

RENEWABLE ENERGY MANAGEMENT SYSTEM

BACKGROUND

Field of Disclosure

[0001] The disclosure generally relates to an energy system, and more particularly, to a renewable energy management system.

Description of Related Art

[0002] One of the most important issues of sustainable management is about developing renewable energy to be provided as the electricity demand of the human society. The solar energy optoelectric transform technique is the subject that the related industry in the world dedicates resources. Nuclear power generation, coal-fired power generation, or thermal power generation can provide the electricity, however, the damage to the natural environment in the power generating process is, for example, carbon dioxide emission, nuclear waste which can not be processed, and so on, all are the conundrum that the developed countries have to face with.

[0003] The renewable energy which is obtained from natural resources also exists problems. For example, the weather of the natural environment, the temperature, the tides, the oceanic phenomena, and so on, all are the puzzle that human can not deal with. Furthermore, the problem about transforming the energy or adjusting the energy and the circuit damage on the power plant induced by the variability of the natural environment are technical problems for the renewable energy developers to be solved.

SUMMARY

[0004] The present disclosure of an embodiment provides a renewable energy management system including an energy system and a monitoring apparatus. The energy system is configured to store battery power. The monitoring apparatus is electrically coupled with the energy system. The monitoring apparatus is configured to select a target curve from a plurality of prediction curves, and each of the prediction curves includes a plurality of time points and a target feed power corresponding to each time point. The monitoring apparatus controls the energy system to provide target feed power at each time point to an external energy system. The monitoring apparatus computes a smooth compensation parameter when determining that a change rate of an actual feed curve of the energy system is larger than a rated value, and adjusts the actual feed curve according to the smooth compensation parameter, such that the actual feed curve of the energy system satisfies the target curve.

[0005] The renewable energy management system and method provide beneficial effects:

(1) The power-supplying mode for the next day can be selected by the weather forecast, and the change rate of the power supply can be controlled within a range for maintaining the system stabilization.

(2) The electric quantity of renewable energy can be predicted, such that the initial battery power of the next period can be estimated when the current time period is going to be finished. Therefore, the effect of protecting the battery circuit and exerting the best charging-discharging of the battery can be achieved.

(3) The time period of the supplying peak can be controlled to overcome the problem that the renewable energy system in the prior art can only provide the maximum power in the time period of the supplying peak, and the effect of maintaining the plant stabilization can be achieved.

[0006] The following drawings and descriptions of the disclosure are shown in detail, though they are not limited herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The disclosure can be more fully understood by reading the following detailed description of the embodiments, with reference made to the accompanying drawings as described below. It should be noted that the features in the drawings are not necessarily to scale. The dimensions of the features may be arbitrarily increased or decreased for clarity of discussion.

[0008] Fig. 1 is a block diagram illustrating a renewable energy management system in some embodiments of the present disclosure.

[0009] Fig. 2 is a flow chart illustrating a renewable energy management method according to some embodiments of the present disclosure.

[0010] Fig. 3A is a target curve diagram according to some embodiments of the present disclosure.

[0011] Fig. 3B is a curve diagram of the renewable energy management method according to some embodiments of the present disclosure.

[0012] Fig. 4 is a block diagram of a monitoring apparatus inside the renewable energy management system in Fig. 1 according to some embodiments of the present disclosure.

[0013] Fig. 5 depicts dynamically modifying the target curve of the renewable energy management system according to some embodiments of the present disclosure.

[0014] Fig. 6 depicts an actual supplying-power curve which is adjusted by the renewable energy management system according to the target curve according to some embodiments of the present disclosure.

[0015] For the sake of understanding the disclosure incorporating with the descriptions, purposes, features, advantages, and embodiments, the numbers of the drawings are listed below:

100	renewable energy management system
110	monitoring apparatus
111	decision circuit
113	control circuit
115	smooth compensation circuit
120	energy system
121	electricity generating device
123	electricity storage device
125	charge-discharge control circuit
300	external energy system

200	renewable energy management method
H1-H4	houses
S210-S270	steps
$P_1(t)$, $P_2(t)$, $P_3(t)$	prediction curve
$GE(t)$	electric-power generation curve
$P_c(t)$	target curve
$P_{real}(t)$	actual feed curve
A, B, C, D, E, T, O, M_x , N_x , K1, K2, T_{G1} , T_{G2} , T_{P1} , T_{P2}	time points
M_{y1} , M_{y2} , N_{y1} , N_{y2}	electric quantity
T_{peak} , G_{peak}	time period
P_{max} , G_{max}	supplying maximum

DETAILED DESCRIPTION

[0016] The following examples of which are illustrated in the accompanying drawings for the structural and operational features of the disclosure:

[0017] The different embodiments or examples are provided below for practicing different features of the disclosure. For the sake of brevity, the following embodiments of describing elements and arrangements are shown. It should be noted that the embodiments are shown as some practices without limitation therein. Furthermore, the element symbols and/or alphabets can be used repeatedly in each embodiment for distinguishing the same or similar elements

or operations and are not intended to limit the technical elements and the order of the operations in the present disclosure.

[0018] Reference is made to Fig. 1, which is a block diagram illustrating a renewable energy management system in some embodiments of the present disclosure. The renewable energy management system 100 includes a monitoring apparatus 110 and an energy system 120. The monitoring apparatus 110 of the renewable energy management system 100 is electrically coupled with an external energy system 300. The energy system 120 includes a plurality of electricity generating devices 121 and a plurality of electricity storage devices 123. The energy system 120 is configured to store battery power. For example, the plurality of electricity generating devices 121 of the energy system 120 is configured to receive solar energy and to transform the solar energy into electricity by optoelectronic transform technique. The electricity storage device 123 of the energy system 120 stores the electricity which is transformed. The energy system 120 can be sited in the community, the school, the plant, the company, and on the like, and the energy system 120 is not limited to the location and the scale of electricity utilization in the present disclosure.

[0019] In some embodiments, the renewable energy management system 100 can control the time period of the power-supplying peak to overcome problems, such as the power supply of the current energy system is unstable, the electricity utilization a day varies extraordinarily, and the weather condition changes suddenly. A detailed description of how to control the electricity generation in the peak duration will be disclosed below.

[0020] Taking that the energy system 120 is sited in the community as an example. As shown in Fig. 1, the community has multiple houses H1-H4. The electricity generating device 121, the electricity storage device 123, and a charge-discharge control circuit 125 are disposed in the house H1. The electricity storage device 123 is electrically coupled with the electricity generating device 121, such that the electricity storage device 123 can store electricity that the electricity generating device 121 generates. In the daytime, the electricity generating device 121 of each house can generate electricity for the self-usage of the house. The house which does not dispose the electricity storage device 123 can provide the residual electricity to the external energy system 300 for storage. The external energy system 300 is, for example, the power grid system that is disposed with the power storing system, the power generating system, and the monitoring center. In some embodiments, the charge-discharge control circuit 125 is electrically coupled with the electricity generating device 121, the electricity storage device 123, and the monitoring apparatus 110. In some embodiments, the houses H2-H4 also include the electricity generating device 121 and the charge-discharge control circuit 125, and the electricity storage device 123 can be disposed in the houses optionally. The monitoring apparatus 110 is electrically coupled with the charge-discharge control circuit 125 of the houses H1-H4 respectively. The charge-discharge control circuit 125 is configured to adjust the power-supplying output, the electricity storage, and the similar operations of the electricity generating device 121 and the electricity storage device 123 of each house.

[0021] The monitoring apparatus 110 is electrically coupled with the energy system 120. The monitoring apparatus 110 is configured to manage and

dispatch the renewable energy in the renewable energy management system 100, and also control the power-supplying quantity of each time point. For example, the monitoring apparatus 110 pre-stores power-supplying modes related to different weather conditions and selects the most suitable power-supplying mode according to the weather forecast of the next day for the management and the electricity dispatch of the next day. The monitoring apparatus 110 controls the energy system 120 to provide electricity according to the time points and the electric quantity corresponding to the time points which are recorded by the power-supplying mode. Therefore, after processing of a day, the actual power supply of the energy system 120 is the same with or similar to the record of the power-supplying mode. The operations of the renewable energy management system 100 are described below.

[0022] Reference is made to Fig. 2. Fig. 2 is a flow chart illustrating a renewable energy management method 200 according to some embodiments of the present disclosure. As shown in Fig. 2, in step S210, the monitoring apparatus 110 selects a target curve from a plurality of prediction curves and adjusts an initial electric quantity of the battery power. Each prediction curve is a continuous-time function that includes a plurality of time points and the target feed power corresponding to each time point. In some other embodiments, the prediction curve can be the discrete-time electric quantity function.

[0023] The prediction curve is the time-electric quantity curve in each power-supplying period (e.g., a day), which indicates the electric quantity at each time point. For the sake of brevity, the electric quantity which can be provided at each corresponding time point is the electric quantity at 10 a.m. or the electric

quantity which can be provided during a time interval, such as the electric quantity which is provided from 10 a.m. to 11 a.m. or from 2 p.m. to 2:30 p.m.. It should be noted that the time interval is not limited to the examples above. The embodiments of the electric quantity of a time interval with any starting time point (e.g., 2 p.m.) through a time length (e.g., 30 minutes or 60 minutes) belong to the scope of the present disclosure.

[0024] The prediction curves can be smooth curves that are designed in advance. For example, the slope of the prediction curve at each point is between a first threshold $r1$ and a second threshold $r2$. For showing the smooth level of the prediction curve $P(t)$, the slope of the prediction curve $P(t)$ (i.e., the instantaneous change rate at each time point) $dP(t)/dt$, will be controlled to satisfy the following conditions: $r2 < dP(t)/dt < r1$. In some embodiments, $r1$ is the upper bound of the change rate of the power supply. For example, $r1$ is 0.1%. In some embodiments, $r2$ is the lower bound of the change rate of the power supply. For example, $r2$ is -0.1%. Therefore, in step S210, the target curve which is selected from the plurality of prediction curves by the monitoring apparatus 110 is also the smooth curve.

[0025] The target curve is the time-electric quantity curve, and the total supplying electric quantity which is the sum of the electric quantity at each time point (e.g., integrating the curve by time, $\int P(t)dt$) has to be the same as the total electric quantity ($E_{PV_estimated}$) which is predicted that the next day the energy system 120 generates.

[0026] Therefore, the total generating electric quantity that the renewable energy management system 100 generates will be similar to the total supplying electric

quantity that the renewable energy management system 100 provides in the same day according to the prediction techniques for the supplying power and the generating power (by the optoelectric transform to generate the electric), and the change rate of the supplying power is smooth. Therefore, the problem that the instantaneous change rate of the supplying power of the renewable energy management system 100 is so large that the system is unstable and cannot adjust the disturbance immediately is solved.

[0027] Continuing step S210, after obtaining the total generating electric quantity and the total supplying electric quantity which are predicted, the monitoring apparatus 110 adjusts current battery power, such that the current battery power is smaller than a first electric quantity and larger than a second electric quantity. The first electric quantity is a difference value between the power that the battery is charged from 0% to 100% and the power that the battery consumes itself. The second electric quantity is the initial electric quantity of the target curve. For example, the battery is capable of storing the total electric quantity, 200000 MW(megawatts), and the total generating electric quantity the next day which is predicted is 190000 MW. If the battery power remains the electric quantity 60000 MW at about 11:30 p.m., and the initial electric quantity corresponding to the initial time point (i.e., the time point when starting to provide power) of the target curve which is selected according to the weather report of the next day is 10000 MW, the battery power will be adjusted to 10000 MW, that is, the redundant electric quantity, 50000 MW, will be outputted to other power grid system (not shown in the figure).

[0028] Therefore, because the battery power is scheduled in advance, the electric quantity to be provided is reserved in advance and the capacity of the battery to store the electricity is also made some space for storing the generated electricity in the future (e.g., the next day), the high voltage pressure of the battery can be prevented from keeping generating electricity in the daytime (e.g., the generated electric quantity is larger than the supplied electric quantity). For example, if the electric quantity 50000 WM was not outputted to other power grid, the sum of the total predicted generating electric quantity 190000 MW and the battery residual electric quantity 60000 MW is 250000 MW. However, because the battery storage capacity is only 200000 MW, 50000 MW of the electric quantity which cannot be stored will be spilled out and the battery will also be damaged easily due to the high voltage. In the embodiment, the remained battery power in the initial time is also enough to supply electricity normally during generating power, and the situation of the lack of electric quantity will not occur.

[0029] Reference is made to Fig. 3A, which is a target curve diagram according to some embodiments of the present disclosure. The monitoring apparatus 110 stores a plurality of prediction curves. As shown in Fig. 3A, in the axis of time, the segment from point O to point T indicates a time period, for example, from 0:0 a.m. to 11:59 p.m.. The first prediction curve $P_1(t)$, the second prediction curve $P_2(t)$, and the third prediction curve $P_3(t)$ indicate that the energy system 120 starts to supply the electric quantity at point A (e.g., 6:15 a.m.) and increasingly supplies the electric quantity according to the time. The time segment from time point C (e.g., 5:00 p.m.) to time point E (e.g., 8:00 p.m.) is the supplying peak, and time point D (e.g., 6:30 p.m.) is the supplying maximum. After the supplying

maximum, the supplying electric quantity is decreased gradually as time goes on, and the supplying electric quantity will be zero at time point B (e.g., 11:15 p.m.).

[0030] In Fig. 3A, the first prediction curve $P_1(t)$, the second prediction curve $P_2(t)$, and the third prediction curve $P_3(t)$ corresponding to the time period (e.g., 24 hours) are applied for providing the electric quantity based on different weather conditions. The better the weather condition is (e.g., sunny and cloudless), the more electric quantity generated by the energy system 120 with the optoelectric transform is. The worse the weather condition is (e.g., the dark clouds with lightning), the less electric quantity generated by the energy system 120 with the optoelectric transform is. For example, at time point C (e.g., 5:00 p.m.), the first prediction curve $P_1(t)$ is suitable for the sunny weather, so the first prediction curve $P_1(t)$ provides the electric quantity more than the second prediction curve $P_2(t)$ and the third prediction curve $P_3(t)$. It should be noted that three prediction curves are taken as the embodiment in the present disclosure, however, the prediction curve number is not limited herein and different numbers and curve patterns can be designed based on the actual demands.

[0031] Reference is further made to Fig. 2, in step S220, according to the target curve which is selected, the monitoring apparatus 110 controls the energy system 120 to supply the target feed power of the target curve at each time point. For example, the target feed power is forwarded to the external energy system 130 or other houses of the energy system 120. The monitoring apparatus 110 controls the energy system 120 to supply power according to the target curve, the description shows below.

[0032] Reference is made to Fig. 3B, which is a curve diagram of the renewable energy management method according to some embodiments of the present disclosure. As shown in Fig. 3B, the electric-power generation curve $GE(t)$ is the curve of the electric quantity that the power is actually generated. Each point on the target curve $P_C(t)$ corresponds to a time point and the target feed power, that is, the energy system 120 will generate power at the time point with the target feed power. In some embodiments, the monitoring apparatus 110 receives the weather forecast data and determines the electric-power generation curve $GE(t)$ according to the weather forecast data. The sum of the electric quantity at each time point on the electric-power generation curve $GE(t)$ (i.e., the area between the electric-power generation curve $GE(t)$ and the time axis) is the total generating electric quantity of the energy system 120 a day. For example, the electric-power generation curve $GE(t)$ is obtained according to the prediction technique about the optoelectronic transform. In some other embodiments, in step S210 of Fig. 2, the step of selecting the target curve from the plurality of prediction curves, the total generating electric quantity at each time point of each prediction curve and the total generating electric quantity of the electric-power generation curve $GE(t)$ is computed for selecting the prediction curve whose total supplying electric quantity is the same or similar to the total generating electric quantity, and the selected prediction curve is applied to be the target curve $P_C(t)$.

[0033] On the other hand, reference is further made to Fig. 1 and Fig. 3B, the monitoring apparatus 110 estimates the storable electric quantity at each time point according to the electric-power generation curve $GE(t)$. For example, at time point M_x , the storable electric quantity is M_{y1} , and the target feed power of the target curve $P_C(t)$ (if the first prediction curve $P_1(t)$ is selected) is M_{y2} .

Because the storable electric quantity M_{y1} is larger than the target feed power M_{y2} , the monitoring apparatus 110 controls the energy system 120 to charge, and the redundant electric quantity (e.g., the difference value between M_{y1} and M_{y2}) is stored in the electricity storage device 123 (as shown in Fig. 1).

[0034] The monitoring apparatus 110 sends a charge command to the charge-discharge control circuit 125, such that the charge-discharge control circuit 125 makes the electricity storage device 123 be charged. At this time, the electric quantity forwarded by the energy system 120 is the power, subtracting the storage power of the electricity storage device 123 from the instantaneous generating power of the electricity generating device 121, such that the electric quantity forwarded by the energy system 120 is close to the target feed power M_{y2} .

[0035] At time point N_x , the storable electric quantity is N_{y2} . At this time, the target feed power of the target curve $P_C(t)$ is N_{y1} . Because the storable electric quantity N_{y2} is smaller than the target feed power N_{y1} , the monitoring apparatus 110 makes the energy system 120 be discharged, and the demanded electric quantity (e.g., the difference value between N_{y2} and N_{y1}) is provided by the electricity storage device 123 (as shown in Fig. 1).

[0036] In some embodiments, the monitoring apparatus 110 sends a discharge command to the charge-discharge control circuit 125, such that the charge-discharge control circuit 125 makes the electricity storage device 123 be discharged. At this time, the electric quantity which the energy system 120 can supply includes the sum of the charged power of the electricity generating device 121 and the discharged power of the electricity storage device 123.

[0037] In some other embodiments, the charge-discharge control circuit 125 can also be disposed in the monitoring apparatus 110, and it is the charge-discharge control circuit of the monitoring apparatus 110 that adjusts the electricity generating device 121 and the electricity storage device 123 of each house.

[0038] As shown in Fig. 1 and Fig. 2, in step S230, the monitoring apparatus 110 determines whether the change rate of the actual feed curve in the energy system 120 is larger than the rated value. The actual feed curve is the time-electric quantity curve that the energy system 120 supplies the actual electric quantity of each time point of the day. For example, after the monitoring apparatus 110 controls the power-supplying mode of the energy system 120 according to the target curve, the energy system 120 may induce the condition that the instantaneous change rate of the electricity generating device 121 changes sharply because the weather condition at the time changes dramatically, such that the actual power-supplying rate is larger than the rated value and the supplied power cannot satisfy the target curve. Then, if the determination of step S230 that the change rate of the actual feed curve in the energy system 120 is not larger than the rated value is made, the flow chart goes back to step S220. If the determination of step S230 that the change rate of the actual feed curve in the energy system 120 is larger than the rated value is made, the smooth compensation parameter is computed in step S240. The step of computing the smooth compensation parameter is described below.

[0039] Reference is made to Fig. 4, which is a block diagram of a monitoring apparatus 110 inside the renewable energy management system 100 in Fig. 1 according to some embodiments of the present disclosure. In Fig. 4, the

monitoring apparatus 110 includes a decision circuit 111, a control circuit 113, and a smooth compensation circuit 115. The control circuit 113 is electrically coupled with the decision circuit 111 and the smooth compensation circuit 115 respectively. The decision circuit 111 is configured to select the most suitable target curve (such as step S210 described above) from the plurality of prediction curves according to the weather report, such that the energy system 120 supplies power according to the time and the plurality of prediction curves of the target curve. The control circuit 113 monitors and controls the power-supplying rate of the energy system 120 and determines whether the power-supplying rate is larger than the rated value (such as step S220 and step S230 described above). When the control circuit 113 determines that the power-supplying rate is larger than the rated value, the control circuit 113 controls the smooth compensation circuit 115 to compute the smooth compensation parameter (such as step S240 described above). For example, when the power-supplying rate is larger than or equal to the rated value, the smooth compensation circuit 115 computes the smooth compensation parameter of the function: $P_{smooth} = P_{smooth,pre} + K * error$, where ' P_{smooth} ' is compensation power, ' $P_{smooth,pre}$ ' is the previous compensation power, ' $error$ ' is the error value between the current supplying power and the average supplying power, and ' K ' is the change rate compensation parameter. The control circuit 113 feedbacks the compensation power to the energy system 120. Therefore, the energy system 120 can adjust the supplying power immediately, such that the power-supplying rate will decrease smoothly and the actual feed curve can be adjusted.

[0040] On the other hand, the control circuit 113 monitors the energy system 120 to determine whether the power-supplying rate becomes smooth. After the

process of smooth compensation controlling, if the energy system 120 works with the smooth supplying power, the smooth compensation circuit 115 outputs a terminating compensation command. For example, when the control circuit 113 determines that the power-supplying rate is smaller than a rated released value, the control circuit 113 controls the smooth compensation circuit 115 to stop computing the smooth compensation parameter. The smooth compensation circuit 115 decreases the compensation power P_{smooth} slowly until zero and finally terminates the smooth compensation for the energy system 120. At the time, the actual feed curve of the energy system 120 matches the target curve.

[0041] Therefore, the monitoring apparatus 110 selects the most suitable target curve according to the weather report to control the energy system 120 to supply power with the mode of the smooth target curve, such that the energy system 120 can supply power stably and the effectiveness of the stable system can be achieved. Furthermore, the monitoring apparatus 110 monitors whether the actual supplying power of the energy system 120 is stable and feedbacks the smooth compensation parameter to the energy system 120 immediately, such that the supplying power of the energy system 120 can be adjusted immediately. The supplying power can be corrected with the smooth compensation immediately, such that the energy system 120 works in a stable environment all day.

[0042] Reference is further made to Fig. 1 and Fig. 2. In step S250, the monitoring apparatus 110 computes the sum (or called the first sum) of the residual battery electric quantity at a time point and the generating electric quantity in the future (i.e., the sum of the residual battery electric quantity and the

predicted generating electric quantity), computes the sum (or called the second sum) of the target feed power after the time point (i.e., the area formed by the target curve after the time point and the time axis), and compares the first sum with the second sum to determine whether the difference value between the first sum and the second sum is larger than a threshold. If the difference value is larger than the threshold, the target curve should be reselected. For example, as shown in Fig. 3B, the area after the time point M_x between the electric-power generation curve $GE(t)$ and the time axis is computed to obtain the predicted generating electric quantity, and the predicted generating electric quantity is added to the residual battery electric quantity, then the predicted total suppliable electric quantity is obtained. On the other hand, the area after the time point M_x between the target curve $P_C(t)$ (if the first prediction curve $P_1(t)$ is selected) and the time axis is computed to obtain the total predicted consuming electric quantity. Then, the difference value between the predicted total suppliable electric quantity and the total predicted consuming electric quantity is computed and a determination of whether the difference value is larger than the threshold is made. For example, when the predicted total suppliable electric quantity is smaller than the predicted total consuming electric quantity, it indicates that the electric quantity provided by the energy system 120 according to the target curve $P_C(t)$ (if the first prediction curve $P_1(t)$ is selected) is so large that the energy system 120 cannot provide the quantity (e.g., the weather condition at that time is not good as the weather report indicates). Therefore, the target curve $P_C(t)$ (if the first prediction curve $P_1(t)$ is selected) needs to be adjusted to decrease the electric quantity provided by the energy system 120. In step S260, the monitoring apparatus 110 reselects the target curve $P_C(t)$ (if the first prediction curve $P_1(t)$ is

selected) from the plurality of prediction curves. The reselection includes, for example, regarding the current weather condition at that time. When the weather condition becomes suddenly a cloudy day, it is the prediction curve that has a lower peak of the electric quantity to be selected as the target curve $P_C(t)$. For example, as shown in Fig. 3A, the prediction curve $P_1(t)$ is used as the target curve $P_C(t)$ at first, but the target curve $P_C(t)$ has to be changed to be the prediction curve $P_2(t)$ because of the weather condition.

[0043] Reference is made to Fig. 5, which depicts the actual feed curve which is adjusted by the renewable energy management system based on the target curve according to some embodiments of the present disclosure. As shown in Fig. 5, the predicted total supplyable electric quantity after the time point K1 is smaller than the predicted total consuming electric quantity, the monitoring apparatus 110 selects the prediction curve $P_2(t)$ from the plurality of prediction curves as the new target curve $P_C(t)$. Because the power-supplying mode of the energy system 120 that is changed from the prediction curve $P_1(t)$ to the prediction curve $P_2(t)$ requires a reaction time, the energy system 120 decreases the value of the prediction curve $P_1(t)$ slowly from the time point K1 (e.g., the average value of the prediction curve $P_1(t)$ and the prediction curve $P_2(t)$) to the prediction curve $P_2(t)$, and the target curve $P_C(t)$ is switched to the prediction curve $P_2(t)$ at the time point K2. Therefore, the renewable energy management system 100 can determine whether the target curve $P_C(t)$ has to be adjusted according to the weather report of the short period of time (e.g., the next day, the next four hours of the day, and so on).

[0044] Reference is further made to Fig. 2, in step S250, according to the sum of the residual battery electric quantity in a time point and the future generating electric quantity and the sum of the target feed power after the time point, when the difference value of the two sums is not larger than the threshold, the flow chart goes to step S270. In step S270, a determination of whether the electric quantity monitor in the entire time period (e.g., one day or 24 hours) is finished. If the determination is positive in step S270, it indicates that another time period for the renewable energy prediction and power supplying control is going to start and the flow chart goes back to step S210, the weather report of the next day is used for the renewable energy management technique described above. If the determination in step S270 is negative, the flow chart goes back to step S220 and continues to monitor the power supplying control.

[0045] Reference is made to Fig. 6, which depicts an actual supplying-power curve which is adjusted by the renewable energy management system 100 according to the target curve according to some embodiments of the present disclosure. As shown in Fig. 1 and Fig. 6, after the renewable energy management method is executed, the time-electric quantity curve which is used for supplying the power of the energy system 120 is the actual feed curve $P_{\text{real}}(t)$, which is the curve close to the target curve $P_C(t)$. For example, the actual feed curve $P_{\text{real}}(t)$ and the target curve $P_C(t)$ have the same peak-supplying time-segment, and the peak-supplying time-segment is the time segment including the supplying maximum.

[0046] Descriptions below include the time segments correspond to the electric quantity of the actual feed curve $P_{\text{real}}(t)$, the target curve $P_C(t)$, and the electric-

power generation curve $GE(t)$. In Fig. 6, the maximal power-supplying value of the actual feed curve $P_{real}(t)$ is the supplying maximum P_{max} . During the time segment T_{peak} , from the time point T_{P1} (e.g., two hours before the supplying maximum P_{max}) to the time point T_{P2} (e.g., two hours after the supplying maximum P_{max}), (for example, the supplying maximum P_{max} is at 12 o'clock, and the time segment is from 10:00 a.m. to 2:00 p.m.), the largest electric quantity of the day can be generated. Similarly, the peak value portion of the target curve $P_C(t)$ is sited in the time segment from the time point T_{P1} to the time point T_{P2} . On the other hand, the energy system 120 (in Fig. 1) can generate electricity according to the electric-power generation curve $GE(t)$. When the weather is sunnier, the increasing rate of the curve is sharper, and the generated electric quantity is larger. For example, during the time segment G_{peak} , from the time point T_{G1} (e.g., two hours before the generating maximum G_{max}) to the time point T_{G2} (e.g., two hours after the generating maximum G_{max}) (for example, the generating maximum G_{max} is at 12 o'clock, and the time segment is from 10:00 a.m. to 2:00 p.m.), the largest electric quantity of the day can be generated. The energy system 120 supplies power according to the target curve $P_C(t)$, and the supplying maximum T_{peak} of the actual feed curve $P_{real}(t)$ is determined based on the variety of the target curve instead of the electric-power generation curve $GE(t)$. In the embodiment, the actual feed curve $P_{real}(t)$ and the target curve $P_C(t)$ have the same peak-supplying time-segment T_{peak} , and they do not have to correspond to or overlap with the time segment G_{peak} of the power-generating peak of the electric-power generation curve $GE(t)$. It should be noted that the target curve $P_C(t)$ can be designed that the peak-supplying time-segment T_{peak} of the target curve $P_C(t)$ corresponds to the time segment G_{peak} of the power-generating peak

of the electric-power generation curve $GE(t)$, such that the monitoring apparatus 110 can supply electricity according to the target curve $P_c(t)$.

[0047] Accordingly, the renewable energy management system and method of the present disclosure can select the power-supplying mode for the next day according to the weather report and control the change rate of the power supplying within a pre-defined range to maintain the system stability. Furthermore, the renewable energy management system and method of the present disclosure can predict the electric quantity generated from the renewable energy, such that the initial battery power of the next time period can be estimated when the current time period is going to finished, for protecting the battery circuit and achieving the best charging-discharging effectiveness of the battery. Also, the renewable energy management system and method of the present disclosure can control the time segment of the supplying maximum, and the problem that the known renewable energy system provides the maximum electric quantity only during the time of the generating maximum is solved, the renewable energy management system and method of the present disclosure can achieve the effectiveness of maintaining the stability of the power plant.

[0048] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present disclosure without departing from the scope or spirit of the disclosure. In view of the foregoing, it is intended that the present disclosure cover modifications and variations of this disclosure provided they fall within the scope of the following claims.

[0049] **Industrial applications**

[0050] The renewable energy management system and method provide beneficial effects:

(1) The power-supplying mode for the next day can be selected by the weather forecast, and the change rate of the power supply can be controlled within a range for maintaining the system stabilization.

(2) The electric quantity of renewable energy can be predicted, such that the initial battery power of the next period can be estimated when the current time period is going to be finished. Therefore, the effect of protecting the battery circuit and exerting the best charging-discharging of the battery can be achieved.

(3) The time period of the supplying peak can be controlled to overcome the problem that the renewable energy system in the prior art can only provide the maximum power in the time period of the supplying peak, and the effect of maintaining the plant stabilization can be achieved.

WHAT IS CLAIMED IS:

1. A renewable energy management system, comprising:
an energy system configured to store battery power;
a monitoring apparatus electrically coupled to the energy system, wherein
the monitoring apparatus is configured to:

select a target curve from a plurality of prediction curves, wherein
each of the prediction curves comprises a plurality of time points and a
target feed power corresponding to each time point;

control the energy system to provide target feed power at each time
point to an external energy system;

compute a smooth compensation parameter when determining that
a change rate of an actual feed curve of the energy system is larger than a
rated value; and

adjust the actual feed curve according to the smooth compensation
parameter, such that the actual feed curve of the energy system satisfies
the target curve.

2. The renewable energy management system of claim 1, wherein the
monitoring apparatus is further configured to:

receive weather forecast data;

determine an electric-power generation curve according to the weather
forecast data; and

select the target curve from the plurality of prediction curves according to
the electric-power generation curve, wherein total electric quantity generated at

each time point of the electric-power generation curve is larger than or equal to total electric quantity provided at each time point of the target curve.

3. The renewable energy management system of claim 1, wherein an instantaneous change rate of the target feed power at each time point of the target curve is smaller than a first threshold and is larger than a second threshold.

4. The renewable energy management system of claim 2, wherein the target curve comprises initial time and initial electric quantity corresponding to the initial time, and the monitoring apparatus controls an electric quantity which is stored at the initial time of the energy system to be the initial electric quantity.

5. The renewable energy management system of claim 1, wherein the monitoring apparatus is further configured to:

determine a storable electric quantity at each time point according to an electric-power generation curve;

wherein when the storable electric quantity is larger than the target feed power, the monitoring apparatus controls the energy system to be charged; and

wherein when the storable electric quantity is smaller than the target feed power, the monitoring apparatus controls the energy system to be discharged.

6. The renewable energy management system of claim 1, wherein the monitoring apparatus is further configured to:

reselect the target curve when determining that a difference value between the battery power at the time point and a sum of the target feed power after the time point is larger than a threshold.

7. The renewable energy management system of claim 6, wherein when the monitoring apparatus determines that the difference value is smaller than a rated released value, the monitoring apparatus decreases the smooth compensation parameter to zero gradually.

8. The renewable energy management system of claim 6, wherein the actual feed curve and the target curve have a same peak-supplying time-segment, wherein the peak-supplying time-segment is a time segment that the electric power is utilized at peak.

9. The renewable energy management system of claim 6, wherein the monitoring apparatus is further configured to:

when determining that the difference value, between a sum of the battery power at the time point and a sum of the target feed power after the time point, is not larger than the threshold, keep controlling the energy system based on the target curve to provide the electric power with the target feed power at each time point to the external energy system.

10. The renewable energy management system of claim 4, wherein the target curve comprises a time period, and the monitoring apparatus is further configured to:

when determining that the time period of the target curve is finished, receive the weather forecast data to select the electric-power generation curve of a next time period;

select the target curve among the plurality of prediction curves according to the electric-power generation curve; and

when determining that the battery power is not equal to the initial electric quantity of the target curve, control the battery power of the energy system at the initial time to be the initial electric quantity.