

MANAGEMENT DEVICE AND MANAGEMENT METHOD

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

[0001] The present disclosure relates to management devices and management methods.

2. Description of Related Art

[0002] With growing awareness of environmental issues, there is growing interest
10 in carbon dioxide (CO₂) emissions from production of products distributed on the market. There are cases where a downstream company in a supply chain to which an upstream company in the supply chain delivers a product requests the upstream company to disclose CO₂ emissions from production of the product. The upstream company calculates the CO₂ emissions from the production of the product and discloses the calculated CO₂ emissions to
15 the downstream company.

[0003] For example, Japanese Unexamined Patent Application Publication No. 2016-126372 (JP 2016-126372 A) discloses a method for calculating CO₂ emissions in a transportation process of products (including materials and components). The method for calculating the CO₂ emissions in the transportation process disclosed in JP 2016-126372 A
20 is a method for calculating CO₂ emissions corresponding to the purchase amount of goods based on a predetermined factor table, the industry to which the company belongs, and the purchase amount of the goods.

SUMMARY OF THE INVENTION

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[0004] It is desirable to consider not only CO₂ emissions in a production process but also CO₂ emissions in a transportation process when calculating CO₂ emissions from production of a product. For example, there are cases where a plurality of products (components, raw materials) to be delivered to different destinations is consolidated on a

moving object for transporting products, such as a train or a transport vehicle. It is desired to establish a method for accurately calculating CO₂ emissions in the transportation process of each product to be delivered in such cases.

[0005] The present disclosure provides a management device and management method for accurately calculating CO₂ emissions in a transportation process of each product when a plurality of products is consolidated on a moving object for transporting products.

[0006] (1) A management device according to one aspect of the present disclosure is a management device that manages a moving object that transports a plurality of products as a consolidated load. The products include a first product and a second product. The management device includes: a storage device that stores an amount of energy consumed by the moving object in a transport section; and a control device that calculates CO₂ emissions of the first product from the transportation and CO₂ emissions of the second product from the transportation, based on the amount of energy and a weight ratio between the first and second products loaded on the moving object.

[0007] According to the above configuration, the control device calculates the CO₂ emissions of the first product from the transportation and the CO₂ emissions of the second product from the transportation, based on the amount of energy consumed by the transportation in the transport section where the products are consolidated and the weight ratio between the consolidated products. The CO₂ emissions of the first product from the transportation and the CO₂ emissions of the second product from the transportation can be appropriately calculated by using the weight ratio between the consolidated products.

[0008] (2) In one embodiment, the control device may proportionally divide the amount of energy between the first product and the second product based on the weight ratio to calculate the CO₂ emissions of the first product from the transportation and the CO₂ emissions of the second product from the transportation.

[0009] According to the above configuration, the control device proportionally divides the amount of energy consumed by the transportation in the transport section where the products are consolidated, based on the weight ratio between the consolidated products. The CO₂ emissions of the first product from the transportation and the CO₂ emissions of the

second product from the transportation can be appropriately calculated by proportionally dividing the amount of energy based on the weight ratio.

[0010] (3) In one embodiment, the transport section may include a first section where the first product and the second product are consolidated, and a second section where the first product is loaded and the second product is not loaded. The control device may proportionally divide an amount of energy consumed by the moving object in the first section between the first product and the second product based on the weight ratio between the first and second products, and may proportionally divide an amount of energy consumed by the moving object in the second section to the first product.

[0011] According to the above configuration, the control device proportionally divides, for each section, the amount of energy consumed in the section based on the weight ratio between the consolidated products. Since the first product and the second product are consolidated in the first section, the control device proportionally divides (allots) the amount of energy consumed by the moving object in the first section between the first product and the second product based on the weight ratio. On the other hand, since the second product is not loaded in the second section, the control device proportionally divides (allots) the amount of energy consumed by the moving object in the second section to the first product. By thus proportionally dividing, for each section divided based on whether the products are consolidated, the amount of energy consumed in the section, the CO₂ emissions of the first product from the transportation and the CO₂ emissions of the second product from the transportation can be appropriately calculated.

[0012] (4) In one embodiment, the storage device may store conversion information for converting an amount of energy to CO₂ emissions. The control device may use the conversion information to convert the amount of energy proportionally divided to the first product to the CO₂ emissions of the first product from the transportation and convert the amount of energy proportionally divided to the second product to the CO₂ emissions of the second product from the transportation.

[0013] According to the above configuration, power consumption can be appropriately converted to CO₂ emissions.

[0014] (5) A management method according to another aspect of the present disclosure is a management method for managing a moving object that transports a plurality of products as a consolidated load. The products include a first product and a second product. The management method includes: reading an amount of energy consumed by the moving
5 object in a transport section; and calculating CO₂ emissions of the first product from the transportation and CO₂ emissions of the second product from the transportation, based on the amount of energy and a weight ratio between the first and second products loaded on the moving object.

[0015] According to the present disclosure, in the case where a plurality of products
10 is consolidated on a moving object for transporting products, CO₂ emissions in a transportation process of each product can be accurately calculated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Features, advantages, and technical and industrial significance of exemplary
15 embodiments of the invention will be described below with reference to the accompanying drawings, in which like signs denote like elements, and wherein:

FIG. 1 shows the overall configuration of a management system 100 according to a first embodiment;

20 FIG. 2 shows the hardware configuration of the management system 100 according to the first embodiment;

FIG. 3 is a functional block diagram of a control device 51 showing a function to calculate CO₂ emissions from transportation by a transport train 5;

25 FIG. 4 is a flowchart of a process that is performed by the control device 51 to calculate the CO₂ emissions from the transportation by the transport train 5;

FIG. 5 shows the overall configuration of a management system 100A according to a second embodiment; and

FIG. 6 is a flowchart of a process that is performed by the control device 51 to calculate the CO₂ emissions from the transportation by the transport train 5.

DETAILED DESCRIPTION OF EMBODIMENTS

[0017] Hereinafter, embodiments of the present disclosure will be described in
5 detail with reference to the drawings. The same or corresponding portions are denoted by the same signs throughout the drawings, and description thereof will not be repeated.

First Embodiment

[0018] FIG. 1 shows the overall configuration of a management system 100
according to a first embodiment. FIG. 2 shows the hardware configuration of the
10 management system 100 according to the first embodiment. The management system 100 is a system for managing CO₂ emissions from production of products.

[0019] Referring to FIGS. 1 and 2, the management system 100 includes a server
10 belonging to a company A, a server 20 belonging to a company B, a server 30 belonging to a company C, a server 40 belonging to a company D, and a management center 50 that
15 manages transport vehicles 9A to 9D and a transport train 5.

[0020] In the first embodiment, at least the company A and the company C form a
supply chain. The company A is a company upstream of the company C in the supply chain.
The company A produces products 15 in a factory 1. The products 15 are electronic
components. The products 15 are not limited to the electronic components, and may be
20 various raw materials. The products 15 produced in the factory 1 are grouped into, for example, predetermined delivery units to form product sets 16. The product set 16 is delivered to a factory 3 of the company C via, for example, a plurality of means of transportation.

[0021] In the first embodiment, at least the company B and the company D form a
25 supply chain. The company B is a company upstream of the company D in the supply chain.
The company B produces products 25 in a factory 2. The products 25 are electronic components. The products 25 are not limited to the electronic components, and may be various raw materials. The products 25 produced in the factory 2 are grouped into, for example, predetermined delivery units to form product sets 26. The product set 26 is

delivered to a factory 4 of the company D via, for example, a plurality of means of transportation.

[0022] The server 10 of the company A stores CO2 emissions Qp1 per unit number of products 15. The CO2 emissions Qp1 includes CO2 emissions required to produce the unit number of products 15 using a raw material on a production line of the company A, and CO2 emissions from production of the raw material. CO2 emissions from production of the raw material can be acquired from an upstream company (not shown) in the supply chain. The server 10 also calculates CO2 emissions Qp1set per product set 16 using the CO2 emissions Qp1, and stores the calculated CO2 emissions Qp1set. The CO2 emissions Qp1set is hereinafter also referred to as “CO2 emissions Qp1set in the production process.”

[0023] The server 10 sends the CO2 emissions Qp1set in the production process to the server 30 of the company C in response to a request from the server 30 or when the product set 16 has been delivered to the company C.

[0024] The server 20 of the company B stores CO2 emissions Qp2 per unit number of products 25. The CO2 emissions Qp2 includes CO2 emissions required to produce the unit number of products 25 using a raw material on a production line of the company B, and CO2 emissions from production of the raw material. CO2 emissions from production of the raw material can be acquired from an upstream company (not shown) in the supply chain. The server 20 also calculates CO2 emissions Qp2set per product set 26 using the CO2 emissions Qp2, and stores the calculated CO2 emissions Qp2set. The CO2 emissions Qp2set is hereinafter also referred to as “CO2 emissions Qp2set in the production process.”

[0025] The server 20 sends the CO2 emissions Qp2set in the production process to the server 40 of the company D in response to a request from the server 40 or when the product set 26 has been delivered to the company D.

[0026] The management center 50 manages the transport vehicles 9A to 9D and the transport train 5. For example, a company that operates the management center 50 receives requests for transportation of products from the company A and the company B. The present embodiment illustrates an example in which the management center 50 manages both the transport vehicles 9A to 9D and the transport train 5. However, a management entity that

manages the transport vehicles 9A to 9D and a management entity that manages the transport train 5 may be different. In such a case, a management center that manages the transport vehicles 9A to 9D and a management center that manages the transport train 5 are provided. The transport vehicles 9A to 9D are hereinafter sometimes collectively referred to as

5 “transport vehicles 9” when they are not particularly distinguished from each other.

[0027] The product set 16 is first loaded onto the transport vehicle 9A at the factory 1 of the company A and transported to an A station 6. The product set 16 is then loaded onto the transport train 5 at the A station 6 and transported to a B station 7. The product set 16 is subsequently loaded onto the transport vehicle 9C at the B station 7 and transported to the

10 factory 3 of the company C. The product set 26 is first loaded onto the transport vehicle 9B at the factory 2 of the company B and transported to the A station 6. The product set 26 is then loaded onto the transport train 5 at the A station 6 and transported to the B station 7. The product set 26 is subsequently loaded onto the transport vehicle 9D at the B station 7 and transported to the factory 4 of the company D. In this example, the shipments of the

15 product set 16 and the product set 26 are consolidated onto the transport train 5 and transported from the A station 6 to the B station 7.

[0028] The transport vehicles 9 are vehicle with an internal combustion engine (not shown). The transport vehicles 9 are equipped with a communication device and a Global Positioning System (GPS) receiver, both of which are not shown. The communication device

20 may be, for example, a Data Communication Module (DCM). The transport vehicles 9 are configured to communicate with the management center 50 via the communication device. The transport vehicles 9 are configured to send location information and fuel consumption information to the management center 50 at predetermined intervals. The fuel consumption information indicates the amount of fuel consumed by the transport vehicle 9 during the

25 predetermined interval. The fuel consumption information may be information on the remaining amount of fuel.

[0029] The transport train 5 is driven with electricity or fuel. The transport train 5 may be an electric train or a diesel train. In the first embodiment, the transport train 5 is an electric train that is driven with electricity. The transport train 5 includes a power converter,

a motor, and a communication device, none of which are shown. The transport train 5 is configured to send power consumption (energy consumption) information to the management center 50 at predetermined intervals.

5 [0030] The management center 50 includes a control device 51, a storage device 52, and a communication device 53. The control device 51, the storage device 52, and the communication device 53 are connected to a bus 54. The management center 50 is an example of the “management device” according to the present disclosure.

10 [0031] The control device 51 is configured by, for example, an integrated circuit including a central processing unit (CPU). The control device 51 includes a memory and executes various programs stored in the memory. The various programs include an operating system. The memory includes, for example, a read-only memory (ROM) storing the various programs, and a random access memory (RAM) that functions as a working memory and temporarily stores various types of data necessary to execute the various programs.

15 [0032] The storage device 52 stores a first conversion formula (first conversion information) for converting power consumption to CO₂ emissions, and a second conversion formula (second conversion information) for converting fuel consumption to CO₂ emissions. The first conversion formula may be, for example, a formula of multiplying power consumption by a first CO₂ emissions factor. The first CO₂ emissions factor may be, for example, a value published by a country, a government, or a business operator. The first CO₂ emissions factor may be set for each type of power (whether the power is renewable energy, etc.). The second conversion formula may be, for example, a formula of multiplying fuel consumption by a second CO₂ emissions factor. The second CO₂ emissions factor may be, for example, a value published by a country, a government, or a business operator. The second CO₂ emissions factor may be set for, for example, each type of fuel (gasoline, light oil, biodiesel, etc.). The first conversion formula and the second conversion formula are updated by the control device 51 when, for example, the published first CO₂ emissions factor and the published second CO₂ emissions factor are updated.

25 [0033] The communication device 53 is configured to communicate with each of the servers 10 to 40. Communication between the communication device 53 and each of the

servers 10 to 40 is performed via, for example, the Internet. The communication device 53 is configured to communicate with the transport train 5 and the transport vehicles 9. Communication between the communication device 53 and the transport train 5 and transport vehicles 9 is performed via, for example, the Internet.

5 **[0034]** The control device 51 calculates CO₂ emissions in the transportation process, and reports the calculated CO₂ emissions to destination companies (in the first embodiment, the company C and the company D).

10 **[0035]** In the first embodiment, the management center 50 receives a request for transportation of the product set 16 from the server 10 of the company A. The server 10 notifies the management center 50 of information on the delivery number and weight of the product set 16. The management center 50 also receives a request for transportation of the product set 26 from the server 20 of the company B. The server 20 notifies the management center 50 of information on the delivery number and weight of the product set 26.

15 **[0036]** The transport vehicle 9A and the transport vehicle 9B receive the product set 16 and the product set 26 at the factory 1 of the company A and the factory 2 of the company B, respectively. The transport vehicle 9A transports the product set 16 from the factory 1 of the company A to the A station 6. The transport vehicle 9B transports the product set 26 from the factory 2 of the company B to the A station 6. The shipments of the product set 16 and the product set 26 are consolidated onto the transport train 5 and transported from 20 the A station 6 to the B station 7. Subsequently, the product set 16 is loaded onto the transport vehicle 9C at the B station 7 and delivered to the factory 3 of the company C. The product set 26 is loaded onto the transport vehicle 9D at the B station 7 and delivered to the factory 4 of the company D.

25 **[0037]** In the first embodiment, it is assumed that only the product set 16 is loaded onto the transport vehicles 9A, 9C. It is also assumed that only the product set 26 is loaded onto the transport vehicles 9B, 9D. It is also assumed that only the product sets 16, 26 are loaded onto the transport train 5.

[0038] The control device 51 calculates CO₂ emissions Q_a from the transportation of the product set 16 from the factory 1 of the company A to the A station 6, based on fuel

consumption F_a of the transport vehicle 9A from this transportation. The control device 51 calculates the CO₂ emissions Q_a by substituting the fuel consumption F_a into the second conversion formula. The control device 51 also calculates CO₂ emissions Q_{m1} from the transportation of the product set 16 from the A station 6 to the B station 7 by the transport train 5 by a method described later. The control device 51 also calculates CO₂ emissions Q_c from the transportation of the product set 16 from the B station 7 to the factory 3 of the company C, based on fuel consumption F_c of the transport vehicle 9C from this transportation.

[0039] The control device 51 calculates CO₂ emissions Q_{t1set} in the transportation process of the product set 16 by adding the CO₂ emissions Q_a , the CO₂ emissions Q_{m1} , and the CO₂ emissions Q_c according to the following expression (1).

$$\textbf{[0040]} \quad Q_{t1set} = Q_a + Q_{m1} + Q_c \quad (1)$$

The control device 51 reports the calculated CO₂ emissions Q_{t1set} in the transportation process to the server 30 of the company C via the communication device 53.

[0041] The server 30 of the company C calculates CO₂ emissions Q_{1set} of the delivered product set 16 by adding the CO₂ emissions Q_{p1set} in the production process reported from the company A and the CO₂ emissions Q_{t1set} in the transportation process reported from the management center 50. For example, the server 30 can calculate CO₂ emissions Q_1 of the product 15 by dividing the CO₂ emissions Q_{1set} by the number of products 15 in the product set 16. The server 30 of the company C stores the CO₂ emissions Q_{1set} and the CO₂ emissions Q_1 .

[0042] The control device 51 calculates CO₂ emissions Q_b from the transportation of the product set 26 from the factory 2 of the company B to the A station 6, based on fuel consumption F_b of the transport vehicle 9B from this transportation. The control device 51 calculates the CO₂ emissions Q_b by substituting the fuel consumption F_b into the second conversion formula. The control device 51 also calculates CO₂ emissions Q_{m2} from the transportation of the product set 26 from the A station 6 to the B station 7 by the transport train 5 by a method described later. The control device 51 also calculates CO₂ emissions Q_d from the transportation of the product set 26 from the B station 7 to the factory 4 of the

company D, based on fuel consumption F_d of the transport vehicle 9D from this transportation.

[0043] The control device 51 calculates CO2 emissions Q_{t2set} in the transportation process of the product set 26 by adding the CO2 emissions Q_b , the CO2 emissions Q_{m2} , and the CO2 emissions Q_d according to the following expression (2).

$$[0044] \quad Q_{t2set} = Q_b + Q_{m2} + Q_d \quad (2)$$

The control device 51 reports the calculated CO2 emissions Q_{t2set} in the transportation process to the server 40 of the company D via the communication device 53.

[0045] The server 40 of the company D calculates CO2 emissions Q_{2set} of the delivered product set 26 by adding the CO2 emissions Q_{p2set} in the production process reported from the company B and the CO2 emissions Q_{t2set} in the transportation process reported from the management center 50. For example, the server 40 can calculate CO2 emissions Q_2 of the product 25 by dividing the CO2 emissions Q_{2set} by the number of products 25 in the product set 26. The server 40 of the company D stores the CO2 emissions Q_{2set} and the CO2 emissions Q_2 .

[0046] FIG. 3 is a functional block diagram of the control device 51 showing the function to calculate the CO2 emissions from the transportation by the transport train 5. The control device 51 includes a power consumption acquisition unit 511, an information acquisition unit 512, a proportional division unit 513, a CO2 emissions calculation unit 514, and a storage unit 515. The control device 51 functions as the power consumption acquisition unit 511, the information acquisition unit 512, the proportional division unit 513, the CO2 emissions calculation unit 514, and the storage unit 515 by executing the programs stored in the memory. The power consumption acquisition unit 511, the information acquisition unit 512, the proportional division unit 513, the CO2 emissions calculation unit 514, and the storage unit 515 may be implemented by, for example, dedicated hardware (electrical circuitry).

[0047] The power consumption acquisition unit 511 acquires the power consumption information from the transport train 5 via the communication device 53. The power consumption acquisition unit 511 accumulates the power consumption acquired while

the transport train 5 moves from the A station 6 to the B station 7. The power consumption acquisition unit 511 stores the accumulated power consumption E_{total} in the storage device 52. The power consumption acquisition unit 511 may be configured to output the power consumption E_{total} to the proportional division unit 513.

5 **[0048]** The information acquisition unit 512 acquires information on the delivery number and weight M_c of the product set 16 from the server 10 of the company A. The information acquisition unit 512 stores the information on the delivery number and weight M_c in the storage device 52. The information acquisition unit 512 also acquires information on the delivery number and weight M_d of the product set 26 from the server 20 of the
10 company B. The information acquisition unit 512 stores the information on the delivery number and weight M_d in the storage device 52.

[0049] The proportional division unit 513 reads from the storage device 52 the power consumption E_{total} , the information on the delivery number and weight M_c , and the information on the delivery number and weight M_d . The proportional division unit 513
15 proportionally divides the power consumption E_{total} based on the weight ratio between the product set 16 and the product set 26. The proportional division unit 513 calculates power consumption E_1 allotted to the product set 16 according to the following expression (3). The proportional division unit 513 also calculates power consumption E_2 allotted to the product set 26 according to the following expression (4).

20 **[0050]** $E_1 = E_{total} \times M_c / (M_c + M_d)$ (3)

$E_2 = E_{total} \times M_d / (M_c + M_d)$ (4)

The proportional division unit 513 associates each of the calculated power consumption E_1 and power consumption E_2 with a corresponding one of the delivery numbers, and outputs the power consumption E_1 and power consumption E_2 in association with the delivery
25 numbers to the CO2 emissions calculation unit 514.

[0051] The CO2 emissions calculation unit 514 reads the first conversion formula from the storage device 52. The CO2 emissions calculation unit 514 calculates the CO2 emissions Q_{m1} from the transportation of the product set 16 from the A station 6 to the B station 7 by substituting the power consumption E_1 into the first conversion formula. The

CO2 emissions calculation unit 514 also calculates the CO2 emissions Q_{m2} from the transportation of the product set 26 from the A station 6 to the B station 7 by substituting the power consumption E2 into the first conversion formula. The CO2 emissions calculation unit 514 outputs the CO2 emissions Q_{m1} , Q_{m2} to the storage unit 515.

5 **[0052]** The storage unit 515 associates each of the CO2 emissions Q_{m1} , Q_{m2} with a corresponding one of the delivery numbers, and stores the CO2 emissions Q_{m1} , Q_{m2} in association with the delivery numbers in the storage device 52.

10 **[0053]** FIG. 4 is a flowchart of a process that is performed by the control device 51 to calculate CO2 emissions from transportation by the transport train 5. For example, this flowchart is started when completion of deliveries to the company C and the company D is detected. For example, completion of deliveries to the company C and the company D may be determined based on location information of the transport vehicles 9C, 9D, namely, based on the fact that the transport vehicles 9C, 9D have arrived at the premises of the company C and the premises of the company D, respectively. Alternatively, the control device 51 may
15 determine completion of deliveries to Companies C and D based on receipt of delivery completion notifications from those terminal devices for deliverers that are associated with the transport vehicles 9C, 9D, respectively. Although an example in which each step (hereinafter the term “step” is abbreviated as “S”) in the flowcharts shown in FIG. 4 and FIG. 6 described later is implemented by software processing by the control device 51 is described
20 herein, part or all of the steps may be implemented by hardware (electrical circuitry) fabricated in the control device 51.

25 **[0054]** In S1, the control device 51 acquires information on the delivery number and weight M_c of the product set 16 from the server 10 of the company A via the communication device 53. The control device 51 also acquires information on the delivery number and weight M_d of the product set 26 from the server 20 of the company B via the communication device 53. The control device 51 stores the information on the delivery number and weight M_c of the product set 16 and the information on the delivery number and weight M_d of the product set 26 in the storage device 52.

[0055] In S2, the control device 51 acquires power consumption information from the transport train 5 via the communication device 53, and accumulates the power consumption acquired while the transport train 5 moves from the A station 6 to the B station 7. The control device 51 calculates the accumulated power consumption as power consumption E_{total} . For example, the control device 51 stores the power consumption E_{total} in the storage device 52.

[0056] In S3, the control device 51 reads from the storage device 52 the power consumption E_{total} , the information on the delivery number and weight M_c of the product set 16, and the information on the delivery number and weight M_d of the product set 26. The control device 51 proportionally divides the power consumption E_{total} based on the weight ratio between the product set 16 and the product set 26. Specifically, the control device 51 calculates the power consumption E_1 allotted to the product set 16 and the power consumption E_2 allotted to the product set 26 according to the above expressions (3), (4).

[0057] In S4, the control device 51 reads the first conversion formula from the storage device 52, and calculates the CO2 emissions Q_{m1} from the transportation of the product set 16 from the A station 6 to the B station 7 by substituting the power consumption E_1 into the first conversion formula. The control device 51 also calculates the CO2 emissions Q_{m2} from the transportation of the product set 26 from the A station 6 to the B station 7 by substituting the power consumption E_2 into the first conversion formula.

[0058] In S5, the control device 51 associates each of the CO2 emissions Q_{m1} , Q_{m2} with a corresponding one of the delivery numbers, and stores the CO2 emissions Q_{m1} , Q_{m2} in association with the delivery numbers in the storage device 52. More specifically, the control device 51 stores the CO2 emissions Q_{m1} in association with the delivery number of the product set 16 in the storage device 52. The control device 51 also stores the CO2 emissions Q_{m2} in association with the delivery number of the product set 26 in the storage device 52.

[0059] As described above, when calculating the CO2 emissions in the transportation process, the management center 50 according to the first embodiment performs the following calculation for a transport section where products are consolidated

(in the first embodiment, the section from the A station 6 to the B station 7). The management center 50 proportionally divides the amount of energy consumed by the transportation in this transport section (in the first embodiment, the power consumption of the transport train 5), based on the weight ratio between the consolidated products. By proportionally dividing this amount of energy based on the weight ratio, the CO₂ emissions in the transportation process for each product can be appropriately calculated.

[0060] For example, in the case where there is a transport section where products are consolidated on the transport vehicle 9, the fuel consumption F in this transport section can be proportionally divided based on the weight ratio between the consolidated products.

First Modification

[0061] In the first embodiment, the amount of energy consumed in a transport section where products are consolidated is proportionally divided based on the weight ratio between the consolidated products, and each of the resultant amounts of energy is converted to CO₂ emissions using a conversion formula. However, conversion of the amount of energy to CO₂ emissions and proportional division may be performed in any order. For example, the amount of energy consumed in a transport section where products are consolidated may first be converted to CO₂ emissions, and the resultant CO₂ emissions may then be proportionally divided between the product set 16 and the product set 26 based on the weight ratio between the consolidated products. The first modification may be combined with second and third modifications and a second embodiment that will be described below.

Second Modification

[0062] The first embodiment illustrates an example in which the transport vehicles 9 are vehicles with an internal combustion engine. However, the transport vehicles 9 are not limited to the vehicles with an internal combustion engine. For example, the transport vehicles 9 may be battery electric vehicles. In this case, the transport vehicles 9 include a battery and a drive device that is driven using the power of the battery. In the case where the transport vehicle 9 is a battery electric vehicle, CO₂ emissions from the transportation by the transport vehicle 9 can be calculated using power consumption instead of fuel consumption.

[0063] In the first embodiment, the transport train and the transport vehicles are described as examples of the moving object. However, the moving object is not limited to the transport train and the transport vehicles. The moving object may be, for example, a two-wheeled vehicle, an aircraft, or a helicopter.

5 Third Modification

[0064] It is also conceivable to share information between or among companies using distributed ledger technology in the management system 100. In this case, the servers 10 to 40 and the management center 50 function as nodes, and each node sends to a distributed ledger network transaction data including various types of information to be notified and reported. For example, a distributed ledger platform may be used that can limit sharing of transaction data between or among parties concerned. Sending and receiving information using the distributed ledger technology can make the information more tamper-resistant.

Second Embodiment

15 [0065] The first embodiment and the first to third modifications illustrate an example in which the product set 16 and the product set 26 are loaded onto the transport train 5 at the same station and transported to the same station. However, the product set 16 and the product set 26 may be loaded onto the transport train 5 at different stations, and may be unloaded from the transport train 5 at different stations. The second embodiment illustrates an example in which the product set 16 and the product set 26 are unloaded from the transport train 5 at different stations.

[0066] FIG. 5 shows the overall configuration of a management system 100A according to the second embodiment. The hardware configuration diagram of the management system 100A is the same as in FIG. 2.

25 [0067] Referring to FIG. 5, as in the first embodiment, the management center 50 receives a request for transportation of the product set 16 from the server 10 of the company A. The server 10 notifies the management center 50 of information on the delivery number and weight of the product set 16. The management center 50 also receives a request for transportation of the product set 26 from the server 20 of the company B. The server 20

notifies the management center 50 of information on the delivery number and weight of the product set 26.

[0068] The transport vehicle 9A and the transport vehicle 9B receive the product set 16 and the product set 26 at the factory 1 of the company A and the factory 2 of the company B, respectively. The transport vehicle 9A transports the product set 16 from the factory 1 of the company A to the A station 6. The transport vehicle 9B transports the product set 26 from the factory 2 of the company B to the A station 6. The product set 16 and the product set 26 are consolidated onto the transport train 5 and transported from the A station 6. In the second embodiment, the product set 26 is unloaded at a C station 8 located between the A station 6 and the B station 7. The product set 26 is loaded onto the transport vehicle 9D at the C station 8 and delivered to the factory 4 of the company D. The product set 16 is transported from the C station 8 to the B station 7. The product set 16 is loaded onto the transport vehicle 9C at the B station 7 and delivered to the factory 3 of the company C.

[0069] That is, the product set 16 and the product set 26 are consolidated on the transport train 5 in the transport section from the A station 6 to the C station 8, and only the product set 16 is loaded on the transport train 5 in the transport section from the C station 8 to the B station 7. Hereinafter, the transport section where products are consolidated, that is, the transport section from the A station 6 to the C station 8, is also referred to as “first section,” and the transport section where products are not consolidated, that is, the transport section from the C station 8 to the B station 7, is also referred to as “second section.”

[0070] The control device 51 of the management center 50 accumulates power consumption information acquired from the transport train 5 to calculate power consumption Eja accumulated while the transport train 5 moves from the A station 6 to the C station 8 (hereinafter also referred to as “power consumption Eja in the first section”). The control device 51 also calculates power consumption Ejb accumulated while the transport train 5 moves from the C station 8 to the B station 7 (hereinafter also referred to as “power consumption Ejb in the second section”).

[0071] The control device 51 proportionally divides the power consumption Eja in the first section based on the weight ratio between the product set 16 and the product set 26.

The control device 51 calculates power consumption E_{ja1} in the first section allotted to the product set 16 according to the following expression (5). The control device 51 also calculates power consumption E_{ja2} in the first section allotted to the product set 26 according to the following expression (6).

$$5 \quad [0072] \quad E_{ja1} = E_{ja} \times M_c / (M_c + M_d) \quad (5)$$

$$E_{ja2} = E_{ja} \times M_d / (M_c + M_d) \quad (6)$$

The control device 51 then proportionally divides the power consumption E_{jb} in the second section based on the weight ratio between the product set 16 and the product set 26. The control device 51 calculates power consumption E_{jb1} in the second section allotted to the product set 16 according to the following expression (7). The control device 51 also calculates power consumption E_{jb2} in the second section allotted to the product set 26 according to the following expression (8).

$$[0073] \quad E_{jb1} = E_{jb} \times M_c / (M_c + M_d) \quad (7)$$

$$E_{jb2} = E_{jb} \times M_d / (M_c + M_d) \quad (8)$$

15 Since the product set 26 is not loaded on the transport train 5 in the second section, M_d is zero.

[0074] The control device 51 calculates the power consumption E_1 , namely an allotment of the power consumption of the transport train 5 in the transport section (first section and second section) to the product set 16, according to the following expression (9).

20 The control device 51 also calculates the power consumption E_2 , namely an allotment of the power consumption of the transport train 5 in the transport section to the product set 26, according to the following expression (10).

$$[0075] \quad E_1 = E_{ja1} + E_{jb1} \quad (9)$$

$$E_2 = E_{ja2} + E_{jb2} \quad (10)$$

25 The control device 51 reads the first conversion formula from the storage device 52, and calculates the CO₂ emissions Q_{m1} from the transportation of the product set 16 by the transport train 5 by substituting the power consumption E_1 into the first conversion formula. The control device 51 also calculates the CO₂ emissions Q_{m2} from the transportation of the

product set 26 by the transport train 5 by substituting the power consumption E2 into the first conversion formula.

[0076] The control device 51 associates each of the CO2 emissions Q_{m1} , Q_{m2} with a corresponding one of the delivery numbers, and stores the CO2 emissions Q_{m1} , Q_{m2} in association with the delivery numbers in the storage device 52. The control device 51 calculates the CO2 emissions Q_{t1set} in the transportation process of the product set 16 and the CO2 emissions Q_{t2set} in the transportation process of the product set 26 according to the above expressions (1), (2) using the CO2 emissions Q_{m1} , Q_{m2} stored in the storage device 52.

[0077] The CO2 emissions Q_a from the transportation of the product set 16 from the factory 1 of the company A to the A station 6, the CO2 emissions Q_b from the transportation of the product set 26 from the factory 2 of the company B to the A station 6, the CO2 emissions Q_c from the transportation of the product set 16 from the B station 7 to the factory 3 of the company C, and the CO2 emissions Q_d from the transportation of the product set 26 from the C station 8 to the factory 4 of the company D can be calculated using the fuel consumptions F_a to F_d and the second conversion formula, as described in the first embodiment.

[0078] FIG. 6 is a flowchart of a process that is performed by the control device 51 to calculate CO2 emissions from transportation by the transport train 5. For example, this flowchart is started when completion of deliveries to the company C and the company D is detected.

[0079] In S10, the control device 51 acquires information on the delivery number and weight M_c of the product set 16 from the server 10 of the company A via the communication device 53. The control device 51 also acquires information on a destination of the product set 16 from the server 10 of the company A via the communication device 53. The control device 51 also acquires information on the delivery number and weight M_d of the product set 26 from the server 20 of the company B via the communication device 53. The control device 51 also acquires information on a destination of the product set 26 from the server 20 of the company B via the communication device 53. The control device 51

stores in the storage device 52 the information on the delivery number and weight M_c of the product set 16, the information on the destination of the product set 16, the information on the delivery number and weight M_d of the product set 26, and the information on the destination of the product set 26.

5 **[0080]** The control device 51 can determine at which station to unload the product sets 16, 26 from the transport train 5 based on the information on the destination of the product set 16 and the information on the destination of the product set 26. In this example, the station to unload the product set 16 from the transport train 5 is determined to be the B station 7, and the station to unload the product set 26 from the transport train 5 is determined
10 to be the C station 8. The control device 51 can thus recognize that the product sets 16, 26 are consolidated on the transport train 5 in the section from the A station 6 to the C station 8 (first section), and that only the product set 16 is loaded on the transport train 5 in the section from the C station 8 to the B station 7 (second station).

15 **[0081]** In S11, the control device 51 acquires power consumption information from the transport train 5 via the communication device 53, and calculates the power consumption of the transport train 5 accumulated while the transport train 5 moves from the A station 6 to the C station 8 (in the first section). That is, the control device 51 calculates the power consumption E_{ja} in the first section. The control device 51 stores the power consumption E_{ja} in the first section in the storage device 52.

20 **[0082]** In S12, the control device 51 proportionally divides the power consumption E_{ja} in the first section based on the weight ratio between the product set 16 and the product set 26. Specifically, the control device 51 calculates the power consumption E_{ja1} in the first section allotted to the product set 16 and the power consumption E_{ja2} in the first section allotted to the product set 26 according to the above expressions (5), (6).

25 **[0083]** In S13, the control device 51 acquires power consumption information from the transport train 5 via the communication device 53, and calculates the power consumption of the transport train 5 accumulated while the transport train 5 moves from the C station 8 to the B station 7 (in the second section). That is, the control device 51 calculates the power consumption E_{jb} in the second section.

[0084] In S14, the control device 51 proportionally divides the power consumption Ejb in the second section based on the weight ratio between the product set 16 and the product set 26. Specifically, the control device 51 calculates the power consumption Ejb1 in the second section allotted to the product set 16 and the power consumption Ejb2 in the second section allotted to the product set 26 according to the above expressions (7), (8). In this case, the control device 51 sets the weight Md to zero.

[0085] In S15, the control device 51 calculates the power consumption E1 that is an allotment of the power consumption of the transport train 5 to the product set 16 and the power consumption E2 that is an allotment of the power consumption of the transport train 5 to the product set 26, according to the above expressions (9), (10).

[0086] In S16, the control device 51 reads the first conversion formula from the storage device 52, and calculates the CO2 emissions Qm1 from the transportation of the product set 16 by the transport train 5 by substituting the power consumption E1 into the first conversion formula. The control device 51 also calculates the CO2 emissions Qm2 from the transportation of the product set 26 by the transport train 5 by substituting the power consumption E2 into the first conversion formula.

[0087] In S17, the control device 51 associates each of the CO2 emissions Qm1, Qm2 with a corresponding one of the delivery numbers, and stores the CO2 emissions Qm1, Qm2 in association with the delivery numbers in the storage device 52. More specifically, the control device 51 stores the CO2 emissions Qm1 in association with the delivery number of the product set 16 in the storage device 52. The control device 51 also stores the CO2 emissions Qm2 in association with the delivery number of the product set 26 in the storage device 52.

[0088] As described above, in the case where the product set 16 and the product set 26 are unloaded from the transport train 5 at different stations, the management center 50 according to the second embodiment divides the transport section for transportation by the transport train 5 into the first section where the product set 16 and the product set 26 are consolidated and the second section where the product set 16 and the product set 26 are not consolidated. The management center 50 then proportionally divides, for each section, the

power consumption (energy consumption) in the section based on the weight ratio between the consolidated products. Accordingly, even when the product set 16 and the product set 26 are unloaded from the transport train 5 at different stations, the CO₂ emissions in each section can be appropriately calculated.

5 **[0089]** Although an example in which two sets (products), namely the product set 16 and the product set 26, are consolidated on the transport train 5 is described above, three or more sets may be consolidated on the transport train 5. For example, in the case where three sets are consolidated on the transport train 5, the transport section can be divided into a section where the three sets are consolidated, a section where two of the three sets are
10 consolidated, and a section where one of the three sets is loaded. Alternatively, the transport section may be divided based on the stations at which the transport train 5 stops. For example, it is assumed that the transport train 5 transports products from an A station that is a departure station of the transport train 5 to a B station that is a destination station of the transport train 5, and the transport train 5 stops at a C station and a D station that are located between the A
15 station and the B station. In this case, the transport section of the transport train 5 can be divided into the section from the A station to the C station, the section from the C station to the D station, and the section from the D station to the B station. Power consumption can be allotted to each product based on the weight ratio between or among the products loaded in each section.

20 **[0090]** It is also conceivable that the product set 16 is loaded onto one transport vehicle 9 at the factory 1 of the company A, the product set 26 is then loaded onto the transport vehicle 9 at the factory 2 of the company B, and the transport vehicle 9 transports the product set 16 and the product set 26 to the A station 6. In this case, the transport section of the transport vehicle 9 can also be divided into the section from the factory 1 to the factory
25 2 and the section from the factory 2 to the A station 6, and the fuel consumption can be proportionally divided based on the weight ratio. CO₂ emissions from the transportation by the transport vehicle 9 can thus be appropriately proportionally divided.

[0091] The embodiments disclosed herein should be construed as illustrative in all respects, and not restrictive. The scope of the present disclosure is shown by the scope of

claims rather than the above description, and is intended to include all modifications within the meaning and scope equivalent to the scope of claims.

CLAIMS

1. A management device that manages a moving object that transports as a consolidated load a plurality of products including a first product and a second product, the management device characterized by comprising:

a storage device that stores an amount of energy consumed by the moving object in a transport section; and

a control device that calculates CO₂ emissions of the first product from the transportation and CO₂ emissions of the second product from the transportation, based on the amount of energy and a weight ratio between the first and second products loaded on the moving object.

2. The management device according to claim 1, wherein the control device proportionally divides the amount of energy between the first product and the second product based on the weight ratio to calculate the CO₂ emissions of the first product from the transportation and the CO₂ emissions of the second product from the transportation.

3. The management device according to claim 2, wherein

the transport section includes a first section where the first product and the second product are consolidated, and a second section where the first product is loaded and the second product is not loaded, and

the control device proportionally divides an amount of energy consumed by the moving object in the first section between the first product and the second product based on the weight ratio between the first and second products, and proportionally divides an amount of energy consumed by the moving object in the second section to the first product.

4. The management device according to claim 2 or 3, wherein

the storage device stores conversion information for converting an amount of energy to CO₂ emissions, and

the control device uses the conversion information to convert the amount of energy proportionally divided to the first product to the CO₂ emissions of the first product from the transportation and convert the amount of energy proportionally divided to the second product to the CO₂ emissions of the second product from the transportation.

5. A management method for managing a moving object that transports as a consolidated load a plurality of products including a first product and a second product, the management method characterized by comprising:

reading an amount of energy consumed by the moving object in a transport section;
and

calculating CO₂ emissions of the first product from the transportation and CO₂ emissions of the second product from the transportation, based on the amount of energy and a weight ratio between the first and second products loaded on the moving object.