



US012384257B2

(12) **United States Patent**
Hoshino

(10) **Patent No.:** **US 12,384,257 B2**
(45) **Date of Patent:** **Aug. 12, 2025**

(54) **VEHICLE CONTROLLER FOR REDUCTION
OF POWER CONSUMPTION WHILE
TOWING**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(71) Applicant: **TOYOTA JIDOSHA KABUSHIKI**
KAISHA, Aichi-ken (JP)

(72) Inventor: **Yu Hoshino**, Toyota (JP)

(73) Assignee: **TOYOTA JIDOSHA KABUSHIKI**
KAISHA, Aichi-ken (JP)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 196 days.

10,421,366	B2 *	9/2019	Birkenbeil	.....	B60L 1/02
11,072,321	B2 *	7/2021	Wenger	.....	B60W 20/13
11,247,570	B2 *	2/2022	Oh	.....	B60W 30/18127
11,342,568	B2 *	5/2022	Umayahara	.....	B60L 3/00
11,801,757	B2 *	10/2023	Sawada	.....	B60L 15/20
11,983,969	B2 *	5/2024	Biberstein	.....	B60R 16/0236
12,162,360	B2 *	12/2024	Kirchhoff	.....	B60L 1/02
2022/0260378	A1 *	8/2022	Hanchett	.....	G01C 21/3461
2023/0173950	A1 *	6/2023	Wu	.....	H01M 8/04925
					701/22
2024/0051421	A1 *	2/2024	Du	.....	B60L 3/00

FOREIGN PATENT DOCUMENTS

JP 2014-045587 A 3/2014

* cited by examiner

Primary Examiner — Todd Melton

(74) Attorney, Agent, or Firm — HAUPTMAN HAM,
LLP

(57) **ABSTRACT**

A vehicle controller that is configured to control traveling of an electric vehicle which is a battery electric automobile or a fuel cell automobile, in which, when the electric vehicle performs towing, the vehicle controller judges whether or not power consumption reduction is needed based on an output of a battery that is configured to supply electric power to a traveling motor and the amount of remaining stored energy, and partially limits the function of the electric vehicle if the power consumption reduction is needed, and the amount of remaining stored energy is the amount of remaining charge in the battery when the electric vehicle is the battery electric automobile, and is the amount of remaining stored hydrogen when the electric vehicle is the fuel cell automobile.

9 Claims, 7 Drawing Sheets

(65) **Prior Publication Data**

US 2024/0051403 A1 Feb. 15, 2024

(30) **Foreign Application Priority Data**

Aug. 10, 2022 (JP) 2022-128354

(51) **Int. Cl.**

B60L 15/20 (2006.01)

B60L 58/10 (2019.01)

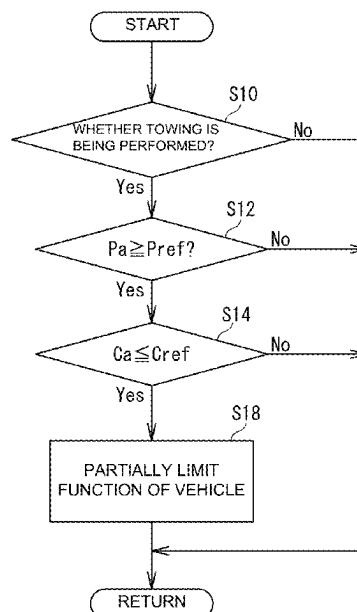
(52) **U.S. Cl.**

CPC **B60L 15/2045** (2013.01); **B60L 58/10**
(2019.02); **B60L 2200/36** (2013.01); **B60L**
2240/12 (2013.01); **B60L 2240/54** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.



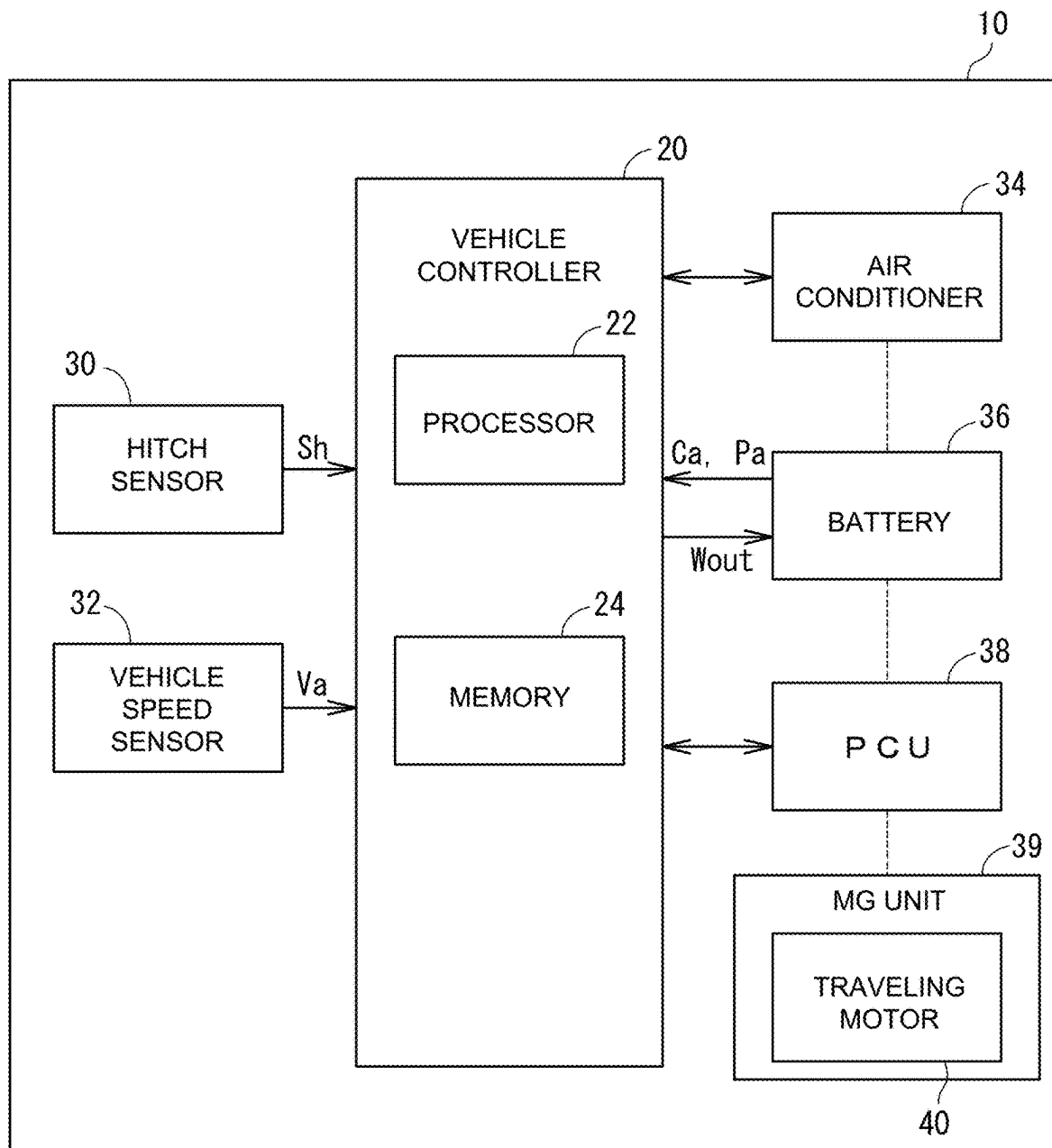


FIG. 1

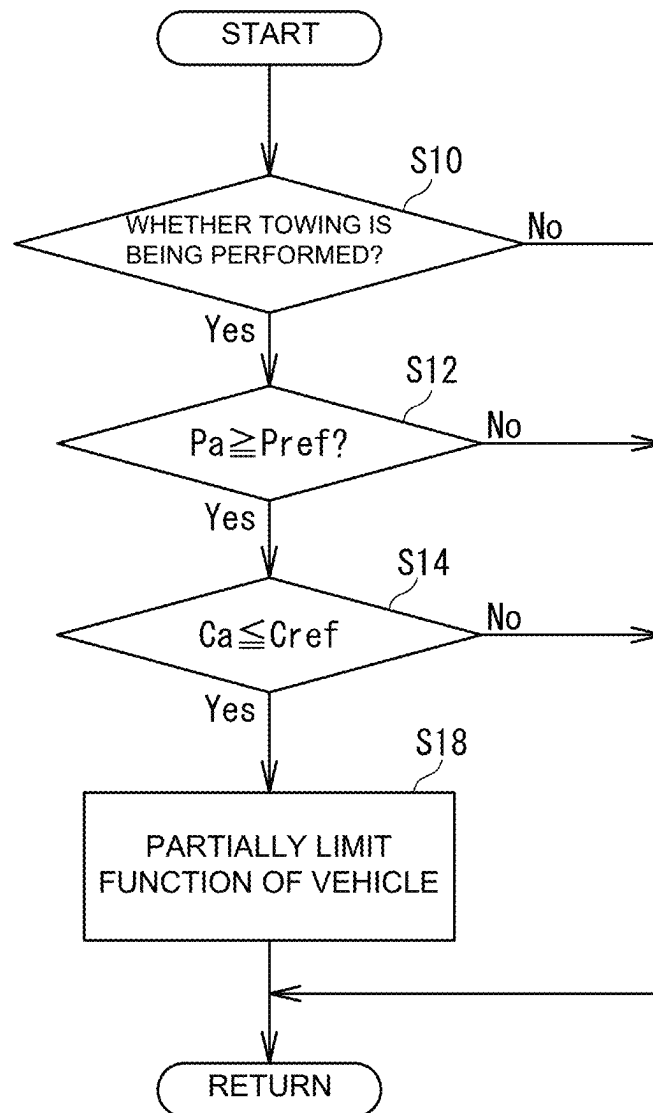


FIG. 2

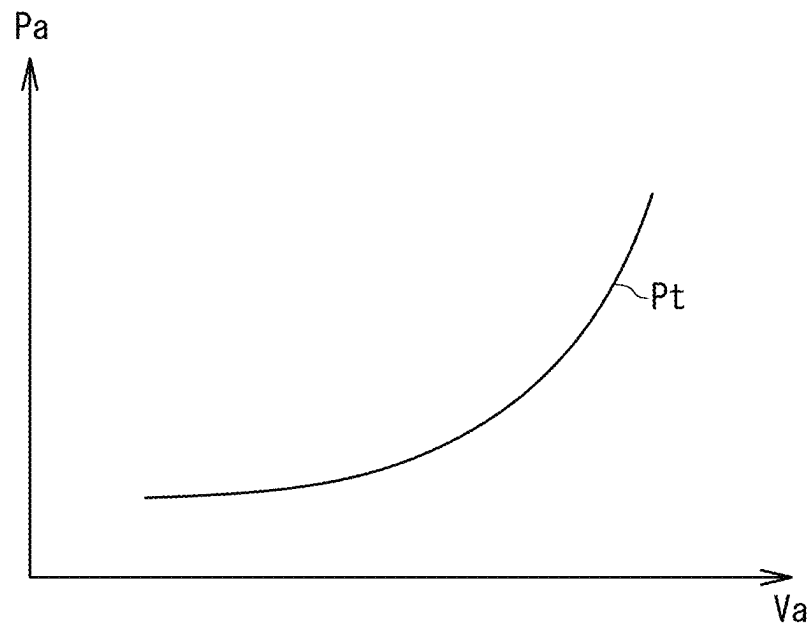


FIG. 3

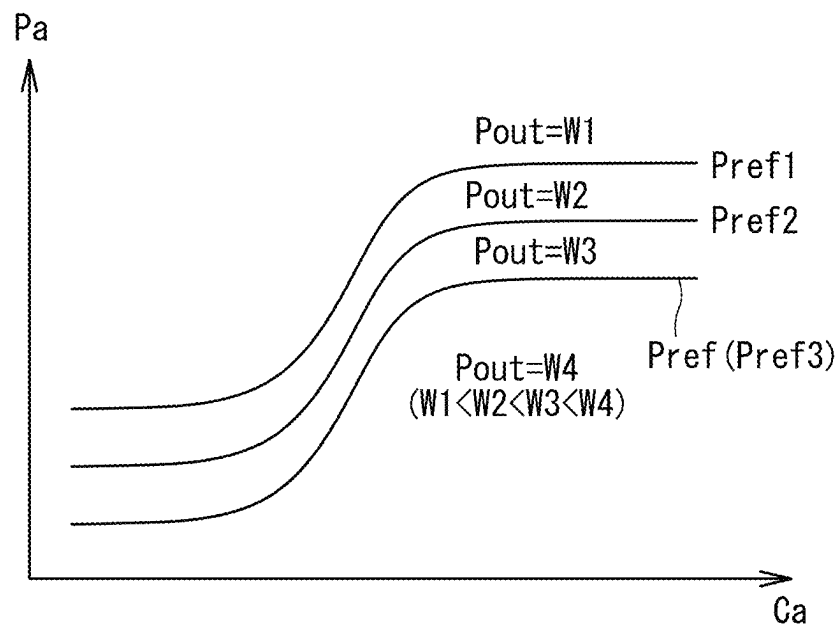


FIG. 4

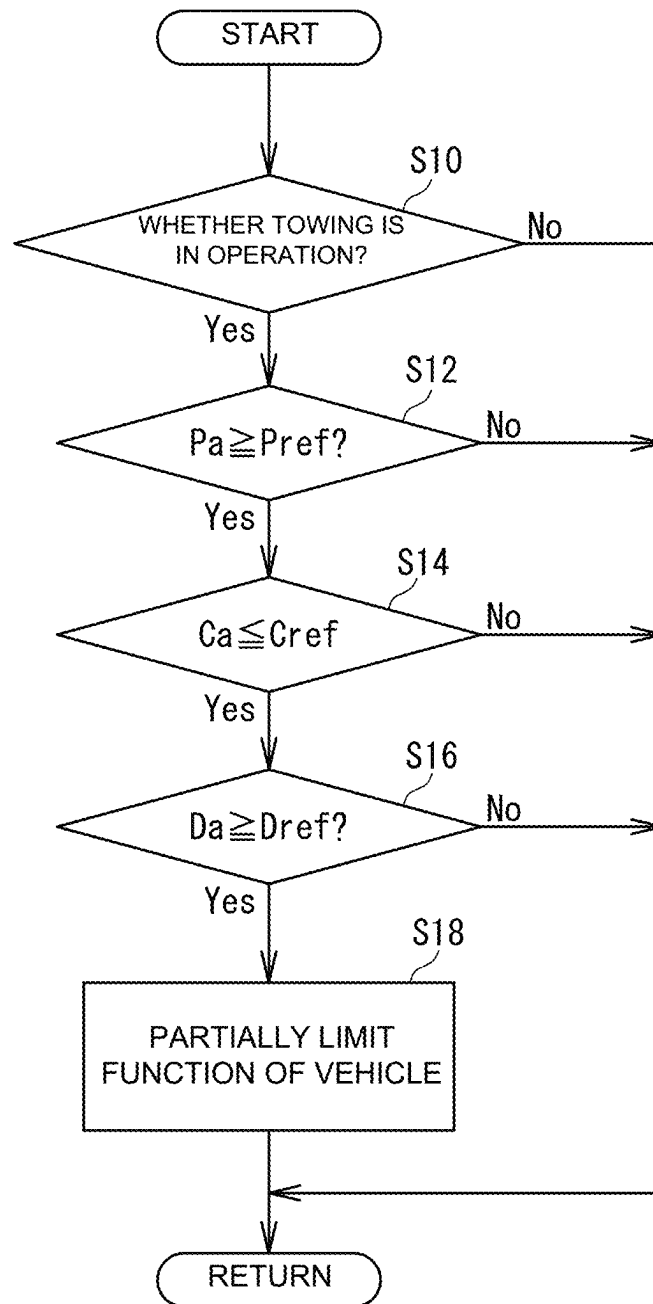


FIG. 5

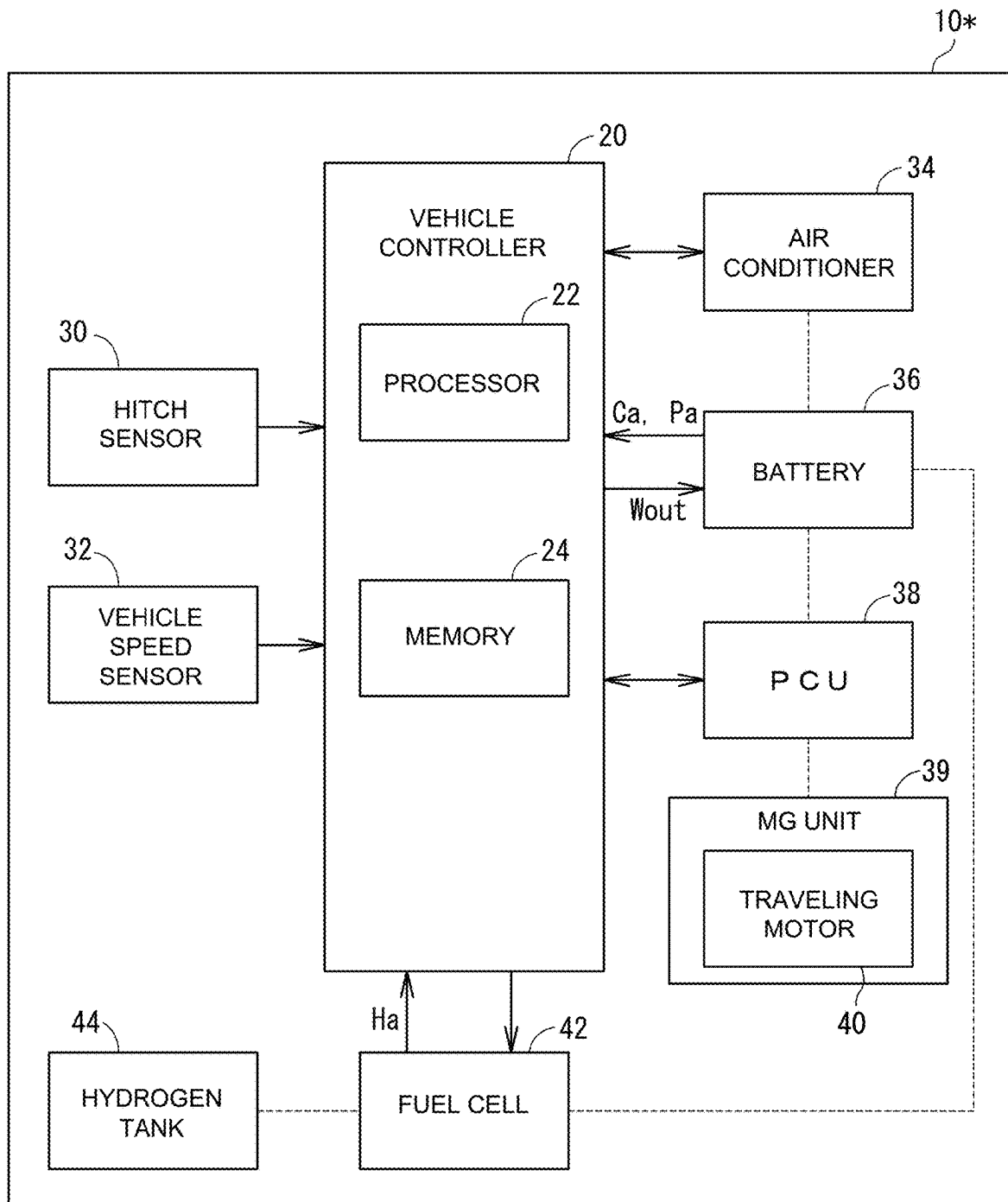


FIG. 6

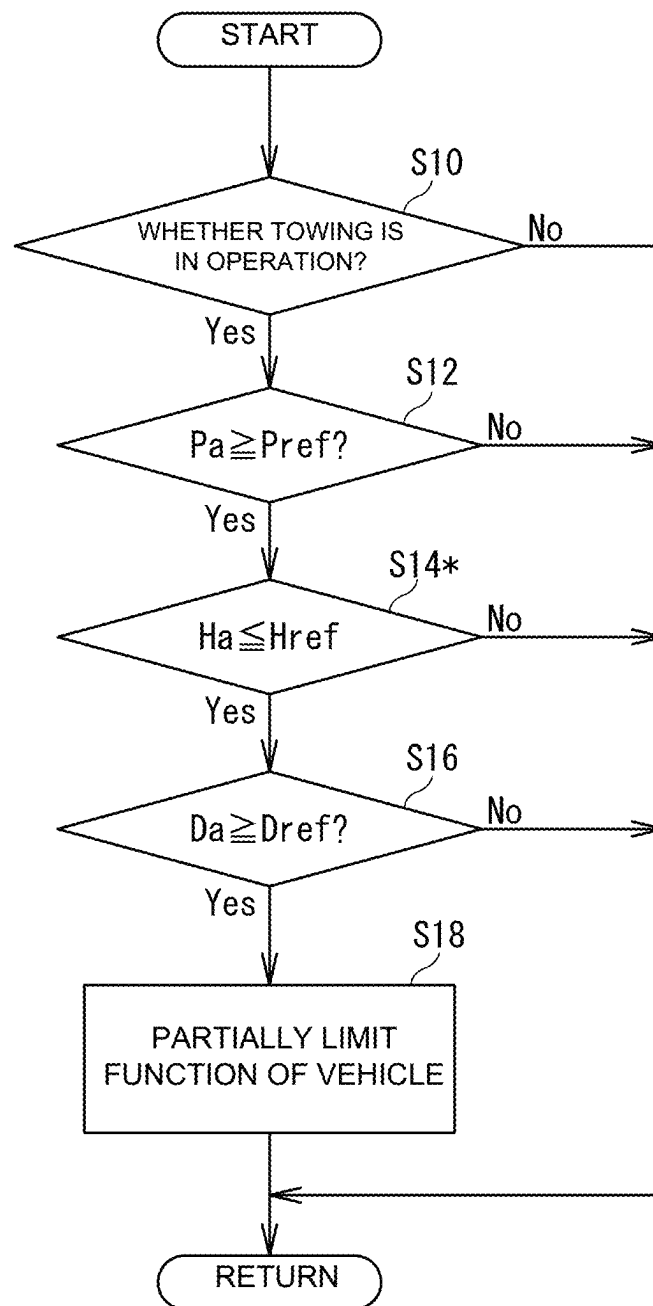


FIG. 7

1

VEHICLE CONTROLLER FOR REDUCTION OF POWER CONSUMPTION WHILE TOWING

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority to Japanese Patent Application No. 2022-128354 filed on Aug. 10, 2022, which is incorporated herein by reference in its entirety including the specification, claims, drawings, and abstract.

TECHNICAL FIELD

This specification discloses a vehicle controller that is configured to control traveling of an electric vehicle which is a battery electric automobile or a fuel cell automobile.

BACKGROUND

Heretofore, electric vehicles that travel by power output from a traveling motor have been widely known. Such electric vehicles include battery electric automobiles and fuel cell automobiles.

When towing another vehicle, such an electric vehicle consumes more power than in a case where the electric vehicle travels alone. This causes a problem that the vehicle's cruising distance becomes shorter.

In order to suppress an increase in power consumption due to towing, Patent Document 1 discloses a technique of lowering a limit value of electric power flowing through a switching element when towing is in being performed as compared to a case where towing is not being performed. According to the technique of Patent Document 1, since power consumption is reduced when towing is being performed, it is possible to suppress a decrease in the vehicle's cruising distance due to towing.

CITATION LIST

PATENT DOCUMENT 1: JP 2014-045587 A

However, even when towing is being performed, a required cruising distance can be achieved if the vehicle has a sufficient amount of remaining stored energy or consumes relatively small electric power. Meanwhile, when a limit value of electric power flowing through a switching element is lowered, a vehicle speed is limited and the function of an air conditioner is limited. In other words, according to the technique of Patent Document 1, the behavior of the vehicle desired by an occupant cannot be achieved when towing is being performed.

To address this, this example discloses a vehicle controller capable of implementing the behavior of the vehicle desired by the occupant as much as possible while achieving a required cruising distance.

SUMMARY

A vehicle controller disclosed in this specification is a vehicle controller that is configured to control traveling of an electric vehicle which is a battery electric automobile or a fuel cell automobile, in which, when the electric vehicle performs towing, the vehicle controller judges whether or not power consumption reduction is needed, based on an output of a battery that is configured to supply electric power to a traveling motor and the amount of remaining stored energy, and partially limits the function of the electric

2

vehicle if the power consumption reduction is needed, and the amount of remaining stored energy is the amount of remaining charge in the battery when the electric vehicle is the battery electric automobile, and is the amount of remaining stored hydrogen when the electric vehicle is the fuel cell automobile.

With such a configuration, even when towing is being performed, the function of the vehicle may not be limited, depending on the output of the battery and the amount of remaining stored energy. Accordingly, it is possible to implement the behavior of the vehicle desired by the occupant as much as possible while achieving a required cruising distance.

In this case, the vehicle controller may judge that the power consumption reduction is needed if the output of the battery is equal to or larger than a predetermined reference output and the amount of remaining stored energy is equal to or smaller than the amount of reference remaining energy.

With such a configuration, no function limitation is imposed if the output of the battery is small or the amount of remaining stored energy is large. Thus, it is possible to implement the behavior of the vehicle desired by the occupant as much as possible while achieving a required cruising distance.

Meanwhile, the vehicle controller may judge whether or not the power consumption reduction is needed based on a distance to a point at which energy is to be supplied, in addition to the output of the battery and the amount of remaining stored energy.

With such a configuration, no function limitation is imposed, depending on the distance to the point at which energy is to be supplied. Thus, it is possible to implement the behavior of the vehicle desired by the occupant as much as possible while achieving a required cruising distance.

Meanwhile, if the power consumption reduction is needed, the vehicle controller may execute at least one of: reduction of a vehicle speed; limitation on the output of the battery; forcible switching of an air conditioner to an internal air circulation operation mode; and limitation on an output of the air conditioner.

Such a configuration makes it possible to reduce power consumption and achieve a required cruising distance.

Meanwhile, if the power consumption reduction is needed, the vehicle controller may change how the function is limited and the amount of limitation based on at least one of the output of the battery and the amount of remaining stored energy.

Such a configuration makes it possible to suppress an adverse effect caused by the function limitation.

Meanwhile, the vehicle controller may judge whether or not the towing is being performed based on at least one of a hitch signal output from a hitch sensor and the output of the battery relative to a vehicle speed.

Such a configuration makes it possible to properly judge whether or not towing is being performed.

According to the technique disclosed in this specification, it is possible to implement the behavior of the vehicle desired by the occupant as much as possible while achieving a required cruising distance.

BRIEF DESCRIPTION OF DRAWINGS

An embodiment of the present disclosure will be described based on the following figures, wherein:

FIG. 1 is a block diagram illustrating the configuration of an electric vehicle;

3

FIG. 2 is a flowchart illustrating a flow of processing on power consumption management;

FIG. 3 is a diagram illustrating an example of an output power threshold at which towing is deemed to be performed;

FIG. 4 is a diagram illustrating an example of a reference output that varies depending on a charging rate;

FIG. 5 is a flowchart illustrating another example of a flow of processing on power consumption management;

FIG. 6 is a block diagram illustrating the configuration of an electric vehicle of another example; and

FIG. 7 is a flowchart illustrating a flow of processing on power consumption management executed by a vehicle controller of FIG. 6.

DESCRIPTION OF EMBODIMENTS

Hereinbelow, the configuration of a vehicle controller 20 will be described with reference to the drawings. FIG. 1 is a block diagram illustrating the configuration of an electric vehicle 10 equipped with the vehicle controller 20. This electric vehicle 10 is a battery electric automobile using electric power accumulated in a battery 36 as its energy source. In addition, the electric vehicle 10 includes a towing hitch (not illustrated) that is coupled to another vehicle (such as a trailer) via a towing bar when the electric vehicle tows this vehicle.

As will be described in detail later, the vehicle controller 20 is configured to judge whether or not towing is being performed and, when towing is being performed, partially limit the function of the electric vehicle 10 according to output power Pa of the battery 36 and a charging rate Ca of the battery 36. The vehicle controller 20 is physically a computer having a processor 22 and a memory 24. This “computer” may be a micro-controller in which a computer system is embedded in a single integrated circuit. In addition, the vehicle controller 20 is not limited to a single computer, and may be constituted of multiple computers that are located physically away from each other.

A vehicle speed sensor 32 is configured to detect a traveling speed of the electric vehicle 10 and transmit its result to the vehicle controller 20 as a vehicle speed Va. A hitch sensor 30 is a sensor provided to a towing hitch, and is configured to detect whether or not towing is being performed and transmit its result to the vehicle controller 20 as a hitch signal Sh. As the hitch sensor 30, a load sensor or the like that is configured to detect a load applied to the towing hitch maybe used, for example.

The battery 36 includes a secondary battery capable of charging and discharging, for example. The secondary battery included in the battery 36 is configured to accumulate electric power for traveling of the electric vehicle 10 and electric power for driving electric components including an air conditioner 34. A lithium-ion battery may be employed as the secondary battery, for example. Note, however, that the secondary battery is not limited to a lithium-ion battery, and other secondary batteries (such as a nickel hydride battery) may be employed. In addition, as the battery 36, an electrolyte secondary battery may be employed, or alternatively a full-solid secondary battery may be employed. The battery 36 can be charged from an external power source as needed.

The ratio of the amount of remaining charge in this battery 36 to its fully charged amount is transmitted to the vehicle controller 20 as the charging rate Ca. In the battery electric automobile, the charging rate Ca is a parameter indicating the amount of remaining stored energy. In addition, an

4

output upper limit Wout of electric power input and output to and from the battery 36 is managed by the vehicle controller 20.

A power control unit (hereinafter referred to as a “PCU”) 38 is constituted of a controller including a processor, an inverter, and a converter (all of which are not illustrated), for example. The controller of the PCU 38 is configured to receive an instruction (control signal) from the vehicle controller 20 and control the inverter and the converter according to this instruction. The vehicle controller 20 is configured to control a traveling motor 40 and the vehicle speed Va via the PCU 38.

An MG unit 39 includes at least one motor generator. Each motor generator functions as an electric motor that is configured to convert electric power supplied from the battery 36 via the PCU 38 into power, and also functions as a power generator that is configured to convert braking power into electric power. In addition, the at least one motor generator includes the traveling motor 40 that is configured to output power for traveling of a vehicle. The at least one motor generator including the traveling motor 40 is driven and controlled by the PCU 38.

The air conditioner 34 is an electric component that is configured to adjust a temperature inside a vehicle compartment. For example, the air conditioner 34 is a heat pump type air conditioner that is configured to cool down and warm up the vehicle compartment by expansion/contraction of refrigerant and heat exchange between the refrigerant and another fluid. The air conditioner 34 is driven by power supply from the battery 36. The vehicle controller 20 performs control to drive the air conditioner 34 in response to an operation instruction from an occupant. The air conditioner 34 is capable of operating in an external air introduction operation mode in which cooling and heating is performed while taking in the air outside the vehicle, and in an internal air circulation operation mode in which cooling and heating is performed while circulating the air inside the vehicle. In general, the internal air circulation operation mode can achieve a greater reduction in power consumption than can the external air introduction operation mode.

Next, power consumption management by the vehicle controller 20 will be described. As described previously, the vehicle controller 20 judges whether or not towing is being performed and, when towing is being performed, partially limits the function of the electric vehicle 10 according to the output power Pa of the battery 36 and the charging rate Ca of the battery 36. The vehicle controller has such a configuration in order to implement the behavior of the vehicle desired by the occupant as much as possible while achieving a required cruising distance.

Specifically, in a case where the electric vehicle 10 is towing another vehicle, the amount of electric power required for traveling of the electric vehicle 10 increases significantly as compared to a case where towing is not being performed. Accordingly, when towing is being performed, the charging rate Ca of the battery 36 decreases so drastically that a sufficient cruising distance may not be able to be achieved. To cope with this, when towing is being performed, it is conceivable to forcibly decrease the output upper limit Wout of the output power Pa from the battery 36 to forcibly reduce power consumption. Such a configuration makes it possible to achieve a sufficient cruising distance. However, in the case of forcibly reducing power consumption, measures need to be taken such as decreasing the vehicle speed Va and limiting the function of the air conditioner 34, and therefore the behavior of the vehicle desired by the occupant cannot be implemented.

5

Thus, even when towing is being performed, the vehicle controller **20** of this example does not forcibly reduce power consumption if the output power P_a is small or the charging rate C_a is high. This prevents the vehicle speed V_a from being decreased and prevents the function of the air conditioner **34** from being limited against the occupant's will. On the other hand, if the output power P_a is large and the charging rate C_a is low when towing is being performed, the vehicle controller **20** partially limits the function of the electric vehicle **10** to forcibly reduce power consumption. This makes it possible to achieve a sufficient cruising distance even when towing is being performed. Hereinbelow, a flow of this processing on power consumption management will be described with reference to FIG. 2.

As illustrated in FIG. 2, the vehicle controller **20** monitors whether or not towing is being performed (S10). Here, whether or not towing is being performed may be judged based on the hitch signal Sh , for example. Alternatively, in another mode, the vehicle controller **20** may judge whether or not towing is being performed based on the output power P_a relative to the vehicle speed V_a instead of or in addition to the hitch signal Sh . In this case, the vehicle controller **20** previously stores a threshold P_t of the output power P_a at which towing is deemed to be performed. This threshold P_t varies depending on the vehicle speed V_a . FIG. 3 is a diagram illustrating an example of the threshold P_t . In FIG. 3, the horizontal axis indicates the vehicle speed V_a of the electric vehicle **10**, and the vertical axis indicates the output power P_a of the battery **36**. In the example of FIG. 3, the threshold P_t increases as the vehicle speed V_a increases. The vehicle controller **20** may judge that towing is being performed if the current output power P_a is equal to or higher than this threshold P_t .

If towing is being performed (Yes in S10), the vehicle controller **20** compares the output power P_a of the battery **36** with a reference output P_{ref} (S12). The reference output P_{ref} is a value sufficiently larger than the output power P_a observed when towing is not being performed. The value of the reference output P_{ref} is determined in advance and stored in the memory **24**. This reference output P_{ref} may be a fixed value, or may be a variable value that varies depending on the season, the vehicle speed V_a , and the like.

If the output power P_a is lower than the reference output P_{ref} (No in S12), the possibility that this will result in an insufficient cruising distance is conceivably low. In this case, the vehicle controller **20** judges that no power consumption reduction is needed, and returns the process to Step S10 without limiting the function of the vehicle to be described later.

On the other hand, if the output power P_a is equal to or higher than the reference output P_{ref} (Yes in S12), the vehicle controller **20** compares the charging rate C_a of the battery **36** (i.e., the amount of remaining energy) with a reference charging rate C_{ref} (S14). The reference charging rate C_{ref} is a charging rate conceived as necessary to achieve a sufficient cruising distance, and is the amount of remaining energy used as a reference. The value of the reference charging rate C_{ref} is also determined in advance and stored in the memory **24**. This reference charging rate C_{ref} may be a fixed value, or may be a variable value that varies depending on the season, the vehicle speed V_a , and the like.

If the charging rate C_a is higher than the reference charging rate C_{ref} (No in S14), the possibility that this will result in an insufficient cruising distance is conceivably low. In this case, the vehicle controller **20** judges that no power consumption reduction is needed, and returns the process to Step S10 without limiting the function of the vehicle.

6

On the other hand, if the charging rate C_a is equal to or lower than the reference charging rate C_{ref} (Yes in S14), the vehicle controller **20** judges that power consumption reduction is needed. In this case, in order to reduce power consumption of the vehicle, the vehicle controller **20** partially limits the function of the vehicle as compared to a case where towing is not being performed (S18). Specifically, the vehicle controller **20** executes at least one of: reduction of the vehicle speed V_a ; reduction of the output upper limit W_{out} of the output power P_a of the battery **36**; limitation on the output of the air conditioner **34**; and forcible switching of the air conditioner to the internal air circulation operation mode. The limitation on the output of the air conditioner **34** can be achieved by increasing a target temperature of an evaporator during cooling operation or increasing an upper limit of the rotation speed of a blower, for example. Meanwhile, if the air conditioner operates in the internal air circulation operation mode during heating operation, windows may be fogged. For this reason, the forcible switching to the internal air circulation operation mode is executed during cooling operation. In any case, by executing at least one of these, it is possible to reduce power consumption of the battery **36** and achieve a sufficient cruising distance. Note that, when starting to partially limit the above functions, the vehicle controller **20** may notify the occupant of a message saying that such function limitation is to be started in order to achieve sufficient cruising distance.

As is clear from the above description, in this example, if the output power P_a is high and the charging rate C_a is low when towing is being performed, the function of the vehicle is partially limited. Thereby, power consumption can be reduced and a sufficient cruising distance can be achieved. On the other hand, even when towing is being performed, the function of the vehicle is not limited if the output power P_a is low or the charging rate C_a is high. Thereby, the behavior of the vehicle desired by the occupant can be implemented.

Note that, in the example of FIG. 2, it is judged whether or not power consumption reduction is needed and whether or not the function limitation is needed, based on the comparison result between the output power P_a and the reference output P_{ref} and the comparison result between the charging rate C_a and the reference charging rate C_{ref} ; however, another mode may be employed for judging whether or not the function limitation is needed based on the output power P_a and the charging rate C_a . For example, with the reference output P_{ref} set as a variable value that varies depending on the charging rate C_a , whether or not the function limitation is needed may be judged based on comparison between this reference output P_{ref} and the output power P_a . FIG. 4 is a diagram illustrating an example of the reference output P_{ref} in this case. In FIG. 4, the horizontal axis indicates the charging rate C_a , and the vertical axis indicates the output power P_a . In the example of FIG. 4, the reference output P_{ref} decreases drastically when the charging rate C_a becomes equal to or lower than a certain value. The vehicle controller **20** identifies the value of the reference output P_{ref} corresponding to the current charging rate C_a , and partially limits the function of the vehicle if the current output power P_a of the battery **36** is equal to or higher than the reference output P_{ref} thus identified. Even when the output power P_a is high, this configuration can avoid the function limitation when the charging rate C_a is high. On the other hand, even when the output power P_a is low to some extent, the function limita-

tion is started when the charging rate C_a is low. This makes it possible to prevent an insufficient cruising distance more reliably.

Meanwhile, how the function of the vehicle is limited or the amount of limitation may be changed based on at least one of the output power P_a and the charging rate C_a . For example, the vehicle controller **20** may change how the function is limited according to the magnitude of the charging rate C_a . For example, the vehicle controller **20** previously stores a first reference charging rate C_{ref1} and a second reference charging rate C_{ref2} that is lower than the first reference charging rate C_{ref1} . In a case where the vehicle's function limitation is needed, the vehicle controller **20** may limit the output of the air conditioner **34** if the charging rate C_a is equal to or lower than the first reference charging rate C_{ref1} and is higher than the second reference charging rate C_{ref2} , and may limit the vehicle speed V_a in addition to limiting the output of the air conditioner **34** if the charging rate C_a is equal to or lower than the second reference charging rate C_{ref2} .

Meanwhile, the upper limit W_{out} of the output power P_a may be reduced as the output power P_a becomes higher or as the charging rate C_a becomes lower. For example, the vehicle controller **20** may previously store three reference outputs P_{ref1} , P_{ref2} , and P_{ref3} as illustrated in FIG. 4. In the example of FIG. 4, the first reference output P_{ref1} is higher than the second reference output P_{ref2} , and the second reference output P_{ref2} is higher than the third reference output P_{ref3} . While towing is being performed, if the output power P_a is equal to or higher than the first reference output P_{ref1} , the vehicle controller **20** sets the upper limit W_{out} of the output power to $W1$. In addition, the vehicle controller **20** may set W_{out} to $W2$ (here, $W2 > W1$) if the output power P_a satisfies $P_{ref1} > P_a \geq P_{ref2}$, and set W_{out} to $W3$ (here, $W3 > W2$) if the output power P_a satisfies $P_{ref2} > P_a \geq P_{ref3}$. This configuration makes the upper limit W_{out} of the output power P_a lower as the current output power P_a becomes higher. This makes it possible to more reliably achieve a sufficient cruising distance and implement the behavior of the vehicle desired by the occupant at the same time.

Meanwhile, in the above description, whether or not power consumption reduction is needed is judged based on the output power P_a and the charging rate C_a . However, whether or not the vehicle's function limitation is needed may be judged in consideration of another parameter in addition to the output power P_a and the charging rate C_a . For example, the vehicle controller **20** may judge whether or not the function limitation is needed based on the output power P_a , the charging rate C_a , and a distance D_a to a point at which power is to be supplied (power supply point). FIG. 5 is a flowchart illustrating a flow of power consumption management in this case.

As illustrated in FIG. 5, in this case, the vehicle controller **20** also judges whether or not towing is being performed (S10), compares the output power P_a with the reference output P_{ref} (S12), and compares the charging rate C_a with the reference charging rate C_{ref} (S14). In addition, if towing is being performed, $P_a \geq P_{ref}$ is satisfied, and $C_a \leq C_{ref}$ is satisfied (Yes in S14), the vehicle controller **20** further compares the distance D_a to the power supply point with a reference distance D_{ref} (S16).

The power supply point is a point at which energy is to be supplied. This power supply point is a point equipped with charging equipment, and is a charging station or home, for example. The location of the power supply point is registered in a vehicle's navigation system in advance. The vehicle controller **20** acquires the moving distance D_a from

the present location to the power supply point using the function of the navigation system.

The value of the reference distance D_{ref} is determined in advance and stored in the memory **24**. This reference distance D_{ref} may be a fixed value, or may be a variable value that varies depending on at least one of the output power P_a and the charging rate C_a . Accordingly, the reference distance D_{ref} may be a variable value that decreases as the output power P_a increases, or may be a variable value that decreases as the charging rate C_a decreases, for example. Alternatively, in another mode, the vehicle controller **20** may set the reference distance D_{ref} by estimating the distance that the vehicle can travel until the charging rate C_a reaches a prescribed allowable lower limit based on an average value of the latest output power P_a and the current charging rate C_a and setting the travel distance thus estimated as the reference distance D_{ref} .

As a result of the comparison between the distance D_a to the power supply point and the reference distance D_{ref} , if $D_a < D_{ref}$ is satisfied (No in S16), the vehicle controller **20** judges that, since the battery **36** will be charged in the near future, the possibility that the cruising distance will become insufficient is low. In this case, the vehicle controller **20** judges that no power consumption reduction is needed, and returns the process to Step S10 without limiting the function of the vehicle.

On the other hand, if $D_a \geq D_{ref}$ is satisfied (Yes in S16), the vehicle controller **20** judges that there is a possibility that the cruising distance will become insufficient. In this case, the vehicle controller **20** limits the function of the vehicle (S18).

In this manner, by judging whether or not the function limitation is needed in consideration of the distance D_a to the power supply point in addition to the output power P_a and the charging rate C_a , it is possible to reduce the chance of executing the function limitation and to implement the behavior of the vehicle desired by the occupant more reliably.

In the above description, the battery electric automobile equipped with only the battery **36** as its energy source has been cited as an example. However, the technique disclosed in this specification may be applied to a fuel cell automobile equipped with a fuel cell. FIG. 6 is a block diagram illustrating an example of an electric vehicle **10*** that is a fuel cell automobile. In this case, the electric vehicle **10*** includes a hydrogen tank **44** that stores hydrogen, and a fuel cell **42**. The amount of remaining hydrogen in the hydrogen tank **44** (i.e., the amount of remaining energy) is detected by a sensor and transmitted to the vehicle controller **20** as an amount of remaining hydrogen H_a . The fuel cell **42** is a power generating device that is configured to generate power by reaction of hydrogen with oxygen. Electric power generated in the fuel cell **42** is stored in the battery **36**. The vehicle controller **20** is configured to control the amount of power to be generated in this fuel cell **42**.

FIG. 7 is a flowchart illustrating a flow of processing on power consumption management executed by the vehicle controller **20** of FIG. 6. As is clear from FIG. 7, in this case, the vehicle controller **20** compares the amount of remaining hydrogen H_a (i.e., the amount of remaining energy) with a reference amount of remaining hydrogen ($S14^*$) instead of the comparison between the charging rate C_a and the reference charging rate C_{ref} . If $H_a > H_{ref}$ is satisfied (No in $S14^*$), the vehicle controller **20** judges that no function limitation is needed. On the other hand, if $H_a \leq H_{ref}$ is satisfied (Yes in $S14^*$), the vehicle controller **20** makes the process proceed to Step S16 to compare the distance D_a to a point at which energy is to be supplied (energy supply

9

point) with the reference distance Dref. Note that, in this case, the energy supply point is a hydrogen station, for example.

In addition, although only the amount of remaining hydrogen Ha is monitored as the amount of remaining energy in FIG. 7, the charging rate Ca of the battery 36 may also be monitored. For example, even when the amount of remaining hydrogen $H_a \leq H_{ref}$ is satisfied, the possibility that the cruising distance will become insufficient may be judged as low if the charging rate Ca of the battery 36 is higher than the predetermined reference charging rate Cref.

REFERENCE SIGNS LIST

10, 10* ELECTRIC VEHICLE
20 VEHICLE CONTROLLER
22 PROCESSOR
24 MEMORY
30 HITCH SENSOR
32 VEHICLE SPEED SENSOR
34 AIR CONDITIONER
36 BATTERY
39 MG UNIT
40 TRAVELING MOTOR
42 FUEL CELL
44 HYDROGEN TANK

The invention claimed is:

1. A vehicle controller configured to control traveling of an electric vehicle which is any of a battery electric automobile and a fuel cell automobile, wherein the vehicle controller is configured to

when the electric vehicle performs towing, in response to that an output of a battery configured to supply electric power to a traveling motor is equal to or higher than a predetermined reference output and an amount of remaining stored energy is equal to or lower than a predetermined amount of reference remaining energy, judge that power consumption reduction is needed, and partially limit a function of the electric vehicle, and when the electric vehicle does not perform towing, in response to that the output of the battery is equal to or higher than the predetermined reference output and the amount of remaining stored energy is equal to or lower than the predetermined amount of reference remaining energy, not limit the function of the electric vehicle, and the amount of remaining stored energy is an amount of remaining charge in the battery in a case that the electric vehicle is the battery electric automobile, and is an amount of remaining stored hydrogen in a case that the electric vehicle is the fuel cell automobile.

2. The vehicle controller according to claim 1, wherein the vehicle controller is configured to judge whether or not the power consumption reduction is needed based on a distance to a point at which energy is to be supplied, in addition to the output of the battery and the amount of remaining stored energy.

10

3. The vehicle controller according to claim 1, wherein, the vehicle controller is configured to, in response to judging that the power consumption reduction is needed, execute at least one of:

a reduction of a vehicle speed of the electric vehicle;
a limitation on the output of the battery of the electric vehicle;
a forcible switching of an air conditioner to an internal air circulation operation mode of the electric vehicle; and
a limitation on an output of the air conditioner of the electric vehicle.

4. The vehicle controller according to claim 1, wherein, the vehicle controller is configured to, in response to judging that the power consumption reduction is needed, change how the function is limited and an amount of limitation based on at least one of the output of the battery and the amount of remaining stored energy.

5. The vehicle controller according to claim 1, wherein the vehicle controller is configured to, in response to that the output of the battery relative to a vehicle speed of the electric vehicle is equal to or higher than an electric power threshold, and the electric power threshold increases as the vehicle speed increases, judge that the towing is being performed.

6. The vehicle controller according to claim 1, wherein the vehicle controller is configured to, when the electric vehicle performs towing another vehicle, in response to judging that the power consumption reduction is needed, partially limit the function of the electric vehicle without limiting a function of the another vehicle.

7. The vehicle controller according to claim 6, wherein the vehicle controller is configured to, when the electric vehicle performs towing, in response to that (i) the output of the battery is equal to or higher than the predetermined reference output, (ii) the amount of remaining stored energy is equal to or lower than the predetermined amount of reference remaining energy, and (iii) a distance to a point at which energy is to be supplied is equal to or greater than a predetermined distance, judge that power consumption reduction is needed, and partially limit the function of the electric vehicle.

8. The vehicle controller according to claim 7, wherein, the vehicle controller is configured to, in response to judging that the power consumption reduction is needed, execute at least one of: a reduction of a vehicle speed of the electric vehicle; a limitation on the output of the battery of the electric vehicle; a forcible switching of an air conditioner to an internal air circulation operation mode of the electric vehicle; and a limitation on an output of the air conditioner of the electric vehicle.

9. The vehicle controller according to claim 8, wherein the vehicle controller is configured to, in response to that the output of the battery relative to a vehicle speed of the electric vehicle is equal to or higher than an electric power threshold, and the electric power threshold increases as the vehicle speed increases, judge that the towing is being performed.

* * * * *