

DESCRIPTION

GREENHOUSE GAS EMISSIONS MANAGEMENT METHOD AND GREENHOUSE
GAS EMISSIONS MANAGEMENT SYSTEM

Technical Field

[0001]

The present invention relates to a technique for managing emissions of greenhouse gas in a supply chain of fuel.

Background Art

[0002]

Fuel is supplied to consumers, such as factories or houses, through a supply chain including production of crude oil or natural gas, which is a raw material, processing of various types of fuel oil or liquefied natural gas (LNG) from the raw material, and transportation of processed fuel. From the point of view of a reduction in emissions of greenhouse gases (GHG), it is requested that the emissions of GHG in a process of supplying these fuels through the supply chain be accurately grasped.

[0003]

For example, Patent Literature 1 describes a technique for processing sensory data that has been measured by a measuring device to generate audit data relating to energy consumption, carbon emissions, or the

like, and storing the audit data by using a block chain. Furthermore, Patent Literature 2 describes a fuel trading coordination system that enables a CO₂ emission intensity of each fuel to be referred to in procuring fuel, such as hydrogen, from a plurality of fuel suppliers.

Citation List

Patent Literature

[0004]

Patent Literature 1: WO 2019/193583 A

Patent Literature 2: WO 2021/192205 A

Summary of Invention

Technical Problem

[0005]

On the other hand, in grasping GHG emissions, it is requested that an attempt be made to perform measurement, reporting, and verification (MRV) such that respective business operators that constitute a supply chain measure GHG emissions on the basis of a common rule, and report results of measurement (reporting), and a third-party organization verifies the content of reporting.

[0006]

However, the citations described above only describe a technique for assuring energy consumption, carbon

emissions, or the like of an individual business operator (Patent Literature 1) or a technique for providing reference information when a consumer procures product fuel (Patent Literature 2). On the other hand, there is a plurality of supply chains to supply fuel as a product, and each of the supply chains is constituted by a plurality of business operators. Patent Literatures 1 and 2 described above do not disclose a technique relating to a platform that these multiple business operators participate in to perform MRV.

[0007]

The present invention has been made in such a background, and provides a technique for managing emissions of greenhouse gas from constituent business operators that constitute a supply chain of fuel.

Solution to Problem

[0008]

The present invention is a greenhouse gas emissions management method for a supply chain of fuel, the greenhouse gas emissions management method including:

a process of acquiring a plurality of data sets from a plurality of constituent business operators via a data communication system, the plurality of constituent business operators constituting the supply chain from production of

a raw material to supply of the fuel, and being business operators selected from a business operator group consisting of a producer that produces the raw material of the fuel, a raw material transporter that transports the raw material, a processor that processes the fuel from the raw material, a fuel transporter that transports the fuel, and a supplier that supplies the fuel to a consumer, the plurality of data sets being obtained by associating identification data with emissions specifying data, the identification data identifying a greenhouse gas emissions management method for a supply chain of fuel, the greenhouse gas emissions management method including:

a process of acquiring a plurality of data sets from a plurality of constituent business operators via a data communication system, the plurality of constituent business operators constituting the supply chain from production of a raw material to supply of the fuel, and being business operators selected from a business operator group consisting of a producer that produces the raw material of the fuel, a raw material transporter that transports the raw material, a processor that processes the fuel from the raw material, a fuel transporter that transports the fuel, and a supplier that supplies the fuel to a consumer, the plurality of data sets being obtained by associating identification data with emissions specifying data, the

identification data identifying the raw material or the fuel to be sent to a downstream side of the supply chain after each of the plurality of constituent business operators has performed business, the emissions specifying data specifying emissions of greenhouse gas that has been emitted according to performing of the business for the raw material or the fuel that has been identified by the identification data;

a process of causing a computer to calculate the emissions of the greenhouse gas for the plurality of constituent business operators on the basis of plural pieces of the emissions specifying data that have been acquired from the plurality of constituent business operators; and

a process of causing the computer to sum the emissions of the greenhouse gas for all of the plurality of constituent business operators that constitutes a single supply chain that is specified by the identification data, and obtain total emissions of the greenhouse gas for the fuel supplied through the single supply chain.

[0009]

The greenhouse gas emissions management method may have the characteristics described below.

(a) The identification data includes information indicating a sending destination of the raw material or the

fuel to be sent from the producer or the processor, a transportation section of the raw material or the fuel to be transported by the raw material transporter or the fuel transporter, or a sending source of the fuel to be sent to the supplier, and all of the plurality of constituent business operators that constitutes the single supply chain are specified on the basis of the information indicating the sending destination, the transportation section, or the sending source.

(b) The emissions specifying data includes original data of at least one type of (1) to (4) described below, or its processed data:
measured;

(3) activity data that is specified according to operation of the business of the constituent business operator; and

(4) the emissions of the greenhouse gas that have been calculated by performing engineering calculation of the operation content of the facility for performing the business of the constituent business operator.

(c) A process of causing a computer to obtain a combination of data acquisition resources that causes a lowest cost within a range of preset constraints of selection of the data acquisition resources, in a case where the constituent business operator has a plurality of

data acquisition resources relating to acquisition of pieces of the original data of types described in (1) to (4) pieces of the original data of types described in (1) to (4) in (b), is further included.

[0010]

(d) The following processes are further included: a process of causing the computer to generate a business operator model indicating a relationship between a handling amount of the raw material or the fuel and the emissions of the greenhouse gas on a condition that a facility configuration is in common with the facility configuration of a single constituent business operator selected from the plurality of constituent business operators; a process of causing the computer to estimate the emissions of the greenhouse gas by using the business operator model on the basis of an actual handling amount of the raw material or the fuel that has been specified according to the performing of the business when the emissions specifying data is obtained for the single constituent business operator; and a process of causing the computer to make a comparison between the emissions of the greenhouse gas that have been calculated on the basis of the emissions specifying data acquired from the single constituent business operator and the emissions of the greenhouse gas that have been estimated by using the business operator

model. The business operator model is generated on the basis of a result of machine learning of a correspondence relationship among the emissions specifying data included in the plurality of data sets acquired in past, the emissions of the greenhouse gas that have been calculated from the emissions specifying data, and the actual handling amount of the raw material or the fuel.

(e) The emissions of the greenhouse gas for the plurality of constituent business operators are retained in a block chain ledger, the emissions being calculated in the process of causing the computer to calculate the emissions of the greenhouse gas.

(f) In the process of causing the computer to obtain the total emissions of the greenhouse gas for the fuel, a new supply chain is generated by replacing some of the plurality of constituent business operators that constitutes the single supply chain with some of the plurality of constituent business operators that constitutes another supply chain, and the total emissions of the greenhouse gas are obtained for the fuel that is supplied through the new supply chain.

(g) The fuel is any of liquefied natural gas that has been processed from natural gas serving as the raw material, ammonia that has been processed from the natural gas serving as the raw material, hydrogen or synthetic

methane, fuel oil that has been processed from crude oil serving as the raw material, or biomethane that has been processed from organic waste serving as the raw material.

(h) The greenhouse gas is at least any one of carbon dioxide, methane, or nitrous oxide.

Advantageous Effects of Invention

[0011]

According to the present invention, a plurality of data sets obtained by associating identification data with emissions specifying data is acquired from constituent business operators that constitute a supply chain. The identification data identifies a raw material or fuel to be sent to a downstream side of the supply chain after performing business, and the emissions specifying data specifies emissions of greenhouse gas emitted according to performing of business. Therefore, total emissions of greenhouse gas can be managed for fuel that is supplied through each supply chain.

Brief Description of Drawings

[0012]

Fig. 1 is a schematic diagram illustrating a configuration example of a supply chain of fuel supply.

Fig. 2 is a block diagram illustrating a

configuration example of a GHG emissions management system.

Fig. 3 is an explanatory diagram illustrating a relationship between GHG emissions of each constituent business operator and total GHG emissions of a supply chain.

Fig. 4 is a schematic diagram illustrating a flow of data processing for calculating GHG emissions.

Fig. 5 is a flowchart illustrating a flow of an operation to calculate GHG emissions of each constituent business operator.

Fig. 6 is a flowchart illustrating a flow of an operation to obtain total GHG emissions of a supply chain.

Fig. 7 is a first schematic diagram illustrating an example in which a constituent business operator has been replaced to generate a new supply chain.

Fig. 8 is a second schematic diagram illustrating an example in which a constituent business operator has been replaced to generate a new supply chain.

Fig. 9 is a flowchart illustrating a flow of an operation to search for an optimum combination of data acquisition resources from plural types of data acquisition resources.

Fig. 10 is a flowchart illustrating a flow of an operation to make a comparison between an estimated value and a calculated value of GHG emissions.

Description of Embodiments

[0013]

First, a configuration example of a fuel supply chain (SC) for which emissions of greenhouse gas (GHG) are managed by using an emissions management system (hereinafter also simply referred to as a "management system") according to an embodiment is described. The present management system is applicable to the management of emissions of GHG in an SC that supplies a consumer with a fuel using crude oil or natural gas as a raw material, such as liquefied natural gas (LNG) that has been processed from natural gas, ammonia that has been processed from natural gas, hydrogen or synthetic methane, fuel oil (gasoline, kerosene, diesel fuel, heavy oil, or the like) that has been processed from crude oil, or biomethane that has been processed from organic waste (garbage, waste paper, livestock excretions, or the like).

[0014]

Furthermore, a GHG to be managed is not particularly limited, but examples of a GHG of interest in supplying the fuel described above include carbon dioxide, methane, and nitrous oxide. The present management system may be configured to be able to manage a single type of GHG, or may be configured to manage plural types of GHGs.

[0015]

The present management system can be used by a business operator selected from a group of business operators consisting of a producer that produces a raw material of fuel, a raw material transporter that transports the raw material, a processor that processes the fuel from the raw material, a fuel transporter that transports the fuel, and a supplier that supplies the fuel to consumers, as a constituent business operator that constitutes an SC from production of the raw material to supply of the fuel to the consumers.

[0016]

For example, Fig. 1 illustrates an example of a production-region processing type SC (SC1 to SC3) in which fuel is processed in a production region of a raw material that has been produced overseas when viewed from a consumption region where consumers are present, the processed fuel is transported on the sea to the consumption region, and the fuel is supplied to each of the consumers. Examples of a fuel to be supplied through such an SC include LNG, ammonia, hydrogen-synthetic methane, and biomethane.

[0017]

Each of SC1 to SC3 illustrated in Fig. 1 includes a producer that produces a raw material such as natural gas,

a processor that processes fuel, such as LNG or liquid ammonia, from the natural gas, a fuel transporter that transports the processed fuel on the sea to a consumption region, and a supplier that supplies the transported fuel to each consumer. The fuel may be of the personal use such that houses, office buildings, or the like serve as consumers, or may be of the business use such that factories, traffic facilities, or the like serve as consumers.

[0018]

Furthermore, each of the SCs is constituted by a plurality of constituent business operators, and these constituent business operators have an individual contract or perform procurement from the market to supply a raw material, fuel, or transportation services to each other. As a result of this, when viewed from the consumers, there is a plurality of SCs, SC1 to SC3, for a single type of fuel.

[0019]

Furthermore, a configuration of the SC is not limited to the example illustrated in Fig. 1. For example, in directly supplying the produced fuel to consumers by using pipeline transportation, in a case where a pipeline facility is operated by the supplier, an SC including "producer => processor => supplier" as constituent business

operators can be formed.

In addition, in a case where multiple types of fuels are processed in the same manner as fuel oil that is processed from crude oil, a raw material is transported to a consumption region where consumers are present, and then fuels are processed in some cases. In these cases, an SC including “producer => raw material transporter => processor => supplier” as constituent business operators can be formed.

[0020]

When an individual fuel such as LNG or ammonia is focused on, a configuration of an SC is not limited to the one type illustrated in Fig. 1 (producer => processor => fuel transporter => supplier), and plural types of SCs, such as the example described above of pipeline transportation (producer => processor => supplier), are included in some cases.

[0021]

As described above, fuel is supplied to consumers through an SC including a plurality of constituent business operators. At this time, the constituent business operators perform their own businesses in the SC by using their own facilities. Specifically, the producer produces natural gas or crude oil serving as a raw material from a production well, by using a production facility, and the

processor processes fuel from the raw material, by using a processing facility. Furthermore, the raw material transporter or the fuel transporter transports the raw material or the fuel, by using a transportation facility, and the supplier supplies the fuel to the consumers, by using a supply facility.

[0022]

The respective constituent business operators that constitute the SC emit GHG, when performing their own businesses by using the facility. For example, if fuel is burnt in order to obtain energy required to operate the facility, carbon dioxide or nitrous oxide is emitted. In a case where energy such as electric power is procured from the outside but in a case where fuel is burnt at a supply source of energy, carbon dioxide or nitrous oxide is emitted according to consumption of the energy.

[0023]

Furthermore, natural gas is mainly composed of methane, and methane is contained in light gas that is generated during treatment performed on crude oil in some cases. During production or treatment of natural gas or crude oil described above, or transportation or storage of LNG, methane slightly leaks from facilities of the respective constituent business operators in some cases.

[0024]

Accordingly, if GHG emitted by the respective constituent business operators in the SC is grasped, emissions of GHG in the entirety of the SC from production of a raw material to supply of fuel can be grasped for a fuel to be consumed by consumers.

A management system according to the present embodiment is configured to be able to acquire, for a fuel to be supplied to consumers, data for specifying emissions of GHG in an SC relating to supply of the fuel from a plurality of constituent business operators.

[0025]

Hereinafter, the description of Figs. 2 to 10 is provided by using, as an example, a case where LNG that has been processed from natural gas serving as a raw material is supplied as fuel to consumers through the SC “producer => processor => fuel transporter => supplier” illustrated in Fig. 1.

[0026]

Fig. 2 is a block diagram illustrating a configuration example of the management system according to the present embodiment. A management system 3 in the present example is constituted by, for example, a cloud computing system. The management system 3 is connected to computer terminals (a producer terminal 11, a processor terminal 12, a fuel transporter terminal 13, a supplier

terminal 14, and a consumer terminal 15) of constituent business operators and consumers of the plurality of SCs, SC1 to SC3, described with reference to Fig. 1.

Furthermore, the management system 3 is also connected to a management computer 20 of a manager that provides the management system 3.

[0027]

The management system 3 acquires a data set obtained by associating identification data with emissions specifying data, via a not-illustrated data communication system (a data communication unit) from the computer terminals (the producer terminal 11, the processor terminal 12, the fuel transporter terminal 13, and the supplier terminal 14) of the constituent business operators that are connected to the management system 3. The identification data is used to identify a raw material or fuel. The emissions specifying data is used to specify emissions of GHG emitted according to performing of business of each of the constituent business operators.

Specific configuration examples of the “identification data” and the “emissions specifying data” described above are described below with reference to Figs. 3 and 4.

[0028]

Fig. 3 is an explanatory diagram illustrating a

relationship between GHG emissions in each of the constituent business operators that constitute a certain SC and total GHG emissions in the entirety of the SC. As described with reference to Fig. 1, all of the fuels are supplied to consumers via any of SC1 to SC3. Accordingly, as schematically illustrated in Fig. 3, each of the constituent business operators of the certain SC associates identification data with a raw material or fuel to be sent to a downstream side of the SC after performing of its own business. The identification data has a data configuration that can identify the raw material or the fuel that has been described above, and can indicate when the raw material or the fuel has been produced, processed, transported, or received.

[0029]

Moreover, the identification data may include information indicating a sending destination of the raw material or the fuel to be sent from the producer or the processor, a transportation section of the raw material or the fuel to be transported by the raw material transporter or the fuel transporter, or a sending source of the fuel to be sent to the supplier. A specific example is given for the SC illustrated in Fig. 3. The information described above corresponds to information identifying each of the processor serving as a sending destination of a raw

material to be sent from the producer, the supplier serving as a sending destination of a fuel to be sent from the processor, a transportation section (the processor serving as a reception source of the fuel and the supplier serving as a transportation destination of the fuel) of the fuel transporter, and the processor serving as a sending source of the fuel to be sent to the supplier.

[0030]

The management system 3 acquires these pieces of identification data via the terminals 11 to 15 of the respective constituent business operators, and therefore it can be specified when a fuel to be supplied to consumers has been produced, processed, transported, and received by which constituent business operator, and which constituent business operator the fuel has been sent to or received from. This can specify all of the constituent business operators that constitute an SC relating to the fuel to be supplied to the consumers.

[0031]

If an SC can be specified for a fuel to be supplied from a certain supplier to consumers, emissions E_1 to E_4 of GHG that is emitted in accordance with performing of businesses relating to production, processing, transportation, and reception in constituent business operators that constitute the SC can be specified, as

illustrated in Fig. 3. Then, by summing GHG emissions of these individual constituent business operators, total GHG emissions E can be obtained for the fuel to be supplied from the SC.

[0032]

Next, emissions specifying data that is acquired from each of the constituent business operators together with the identification data is described. The emissions specifying data is used to calculate GHG GHG emissions E_n ($n = 1$ to 4) from each of the constituent business operators illustrated in Fig. 3.

Here, in an industry relating to fuel supply, an officially determined GHG emissions estimation method is known. For example, the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for Estimating Greenhouse Gas Emissions and Sinks, the 2019 Refinement to the 2006 IPCC Guidelines, or guidelines determined by the competent environmental policy authorities in each country (for example, the Ministry of the Environment in Japan) determine details of a method for calculating GHG emissions derived from burning of fossil fuel or production of oil, natural gas, and other energy in the processing industry for each of the businesses of production, refining and storage, transportation, supply, and the like, and the details are publicly known. Furthermore, another example

of the proposed GHG emissions estimation method is “Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Industry (2021)” formulated by the American Petroleum Institute (API).

[0033]

A basic approach of the calculation methods determined by these guidelines is to calculate GHG emissions by multiplying “activity data” specified according to the operation of business such as production, processing (refining), transportation, supply, or the like of a raw material by a predetermined emission factor (coefficient multiplication). Examples of the activity data include energy consumption in each constituent business operator, and the number of valves, flanges, or vents (the number of leakage sources) that are provided in a facility of each of the constituent business operators. Furthermore, examples of activity data peculiar to each of the constituent business operators include an amount of production of natural gas or crude oil in production of a raw material, an amount of treatment of the raw material or fuel in processing and transportation, and an amount of supply (a sales amount) of fuel to a consumer in supply.

[0034]

Furthermore, in addition to the methods described in these guidelines, a calculation method having higher

accuracy has been proposed. An example of the calculation method having higher accuracy is a method for actually measuring GHG emissions from a facility of each constituent business operator by using an infrared camera or the like (actual measurement). Furthermore, a result of measuring GHG emissions by performing actual measurement can also be used to update an emission factor in the coefficient multiplication described above. Stated another way, actual measurement is performed to grasp GHG emissions for an individual device serving as a target of measurement. Next, updating can be performed to obtain an emission factor of a certain device from a relationship between a result of actual measurement and activity data indicating a state of operation of the certain device.

[0035]

Another example is a method for calculating GHG emissions by performing simulation to grasp a result of reproducing an internal state of a facility or the mass balance of a raw material or fuel at the time of feeding to the facility and the time of delivery from the facility, and performing engineering calculation of the operation content of each facility (engineering calculation).

[0036]

Fig. 4 is a conceptual diagram schematically illustrating the various GHG calculation methods described

above, for example, for a fuel processor. The GHG calculation methods described above are roughly classified into a top-down method in which GHG emissions from a facility of a processor are collectively grasped, and a bottom-up method in which individual GHG emissions from a plurality of positions in the facility are grasped and piled up.

[0037]

Actual measurement is applicable to both the top-down method and the bottom-up method. An example of a case where actual measurement using infrared rays is applied to the top-down method is described. A boundary of estimation of GHG emissions is set for a business performing region where a facility of a processor is provided. This estimation boundary is imaged from the sky by using an infrared camera 44 mounted on a drone 41, an artificial satellite 42, or an aircraft 43, and an infrared image of a wavelength emitted from GHG is acquired. Then, the concentration of GHG in the region is obtained from an intensity of detected infrared rays, and GHG emissions are calculated from this concentration. Note that details of the business performing region or the estimation boundary will be described later.

[0038]

Furthermore, an example of a case where actual

measurement using infrared rays is applied to the bottom-up method is described. An infrared image of an individual place where GHG is assumed to be emitted (in the example of Fig. 4, a vent of a storage tank of a raw material or fuel, a chimney, or a flange of piping) is acquired. An example of a method for acquiring the infrared image is to capture an image by using the infrared camera 44 that is mounted on the drone 41 or is installed at the site. Then, GHG emissions from the individual place are calculated on the basis of an approach that is similar to an approach of the top-down method.

[0039]

In actual measurement, either the top-down method or the bottom-up method does not always need to be employed. For example, the bottom-up method is employed for a principal GHG emission portion, and an infrared image having high precision or high resolution is acquired at a close distance from the emission position, and GHG emissions are calculated. On the other hand, in order to comprehensively grasp GHG emission portions, the top-down method is employed, an infrared image is acquired above the estimation boundary where the facility is provided, and for portions that have not been individually imaged, GHG emissions are calculated from a result of imaging the estimation boundary. Then, the GHG emissions that have

been calculated according to the bottom-up method/the top-down method are added while avoiding duplication of the same GHG emission portion.

[0040]

Moreover, coefficient multiplication or engineering calculation is applicable to the bottom-up method. In coefficient multiplication, the content of operation of each business, such as a result of measuring a supply flow rate of a raw material or an intermediate raw material in an individual facility that processes fuel, a production flow rate of the processed fuel, or fuel or power consumption, is integrated to obtain activity data. Furthermore, in a case where the number of GHG leakage sources is employed as the activity data, the number of valves, flanges, or vents serving as the GHG leakage sources in the estimation boundary is obtained. Then, calculation, such as multiplying the activity data by a coefficient, is performed according to the calculation formula defined by the guidelines, and therefore GHG emissions can be calculated.

[0041]

Furthermore, in engineering calculation, similarly, a result of measuring a supply flow rate of a raw material or an intermediate raw material, a production flow rate of processed fuel, or fuel or power consumption in an

individual facility is input to a simulation model or a mass balance model that has been prepared in advance, and therefore GHG emissions can be calculated.

Any one of coefficient multiplication and engineering calculation or any one of coefficient multiplication, engineering calculation, and actual measurement does not always need to be employed. These methods may be used together while avoiding double counting of GHG emissions.

[0042]

The methods for calculating GHG emissions in a fuel processor that have been described above with reference to Fig. 4 are similarly applicable to calculation of GHG emissions in another constituent business operator in the SC illustrated in Fig. 3. In this case, the management system 3 in the present example acquires, as the emissions specifying data, original data of at least one type of (1) to (4) described below or its processed data from each of the constituent business operators.

[0043]

(1) Actual measurement (the top-down method): the concentration of GHG emitted in an estimation boundary that has been set to correspond to a business performing region of a constituent business operator, or GHG emissions in the estimation boundary that have been calculated from the

measured concentration of GHG. Here, examples of the “business performing region” include a region where a production facility that produces natural gas or crude oil in the case of the producer, and a region where a processing facility that processes fuel in the case of the processor. Other examples include a transportation facility itself in a case where the raw material transporter or the fuel transporter transports a raw material or fuel by using a vessel as the transportation facility, a region where the transportation facility is provided in a case where transportation is performed by using the pipeline as the transportation facility, and a region where a supply facility, such as a fuel tank or a pump, for supplying fuel to consumers is provided in the case of the supplier. Each constituent business operator sets the “estimation boundary” as a range serving as a target of the report of GHG emissions, for the business performing region described above. This estimation boundary is set to include an emission source that emits GHG or a region where business relating to the “activity data” described above is operated on the basis of the guidelines described above.

[0044]

(2) Actual measurement (the bottom-up method): the concentration of GHG that has been measured at a GHG

emission position in a facility for performing business of a constituent business operator, or GHG emissions from the facility that have been calculated from the measured concentration of GHG.

(3) Coefficient multiplication: activity data specified according to operation of business of a constituent business operator.

(4) Engineering calculation: GHG emissions calculated on the basis of calculation (the simulation model or the mass balance model) indicating the operation content of a facility for performing business of a constituent business operator.

[0045]

In (1) to (4) described above, examples of the original data include a result of measuring the concentration of GHG in actual measurement, activity data in coefficient multiplication, and various input values that are input to the simulation model or the mass balance model in engineering calculation. Furthermore, an example of the processed data is a value of GHG emissions from an individual emission position or a facility that have been calculated in actual measurement, coefficient multiplication, and engineering calculation.

[0046]

Then, as schematically illustrated in Fig. 4, in a

case where the original data has been acquired, GHG emissions are calculated according to each of the methods. Furthermore, in a case where GHG emissions have been acquired as the processed data, GHG emissions including a result of calculating GHG emissions from the original data are integrated while avoiding double counting, and GHG emissions E_n are calculated for a corresponding constituent business operator. Figs. 3 and 4 illustrate a case where GHG emissions E_n are calculated as emission intensity [kg/ton] (GHG emissions per unit amount of a raw material/fuel).

[0047]

On the other hand, actual measurement (the top-down method/the bottom-up method), coefficient multiplication, and engineering calculation require data acquisition resources that are different from each other. For example, in actual measurement, a service of acquiring an infrared image by using the drone 41, the artificial satellite 42, and the aircraft 43 needs to be used. Furthermore, in a case where an infrared image of a constituent business operator itself is acquired, a device such as the drone 41 or the infrared camera 44 needs to be prepared, and the personnel who perform imaging need to be secured.

[0048]

On the other hand, in coefficient multiplication, a

means for acquiring each activity data (for example, a means for measuring energy consumption, or an amount of treatment or a supply amount of a raw material/fuel, or a management database for grasping the number of valves, flanges, or vents serving as GHG leakage sources), or a calculation system that calculates GHG emissions on the basis of the calculation method defined by the guidelines needs to be constructed in a computer. On the other hand, in engineering calculation, the simulation model or the mass balance model needs to be constructed in a computer, and a measuring means for acquiring various input values to be input to the model is also required. Note that in a case where the management system 3 of the present disclosure acquires the original data of coefficient multiplication or engineering calculation as the emissions specifying data, the calculation system of coefficient multiplication, or the simulation model or the mass balance model of engineering calculation may be constructed in the management system 3.

[0049]

Each of the constituent business operators selects a method for calculating GHG emissions in such a way that GHG emissions having required accuracy can be calculated within a range of cost constraints or time constraints, and prepares data acquisition resources that are suitable for

each method.

In this point, the management system 3 of the present example has a function of performing an arithmetic operation to obtain an optimum combination of data acquisition resources that corresponds to a preset purpose within a range of constraints on selecting data acquisition resources that can be employed by a constituent business operator. The specific content of this function will be described later.

[0050]

The management system 3 of the present example acquires pieces of emissions specifying data of respective constituent business operators by using their terminals 11 to 15, and therefore the management system 3 can calculate GHG emissions E_n ($n = 1$ to 4) for these constituent business operators. A result of calculating the GHG emissions E_n may be retained, for example, in a block chain ledger to secure authenticity.

[0051]

In a case where GHG emissions E_n are managed by using the block chain ledger, the GHG emissions E_n are verified by these constituent business operators by using a publicly known block chain technique, and are recorded. For example, the block chain ledger is managed by using management application software that has been installed in

a terminal of each of the constituent business operators (the producer terminal 11, the processor terminal 12, the fuel transporter terminal 13, the supplier terminal 14, and the consumer terminal 15) that is connected to the management system 3. Here, the block chain ledger may be shared by all of the constituent business operators that are connected to the management system 3, and GHG emissions E_n of each of the constituent business operators may be verified and recorded. Furthermore, a range of sharing the block chain ledger may be limited, block chain ledgers that are different from each other may be provided for SC1 to SC3 illustrated in Fig. 1, and GHG emissions E_n may be verified and recorded by only constituent business operators that constitute each of SC1 to SC3. Note that a terminal that verifies and recorded the block chain ledger may include the management computer 20 of the manager.

[0052]

As described above, GHG emissions at a time when each of the constituent business operators has produced, has processed, has transported, or has received a raw material or fuel can be specified on the basis of emissions specifying data included in a data set acquired from each of the constituent business operators. Furthermore, an SC for fuel to be supplied from a certain supplier to consumers can be specified on the basis of identification

data associated with this emissions specifying data.

[0053]

Then, the management system 3 sums GHG emissions for all of the constituent business operators that constitute the SC specified on the basis of the identification data, and therefore the management system 3 can obtain total GHG emissions for the fuel supplied from the SC. From this point of view, the management system 3 of the present example has a function of a total emissions calculation unit.

[0054]

By obtaining the total GHG emissions, a consumer can know total GHG emissions from the SC relating to fuel for the supply of the fuel from the supplier, by using the consumer terminal 15. Similarly, constituent business operators that constitute each SC can know total GHG emissions from an SC relating to their own businesses, by using the terminals 11 to 15.

[0055]

Moreover, the management system 3 of the present example calculates individual GHG emissions for each of the constituent business operators that constitute a plurality of SCs, SC1 to SC3. By employing this configuration, a new SC' can be generated by replacing some of the constituent business operators that constitute a certain SC with

constituent business operators that constitute another SC, and total GHG emissions in a case where fuel is supplied from this new SC' can be obtained.

[0056]

An operation of the management system 3 having the configuration and the functions that have been described above is described below with reference to Figs. 5 and 6. Fig. 5 illustrates an operation to acquire emissions specifying data from each constituent business operator, and calculate and record GHG emissions, and Fig. 6 illustrates an operation to calculate total GHG emissions for a selected SC.

[0057]

In Fig. 5, communication is performed with the terminal 11 to 15 of each constituent business operator via a communication system of the management system 3 (START), a data set is acquired, and identification data and emissions specifying data are updated (step S101, a process of acquiring a data set). Next, GHG emissions are calculated from the acquired emissions specifying data for each of the constituent business operators (step S102, a process of calculating GHG emissions). The calculated GHG emissions and the identification data are retained in a block chain ledger in association with each other (step S103).

[0058]

Then, a timing of shipping a raw material or fuel from each of the constituent business operators is waited for (step S104; NO), and if shipping has been performed (step S104; YES), steps S101 to 103 described above are performed to recalculate GHG emissions.

[0059]

Here, examples of the timing of shipping include a timing of delivering fuel to a transportation ship or the like of the transporter in the case of the processor, a timing of unloading a raw material or fuel from the transportation ship in the case of the raw material transporter or the fuel transporter, and a timing of supplying fuel from a supply facility of the supplier to the consumer in the case of the supplier. Furthermore, shipping is continuously performed via a pipeline, for example, between the producer and the processor or between the supplier and the consumer in some cases. In such cases, as an example, GHG emissions are recalculated at preset intervals (for example, every day or every week).

[0060]

GHG emissions are calculated for an SC relating to fuel supplied to the consumer, by using GHG emissions of each of the constituent business operators that have been calculated as described above (Fig. 6, START). In this

operation, first, the selection of an SC for which total GHG emissions will be calculated is received (step S201). At this time, a plurality of SCs, SC1 to SC3, to choose from may be displayed to the terminals 11 to 15 that are connected to the management system 3, as illustrated in Fig. 1, and the selection of a specified SC may be directly received. On the other hand, for example, if the consumer has selected a supplier of fuel that the consumer is being supplied with or fuel that the consumer is considering to be supplied with, an SC relating to the fuel may be specified on the basis of latest identification data.

[0061]

Next, selection is received as to whether a constituent business operator will be replaced in the selected SC (step S202). A case where a constituent business operator is replaced will be described with reference to Figs. 7 and 8 together, and therefore here, the description proceeds with a case where replacement is not performed (step S202; NO).

[0062]

In this case, for example, current GHG emissions are read for constituent business operators that constitute the selected SC (step S203). Next, the read GHG emissions are summed to calculate total GHG emissions for the selected SC (step S206, a process of obtaining total GHG emissions), a

result is output to the terminals 11 to 15 serving as a request source, and the operation is terminated (step S207, END).

By performing the operation described above, total GHG emissions E can be calculated for the selected SC, as illustrated in Fig. 3, and a result can be reported to the request source.

[0063]

Here, in supplying fuel from the supplier to consumers, a storage tank that stores fuels to be supplied to the consumers stores fuels that are different in a timing of calculating GHG emissions due to, for example, a difference in a timing of unloading in some cases. At this time, GHG emissions of each of the constituent business operators can change between these fuels that are different in a calculation timing in some cases.

Furthermore, fuels that respectively have passed through plural different SCs, SC1 to SC3 are mixed in a single storage tank in some cases.

[0064]

In these cases, determination may be performed as to what ratio fuels that are associated with respective pieces of identification data are stored at, and a weighting addition value that corresponds to a content ratio may be obtained for total GHG emissions of these fuels.

In order to determine a ratio of respective fuels included in the storage tank, in addition to information that is included in the identification data and indicates “when fuel has been received”, information relating to an amount of reception in the storage tank of fuel added with the identification data, and a timing and an amount of supply of the fuel to the consumer is acquired in advance as the emissions specifying data. Then, a ratio of the respective fuels in the storage tank can be determined on the basis of these pieces of information by using an approach, such as the first-in first-out method or the moving average method, of an inventory evaluation method.

[0065]

In addition, in a case where a fuel, such as LNG, that is volatile liquid is stored in the storage tank, a composition of the fuel changes according to volatilization of a light component during a storage period in some cases. In these cases, the light component that has volatilized is also associated with GHG emissions of constituent business operators (the producer, the processor, and the fuel supplier) on an upstream side of an SC. Therefore, if the component of the fuel in the storage tank has changed due to volatilization of the light component, total GHG emissions of the fuel also change. In the process described above for calculating total GHG emissions, the

total GHG emissions may be calculated in consideration of an influence of a change in the composition of the fuel in the storage tank, as described above.

[0066]

The management system 3 according to the present embodiment has the advantageous effect described below. A plurality of data sets in which identification data and emissions specifying data have been associated with each other is acquired from constituent business operators that constitute an SC. The identification data identifies a raw material or fuel to be sent to a downstream side of the SC after the performing of business. The emissions specifying data specifies emissions of GHG that has been emitted according to the performing of the business. This enables total GHG emissions to be managed for a fuel that has been supplied from each SC.

[0067]

Next, a case where a constituent business operator is replaced in step S202 of Fig. 6 (step S202; YES) is described. In this case, a change in a constituent business operator of an SC for which calculation will be performed for total GHG emission is received (step S204).

[0068]

Fig. 7 illustrates an example where the fuel transporter has been replaced in SC1 surrounded with a

broken line to generate new SC1' surrounded with a solid line. Furthermore, Fig. 8 illustrates an example where the producer and the processor that is supplied with a raw material from this producer via a pipeline have been replaced together in SC2 surrounded with a broken line to generate new SC2' surrounded with a solid line.

[0069]

For example, current GHG emissions are read for new SC1' and SC2' that have been generated by replacing a constituent business operator or constituent business operators, as described above (step S205). An operation to calculate total GHG emissions for SC1' and SC2' described above after that, and output a result of calculation is similar to an operation in a case where no constituent business operators are changed (steps S206 and S207).

[0070]

The management system 3 in the present example stores GHG emissions of individual constituent business operators of an SC, and therefore total GHG emissions can also be calculated for new SC' obtained by changing constituent business operators included in the SC. Therefore, consideration can be performed to grasp, in advance, for example, an influence of a change in a chartered ship of the raw material transporter or the fuel transporter or a change in the producer or the processor

serving as a procurement source of a raw material or fuel on total GHG emissions.

[0071]

Next, two examples of an application function of the management system 3 in the present example are described.

Fig. 9 is a flowchart relating to an operation to optimize selection of data acquisition resources for a constituent business operator to acquire original data. As described in detail with reference to Fig. 4, the original data is used as the emissions specifying data with no change or after processing to obtain processed data. On the other hand, each of the constituent business operators selects a method for calculating GHG emissions in such a way that GHG emissions having required accuracy can be calculated within a range of cost constraints or the like, and prepares data acquisition resources that are suitable for each method, as described above.

[0072]

On the other hand, the original data is acquired at a large number of places in a facility of a constituent business operator, and this results in a large number of data acquisition resources. Furthermore, data acquisition resources to be employed differ depending on which position of which facility a calculation method, such as actual measurement (the top-down method/the bottom-up method),

coefficient multiplication, or engineering calculation that has been described above, will be employed to calculation of GHG emissions from. In addition, the selection of the data acquisition resources affects a cost or the calculation accuracy of GHG emissions to be calculated. In such a case, each of the constituent business operators fails to easily specify an optimum combination of data acquisition resources for acquiring the original data in some cases.

[0073]

Accordingly, the management system 3 in the present example has a function of obtaining a combination of data acquisition resources at a lowest cost within a preset range of constraints of selection of data acquisition resources in a case where there are a plurality of data acquisition resources relating to acquisition of the original data.

With respect to this function, for example, the management system 3 lists up, for each of the constituent business operators, items of the original data that are required in a case where actual measurement (the top-down method/the bottom-up method), coefficient multiplication, or engineering calculation that has been described above is employed to calculate GHG emissions. Specific examples of the items of the original data include the items describe

above in (1) to (4).

[0074]

Furthermore, for example, in a case where an infrared image is acquired by using the top-down method using the artificial satellite 42 or the aircraft 43, GHG emissions from respective positions of a facility can be collectively grasped, and therefore from the perspective of an individual emission position, a cost of acquiring an infrared image is relatively low. On the other hand, a decrease in a resolution due to acquisition of an infrared image from a remote position is likely to cause a decrease in the accuracy of calculation of GHG emissions. In contrast, in acquiring an infrared image by using the bottom-up method, a task of imaging individual emission positions is required, and a cost of acquiring an infrared image is relatively high. On the other hand, an infrared image can be acquired near a GHG emission position, and therefore the accuracy of calculation of GHG emissions is likely to be high.

Accordingly, the management system 3 acquires, in advance, information relating to a cost of using data acquisition resources required to acquire these pieces of original data and information relating to the accuracy of GHG emissions that are calculated on the basis of emissions specifying data that has been obtained from the pieces of

original data.

[0075]

On the condition that these pieces of advance information have been prepared, a request for optimization research is received from the terminals 11 to 14 of respective constituent business operators (START). Then, information relating to a data acquisition resource that is available to a constituent business operator serving as a request source is acquired for each of the listed-up pieces of original data (step S301). At this time, similarly to actual measurement of the top-down method and the bottom-up method that have been described above, in a case where a plurality of data acquisition resources is available, pieces of information relating to all of the available data acquisition resources are acquired.

[0076]

Then, after the information has been acquired, a search is conducted for a combination of data acquisition resources that causes a lowest cost in calculating GHG emissions of a facility of the constituent business operator by using these available data acquisition resources (step S302, a process of obtaining a combination of data acquisition resources).

A combination of data acquisition resources that satisfies such conditions can be searched for by the

management system 3 by using general-purpose optimization software. Examples of such software include modeFRONTIER from ESTECO, HyperStudy from Altair, Optimas from Noesis Solutions, and HEED from Red Cedar Technology. Here, a search for a combination of data acquisition resources by using general-purpose optimization software is not mandatorily required, and an optimum combination may be searched for by using a dedicatedly developed search tool.

[0077]

The optimum combination can be searched for according to a genetic algorithm or particle swarm optimization by using such optimization software or search tool. Specific examples of an algorithm for performing these optimization methods include the neighborhood cultivation genetic algorithm (NCGA), the normal boundary intersection (NBI), and the indirect optimization on the basis of self-organization (IOSO). However, a search for the optimum combination is not limited to the case of using these methods described as an example, and an arbitrary method that enables a search for a combination that causes a lowest cost in using a large number of data acquisition resources can be employed.

[0078]

Furthermore, here, a lower limit value may be set for the accuracy of each emissions specifying data, and a

search may be conducted for a combination of data acquisition resources that causes a lowest cost within a range of the accuracy constraints described above. On the other hand, in contrast to the example described above, an upper limit may be set for a total cost of a combination of data acquisition resources, and a search may be conducted for a combination of data acquisition resources that causes each emissions specifying data to have highest accuracy.

[0079]

When the search described above has been finished, a combination of data acquisition resources that causes a lowest cost, which is a search result, is presented to the constituent business operator serving as the request source (step S303), and the operation is terminated (END).

[0080]

Next, Fig. 10 is a flowchart relating to an operation to verify GHG emissions that have been calculated on the basis of the emissions specifying data. As illustrated in Fig. 2, the management system 3 is configured to acquire the emissions specifying data from each of a plurality of constituent business operators that has the common content of business, such as the producers or the processors. If constituent business operators have the common content of business, but the configuration or scale of a facility to be used to perform the business

differs, the content of emissions specifying data differs. On the other hand, these plural constituent business operators include business operators that have a similar configuration of a facility in some cases. Furthermore, as described with reference to Fig. 5, the emissions specifying data is repeatedly acquired, for example, every time of shipping of a raw material or fuel, and GHG emissions are calculated.

[0081]

Emissions specifying data acquired from a business operator that has a similar facility configuration is repeatedly acquired, as described above, and therefore a relationship between a handling amount of a raw material or fuel and GHG emissions can be specified for each constituent business operator that has a common facility configuration. Accordingly, if a business operator model indicating the relationship described above is generated, and an actual handling amount of a raw material or fuel is input to this business operator model, standard GHG emissions that correspond to the actual handling amount can be specified for constituent business operators that have a common facility configuration.

[0082]

With respect to the function described above, the management system 3 (START) generates a business operator

model indicating a relationship between a past handling amount of a raw material or fuel and GHG emissions for a plurality of constituent business operators that has a common facility configuration (step S401). The business operator model can be generated on the basis of a result of machine-learning a correspondence relationship among emissions specifying data included in a plurality of data sets acquired in the past, GHG emissions calculated from the emissions specifying data, and an actual handling amount of a raw material or fuel. A machine learning method is not particularly limited, and a publicly known method, such as a deep neural network, support vector regression, random forest regression, or partial least squares, can be used. Furthermore, performing machine learning to generate the business operator model is not mandatorily required. For example, a least-squares method may be performed by using emissions specifying data or a handling amount of a raw material or fuel as an explanatory variable and using GHG emissions as an estimator variable, and an obtained relational expression may be used as the business operator model.

[0083]

Next, GHG emissions are estimated by using the business operator model described above on the basis of an actual handling amount of a raw material or fuel that has

been specified according to the performing of business of a certain constituent business operator in obtaining emissions specifying data for the certain constituent business operator (step S402, a process of estimating GHG emissions). Furthermore, GHG emissions are calculated on the basis of the emissions specifying data acquired from the same constituent business operator. After that, a comparison is made between the GHG emissions calculated from the emissions specifying data and an estimated value of GHG emissions (step S403, a process of comparing GHG emissions), a result of comparison is output to the terminal 11 to 14 of the constituent business operator or the management computer 20 (step S404), and the operation is terminated (END).

[0084]

As described above, a comparison is made between standard GHG emissions serving as an estimated value of a business operator model and GHG emissions that have been calculated on the basis of emissions specifying data acquired from a constituent business operator, and therefore the latter GHG emissions can be verified. Stated another way, in a case where the calculated GHG emissions are significantly different from the standard GHG emissions, it can be detected that there is a possibility of an input error of the emissions specifying data or the

occurrence of a trouble in data acquisition resources or a facility body.

[0085]

As the management system 3 described above, an example where a cloud computing system has a GHG emissions management function is illustrated in Fig. 2, but a configuration of the management system 3 is not limited to this example. For example, the management system 3 may be configured in a server system of a manager that provides the GHG emissions management function.

Reference Signs List

[0086]

- 11 Producer terminal
- 12 Processor terminal
- 13 Fuel transporter terminal
- 14 Supplier terminal
- 15 Consumer terminal
- 2 Management computer
- 3 Management system
- 41 Drone
- 42 Artificial satellite
- 43 Aircraft
- 44 Infrared camera

CLAIMS

1. A greenhouse gas emissions management method for a supply chain of fuel, the greenhouse gas emissions management method comprising:

a process of acquiring a plurality of data sets from a plurality of constituent business operators via a data communication system, the plurality of constituent business operators constituting the supply chain from production of a raw material to supply of the fuel, and being business operators selected from a business operator group consisting of a producer that produces the raw material of the fuel, a raw material transporter that transports the raw material, a processor that processes the fuel from the raw material, a fuel transporter that transports the fuel, and a supplier that supplies the fuel to a consumer, the plurality of data sets being obtained by associating identification data with emissions specifying data, the identification data identifying the raw material or the fuel to be sent to a downstream side of the supply chain after each of the plurality of constituent business operators has performed business, the emissions specifying data specifying emissions of greenhouse gas that has been emitted according to performing of the business for the raw material or the fuel that has been identified by the identification data;

a process of causing a computer to calculate the emissions of the greenhouse gas for the plurality of constituent business operators on a basis of plural pieces of the emissions specifying data that have been acquired from the plurality of constituent business operators; and

a process of causing the computer to sum the emissions of the greenhouse gas for all of the plurality of constituent business operators that constitutes a single supply chain that is specified by the identification data, and obtain total emissions of the greenhouse gas for the fuel supplied through the single supply chain.

2. The greenhouse gas emissions management method according to claim 1, wherein the identification data includes information indicating a sending destination of the raw material or the fuel to be sent from the producer or the processor, a transportation section of the raw material or the fuel to be transported by the raw material transporter or the fuel transporter, or a sending source of the fuel to be sent to the supplier, and the all of the plurality of constituent business operators that constitutes the single supply chain are specified on a basis of the information indicating the sending destination, the transportation section, or the sending source.

3. The greenhouse gas emissions management method

according to claim 1, wherein the emissions specifying data includes original data of at least one type of (1) to (4) described below, or processed data of the original data:

(1) a concentration of the greenhouse gas emitted into an estimation boundary that has been set to correspond to a region of performing of the business of each of the plurality of constituent business operators, or the emissions of the greenhouse gas into the estimation boundary, the emissions being calculated from the concentration of the greenhouse gas that has been measured;

(2) the concentration of the greenhouse gas that has been measured at a position of emission of the greenhouse gas from a facility for performing the business of each of the plurality of constituent business operators, or the emissions of the greenhouse gas from the facility, the emissions being calculated from the concentration of the greenhouse gas that has been measured;

(3) activity data that is specified according to operation of the business of each of the plurality of constituent business operators; and

(4) the emissions of the greenhouse gas that have been calculated by performing engineering calculation of operation content of the facility for performing the business of each of the plurality of constituent business operators.

4. The greenhouse gas emissions management method according to claim 3, further comprising a process of causing the computer to obtain a combination of data acquisition resources that causes a lowest cost within a range of preset constraints of selection of the data acquisition resources, in a case where each of the plurality of constituent business operators has a plurality of the data acquisition resources relating to acquisition of pieces of the original data of types described in (1) to (4).

5. The greenhouse gas emissions management method according to claim 1, further comprising:

a process of causing the computer to generate a business operator model indicating a relationship between a handling amount of the raw material or the fuel and the emissions of the greenhouse gas on a condition that a facility configuration is in common with the facility configuration of a single constituent business operator selected from the plurality of constituent business operators;

a process of causing the computer to estimate the emissions of the greenhouse gas by using the business operator model on a basis of an actual handling amount of the raw material or the fuel that has been specified according to the performing of the business when the

emissions specifying data is obtained for the single constituent business operator; and

a process of causing the computer to make a comparison between the emissions of the greenhouse gas that have been calculated on a basis of the emissions specifying data acquired from the single constituent business operator and the emissions of the greenhouse gas that have been estimated by using the business operator model.

6. The greenhouse gas emissions management method according to claim 5, wherein the business operator model is generated on a basis of a result of machine learning of a correspondence relationship among the emissions specifying data included in the plurality of data sets acquired in past, the emissions of the greenhouse gas that have been calculated from the emissions specifying data, and the actual handling amount of the raw material or the fuel.

7. The greenhouse gas emissions management method according to claim 1, wherein the emissions of the greenhouse gas for the plurality of constituent business operators are retained in a block chain ledger, the emissions being calculated in the process of causing the computer to calculate the emissions of the greenhouse gas.

8. The greenhouse gas emissions management method according to claim 1, wherein in the process of causing the

computer to obtain the total emissions of the greenhouse gas for the fuel, a new supply chain is generated by replacing some of the plurality of constituent business operators that constitutes the single supply chain with some of the plurality of constituent business operators that constitutes another supply chain, and the total emissions of the greenhouse gas are obtained for the fuel that is supplied through the new supply chain.

9. The greenhouse gas emissions management method according to claim 1, wherein the fuel is any of liquefied natural gas that has been processed from natural gas serving as the raw material, ammonia that has been processed from the natural gas serving as the raw material, hydrogen or synthetic methane, fuel oil that has been processed from crude oil serving as the raw material, or biomethane that has been processed from organic waste serving as the raw material.

10. The greenhouse gas emissions management method according to claim 1, wherein the greenhouse gas is at least any one of carbon dioxide, methane, or nitrous oxide.

11. A greenhouse gas emissions management system for a supply chain of fuel, the greenhouse gas emissions management system comprising:

a data communication unit that acquires a plurality of data sets from a plurality of constituent business

operators, the plurality of constituent business operators constituting the supply chain from production of a raw material to supply of the fuel, and being business operators selected from a business operator group consisting of a producer that produces the raw material of the fuel, a raw material transporter that transports the raw material, a processor that processes the fuel from the raw material, a fuel transporter that transports the fuel, and a supplier that supplies the fuel to a consumer, the plurality of data sets being obtained by associating identification data with emissions specifying data, the identification data identifying the raw material or the fuel to be sent to a downstream side of the supply chain after each of the plurality of constituent business operators has performed business, the emissions specifying data specifying emissions of greenhouse gas that has been emitted according to performing of the business for the raw material or the fuel that has been identified by the identification data;

a business operator emissions calculation unit that calculates the emissions of the greenhouse gas for the plurality of constituent business operators on a basis of plural pieces of the emissions specifying data that have been acquired by the data communication unit for the plurality of constituent business operators; and

a total emissions calculation unit that sums the emissions of the greenhouse gas that have been calculated by the business operator emissions calculation unit for all of the plurality of constituent business operators that constitutes a single supply chain that is specified by the identification data, and obtains total emissions of the greenhouse gas for the fuel supplied through the single supply chain.