

CLAIMS

What is claimed is:

1. A method for recognizing an operating state of a photovoltaic string, comprising:
 - calculating a theoretical power and a theoretical maximum short-circuit current of the photovoltaic string under a current operating condition, wherein the photovoltaic string is a circuit unit with a DC output formed by at least two photovoltaic modules connected in series;
 - calculating a typical year theoretical power and a typical year maximum short-circuit current of the photovoltaic string;
 - establishing standard state parameters of the photovoltaic string based on the theoretical power, the theoretical maximum short-circuit current, the typical year theoretical power, and the typical year maximum short-circuit current of the photovoltaic string, wherein the standard state parameters comprise a power threshold and a short-circuit current threshold of the photovoltaic string;
 - acquiring operating state parameters of the photovoltaic string under the current operating condition, wherein the operating state parameters comprise an operating power and an operating current of the photovoltaic string; and
 - determining the operating state of the photovoltaic string by comparing the operating state parameters of the photovoltaic string with the corresponding standard state parameters of the photovoltaic string.
2. The method according to claim 1, wherein establishing the standard state parameters of the photovoltaic string based on the theoretical power, the theoretical maximum short-circuit current, the typical year theoretical power, and the typical year maximum short-circuit current of the photovoltaic string comprises:
 - determining a smaller one of the theoretical power and the typical year theoretical power of the photovoltaic string as the power threshold; and

determining a smaller one of the theoretical maximum short-circuit current and the typical year maximum short-circuit current of the photovoltaic string as the short-circuit current threshold.

3. The method according to claim 1, wherein before calculating the theoretical power and the theoretical maximum short-circuit current of the photovoltaic string under the current operating condition, the method further comprises:

acquiring, at a preset interval, an instantaneous irradiance of a photovoltaic field station where the photovoltaic string is installed;

determining a period during which the instantaneous irradiance of the photovoltaic field station is greater than or equal to an irradiance threshold as a detection period; and

determining an operating condition in a specified period within the detection period as the current operating condition.

4. The method according to claim 1, wherein calculating the theoretical power and the theoretical maximum short-circuit current of the photovoltaic string under the current operating condition comprises:

acquiring an irradiance, an ambient temperature, and a wind speed of a photovoltaic field station under the current operating condition based on meteorological data corresponding to the photovoltaic field station in response to presence of the meteorological data;

calculating temperatures of the photovoltaic modules in the photovoltaic string under the current operating condition based on the irradiance, the ambient temperature, and the wind speed of the photovoltaic field station under the current operating condition;

calculating temperatures of cells of the photovoltaic modules under the current operating condition based on the temperatures of the photovoltaic modules;

calculating an average operating temperature of the cells of the photovoltaic modules corresponding to the current operating condition based on irradiances of the photovoltaic modules at a detection time corresponding to the current operating condition

in a typical year and the temperatures of the photovoltaic modules at the detection time corresponding to the current operating condition in a typical year; and

calculating the theoretical power and theoretical maximum short-circuit current of the photovoltaic string under the current operating condition based on the irradiance of the photovoltaic field station under the current operating condition, the average operating temperature of the cells of the photovoltaic modules and the temperatures of the cells of the photovoltaic modules under the current operating condition.

5. The method according to claim 1, wherein calculating the theoretical power and the theoretical maximum short-circuit current of the photovoltaic string under the current operating condition comprises:

acquiring a maximum current in all photovoltaic strings under the current operating condition in response to a case where the meteorological data corresponding to the photovoltaic field station is not present;

calculating an irradiance of the photovoltaic field station under the current operating condition based on the maximum current; and

calculating the theoretical power and theoretical maximum short-circuit current of the photovoltaic string in the photovoltaic field station based on the irradiance of the photovoltaic field station under the current operating condition, the short-circuit current of the photovoltaic modules under a standard operating condition and irradiances of the photovoltaic modules under a standard test condition.

6. The method according to claim 1, wherein calculating the typical year theoretical power and the typical year maximum short-circuit current of the photovoltaic string comprises:

acquiring irradiances of the photovoltaic field station in a typical year according to a geographic location of the photovoltaic field station, wherein an interval of collecting an irradiance of the photovoltaic field station in the typical year is identical to an interval of acquiring an irradiance of the photovoltaic field station under an operating condition;

selecting a maximum irradiancy among the irradiancies of the photovoltaic field station in the typical year at a detection time corresponding to the current operating condition; and

calculating the typical year theoretical power and the typical year maximum short-circuit current of the photovoltaic string in the photovoltaic field station based on the maximum irradiancy.

7. The method according to claim 1, wherein determining the operating state of the photovoltaic string by comparing the operating state parameters of the photovoltaic string with the corresponding standard state parameters of the photovoltaic string comprises:

determining that a power of the photovoltaic string is inflated in response to a case where the operating state parameters of the photovoltaic string are greater than the standard state parameters of the photovoltaic string for a duration longer than a first time-threshold;

determining that a short-circuit occurs in the photovoltaic string in response to a case where a current in the operating state parameters of the photovoltaic string is less than a current threshold for a duration greater than a second time-threshold; and

determining that the current or the power of the photovoltaic string is low in response to a case where the operating state parameters of the photovoltaic string are less than weighted standard state parameters of the photovoltaic string for a duration greater than a third time-threshold.

8. An apparatus for recognizing an operating state of a photovoltaic string, comprising:

a first calculating module, configured to calculate a theoretical power and a theoretical maximum short-circuit current of the photovoltaic string under a current operating condition, wherein the photovoltaic string is a circuit unit with a DC output formed by at least two photovoltaic modules connected in series;

a second calculating module, configured to calculate a typical year theoretical power and a typical year maximum short-circuit current of the photovoltaic string;

a standard establishing module, configured to establish standard state parameters of the photovoltaic string based on the theoretical power, the theoretical maximum short-circuit current, the typical year theoretical power, and the typical year maximum short-circuit current of the photovoltaic string, wherein the standard state parameters comprise a power threshold and a short-circuit current threshold of the photovoltaic string;

a first acquiring module, configured to acquire operating state parameters of the photovoltaic string under the current operating condition, wherein the operating state parameters comprise an operating power and an operating current of the photovoltaic string; and

a determining module, configured to determine the operating state of the photovoltaic string by comparing the operating state parameters of the photovoltaic string with the corresponding standard state parameters of the photovoltaic string.

9. A computer device, comprising a processor and a memory storing at least one instruction, at least one program, a code set, or an instruction set; wherein the at least one instruction, the at least one program, the code set, or the instruction set, when loaded and executed by the processor, causes the processor to perform the method as defined in any one of claims 1 to 7.

10. A non-transitory computer-readable storage medium storing at least one instruction, at least one program, a code set, or an instruction set; wherein the at least one instruction, the at least one program, the code set, or the instruction set, when loaded and executed by a processor of a computer device, causes the computer device to perform the method as defined in any one of claims 1 to 7.