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(54) **INTELLIGENT SYSTEM FOR MONITORING AND CAPITALIZING OF THE GREEN ENERGY PRODUCED BY PHOTOVOLTAIC PANELS**

(57) The intelligent system for monitoring and capitalizing of the green energy produced by photovoltaic panels, according to the invention, solves the technical problem by the fact that it consists of several photovoltaic panels organized in groups, each of the panel having on its backside a hardware and each group being connected by a wire or wireless connection to a communication aggregator that collects telemetry (from P.V. panels, inverters, smart meters, grid equipment and/or other measurement equipment) and provides and/or integrates security services and/or protocols. The aggregator has the role to transmit the measured data in a correct, coherent and secure way to the services distributed in a calculation and manipulation data cloud.

The intelligent system for monitoring and capitalizing of the green energy produced by photovoltaic panels, according to the invention, mitigates the disadvantages of the used solutions due to the blockchain that it consists.

The equipment and services in the cloud provide data auditing, accreditation, encryption and tamper proofing. In this way, each unit of energy, generated by P.V. panels, but not limited to, is assigned a blockchain linked unique number which contains and/or reference, but is not limited to, the physical location combined with a UTC traceable time stamp and the quantity of the measured energy together with environmental data. In this way, the energy transfer is permanently monitored, and it is traceable and trusted by the means of blockchain technologies thus creating a unique time traceable documented trail of energy transactional history, comprising but not limited to, genesis, ownership, exchange and consumption. The blockchain is responsible to assign each generated power quantity encrypted watt a certain quantity of tokens in the blockchain.

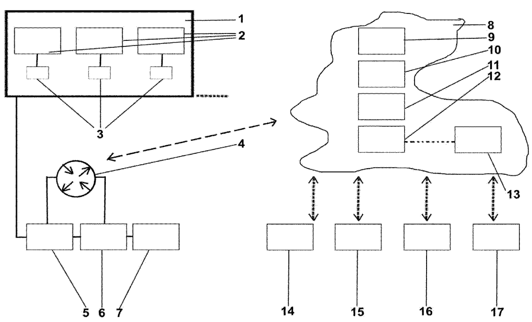

FIG. 1

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Description

[0001] The invention refers to an intelligent system that is perform a number of functions in relation to the operation of the photovoltaic and/or photovoltaic and thermal panels (or other green sources of energy such as wind turbines, but not limited to, that have a characteristic of unpredictable availability of electricity production; further in the document, the references are going to be made with P.V. panels with the purpose of ease of exposition), home users (consumers and prosumers), commercial users (consumers and prosumers), green energy producers (P.V. farms, wind turbines farms, etc.), electrical grid operators (transporters and distributors) and other large scale energy producers.

[0002] To achieve its functionality, the system is monitoring several factors, such as, but not limited to, P.V. panel's voltage, current and temperature, ambient temperature, local air speed, local air pressure, local humidity, power consumption from the grid, power output to the grid, electrical grids characteristics (base frequency, energy flow direction, voltage, current, harmonics, etc.).

[0003] Based on the biggest two use cases, but not limited to, P.V. panels currently installed are deployed for electrical energy generation, both by individuals in their homes and big companies, who wish to increase their cost efficiency and to significantly mitigate their carbon emission footprint on the environment by producing green energy.

[0004] One common drawback of the systems currently under use, involving solutions for production of electrical energy using P.V. panels, is that they cannot integrate and/or provide relevant third parties with low latency and high granularity operational and monitoring data, and control. Furthermore, the data that is collected using currently deployed systems and/or solutions does not adhere to a uniform standard and/or metrology protocol and/or set of norms; also, currently under use systems and/or solutions are subject to highly erratic time induced precision factor derating, drift and/or degradation with no means of traceable recalibration or realignment to a traceable metrology standard. The systems currently in use consistently ensure that the collected data telemetry is being limited at maximum 0,5% total error of energy quantization.

[0005] The technical problem to be solved by the invention is to design a system that works using P.V. panels capable of continuous monitoring both the operational parameters of the panels and the quantity and quality of the energy transferred in the national grid system, while being able to capitalize this energy in real time.

[0006] The proposed system mitigates all the aforementioned drawbacks, furthermore, based on the blockchain component, it provides, but it is not limited to, the time aligned, defined and/or limited, traceability and anti-counterfeiting metrology alignment elements that are backwards traceable to an SI metrology standard. The repetitive higher precision of the system enables, but is not limited to, continuous performance and efficiency assessment of P.V. panels and also traces back, but is not limited to, the I.V. performance evolution in time using the blockchain while factoring in the specific details directly linked to the working conditions of PV panels.

[0007] According to the invention, the intelligent system for monitoring and capitalizing the green energy produced by P.V. panels solves the technical problem by proposing several elements, integrated and part of the system, that monitor the P.V. panels parameters, invertor output characteristics (that include, but are not limited to, voltage, current, frequency), smart meter measured parameters (that include, but are not limited to, voltage, current, frequency, power factor quality, harmonics, and other direct or derived measurements), grid equipment parameters (that include, but are not limited to, voltage, current, frequency, power factor quality, harmonics, temperature and other direct or derived measurements).

[0008] In fact, the system consists of several photovoltaic panels organized in groups, each of the panel having on its backside a hardware and each group being connected by a wire or wireless connection to a communication aggregator that collects telemetry (from P.V. panels, inverters, smart meters, grid equipment and/or other measurement equipment) and provides and/or integrates security services and/or protocols. The aggregator has the role to transmit the measured data in a correct, coherent and secure way to the services distributed in a calculation and manipulation data cloud. The equipment designed for P.V. panel monitoring is a discrete device but also it is fully integrated as a subcomponent of the P.V. panel.

[0009] The equipment and services in the cloud provide data auditing, accreditation, encryption and tamper proofing. In this way, each unit of energy, generated by P.V. panels, but not limited to, is assigned a blockchain linked unique number which contains and/or reference, but is not limited to, the physical location combined with a UTC traceable time stamp and the quantity of the measured energy together with environmental data. In this way, the energy transfer is permanently monitored, and it is traceable and trusted by the means of blockchain technologies thus creating a unique time traceable documented trail of energy transactional history, comprising but not limited to, genesis, ownership, exchange and consumption.

[0010] The system has, but must not necessarily have to, include a hardware subsystem or element to be fitted to an electrical energy transformer, power station or power grid subcomponent, another hardware is connected, but must not necessarily, to the extended geographical area energy network. Another hardware subsystem and or element is, but does not necessarily have to, connected to the final beneficiary of the energy generated by the photovoltaic panels.

[0011] The traceability mechanism is based on blockchain services that contain specific anti-fraud methods, mechanisms, components and features that add unique authenticity details to the aforementioned electrical energy data thus enabling the capitalization of potential P.V. electrical energy that is produced. Simultaneously, the system hereby described supplies low latency analytical data through a series of directly measured and/or directly derived parameters, that enable the functional description of the last mile electrical grid condition. The system potentially provides low latency inter-grid balancing data and parameters relevant to very large electrical energy distribution systems for increasing the operational efficiency. The invention is intended to be used in both domestic and industrial fields, with the remark that the system performs at its highest efficiency in case of consumers that use and/or require time scheduled energy delivery. However, the proposed system encompasses a variety of functional features that are relevant in the use case of the exchange of very large quantity spot electrical energy requests, this use case being very relevant but not limited to the charging stations for electric mobility platforms and peak energy draws for national grids.

[0012] The intelligent system for monitoring and capitalizing the green energy produced by P.V. panels, and adding more use cases to the electrical grid regarding integrating green energy sources in its componence, according to the invention, includes, but it is not limited to the following advantages and/or attributes and/or functionalities:

A. The repetitive and blockchain traceable precision of the data collected by the system with a 0,5% maximum total error of energy quantization.
B. Energy usage by the system components 100% traceable, of which some, such as, but not limited to, those responsible for collecting P.V. data, from green sources do not draw more than 0.1% of the energy produced by a typical 300W P.V. panel.
C. It reduces the environmental pollution.
D. It is efficient with regard to the collected and processed data.
E. It is an efficient system with regard to the energy capitalization that significantly reduces the pay time of the producer of such energy and the capitalized value is highly accurate and in real time.
F. It offers the owners of the P.V. panels the possibility to increase the efficiency of the return on the investment.
G. Dynamically balanced renewable energy trading.
H. Continuously updated system data history.
I. Data driven energy flow optimization and analysis.
J. Current and/or future energy monetization as collateral for financial and/or monetary services.
K. Autonomous, auto adaptive and guided response to imminent and/or critical scenarios involving, but not limited to, consumers, prosumers and energy network (which applies to confined and/or extended geographical area networks)
L. Virtual segmentation of the last mile section of the energy grid.

[0013] An example of implementation of the system, according to the invention, is presented below, in relation with **Figure 1** which represents the intelligent system for monitoring and capitalizing of the green energy produced by photovoltaic panels, with the following components:

1. Photovoltaic panels group
2. Photovoltaic panels
3. hardware data acquisition for P.V. panels
4. Communication aggregator
5. Inverter
6. Smart meter
7. Energy distribution grid
8. Cloud
9. Blockchain services
10. A.I. + M.L. services
11. Data processing and storage services
12. Trading platforms + associated services
13. Other services
14. Other grid equipment
15. 3d party integrated in the system
16. Other equipment that is integrated (such as D.S.R. responsible equipment)
17. Other control and/or data acquisition equipment

[0014] The system consists of some groups **1** of P.V. panels **(2),** each of the P.V. panels having a hardware **(3)** on its backside (electrical connection noted with a single crossed line) and each group **(1)** of P.V. panels being connected by wire or wireless connection to a communication aggregator **(4)** that provides telemetry and securing services and/or computational services. The P.V. panels are electrically connected (data and/or control line is noted with a double-crossed line) the inverter **(5),** that outputs the energy into an electrical smart meter **(6)** that is also connected to the energy distribution grid **(7).**

[0015] Telemetry works based on a mathematic model which enables the exact identification of the source of the gathered information, namely the photovoltaic panel (2). The mathematic model is in the shape of a measured set of values, such as electrical current and temperature.

[0016] The aggregator **(4)** has the role to transmit (via internet or other wired and/or wireless means, shown in the figure by the dashed line) measured values in a correct and secure way to the services distributed in a cloud **(8)** that is meant to calculate and manipulate the data. The equipment and/or services in the cloud **(8)** provide data auditing, accreditation and encryption services which means that they are providing services specific to a blockchain **(9),** A.I. + M.L. **(10)** services, processing and storage **(11),** trading platforms **(12)** and other services **(13).**

[0017] There are also be other connected parties to the cloud **8,** such as, but not limited to, other grid equipment (connected via **(3)** or other means) **(14),** 3rd parties that integrate into the system **(15),** other equipment **16** that enable demand side response (D.S.R.) functionality, that is controlled by **(3)** or other means (such as, but not limited to, heaters, coolers, batteries)**(17)** and other control and/or data acquisition equipment that is either proprietary or part of our system,

[0018] In this way, each watt of energy generated by the photovoltaic panels **2** is assigned by the blockchain **9** an unique number which contains the location in time and space and the value of the measured energy. In this way, each watt is monetarized and its traceability in time and space along with the value evolution is also known. The encryption eliminates any risk that the same Watt of energy is encrypted multiple times. The blockchain **(9)** is responsible to assign each generated power quantity encrypted watt a certain quantity of tokens in the blockchain.

[0019] The means by which the aforementioned items is achieved is via a particular implementation of a system capable of applying algorithms, theorems, formulas and other means specific to System Control Theory. The purpose of the aforementioned control system is to tend to achieve balance in the system comprised, but it is not limited to elements that create, consume, transport, trade, rely on or store energy. The logic generated by the control system is applied at one or multiple levels of the energy grid, on one or multiple components at particular moments in time or simultaneously.

[0020] A more exhaustive explanation of the functional details regarding current and/or future energy monetization as collateral for financial and/or monetary services goes as follows: based on data obtained from OUR SYSTEM and processed internally, but not exclusively by machine learning, A.I. and other methods of computing, mathematical inferences is made and is, but is it not limited to, translation to financial and/or monetary factors that is applied directly or in a derived means to some credit schemas and/or potential monetization instruments by other external parties.

[0021] Reducing environmental pollution is mainly achieved by, but not limited to, facilitating the availability of green energy that otherwise could have not been produced and/or used due to grid related factors. This has a few effects, such as, but not limited to, reducing the usage of other means of energy production that have a higher impact on the environment and raising the quality of the power factor in the grid, therefore reducing the need to correct it, which is a process that ultimately consumes energy. Furthermore, having control over energy generation and energy flow create alternative means of consuming less energy from intensive CO2 emitting sources, such as optimizing, through dynamic balancing, the moment of energy consumption when appropriate.

[0022] The efficiency of data collection and processing is achieved, but it is not limited to, applying a logic of distributed responsibility across the hardware and software components involved in the system. If deemed appropriate, through internal computational methods, each layer does several operations regarding the data and optimize the means and/or characteristics of the transmission (for example, but not limited to, when data is sent, what data is contained in the transmission, how is the data formatted and what transmission protocol is used). Also, data storage at different steps of the processes involved, plays a key role on the efficiency of the system; when deemed appropriate, through internal computational methods, data storage is routed to different means of storage or take different formats (for example, but not limited to, data accuracy is dynamically adjusted, storing only metadata and/or derivate data and/or generating other data that related in whole or in part to the original data).

[0023] The increased efficiency of the R.O.I. in the case of P.V. panels owners is mainly due to the potential for monetization of higher quantity and/or quality of the energy that is produced, that is available for, but it is not limited to, either sale, internal consumption and/or energy storage on local and/or remote solutions.

[0024] The renewable energy trading, sourced from the P.V. panels by, but not limited to, home prosumers, commercial prosumers and dedicated renewable energy producers is hindered by the unpredictable availability, intrinsic to the energy source behaviour. At the time of the production the energy grid is loaded at full capacity and/or unavailable for transporting a larger quantity of energy. To address this, there are a number of proposed measures, in example, but not limited to: analysing the historical data and applying computational methods to it, in order to predict with a high certainty degree, when the energy is going to be produced in the future. This data is provided to the grid operator and/or various grid components and/or various grid subsections, potentially contribute to the decision of what sources of energy are and/or should be powering the grid at any time, with the aim, but not limited to, usage of as much renewable energy as possible at any given time.

[0025] The proposed system, through its proposed features, components and/or functionalities and/or intrinsic features, is used a support element for current and/or future energy monetization such as, but not limited to, collateral for financial and/or monetary services and/or instruments. The system could provide an interested party with a metric and/or synthetic mathematical coefficients, in regard to current and/or expected energy produced by an energy production system, and then a interested party, such as, but not limited to financial institution, could leverage it as collateral for accessing and/or using, but not limited to, financial and/or monetary services and/or instruments.

[0026] The autonomous, auto adaptive and guided response to imminent and/or critical scenarios involving, but not limited to, consumers, prosumers and energy network (which apply to confined and/or extended geographical area networks) represents the integration between proprietary hardware and/or 3rd party hardware components and/or hardware systems, cloud related services and/or computing methods and/or hardware based decision generated logic, involving devices and/or components in the proposed system that take decisions and/or actions based on previous and/or continuously updated configurations and/or commanded decisions. This functionality relies on the fast data transmission of the system and decentralized and/or centralized decision factor and reliability of the transmission medias that the system has available. Given those properties and/or functionalities and/or factors, the system, autonomously or directly controlled, make decisions, such as, but not limited to, switching the energy routing in the electrical grid (at different levels and/or points). One example of achieved functionality, but not limited to, could be the case of loss of internet and/or radio communication (for example, but not limited to, GSM connection) access and/or access by other conventional means that would leave the electrical grid control and/or monitoring devices without a means of external data and/or control access; in this scenario, the hardware components and/or control devices integrated in our proposed system, would perform a series of various autonomous functions in a network defined by the proposed system that enables them to communicate at different levels and take decisions regarding the energy grid; this is achieved via proprietary means of communication and/or already defined protocols, such as, but not limited to, Bluetooth Mesh, Thread and/or Zigbee.

[0027] The last mile virtual segmentation functionality refers to the potential for exploitation of the intrinsic property of energy flow in an electrical conductor, as described in the Kirkoff Theorem, that the last mile of the energy distribution grid has; the grid behaves like islands/loops. In example, one continuous length of electrical conductor from the energy grid is used simultaneously in multiple localized energy exchange loops that form on virtual segments of the electrical conductor, based on a system with potentially multiple points of energy injection and simultaneously multiple points of energy consumers that use for energy transfer just a part of the grid, not the whole conductor.

[0028] The proposed system is defined by, but not limited to, several functional components/actors, each fulfilling a function and/or purpose when it comes to the operation and/or functionality of the system. In this regard, we define the following entities, each with a set of attributes and/or capabilities and/or functionalities, of which some or all is present in a particular implementation:

A. The grid operator, which is capable of, but it is not limited to:

- a. Energy transport data acquisition and transmission
- b. Energy distribution data acquisition and transmission
- c. Last mile energy distribution data acquisition and transmission
- d. Energy storage data acquisition, transmission and control

B. Green energy producer, which is capable of, but it is not limited to:

- a. Energy source data acquisition and transmission
- b. Energy source data acquisition, transmission and control
- c. Grid energy meter data acquisition and transmission
- d. Demand side response data acquisition, transmission and control
- e. Local energy storage data acquisition, transmission and control

C. Commercial prosumer, which is capable of, but it is not limited to:

- a. P.V. panel data acquisition and transmission
- b. P.V. inverter data acquisition, transmission and control
- c. Smart meter data acquisition and transmission
- d. Grid energy meter data acquisition and transmission
- e. Demand side response data acquisition, transmission and control
- f. Local energy storage data acquisition, transmission and control

D. Commercial consumer, which is capable of, but it is not limited to:

- a. Smart meter data acquisition and transmission
- b. Grid energy meter data acquisition and transmission
- c. Demand side response data acquisition, transmission and control
- d. Local energy storage data acquisition, transmission and control

E. Home prosumer, which is capable of, but it is not limited to:

- a. P.V. panel data acquisition and transmission
- b. P.V. inverter data acquisition, transmission and control
- c. Smart meter data acquisition and transmission
- d. Grid energy meter data acquisition and transmission
- e. Demand side response data acquisition, transmission and control
- f. Local energy storage data acquisition, transmission and control

F. Home consumer, which is capable of, but it is not limited to:

a. Smart meter data acquisition and transmission
b. Grid energy meter data acquisition and transmission
c. Demand side response data acquisition, transmission and control
d. Local energy storage data acquisition, transmission and control

Claims

1. Intelligent system for monitoring and capitalizing the green energy produced by photovoltaic panels, **where in,** it consists of some groups **(1)** of P.V. panels **(2),** each of them having a hardware **(3)** on its backside and each group **(1)** of panels **(2)** being connected by wire or wireless connection to a communication aggregator **(4)** that provides telemetry and securing services, the system also consisting of an inverter **(5)** that outputs the energy into an electrical Smart meter **(6)** connected an energy distribution grid **(7),** the aggregator **(4)** having the role to transmit measured values in a correct and secure way to the services distributed in a cloud **(8)** that is meant to calculate and manipulate the data.

2. Intelligent system for monitoring and capitalizing the green energy produced by photovoltaic panels according to claim 1, **where in,** the equipment and/or services in the cloud **(8)** provide data auditing, accreditation and encryption services which means that they are providing services specific to a blockchain **(9),** namely A.I. + M.L. **(10)** services, processing and storage **(11),** trading platforms **(12)** and other services **(13).**

3. Intelligent system for monitoring and capitalizing the green energy produced by photovoltaic panels according to claim 1, **where in,** the cloud **8** , is, but not limited to, containing other grid equipment **(14)** connected via the aggregator **(4)** or other means, 3rd parties **(15)** integrated in the system, another equipment **16** that enables demand side response (D.S.R.) functionality controlled by a hardware **(3)** or other means, such as, but not limited to, heaters, coolers, batteries and another control and/or data acquisition equipment (17) that is either proprietary or part of our system,

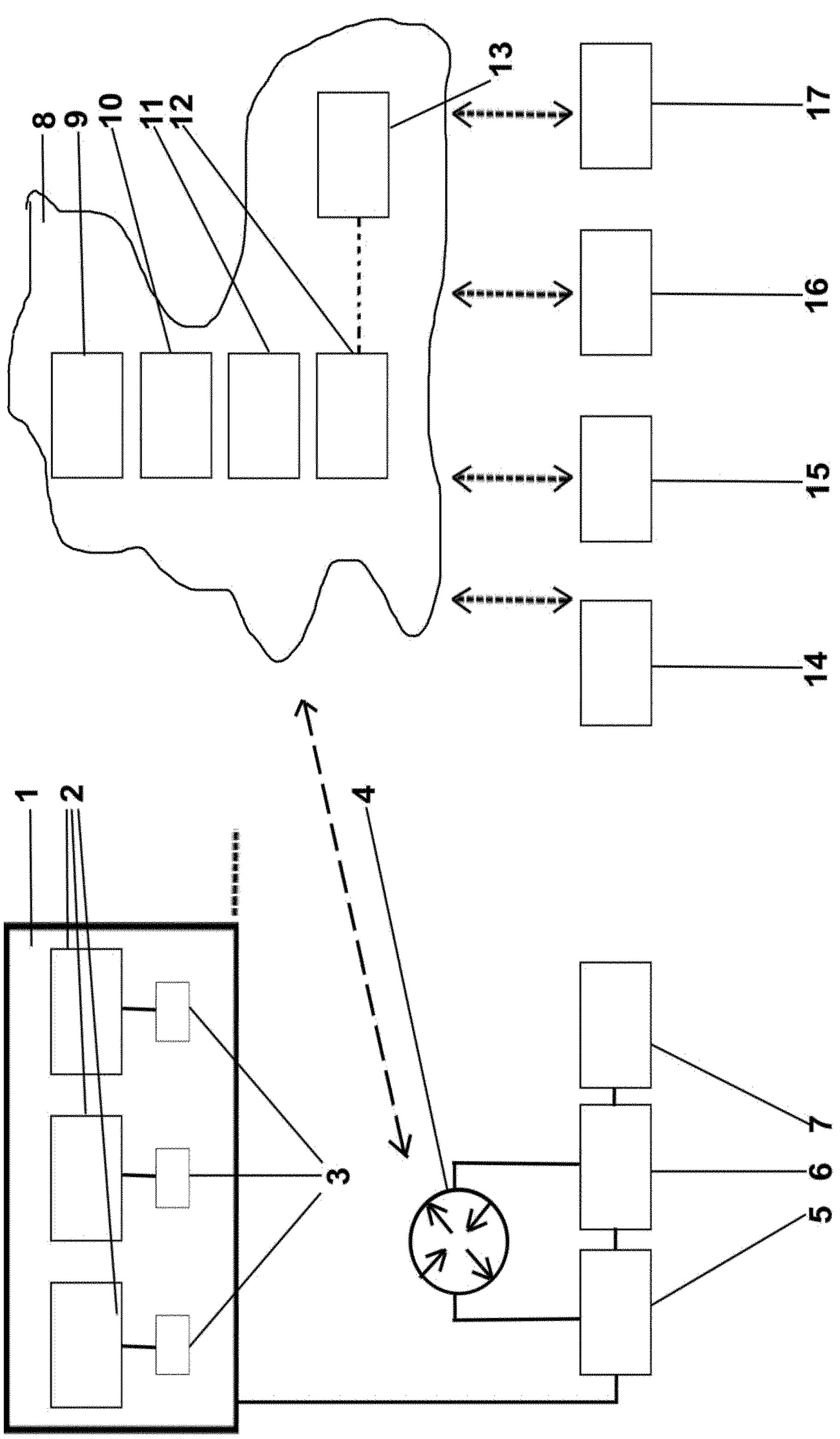

FIG. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 23 02 0110

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	CALVAGNA ANDREA ET AL: "Providing Trust in a Dynamic Distributed Energy Production Scenario by means of a Blockchain", 2022 WORKSHOP ON BLOCKCHAIN FOR RENEWABLES INTEGRATION (BLORIN), IEEE, 2 September 2022 (2022-09-02), pages 13-18, XP034286416, DOI: 10.1109/BLORIN54731.2022.10028019 [retrieved on 2023-02-03] * section 2, 3, 5; figure 1 * -----	1-3	INV. G06Q50/06

TECHNICAL FIELDS SEARCHED (IPC)

G06Q

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	18 August 2023	Haitof, Houssam

CATEGORY OF CITED DOCUMENTS

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