

SMART POWER DISTRIBUTION SYSTEM FOR ELECTRIC VEHICLES

TECHINICAL FIELD

- 5 [01] The present application concerns with the power distribution management for electrical vehicles, specifically, a smart power distribution system for electric vehicles.

BACKGROUND TECHNIQUE

- 10 [02] With the increase in people's awareness of environmental protection, electric vehicles (EV), which are more environmentally friendly than fuel cell vehicles, are becoming more and more popular with the public. However, currently the infrastructure to support the penetration rate of the EVs in Hong Kong is far behind its demand. For example, according to
15 statistics, there were about 11,000 registered electric private cars in Hong Kong in 2019, whereas there were only about 2,000 public charging facilities.

- [03] One of the main reasons of the inadequacy of infrastructure to support EVs as compared to its demand is the limitations of various residential communities to install EV chargers for each car park, for instance, there is limited power supply for each car park and limited space for installation of charging facilities, etc. In addition, since the EV is a large power device, there are considerations as to the safety, and a safety mechanism is vital in
20 ensuring the charging process to be efficient and robust.

- 25 [04] The present application aims to solve the above-mentioned problems.

SUMMARY OF THE INVENTION

- 30 [05] The present application provides a smart power distribution system for electric vehicles (EV), comprising: one or a plurality of EV chargers for charging electric vehicles; a controller, which communicates with the EV chargers, and is used for performing charging management of the said one or a plurality of EV chargers, all EV chargers managed by the controller
35 constitute a smart power distribution network, and the said controller uses a preset power load balancing method to control the charging power of all EV

chargers in the said smart power distribution network; and a back end server, which communicates with the controller, and is used to prepare the charging service for the controller.

[06] In one embodiment, the said back end server communicates with the said
5 controller based on the Message Queuing Telemetry Transport (MQTT) protocol, and the said controller communicates with the said EV charger based on the Open Charge Point Protocol (OCCP).

[07] In one embodiment, the said smart power distribution system for EV also
10 includes a sensor, which is for sensing the real-time power load data of the EV charger and feeding it back to the controller.

[08] In one embodiment, the said controller determines whether the EV violates
15 the charging protocol according to the feedback from the sensor, and performs the following operations on the EV in violation the charging protocol: limiting the EV in violation of the protocol to a safe charging power or to a preset low charging power; and when the main power loading is detected to exceed the maximum available power, restricting all EVs to charge at the minimum charging power, and the load balancer will re-do the
20 balancing.

[09] In one embodiment, the said power load balancing methods comprise: 1)
Even Distribution Algorithm: when the total available power is greater than
25 the sum of charging powers of all EV chargers, all EV chargers are charged at the maximum charging power, when the total available power is less than or equal to the sum of charging powers of all EV chargers, EV chargers are charged at the safe charging power; 2) Priority Distribution Algorithm: the EV chargers are sorted into high priority EV chargers and normal priority EV chargers, when the sum of the maximum charging powers of all high
30 priority EV chargers is less than the total available power, each high priority EV chargers is distributed the maximum charging power, otherwise, each high priority EV charger is distributed the safe charging power; after the high priority charging points are distributed, the remaining power is equally distributed to the normal priority EV chargers; 3) First Come First Served
35 Algorithm: all EV chargers are sorted in2harging queue according to the time of issuance of the charging requests, the controller distributes to all EV chargers a charging power not lower than the minimum charging power;

when the minimum charging power distributed to all EV chargers cannot be maintained; the charging request of the EV chargers is suspended in sequence from the end to the head of the queue, until the minimum charging power of the non-suspended EV chargers can be maintained; 4) Premier Distribution Algorithm: the EV chargers are sorted into premier EV chargers and normal EV chargers, the controller distributes the minimum charging power to each normal EV chargers, and distributes the remaining charging power equally to each premier EV charger.

10 [10] In one embodiment, the said safe charging power is a fixed preset value, or the charging power obtained when the total available power is equally divided among each EV charger.

15 [11] In one embodiment, the said controller characterizes all Evs in the smart power distribution network according to their charging performances, and sends a probing signal to detect each EV's charging characteristics one by one, the said charging characteristics comprise: maximum charging power of the EV, minimum charging power of the EV, the response time of the EV to start charging power from zero to minimum charging power, the response time of the EV to start charging power from zero to maximum charging power, the response time of the EV to decrease the charging power from maximum to minimum, the response time of the EV to decrease the charging power from minimum to zero, the response time of the EV to change the charging power from zero to maximum, the response time of the EV to decrease the charging power from maximum to zero.

25 [12] In one embodiment, when the EV is connected to the EV charger and makes a request to start the charging service, a probing signal will be sent out so to collect the charging characteristics of the EV, if the EV does not respond to the probing signal correctly, the controller will label such EV as the EV having the lowest priority, and will only distribute minimum charging power to such EV.

30 [13] The present application concerns with a smart power distribution system for EV which manages the EV charges through the controller and use the power low balance method to control the charging power of each EV charger, thereby improving the power distribution efficiency and enabling

more EV chargers to be installed in car parks. The present application also includes a fail-safe mechanism to ensure a robust and safe charging process.

BRIEF DESCRIPTION OF THE DRAWINGS

- 5 [14] In order to illustrate the technical problems solved by the present application more clearly, the technical means adopted and the technical effects, particular embodiments will be described in detail herein with accompanying drawings. However, it should be noted that the accompanying drawings described below are only drawings of
10 exemplary embodiments of the present application, it should be noted that drawings of other embodiments may be made by those skilled in the art without departing from the spirit and scope of the invention.
- [15] **Figure 1** is a system connection diagram representing a smart power
15 distribution system for electric vehicles of an embodiment of the present application.
- [16] **Figure 2** is a connection diagram of representing the fail-safe mechanism
20 of an embodiment of the present application.
- [17] **Figure 3** is a flow chart of the EV charging characteristics diagnostic
process of an embodiment of the present application.
- [18] **Figure 4** is a graph showing the response time for the EV charging
25 starting from zero to minimum charging power of an embodiment of the present application.
- [19] **Figure 5** is a graph showing the response time for the EV charging
30 starting from minimum charging power to zero charging power of an embodiment of the present application.
- [20] **Figure 6** is a system block diagram of the server of the embodiment of
the present application.

DETAILED WAYS

- [21] Exemplary embodiments will be described in detail herein, examples of which are illustrated in the accompanying drawings. While the exemplary
5 embodiments can be embodied in various specific forms, it should not be understood that the present application is limited to the embodiments set forth herein. On the contrary, these exemplary embodiments are provided so that the content of the present application will be more thorough and the concept of the present application to those skilled in the art will be
10 more fully conveyed. Under the premise of conforming to the technical concepts of the present application, the structures, performances, effects or other features described in a particular embodiment may be combined into one or more other embodiments in any suitable manner.
- 15 [22] In the description of specific embodiments, detailed descriptions of structures, performances, effects or other features are provided to enable those skilled in the art to fully understand the embodiments. However, it does not rule out the possibility that those skilled in the art under specific
20 circumstances can implement the present application with technical solutions that do not contain the above-mentioned structures, performances, effects or other features.
- 25 [23] The flow chart in the accompanying drawing is only an exemplary demonstration of process, it does not mean that the solution of the present application must include all contents, operations and steps in the flow chart, nor does it mean that the sequence shown in the drawing must be performed accordingly. For example, some operations/steps in the flow chart can be separated, and some operations/steps can be combined or partially combined, etc. The sequence of execution shown in the flow
30 chart can be changed based on actual circumstances without departing from the spirit of the present application.
- [24] The block diagram in the drawings generally represents functional entities and does not necessarily correspond to separate physical entities. That is,

these functional entities may be implemented in the forms of software, or in one or more hardware modules or integrated circuits, or in different networks and/or processing unit devices and/or microcontroller devices.

5 [25] The same labels in the drawings denote the same or similar elements, components or sections, and thus repeated descriptions of the same or similar elements, elements or sections may be omitted hereinafter. It will also be understood that although the numerical definers such as first, second, third, etc. may be used herein to describe various components, 10 elements, or sections, these components, elements, or sections should not be limited by these definers. That is, these definers are only used to distinguish one from the other. For example, the first device may also be referred to as the second device, but this does not deviate from the substantive technical solution of the present application. Additionally, the 15 term “and/or” is meant to include all combinations of any one or more of the listed items.

 [26] In general, the present application concerns with smart power distribution system for EV with a fail-safe mechanism that can coordinate EV chargers to improve power distribution efficiency throughout the whole power 20 distribution network, and the present application will include a fail-safe mechanism to ensure safety during the power distribution process.

 [27] Through the present application, the car parks of each residential communities can fully utilize the power supply and more EV chargers can be installed in the car parks. Also, the present application also enables the 25 charging process to be completed under robust and safe conditions.

 [28] The present application makes use of different strategies to load balance the Evs connected to the distribution network in order to improve the power distribution efficiency and enable more EV chargers to be installed 30 in the car park. Moreover, the invention will apply a fail-safety mechanism to ensure the charging safety over the whole charging processes. Thus, the present application can solve the problem of distributing the power to the connected chargers in a smart way with safety protection. 35

[29] Referring to **Figure 1**, the main components of the present application comprise:

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[30] A back end server **10** which supports the on-site controller with assisting tools, the back end server **10** can communicate with the controller based on the MQTT (Message Queuing Telemetry Transport) protocol. The back end server can be implemented in a cloud infrastructure, so to attain service with high readiness, its functions include: a) user registration, management and authorization; b) charger supply management; c) transaction management; and d) provision of management portal for car park management for billing purposes.

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15 [31] An on-site controller **20** which manages the connected EV charger by the OCCP (Open Charge Point Protocol) 1.6/2.0, or, any protocols which could intercommunicate with the EV Charger in the market. The charging power of the chargers are managed by the controller **20** over the protocol, the controller **20** also performs the power load balancing algorithm. The controller **20** can read the charging current from the charger via the OCCP protocol.

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[32] A sensor **30** which can sense the charging condition of the charging and feed it back to the controller **20**, so that the sensor **30** can read back the actual power consumption from the charging the EV charger in a more instant and accurate manner through the OCCP protocol. This provides a fail-safe mechanism for EV chargers.

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[33] An EV charger (charging point) **40**, which can be managed by the controller **20**, is used to charge the EV **50**.

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[34] A power supply **60** which can supply power to each of the chargers **40** through charging cables.

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[35] All chargers **40** can be paired to the controller **20** through the OCCP

protocol to form a local smart charging network. The charging power from all chargers **40** are managed by the controller **20** in a local smart charging network. The power load balancing algorithm runs on the controller **20** in order to form a robust and efficient power distribution network and support as many chargers as possible.

[36] One of the most challenging problems in EV charging systems is to distribute power to Evs in a robust manner, so that more Evs can be charged simultaneously with a limited power supply. The power utilization index, i.e., PUI can be an indicator of power distribution, wherein 100% PUI means that the system can distribute the maximum charging power in every second if the system power supply is 24KW (supply current being 100A, assuming that the domestic supply voltage is 240V). To achieve the goal, it is necessary to understand the charging parameters from the EV, such as the maximum charging current I_{max} , e.g. 16A single phase or 32A single phase, minimum charging current I_{min} , the charging current control response time $T_{response}$ and its power consumption (KW), so that the connected charger will be set to I_{max} and the EV could be fully charged in the shortest possible time. The charging current control response times in different Evs may vary widely, for example it could be from 5s to 30s. It will impact the reliability of the charging distribution. If the controller provides the power too aggressively without considering the control current response time, overcurrent protection will be triggered under many cases, and leads to system shut down and power outage, which means the circuit breaker will switch off to protect the main power.

[37] The present application supports four power load balance algorithms, including:

[38] a) Even Distribution Algorithm: Based on the even distribution of the maximum charging power or the maximum charging current of the EV, i.e. P_{max} or I_{max} , which can be represented by Equation 1:

$$[39] \quad CP_{OutputPower} = \begin{cases} CP_{i(Pmax)} & \text{if } \frac{P_{ttlavl}}{\sum_{i=0}^n CP_{i(Pmax)}} > 1 \\ CP_{i(PsafetyP)} & \text{if } \frac{P_{ttlavl}}{\sum_{i=0}^n CP_{i(Pmax)}} \leq 1 \end{cases} \quad (1)$$

[40] Wherein, CP = Charging point, which means the EV Charger; $CP_{OutputPower}$ is the output power of the charging point; n is the number of charging points in a local charging network, $CP_{i(Pmax)}$ is the maximum charging power of the i -th charging point, $CP_{i(Psafety)}$ is the safe charging power of the i -th charging point, P_{ttlavl} = total available power. It can be seen from Equation 1 that when the total available power is greater than the sum of the maximum charging powers of all charging points, the maximum charging power can be distributed to all charging points, and when the total available power is less than or equal to the sum of the maximum charging powers of all charging points, the safe charging power is then distributed to all charging points. The safe charging power can be a preset fixed value, or the power obtained when the total available power is equally divided among n charging points. For example, if the power supply system has 24KW or 100A (i.e. as its total available power) and there are three EV charging requests, and all charging requests has P_{max} of 7.680KW or I_{max} of 32A, it means that the sum of all charging points' P_{max} is less than the total available power, so that 7.680KW or 32A will be supplied to all three Evs. If there are 4 charging requests from Evs, and all charging requests has P_{max} of 7.680KW or I_{max} of 32A, it means that the sum of all charging points' P_{max} is greater than the total available power, so that each EV will be provided with safe charging power, such as 6KW or 25A (i.e. the power obtained when the total available power is equally divided into the number of charging points).

[41] b) Priority Distribution Algorithm: The system will provide a higher priority to higher priority charging points, the higher priority charging points can use the I_{max} charging power first, and the remaining power will be evenly distributed to the remaining charging points, this can be explained by Equations 2 and 3:

$$[42] \quad CP_{(hp)}_{OutputPower} =$$

$$\left\{ \begin{array}{l} CP_{i(Pmax),if} < P_{ttlavl} \\ else CP_{i(Psafety)} \end{array} \right\} \quad (2)$$

$$[43] \quad CP_{(np)outputPower} = \frac{(P_{remain})}{m} \quad (3)$$

[44] Wherein, hp = high priority, np = normal priority, $CP_{(hp)outputpower}$ is the
5 output power of the high priority charging point, $CP_{(np) outputpower}$ is the
output power of the normal priority charging point, P_{remain} is the
remaining power after all available power is distributed to high priority
charging points, m is the number of charging points with normal priority.
10 It can be seen that when the sum of the maximum charging powers of all
high priority charging points is less than the total available power, each
high priority charging point is distributed the maximum charging power;
otherwise, if the sum of the maximum charging powers of all high priority
charging points is greater than or equal to the total available power, each
high priority charging point is distributed the safe charging power. After
15 the charging power is distributed to the high priority charging points, the
remaining power is equally distributed to the normal priority charging
points.

[45] First Come First Served Algorithm: all charging points are sorted into a
20 charging queue according to the time of issuance of the charging requests,
the controller keeps distributing to all charging points a charging power
not lower than the minimum charging power P_{min} or minimum charging
current I_{min} . When the total available power P_{ttlavl} cannot maintain the
minimum charging current I_{min} for all the charging points, the charging
25 request of the charging points will be suspended in sequence from the end
to the head of the charging queue, until the minimum charging current
 I_{min} of the non-suspended charging points can be maintained. The
suspended charging points will wait in the queue and will be supplied with
power as soon as the I_{min} could be maintained, this can be represented by
30 Equation 4:

$$[46] \quad CP_{OutputPower} = \left\{ \begin{array}{l} CP_{i(Pmin),if \sum_{i=0}^n CP_{i(Pmin)} \leq P_{ttlavl}} \\ else=0 \end{array} \right\} \quad (4)$$

[47] Wherein, $CP_{i(Pmin)}$ is the minimum charging power of the i -th charging point, it can be seen that when the sum of the minimum charging power of all charging points is less than or equal to the total available power, each charging point is allocated the minimum charging power; otherwise, if the sum of the minimum charging power of all charging points is greater than the total available power, then according to the principle of first come first served, the charging request of charging points is suspended in sequence from the end to the head in the queue until the sum of the minimum charging power of all charging points is less than or equal to the total available power.

[48] d) Premier Distribution Algorithm: The system will distribute the minimum charging power $Pmin$ to all the normal charging points except the premier charging points, the remaining power will then be evenly distributed to the premier charging points.

[49] $CP_{(prem)}_{outputPower} =$

$$\left\{ \begin{array}{l} CP_{i(prem)} = \frac{P_{ttotal} - \sum_{i=0}^M CP_{(norm)i(Pmin)}}{N}, \text{ if } CP_{i(prem)} > CP_{(prem)i(Pmin)} \\ else CP_{i(prem)} = CP_{(prem)i(Pmin)} \end{array} \right\}$$

(5)

[50] Wherein, $prem$ = premier , $norm$ = normal, $CP_{(prem)outputpower}$ is the output power of the premier charging point, $CP_{i(prem)}$ is the charging power of the i -th premier charging point, $CP_{(norm)i(Pmin)}$ is the minimum power of the normal charging point, M is the number of normal charging points, N is the number of premier charging points, $CP_{(prem)i(Pmin)}$ is the minimum charging power of the i -th premier charging point, it can be seen from Equation 5 that the charging power of the i -th premier charging point is the remaining power being evenly distributed by all premier points, and the remaining power is the power obtained after the total available power is distributed to all normal charging points with minimum charging power, when the power obtained as such is greater than minimum charging power of the i -th premier charging point, such power is the charging power of the i -th premier charging point, otherwise, the minimum charging power

of the i -th premier is the charging power of the i -th premier charging point.

[51] The present application can also introduce a diagnostic function to the EV connected to the charging point. Therefore, charging performances of all Evs connected to the network will be characterized by the controller. The controller will send a probing signal to detect the charging characteristics of each EV one by one, it can include:

[52] a) Maximum charging power of the EV, i.e., $\text{Power}_{\max}$.

[53] b) Minimum charging power of the EV, i.e., $\text{Power}_{\min}$.

[54] c) The response time of the EV to start charging power from zero to minimum, i.e., $\text{Time}_{\text{zero_min_response}}$.

[55] d) The response time of the EV to increase the charging power from minimum to maximum, i.e., $\text{Time}_{\min_max_response}$.

[56] e) The response time of the EV to decrease the charging power from maximum to minimum, i.e., $\text{Time}_{\max_min_response}$.

[57] f) The response time of the EV to decrease the charging power from minimum to zero, i.e., $\text{Time}_{\min_zero_response}$.

[58] g) The response time of the EV to start charging the power from zero to maximum, i.e., $\text{Time}_{\text{zero_max_response}}$.

[59] h) The response time of the EV to stop charging the power from maximum to zero, i.e., $\text{Time}_{\max_zero_response}$.

[60] When the EV is connected to the charging point and makes a request to start the charging service, a probing signal will be sent out so to collect the charging characteristics of the EV, this is important to ensure that the load balancing is working normally and to ensure network reliability. If the EV does not respond to the probing signal correctly, the controller will

label the EV as the EV having the lowest priority, and will only distribute minimum charging power to the EV. **Figure 2** represents such connection.

- [61] Referring to **Figure 3**, the flow of the controller to probe the charging characteristics of the EV comprises the following steps:
- [62] **S100**, EV charging diagnostic process starts;
- [63] **S101**, the maximum charging power $Power_{max}$ and the minimum charging power $Power_{min}$ of the EV are probed;
- [64] **S102**, it is determined whether the maximum and minimum charging powers are acquired, if not, it is returned back to **S101** to continue acquisition, otherwise, it is entered to **S103**;
- [65] **S103**, an OCCP command is sent to set the minimum charging power, and measure the response time from zero to the minimum charging power, i.e., $Time_{zero_min_response}$.
- [66] **S104**, an OCCP command is sent to set the maximum charging power, and measure the response time from minimum to maximum charging power, i.e., $Time_{min_max_response}$.
- [67] **S105**, an OCCP command is sent to set the minimum charging power, and measure the response time to decrease the charging power from maximum to minimum, i.e., $Time_{max_min_response}$.
- [68] **S106**, an OCCP command is sent to set the minimum charging power, and measure the response time to decrease the charging power from minimum to zero, i.e., $Time_{min_zero_response}$.
- [69] **S107**, an OCCP command is sent to set the maximum charging power, and measure the response time from zero to maximum charging power, i.e., $Time_{zero_max_response}$.
- [70] **S108**, an OCCP command is sent to stop charging power, and measure the

response time from maximum charging power to zero, i.e., $\text{Time}_{\text{max_zero_response}}$.

[71] **S109**, it is determined whether all data are acquired, if yes, charging
5 service is started in **S110**; if not, the Evs for which not all data are acquired
are labelled as non OCCP-compliant Evs in **S111**, then the charging
service can be started according to the fail-safe mechanism.

[72] Referring to **Figure 4** and **Figure 5**, they provide respectively the
10 response time from zero to minimum and the response time from
minimum to zero in stopping to charge.

[73] The present application introduces a fail-safe characteristic. Since safety
15 is the highest priority in providing a reliable power distribution system, a
feedback power sensor can be set in the present application, which can
provide real-time power load information for each charging point. The
controller will proactively prevent the system from overloading and tackle
some unexpected situations by taking some necessary actions on Evs that
violate the charging protocol, the actions include:

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[74] a) To limit the Evs that violate the protocol to have a safe charging power
only, e.g., 6A single phase.

[75] b) To limit the Evs that violate the protocol to have a low charging power,
25 e.g., $< 10\text{A}$ as a penalty.

[76] c) The main power loading should not exceed the maximum available
30 power. If this situation is detected, all Evs will be limited to have
minimum charging power, and the load balancer will re-do the balancing
again.

[77] The server of the embodiments of the present application may be
35 implemented in a computing device. An exemplary internal structural
diagram of a computing device may be shown in **Figure 6**, such
computing device may include a processor, memory, external interface,

display, and input device connected through a system bus. Among them, the processor is used to provide computing and control abilities. Memory includes non-volatile storage medium and internal memory. Such non-volatile storage medium stores the operating system, application program, database, etc. The internal memory provides an environment for the operation of operating systems and programs in the non-volatile storage media. The external interface includes, for example, a network interface for communicating with an external terminal through network connection. The external interface may also include a USB interface and the like. The display of such computing device can be a liquid crystal display screen or an electronic ink display screen, the input device may be a touch panel covered on the display screen, or may be, for example, a button, a trackball or a touchpad set on the case of the computing device, it can also be an external keyboard, trackpad or mouse, etc. Likewise, the controller can also be implemented in a similar structure.

[78] Those skilled in the art can understand that the structure shown in **Figure 6** is only a block diagram relevant to part of the structure of the solution of the present application, and it does not constitute any limitations on the computing device to which the solution of the present application is applied to, the specific computing device may include more or fewer components than it is shown in the figure, or some components may be combined or have different arrangements.

[79] As described above, those of ordinary skill in the art can understand the implementation methods of the above embodiments, such as all or part of the process in the diagnostic process can be completed by instructing the relevant hardware through a computer program, and the computer program can be stored in a non-volatile computer-readable storage medium, when the computer program is executed, it may include the processes of each above-mentioned methods of the embodiments. Wherein any references to memory, storage, database or other medium made in the embodiments provided in the present application may include non-volatile and/or volatile memory. Non-volatile memory may include read-only memory (ROM), programmable ROM (PROM), electrically programmable ROM (EPROM), electrically erasable programmable

ROM (EEPROM), or flash memory. Volatile memory may include random access memory (RAM) or external cache memory. By way of illustration and not limitation, RAM is available in various forms, such as static RAM (SRAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), double data rate SDRAM (DDRSDRAM), enhanced SDRAM (ESDRAM), synchronous link (Synchlink) DRAM (SLDRAM), Rambus DRAM (RDRAM), direct Rambus RAM (DRDRAM), and Rambus dynamic RAM (RDRAM), etc.

10 [80] The technical features of the above embodiments can be in any combination. For the sake of clear description, not all possible combinations of the technical features in the above embodiments are described. However, as long as there is no contradiction in the combination of these technical features, the combinations are deemed to be in the scope stated in this description.

[81] The computing device described in the present application is a computing device that can automatically perform numerical calculation and/or information processing according to preset or stored instructions in a broad sense, and its hardware may include at least one memory, at least one processor, and at least one communication bus. Wherein, the communication bus is used to realize the communication links between these components. A processor may include, but is not limited to, a microprocessor. The computer hardware may also include an Application Specific Integrated Circuit (ASIC), a Field-Programmable Gate Array (FPGA), a Digital Signal Processor (DSP) and an embedded device, etc. The computing device may also include a network device and/or a user device. Wherein, the network device includes but is not limited to a single network server, a server group composed of multiple network servers, or a cloud composed of a large number of hosts or network servers based on Cloud Computing, wherein, Cloud Computing is a kind of distributed computing which is a virtual supercomputer composed of a group of loosely coupled computer sets.

35 [82] The computing device may be, but is not limited to, any terminal such as a personal computer or a server which can perform human-computer interactions with a user through a keyboard, a touchpad, or a voice-

controlled device. The computing device herein may also include a mobile terminal, which may be, but is not limited to, any electronic device that can perform human-computer interactions with a user through a keyboard, a touchpad, or a voice-controlled device, for example, tablet computers, smartphones, Personal Digital Assistants (PDA), smart wearable devices and other terminals. The network where the computing device is located includes, but is not limited to, the Internet, a wide area network, a metropolitan area network, a local area network and a virtual private network (VPN), etc.

[83] The memory is used to store program codes. The memory may be a circuit with a storage function that has no physical form in an integrated circuit, such as RAM (Random-Access Memory), FIFO (First In First Out), etc. Alternatively, the memory can also be in a physical form, such as a memory stick, a TF card (Trans-flash Card), a smart media card, a secure digital card and a flash card, etc.

[84] The processor may include one or more microprocessors and digital word processors. The processor may invoke the program code stored in the memory to perform the relevant functions. The processor is also called a Central Processing Unit (CPU). It can be a super large-scale integrated circuit, which is a computing Core and a Control Unit.

[85] It should be noted that, for the sake of simple description, the above-mentioned methods of embodiments are all expressed as a series of combinations of actions, but it should be understood by those skilled in the art that the present application is not limited by the sequence of actions described herein. Since according to the present application, certain steps may be performed in other sequences or concurrently. Secondly, it should be understood by those skilled in the art that the embodiments described in the description are all preferred embodiments, and the actions and modules involved are not necessarily required by the present application.

[86] In the above-mentioned embodiments, the description of each embodiment has its own emphasis, for parts that are not described in detail in a certain embodiment, references may be made in the relevant

descriptions of other embodiments.

[87] The above embodiments are only used to illustrate the technical solutions of the present application, but not to limit them; although the present application has been described in detail with reference to the foregoing embodiments, it should be understood by those ordinary skill in the art that: the technical solutions stated in the foregoing embodiments can still be modified, or some technical features thereof can be equivalently replaced; and these modifications or replacements do not depart the spirit of the corresponding technical solutions from the scope of the technical solutions of the embodiments of the present application.

[88] The above-mentioned embodiments only represent several embodiments of the present application, and the descriptions thereof are relatively specific and detailed, but they should not be construed as limiting the scope of the patent application. It should be pointed out that those of ordinary skill in the art, without departing from the concept of the present application, can make certain modifications and improvements which all belong to the scope of protection of the present application. Therefore, the scope of patent protection in the present application shall be subject to the appended claims.

CLAIMS

1. A smart power distribution system for electric vehicles (EV) (50), characterized by:
 - 5 one or a plurality of EV charger (40) for charging electric vehicles (50);
 - a controller (20), which communicates with the EV chargers (40), and is used for performing charging management of the said one or a plurality of EV charger (40), all EV chargers (40) managed by the controller (20) constitute a smart power distribution network, and the said controller (20) uses a preset power load
 - 10 balancing method to control the charging power of all EV chargers (40) in the said smart power distribution network; and
 - a back end server (10), which communicates with the controller (20), and is used to prepare the charging service for the controller (20).
- 15 2. A smart power distribution system for electric vehicles (50) according to claim 1, wherein the said back end server (10) communicates with the said controller (20) based on the Message Queuing Telemetry Transport (MQTT) protocol, and the said controller (20) communicates with the said EV charger (40) based on the Open Charge Point Protocol (OCCP).
- 20 3. A smart power distribution system for electric vehicles (50) according to claim 1, further comprises a sensor (30), for sensing the real-time power load data of the EV charger (40) and feeding it back to the controller (20).
4. A smart power distribution system for electric vehicles (50) according to claim 3, wherein the said controller (20) determines whether the EV (50) violates the
- 25 charging protocol according to the feedback from the sensor (30), and performs the following operations on the EV (50) in violation the charging protocol:
 - limiting the EV (50) in violation of the protocol to a safe charging power or to a preset low charging power; and
 - 30 when the main power loading is detected to exceed the maximum available power, restricting all EVs (50) to charge at the minimum charging power, the load balancer will re-do the balancing.
5. A smart power distribution system for electric vehicles (50) according to claim

1, wherein the said power load balancing methods comprise:

Even Distribution Algorithm: when the total available power is greater than the sum of charging powers of all EV chargers (40), all EV chargers (40) are charged at the maximum charging power, when the total available power is less than or equal to the sum of charging powers of all EV chargers (40), EV chargers (40) are charged at the safe charging power;

Priority Distribution Algorithm: the EV chargers (40) are sorted into high priority EV chargers (40) and normal priority EV chargers (40), when the sum of the maximum charging powers of all high priority EV chargers (40) is less than the total available power, each high priority EV chargers (40) is distributed the maximum charging power, otherwise, each high priority EV charger (40) is distributed the safe charging power; after the high priority charging points are distributed, the remaining power is equally distributed to the normal priority EV chargers (40);

First Come First Served Algorithm: all EV chargers (40) are sorted into a charging queue according to the time of issuance of the charging requests, the controller distributes to all EV chargers (40) a charging power not lower than the minimum charging power; when the minimum charging power distributed to all EV chargers (40) cannot be maintained; the charging request of the EV chargers (40) is suspended in sequence from the end to the head of the queue, until the minimum charging power of the non-suspended EV chargers (40) can be maintained;

Premier Distribution Algorithm: the EV chargers (40) are sorted into premier EV chargers (40) and normal EV chargers (40), the controller (20) distributes the minimum charging power to each normal EV chargers (40), and distributes the remaining charging power equally to each premier EV chargers (40).

6. A smart power distribution system for electric vehicles (50) according to claim 5, wherein the said safe charging power is a fixed preset value, or the charging power obtained when the total available power is equally divided among each EV charger (40).
7. A smart power distribution system for electric vehicles according to claim 1, wherein the said controller (20) characterizes all EVs (50) in the smart power distribution network according to their charging performances, and sends a probing signal to detect each EV's charging characteristics one by one, the

said charging characteristics comprise: maximum charging power of the EV, minimum charging power of the EV, the response time of the EV to start charging power from zero to minimum charging power, the response time of the EV to start charging power from zero to maximum charging power, the response time of the EV to decrease the charging power from maximum to minimum, the response time of the EV to decrease the charging power from minimum to zero, the response time of the EV to change the charging power from zero to maximum, the response time of the EV to decrease the charging power from maximum to zero.

8. A smart power distribution system for electric vehicles (50) according to claim 7, wherein when the EV (50) is connected to the EV charger (40) and makes a request to start the charging service, a probing signal will be sent out so to collect the charging characteristics of the EV (50), if the EV (50) does not respond to the probing signal correctly, the controller (20) will label such EV (50) as the EV (50) having the lowest priority, and will only distribute minimum charging power to such EV (50).