42** stores the subset or all of the plurality of records **242**A-F in a block **450**A in at least one storage device **40**B.

(108) In some examples, the functions can include third, that the validator device **42** achieves a consensus within a plurality of storage devices **40**A-N for a subset or all of the plurality of records **242**A-F. Fourth, that the validator device **42** validates the signatures **264**A-F of the subset or all of the plurality of records **242**A-F by a pre-determined number **464** of the one or more storage devices **40**A-N comprising a validator device **42** within a validation time window.

(109) The lighting system **1** can include a benefactor wallet address **456**A associated with a benefactor wallet that will receive a lighting reward **466**A associated with the respective luminaire **10**A. A block **450**A in the at least one storage device **40**A-N makes a controlling association between the benefactor wallet address **456**A and the lighting reward **466**A. A buyer wallet address **456**B can be associated with a buyer wallet that will receive the lighting reward **466**A from the benefactor wallet. A transfer record **458**A is stored in a record block **450**B in the at least one or more storage devices **40**A-N. The transfer record **458**A represents assigning the lighting reward **466**A from the benefactor wallet address **456**A to the buyer wallet address **456**B, or burning the lighting reward **466**A from the benefactor wallet address **456**A and assigning the benefactor wallet address **456**A a compatible digital currency as specified in the transfer record **458**A. The lighting reward **466**A can include a reward amount: The reward amount **462**A is a rational number, and the value of the reward amount **462**A is based on calculations which include the fixed attribute **240**A or the dynamic metric **240**B as inputs. In some examples, the fixed attribute **240**A is associated with an ideal fixed attribute value **258**A, the dynamic metric **240**B is associated with an ideal dynamic metric value **258**B, and the reward amount **462**A is based on comparing the ideal fixed attribute **258**A or the ideal dynamic metric value **258**B with the respective fixed attribute **240**A or the respective dynamic metric **240**B.

(110) FIG. **5** is a block diagram of a heating, venting, and air cooling (HVAC) system **501** including HVAC devices **510**A-N of an HVAC control group that communicate via an HVAC control network **5** equivalent to the lighting control network **5** of FIG. **1**. The circuitry, hardware, and software of the HVAC system **501** shown is similar to the lighting system of FIG. **1**. However, as shown, HVAC devices **510**A-N include an airflow component **615**, for heating, ventilating, and cooling air proximate to the airflow component. The functionality of HVAC system **501** is the same as lighting system **1**, except the HVAC system **501** is designed to primarily provide heating, venting, and air cooling, rather than lighting. Similarly, the interactions between, programming within, and configurations of the HVAC system elements **503**A-N are the same as those of the lighting system elements **3**A-N, excepting that the HVAC device **510**A-N is designed to primarily provide heating, venting, and air cooling, rather than lighting like the luminaires **10**A-N.

(111) The HVAC system **501** may implement an HVAC value token **552**A, or may implement a lighting value token **452**A or an electrical load value token **752**A (see FIG. **7**) to allow or improve interoperability with a lighting system **1** or an electrical load system **701**.

(112) FIG. **6** is a block diagram of a heating, venting, and air cooling (HVAC) device **510**A-N of the HVAC control group that communicate via an HVAC control network **5** equivalent to the lighting control network **5** of FIG. **1**. The circuitry, hardware, and software of the HVAC device **510**A-N shown is similar to the luminaires **10**A-N of FIG. **3**, and the HVAC devices **510**A-N interface with similar reporting devices **20**A-N to the reporting devices **20**A-N as described in FIG.

2 in the same manner as the luminaires **10**A-N. However, as shown, HVAC devices **510**A-N include an airflow component **615**, with a fan **616** and/or condenser **617** for heating, ventilating, and cooling air proximate to the airflow component. The functionality and programming of HVAC devices **510**A-N are the same as luminaires **10**A-N, except the HVAC devices **510**A-N are designed to primarily provide heating, venting, and air cooling, rather than lighting. A reporting device **20**A-N can track the performance metrics **240**A-Z of the HVAC device **510**A in a similar manner to tracking the performance metrics **240**A-Z of the luminaire device **10**A, and in some implementations the reporting device **20**A may be agnostic or unaware whether the reporting device **20**A is monitoring a luminaire **10**A, an HVAC device **20**A, or an appliance **710**A.

(113) Therefore, FIGS. **2**, **4**, **5**, and **6** in combination depict a heating, venting, or air cooling (HVAC) system **501**, including a plurality of HVAC system elements **503** located in a space **2**, where the HVAC system elements **503**A-N include a plurality of HVAC devices **510**A-N and a plurality of reporting devices **20**A-N. A respective HVAC device **510**A includes an airflow component **615** to heat, vent, or cool air. a driver circuit **310** coupled to the HVAC airflow **615** component to control HVAC airflow operation of the HVAC airflow component **615**. A respective reporting device includes **20**A a reporting device network communication interface system **255** including at least one transceiver **246**A-B configured for communication via a HVAC control network **5** over a HVAC control network communication channel for HVAC control and systems operations. A reporting device processor **230** coupled to the reporting device network communication interface system **255**. A reporting device memory **235** accessible to the reporting device processor **230**, and reporting device programming **236** in the reporting device memory **235**, where execution of the reporting device programming **236** by the reporting device processor **230** configures the reporting device **20**A to implement functions. First, the reporting device **20**A collects a respective performance metric **240**A of the respective HVAC system element **9**. Second, the reporting device **20**A submits a respective record **242**A including the respective performance metric **240**A from the respective HVAC device **510**A to some or all of the reporting devices **20**A-N.

(114) FIG. **7** is an electrical load system **701** and electrical load control network **705** similar to that of FIG. **1**. The electrical load system **701** functions in a similar manner to the lighting system **1**, includes reporting devices **20**D-I, and storage devices **40**A-N like the lighting system **1**, and implements the electrical load value tokenization protocol **800** like the lighting system **1**.

(115) The electrical control network **705** is physically separated into electrical load sub-networks **755**A-B, connected by a WAN **55**. The electrical load system elements **703**A-N of the electrical load control network **705** do not need to be physically proximate, and can span across buildings, cities, countries, and continents if needed. The reporting devices **20**A-N still communicate with the storage devices **40**A-N to submit records **242**A-N. The storage devices **40**A-N in this example are validator devices **42**, and so communicate to achieve consensus, but the storage devices **40**B-N do not need to be in the vicinity **170**A-B of the lighting control sub-network **755**A-B to achieve consensus.

(116) The lighting system elements **3**A-N of the lighting control network **5**, as well as the HVAC system elements **503**A-N also do not need to be proximate, and can also span across buildings, cities, countries, and continents if needed. The electrical load control network **705** can also interoperate or include a lighting control network **5** or HVAC control network **505**, and the distinction between the three control networks **5**, **505**, **705** can be largely arbitrary. Further, the electrical load control network **705** can include various types of electrical load system elements **703**A-N, such as luminaires **10**A-N, HVAC devices **510**A-N, or appliances **710**A-C— any electrical component that consumes or assembly that utilizes electricity to perform a function can be considered an electrical load system element(s) **703**A-N.

(117) In this example, one lighting control sub-network **755**B does not have any storage device **40**A-N within the vicinity **170**B of that electrical load sub-network **755**B. The luminaires **10**D-F and luminaires **10**G-I can also be physically separated and illuminate different vicinities **170**A-B.

FIG. **7** also illustrates that the number of luminaires **10**A-N do not need to be equal to the number of reporting devices **20**A-N. Some reporting devices **10**D-E can record on behalf of multiple luminaires **10**D-F, and some reporting devices **10**F-I can redundantly monitor some luminaires **10**G-I; or, some reporting devices **20**G-I can perform no monitoring or recording of luminaires **10**G-I, and instead may be used to calculate consensus, perform and submit transactions, and report on the lighting control network **5**. The number of storage devices **40**A-N also does not need to be equal to the number of reporting devices **20**A-N or luminaires **10**A-N, HVAC devices **510**A-N, or appliances **710**A-C.

(118) This example also depicts appliances **710**A-C connected to the lighting control network **5**. The appliances **710**A-C can include kitchen fixtures such as a refrigerator **710**A or an oven **710**B. Though not depicted, the appliances **710**A-C can include any kind of electrically-powered or electrical load-carrying device, such as a television, sump pump, garage door opener, sprinkler system, lathe, machining device, assembly line, elevator, MRI machine, lithium-ion battery, solar panel, generator, filtration device, or any other useful electrical tool or sub-system. Further, the appliance **710**C can be tracked as an electrical socket: meaning, the reporting device **201** associated with the electrical socket appliance **710**C has no information on the appliance plugged into the electrical socket appliance **710**C: nevertheless, the reporting device **201** can still monitor dynamic metrics via the electrical socket appliance **710**C, such as the wattage used. This can be combined with detector **260** data, such as sunlight or occupancy, to create performance metrics **240**A-Z about the appliance plugged into the electrical socket appliance **710**C without knowing anything about the appliance plugged into the electrical socket appliance **710**C, other than the fact that it is plugged into the electrical socket appliance **710**C.

(119) When the lighting control network **5** or an HVAC control network **505** includes appliances **710**A-C, it can be called an electrical load control network **705**; likewise, when the lighting system **1** or an HVAC system **501** includes appliances **710**A-C, it can be called an electrical load system **701**: this distinction is largely arbitrary. The storage devices **40**A-N may also generate electrical load value tokens **752**A instead of lighting value tokens **452**A or HVAC value tokens **552**A.

(120) It also should be understood that the lighting control network **5** and the HVAC control network **505** do not need to operate exclusively: a single electrical load control network **705** can implement both the elements of a lighting control network and an HVAC control network **505**. In such an example, reporting devices can record performance metrics **240**A-Z for any number of devices: lighting, HVAC, appliance, or other. The reporting devices **20**A-N can be configured to know what kind of electrical load is being recorded, and have tailored performance metrics **240**A-Z for particular types or categories of devices; or, the reporting devices **20**A-N can be agnostic and unaware of the electrical load being monitored, and track basic metrics such as wattage utilization patterns, heat generation, and power usage when the space **2** is unoccupied.

(121) Therefore, FIGS. **1**-**7** depict a reporting device **20**A including a reporting device network communication interface system **255** with at least one transceiver **246**A-B configured for communication via an electrical load control network **705** over an electrical load control network communication channel for electrical load control and systems operations. A reporting device processor **230** coupled to the reporting device network communication interface system **255**. A reporting device memory **235** accessible to the reporting device processor **230**. Reporting device programming **236** in the reporting device memory **235**, wherein execution of the reporting device programming **236** by the reporting device processor **230** configures the reporting device **20**A to implement functions. First, the reporting device **20**A collects a respective performance metric **240**A of a respective electrical load: an appliance **710**A, luminaire **10**A, or HVAC device **510**A. Second, the reporting device **20**A submits a respective record **242**A including the respective performance metric **240**A from the respective electrical load (appliance **710**A, luminaire **10**A, or HVAC device **510**A) to some or all of a plurality of storage devices **40**A-N.

(122) In some examples, the reporting device **20**A includes a luminaire **10**A. In other examples, the

reporting device **20**A includes an HVAC device **510**A. In further examples, the reporting device **20**A includes an appliance **710**A. The reporting device **20**A can also include a plurality of performance metrics **240**A-Z, including the respective performance metric **240**A, where the plurality of performance metrics **240**A-Z bundle one or more dynamic metrics, one or more fixed attributes, or a combination thereof. The fixed attributes can include a wattage-controlled property of the electrical load system **701** element. The dynamic metrics can include an online percentage over a period of time record of the reporting device, or a user override percentage over the period of time record of the reporting device.

(123) FIG. **8** depicts an electrical load value tokenization protocol **800** for recording performance metrics **240**A-Z of luminaires **10**A-N, HVAC devices **510**A-N, or other appliances **710**A-C. Beginning in block **810**, a reporting device **20**A collects respective performance metric **240**A of a respective electrical load (e.g., an appliance **710**A, luminaire **10**A, or HVAC device **510**A). The electrical load value tokenization protocol **800** can also be for HVAC devices **510**A-N if generating HVAC value tokens **552**A, or for luminaires **10**A-N if generating lighting value tokens **452**A.

(124) In block **820**, the reporting device **20**A submits a respective record **242**A including the respective performance metric **240**A from the respective electrical load (e.g., the luminaire **10**A, HVAC device **510**A, or appliance **710**A) to some or all of a plurality of storage devices **40**A-N.

(125) In block **830**, the storage devices **40**A-N or a subset of storage devices **40**A-F validate a plurality of records **242**A-N, including the respective claim **240**A. If the storage devices **40**A-N are validator devices **42**, next in block **840**, the validator devices **42** achieve a consensus within the plurality of the validator devices **42** for a subset or all of the plurality of records **242**A-F. If the storage devices **40**A-N are database devices **41**, there may be no need to establish consensus, and block **840** may be skipped. Finally, in block **850** at least one storage device **40**A-N stores the subset or all of the plurality of records **242**A-F in a block **450**A of the blockchain **444** of an electrical load control network **705**, where the block **450**A includes an electrical load value token **752**A, such as a lighting value token **452**A or an HVAC value token **552**A.

(126) Again, the lighting value token **452**A can be particularized to performance metrics **240**A-Z collected regarding a luminaire **10**A, and an HVAC value token can be particularized to performance metrics **240**A-Z collected regarding an HVAC device **510**A. Alternatively, the distinction between a lighting value token **452**A, HVAC value token **552**A, and an electrical load value token **752**A can be in name only, and the token types **452**A, **552**A, **752**A can be generic and interchangeable in function. The electrical load value token **752**A can include the lighting value token **452**A or HVAC token **552**A, and the category of tokens which meet the definition of as electrical load value token **752**A on the blockchain **444** or in the database **494** can include the lighting value token **452**A or HVAC token **552**A on the blockchain **444** or in the database **494**. Still further, tokens **452**A, **552**A, **752**A can be particularized to the luminaire **10**A, HVAC device **510**A, or appliance **710**A for which the token **452**A, **552**A, **752**A stores performance metrics **240**A-Z or reward amounts **452**A. This particularization may be structural, such that light value tokens **452**AA-N, HVAC value tokens **552**A-N, and electrical load value tokens **752**A-N cannot be stored on the same blockchain **444** or in the same database **494**, or the particularization may only extend to the content of the token **452**A, **552**A, **752**A, meaning that the tokens **452**A-N, **552**A-N, **752**A-N can be stored on the same blockchain **444** or in the same database **494**, or that the reward amounts **462**A or performance metrics **240**A-Z are denominated in an interchangeable fashion.

(127) Any of the steps or functionality of the electrical load value tokenization protocol **800**, described herein for reporting device **20**A-N and validator device **42** of the lighting system **1** can be embodied in programming or one more applications as described previously. According to some embodiments, "function," "functions," "application," "applications," "instruction," "instructions," or "programming" are program(s) that execute functions defined in the programs. Various programming languages can be employed to create one or more of the applications, structured in a variety of manners, such as object-oriented programming languages (e.g., Objective-C, Java, or

C++), procedural programming languages (e.g., C or assembly language), or firmware. In a specific example, a third-party application (e.g., an application developed using the ANDROID™ or IOS™ software development kit (SDK) by an entity other than the vendor of the particular platform) may be mobile software running on a mobile operating system such as IOS™, ANDROID™, WINDOWS® Phone, or another mobile operating systems. In this example, the third-party application can invoke API calls provided by the operating system to facilitate functionality described herein.

(128) Hence, a machine-readable medium may take many forms of tangible storage medium. Non-volatile storage media include, for example, optical or magnetic disks, such as any of the storage devices in any computer(s) or the like, such as may be used to implement the client device, media gateway, transcoder, etc. shown in the drawings. Volatile storage media include dynamic memory, such as main memory of such a computer platform. Tangible transmission media include coaxial cables; copper wire and fiber optics, including the wires that comprise a bus within a computer system. Carrier-wave transmission media may take the form of electric or electromagnetic signals, or acoustic or light waves such as those generated during radio frequency (RF) and infrared (IR) data communications. Common forms of computer-readable media therefore include for example: a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, DVD or DVD-ROM, any other optical medium, punch cards paper tape, any other physical storage medium with patterns of holes, a RAM, a PROM and EPROM, a FLASH-EPROM, any other memory chip or cartridge, a carrier wave transporting data or instructions, cables or links transporting such a carrier wave, or any other medium from which a computer may read programming code and/or data. Many of these forms of computer readable media may be involved in carrying one or more sequences of one or more instructions to a processor for execution.

(129) The scope of protection is limited solely by the claims that now follow. That scope is intended and should be interpreted to be as broad as is consistent with the ordinary meaning of the language that is used in the claims when interpreted in light of this specification and the prosecution history that follows and to encompass all structural and functional equivalents. Notwithstanding, none of the claims are intended to embrace subject matter that fails to satisfy the requirement of Sections **101**, **102**, or **103** of the Patent Act, nor should they be interpreted in such a way. Any unintended embracement of such subject matter is hereby disclaimed.

(130) Except as stated immediately above, nothing that has been stated or illustrated is intended or should be interpreted to cause a dedication of any component, step, feature, object, benefit, advantage, or equivalent to the public, regardless of whether it is or is not recited in the claims. It will be understood that the terms and expressions used herein have the ordinary meaning as is accorded to such terms and expressions with respect to their corresponding respective areas of inquiry and study except where specific meanings have otherwise been set forth herein. Relational terms such as first and second and the like may be used solely to distinguish one entity or action from another without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," "includes," "including," or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises or includes a list of elements or steps does not include only those elements or steps but may include other elements or steps not expressly listed or inherent to such process, method, article, or apparatus. An element preceded by "a" or "an" does not, without further constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises the element.

(131) Unless otherwise stated, any and all measurements, values, ratings, positions, magnitudes, sizes, and other specifications that are set forth in this specification, including in the claims that follow, are approximate, not exact. Such amounts are intended to have a reasonable range that is consistent with the functions to which they relate and with what is customary in the art to which they pertain. For example, unless expressly stated otherwise, a parameter value or the like may vary

by as much as ±10% from the stated amount.

(132) In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various examples for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed examples require more features than are expressly recited in each claim. Rather, as the following claims reflect, the subject matter to be protected lies in less than all features of any single disclosed example. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

(133) While the foregoing has described what are considered to be the best mode and/or other examples, it is understood that various modifications may be made therein and that the subject matter disclosed herein may be implemented in various forms and examples, and that they may be applied in numerous applications, only some of which have been described herein. It is intended by the following claims to claim any and all modifications and variations that fall within the true scope of the present concepts.

Claims

1. An HVAC device, comprising: an airflow component to heat, vent, or cool air; and a control circuit coupled to the airflow component to control operation of the airflow component; a communication interface system configured to communicate with a validator device; a processor coupled to the communication interface system; an HVAC device memory accessible to the processor; and performance tracking programming in the HVAC device memory; wherein: the performance tracking programming when executed by the processor causes the HVAC device to: measure a first running period of time of the HVAC device; form a respective record based on the first running period of time; sign the respective record with a signature using a key to produce a signed record; and cause the communication interface system to transmit a claim message containing the signed record to the validator device; the claim message is configured to cause the validator device to: validate the signature responsive to determining the key is in a whitelist of keys including at least one of a public key, a private key, or a shared key with a controlled chain of custody stored in a memory of the validator device or the key is not present in a blacklist of keys deemed invalid stored in the memory of the validator device; and validate the signed record at least in part by determining whether the first running period of time overlaps with one or more of a plurality of running periods of time in a history of validated records stored in the memory of the validator device.

2. The HVAC device of claim 1, wherein: the performance tracking programming when executed further causes the HVAC device to measure operating parameters of the HVAC device over the first period of time, the operating parameters comprising one or a combination of: one or more fixed attributes of the HVAC device associated with the first running period of time, or one or more dynamic metrics of the HVAC device associated with the first running period of time; and forming the respective record based on the first running period of time further includes forming the respective record with: the measured one or more fixed attributes, the one or more dynamic attributes, or a combination thereof.

3. The HVAC device of claim 2, wherein the fixed attributes include: an image firmware designation of a firmware image active in the HVAC device memory, a physical attribute of the HVAC device, or a combination thereof.

4. The HVAC device of claim 2, wherein the fixed attributes are factory-programmed, and include a wattage-controlled property of the HVAC device.

5. The HVAC device of claim 2, wherein the dynamic metrics include one or more of the following: an occupancy metric based on occupancy detection, a daylight harvesting metric based on daylight harvesting, a user adjustment metric based on a manual user adjustment, a

configuration change metric based on a scheduled configuration change, or a combination thereof.

6. The HVAC device of claim 2, wherein the fixed attributes are user programmed and include: an attribute based on a square footage of coverage of the HVAC device, a physical location attribute based on a physical location where the HVAC device is installed, an installation date attribute based on an installation date of the HVAC device, a site information attribute based on site information of the physical location, a device operator attribute based on a device operator, or a combination thereof.

7. The HVAC device of claim 1, wherein the key includes an HVAC device private key held within the HVAC device memory.

8. The HVAC device of claim 1, wherein the key includes an HVAC device shared key held within the HVAC device memory.

9. The HVAC device of claim 1, wherein the key is implemented with a secure firmware image placed on the HVAC device.

10. A reporting device, comprising: a reporting device communication interface system configured to communicate with a validator device; a reporting device processor coupled to the reporting device communication interface system; a reporting device memory accessible to the reporting device processor; and performance tracking programming in the reporting device memory; wherein: the performance tracking programming when executed by the reporting device processor causes the reporting device to: measure a running period of time of an electrical load and: i) a fixed attribute of the electrical load, ii) a dynamic metric of the electrical load, or iii) a combination thereof; form a record based on the running period of time of the electrical load and: i) the fixed attribute, ii) the dynamic metric, or iii) the combination thereof; and sign the record with a signature using a key to produce a signed record; cause the reporting device communication interface system to transmit a claim message containing the signed record to the validator device; the claim message is configured to cause the validator device to: validate the signature responsive to determining the key is in a whitelist of keys including at least one of a public key, a private key, or a shared key with a controlled chain of custody stored in a validator device memory of the validator device or the key is not present in a blacklist of keys deemed invalid stored in the memory of the validator device; and validate the signed record at least in part by determining whether the running period of time overlaps with one or more of a plurality of running periods of time in a history of validated records stored in the validator device memory of the validator device.

11. The reporting device of claim 10, wherein the electrical load includes an HVAC device, an appliance, or a luminaire.

12. The reporting device of claim 10 wherein the key is private or shared and held within memory of the electrical load.

13. The reporting device of claim 10, wherein the key is implemented with a secure firmware image placed on the electrical load.

14. An HVAC system, comprising: an HVAC device, a reporting device, and a validator device located in a space; wherein: the HVAC device comprises: an airflow component to heat, vent, or cool air; and a control circuit coupled to the airflow component to control operation of the airflow component; the reporting device includes: a reporting device communication interface system configured to communicate with the validator device; a reporting device processor coupled to the reporting device communication interface system; a reporting device memory accessible to the reporting device processor; and performance tracking programming in the reporting device memory; the performance tracking programming when executed by the reporting device processor causes the reporting device to: measure a first running period of time of the HVAC device and: i) a fixed attribute of the HVAC device, ii) a dynamic metric of the HVAC device, or iii) a combination thereof; form a respective record based on the first running period of time and: i) the fixed attribute, ii) the dynamic metric, or iii) the combination thereof; sign the respective record with a signature using a private or shared key held within the reporting device memory to produce a signed record;

and cause the reporting device communication interface system to transmit a claim message containing the signed record to the validator device; the validator device comprises: a validator device communication interface system configured to communicate with the reporting device; a validator device processor coupled to the validator device communication interface system; a validator device memory accessible to the validator device processor; and validator device programming in the validator device memory; the validator device programming when executed by the validator device processor causes the validator device to: validate the signature responsive to determining the key is in a whitelist of keys including at least one of a public key, a private key, or a shared key with a controlled chain of custody stored in the validator device memory of the validator device or the key is not present in a blacklist of keys deemed invalid stored in the memory of the validator device; and validate the signed record at least in part by determining whether the first running period of time overlaps with one or more of a plurality of running periods of time in a history of validated records stored in the validator device memory of the validator device.

15. The HVAC system of claim 14, wherein a respective unique identifier of the respective record from the reporting device is used to certify the respective record.

16. The HVAC system of claim 14, wherein the respective record of the HVAC device is certified by an owner or an operator of the HVAC system.

17. The HVAC system of claim 14, wherein the validator device programming when executed by the validator device processor causes the validator device to: achieve a consensus of one or more validator devices for a subset or all of the plurality of records by having a certain number of the one or more validator devices verify that the plurality of records is valid; and validate signatures of the subset or all of the plurality of records.

18. The HVAC system of claim 14, further comprising a benefactor wallet address associated with a benefactor wallet in a storage device, the benefactor wallet configured to receive a reward associated with the HVAC device, wherein: a block in the storage device makes a controlling association between the benefactor wallet address and the reward; and the controlling association allows a benefactor owner of the benefactor wallet to utilize the HVAC reward.

19. The HVAC system of claim 18, wherein the reward is based on calculations which include the fixed attribute or the dynamic metric as inputs.

20. The HVAC system of claim 14, further comprising a buyer wallet address associated with a buyer wallet in a storage device, the buyer wallet configured to receive a reward from a benefactor wallet, wherein: a transfer record is stored in a record block in the storage device; and the transfer record represents: assigning the reward from the benefactor wallet address to the buyer wallet address, or burning the reward from the benefactor wallet address and assigning the benefactor wallet address a compatible digital currency as specified in the transfer record.