

PLANT OPERATION ASSISTANCE DEVICE AND PLANT OPERATION ASSISTANCE METHOD

TECHNICAL FIELD

- 5 [0001] The present disclosure relates to assistance for operations of plants, and particularly, to assistance for operations of plants by determining a fuel combination of a plurality of types of fuel used in a plant including a boiler.

BACKGROUND

- 10 [0002] For example, Patent Document 1 discloses an energy trading method using a computer network capable of improving efficiency of fuel trading by allowing a primary energy seller (a fuel supply company, a fuel trading company, or the like) to collectively control management and operations of fuel storage facilities in the facilities of a plurality of secondary energy producers (electric power companies and the like) and replenishment of
15 required fuel. More specifically, when the primary energy seller is informed of a low residual amount of fuel in the fuel storage facilities installed in the plurality of secondary energy producers, the primary energy seller transports primary energy (coal, petroleum, or gas). In this transportation, the type of fuel to be transported is determined by prioritizing a power plant having a small residual amount of fuel and a large consumption amount per day
20 or on the basis of the inventory to be sold early.

Citation List

Patent Literature

[0003]

- 25 Patent Document 1: JP4405269B

SUMMARY

Technical Problem

[0004] In the energy trading method disclosed in Patent Document 1, the primary energy seller makes a fuel transportation plan on the basis of a low residual amount of fuel of the plurality of secondary energy producers collectively. However, there is no description of a fuel producer (hereinafter a fuel supplier) that provides primary energy (fuel) to the primary energy seller. That is, Patent Document 1 does not take a production state of a fuel supplier into consideration.

[0005] On the other hand, the boiler fuel needs to satisfy constraint conditions in use such as fuel combustibility and grindability by a mill. Particularly, the properties of biomass fuel vary greatly because the yield of wood and palm fruits serving as the raw material thereof is easily influenced by climatic conditions and a production site, a raw material, and a storage method affect a water content or the like.

[0006] With the foregoing in view, the inventors of the present invention have devised a method in which an EPC vendor (EPC: Engineering, Procurement and Construction), for example, that holds specifications of devices that constitute a plant (hereinafter a fuel combustion plant) including a device such as a boiler that combusts fuel proposes (plans) a fuel combination (fuel ratio) of fuel used in a fuel combustion plant while taking device properties, fuel properties, and a production state (production prospect) of fuel of a plurality of fuel suppliers into consideration. By doing so, it is possible to provide appropriate operation assistance such as providing a fuel supply plan optimal for a vendor (hereinafter a plant operator) operating a fuel combustion plant in terms of costs and stable fuel supply. Furthermore, since fuel to be used is determined by taking a production state of a fuel supplier into consideration, it is possible for the fuel supplier to make a more appropriate production plan.

[0007] With the foregoing in view, an object of at least one embodiment of the present invention is to provide a plant operation assistance device that performs assistance for operations of a fuel combustion plant by determining a fuel combination to be provided from a plurality of fuel suppliers to a plant operator.

Solution to Problem

[0008] (1) A plant operation assistance device according to at least one embodiment of the present invention is

a plant operation assistance device that determines a fuel procurement plan which is a
5 plan related to procurement of a plurality of types of fuel used in a fuel combustion plant, the device including:

a device information storage unit configured to store device information related to devices that constitute the fuel combustion plant;

a plant operation plan acquisition unit configured to acquire an operation plan which is a
10 plan related to operation of the fuel combustion plant operated by a plant operator;

a candidate fuel information acquisition unit configured to acquire candidate fuel information including at least one of a fuel property, an available amount, and a fuel cost of each of the plurality of types of fuel provided from a plurality of fuel suppliers;

a constituent device information acquisition unit configured to acquire the device
15 information of the at least one of devices that constitute the fuel combustion plant from the device information storage unit; and

a fuel procurement plan determination unit configured to determine the fuel procurement plan capable of realizing the operation plan by determining a procurement amount in each prescribed period, of each of the plurality of types of fuel supplied from each
20 of the plurality of fuel suppliers on the basis of the candidate fuel information, the operation plan, and the device information of the at least one of devices.

[0009] The device information such as specifications of various devices such as devices constituting a device such as a boiler constituting a fuel combustion plant, a combustion device, a heat exchanger, a denitration device, and an exhaust gas processing device is
25 information helpful for selecting a fuel usable in a device such as a boiler and making a maintenance plan, and the device information is held by an EPC vendor who undertakes plant construction, for example.

[0010] According to the configuration of (1), the plant operation assistance device is a

device closely associated with an EPC vendor, for example, that holds the device information such as specifications of devices constituting the fuel combustion plant and determines the fuel procurement plan related to a plurality of types of fuel appropriate for the device information and the operation plan planned by the plant operator using the fuels scheduled to
5 be held by each of the plurality of fuel suppliers as candidates. By determining the fuel procurement plan in this manner, it is possible to determine which type of fuel is to be supplied from which fuel supplier in which amount from the viewpoint of the operation cost and the stability of fuel supply of the fuel combustion plant and to propose the fuel procurement plan optimal for realizing the operation plan to the plant operator.

10 [0011] (2) In some embodiments, in the configuration of (1), the plant operation assistance device further includes:

a fuel procurement plan feedback unit configured to transmit at least part of information of the fuel procurement plan to at least one of the plurality of fuel suppliers.

According to the configuration of (2), since the fuel procurement plan is fed back to the
15 fuel suppliers, each fuel supplier can perform adjustment such as increasing the production of fuel of the fuel type that has a demand or reducing the production of fuel of the fuel type that does not have a demand. Therefore, it is possible to optimize fuel production and stock of the fuel supplier.

[0012] (3) In some embodiments, in the configuration of (2),
20 the fuel procurement plan feedback unit acquires adjustability information indicating whether the available amount of each of the plurality of types of fuel provided from the plurality of fuel suppliers can be adjusted and determines a destination fuel supplier to which at least part of information of the fuel procurement plan is transmitted on the basis of the adjustability information.

25 [0013] The fuel procurement plan is based on the plant operation plan and can be said to be management information of the plant operator (that is, highly confidential information).

According to the configuration of (3), since the fuel procurement plan is fed back to only the fuel supplier of which the fuel amount can be adjusted, it is possible to prevent

information from spreading more than necessary. It is possible to prompt the fuel supplier to increase or reduce the production of fuel and to reduce the procurement cost of the plant operator and the EPC vendor to reduce the cost of the fuel supplier.

[0014] (4) In some embodiments, in the configuration of any one of (1) to (3), the plant operation assistance device further includes:

a fuel use record acquisition unit configured to acquire a fuel use record obtained when the fuel combustion plant is operated according to the fuel procurement plan, the fuel use record including a combustion performance or a fuel use amount of at least one of the plurality of types of fuel; and

a fuel use record feedback unit configured to transmit at least part of information of the fuel use record to at least one of the fuel suppliers.

[0015] Generally, for example, woody biomass fuel is produced from wood (raw wood) produced directly from forests such as thinned wood and industrial waste such as wood scraps, wood chips, and building demolition materials produced by wood processing. The properties such as a water content of biomass fuel vary greatly and the combustion performance is likely to vary in such a way that a water content or the like is affected by the origin, tree species, a storage method, and the like. The combustion performance of fossil fuel such as coal may differ depending on a production site or the like. Therefore, the combustion performance of a fuel supplier may be different from an actual combustion performance when fuel was actually used. If the combustion performance is different, the fuel use amount may deviate from a planned value.

[0016] According to the configuration of (4), the fuel use record obtained by using a plurality of types of fuel supplied on the basis of the fuel procurement plan in operation of the fuel combustion plant is fed back to the fuel supplier that provided the fuel via the plant operation assistance device. In this way, the fuel supplier can optimize the fuel production of the fuel supplier such as production adjustment and stock adjustment by increasing or reducing the production of required fuel and can stably supply fuel to the plant operator more reliably.

[0017] (5) In some embodiments, in the configuration of (4),

the candidate fuel information acquisition unit acquires the candidate fuel information that the fuel supplier has corrected on the basis of the fuel use record.

According to the configuration of (5), it is possible to determine a more accurate fuel
5 procurement plan.

[0018] (6) In some embodiments, in the configuration of any one of (1) to (5), the plant operation assistance device further includes:

a maintenance plan determination unit configured to determine a maintenance plan of the fuel combustion plant on the basis of the device information, the operation plan, and the
10 fuel procurement plan.

According to the configuration of (6), the maintenance plan of the fuel combustion plant is determined on the basis of the fuel procurement plan including the information on used fuel. For example, an ash content in woody biomass fuel is different depending on a fuel type such as bark, wood chips, and waste wood. The ash content and the adhesion property of coal or
15 the like are different depending on a fuel type such as high-grade coal or low-grade coal. The tolerance to failures is different depending on the specification of a device constituting the fuel combustion plant. Therefore, it is possible to determine an appropriate maintenance plan by taking the specifications (the device information) of the fuel combustion plant, the operation plan, and the used fuel type into consideration.

20 [0019] (7) In some embodiments, in the configuration of (6), the plant operation assistance device further includes:

an operation data record acquisition unit configured to acquire an operation data record obtained when the fuel combustion plant is operated according to the fuel procurement plan; and

25 a maintenance plan correction determination unit configured to determine a correction of the maintenance plan on the basis of the operation data record.

According to the configuration of (7), the correction of the maintenance plan is determined on the basis of the operation data record obtained by operating the fuel

combustion plant. By determining the correction of the maintenance plan at that time point according to the operation record, it is possible to update the maintenance plan to a plan appropriate for the type of used fuel.

[0020] (8) In some embodiments, in the configuration of any one of (1) to (7),

5 the fuel procurement plan determination unit determines a fuel usable in the fuel combustion plant among the plurality of types of fuel included in the candidate fuel information on the basis of the candidate fuel information and the device information and calculates the fuel procurement plan on the basis of the candidate fuel information of the fuel determined to be usable, the device information, and the operation plan.

10 According to the configuration of (8), it is possible to propose an optimal operation plan to the plant operator.

[0021] (9) In some embodiments, in the configuration of any one of (1) to (8),

the fuel procurement plan determination unit determines the fuel procurement plan on the basis of the candidate fuel information, the operation plan, and the device information of
15 the at least one of devices using a learning model created by machine-learning a relationship between a past used fuel used in the past in the fuel combustion plant and a past operation record obtained by operating the fuel combustion plant using the past used fuel.

According to the configuration of (9), it is possible to propose an optimal operation plan obtained through machine learning to the plant operator.

20 [0022] (10) In some embodiments, in the configuration of any one of (1) to (9),

the candidate fuel information includes information on the fuel cost.

According to the configuration of (10), since the information of the fuel cost of a fuel is included in the candidate fuel information, it is possible to determine the fuel procurement plan emphasizing the fuel cost in such a way to determine the fuel procurement plan that
25 minimizes the fuel cost, for example.

[0023] (11) In some embodiments, in the configuration of any one of (1) to (10),

the candidate fuel information includes information on the available amount.

According to the configuration of (11), since the information of the available amount is

included in the candidate fuel information, it is possible to determine the fuel procurement plan emphasizing the stable procurement of fuel in such a way to determine the fuel procurement plan that can procure fuel stably, for example.

[0024] (12) In some embodiments, in the configuration of any one of (1) to (11),

5 the candidate fuel information includes information on the fuel property.

According to the configuration of (12), since fuel containing a large amount of ash forming element such as Na, K, and Cl which enhances adhesion of ash generated by combustion, contained in the fuel is likely to increase the maintenance cost, when the components of fuel is included in the candidate fuel information, it is possible to determine
10 the fuel procurement plan emphasizing the maintenance cost in such a way to determine the fuel procurement plan that minimizes the maintenance cost, for example. Similarly, by predicting an ash generation amount, the amount of plaster generated in case of coal, and the use amount of chemicals (as an example, aluminum chemicals that weaken the clinker adhering to a furnace wall to make it easier to peel off and chemicals used in an exhaust gas
15 processing device or an exhaust water processing device may be used but there is no limitation thereto) for suppressing adhesion of ash and environmentally harmful substances, it is possible to determine the fuel procurement plan emphasizing the running cost in such a way to determine the fuel procurement plan that minimizes the running cost, for example.

[0025] (13) In some embodiments, in the configuration of any one of (1) to (12),

20 the plurality of types of fuel includes biomass.

[0026] The production amount of biomass such as woody biomass can change depending on time since the growth of wood serving as a raw material is affected by weather conditions. Moreover, the properties of biomass vary more greatly than fossil fuel.

According to the configuration of (13), it is possible to propose an optimal operation
25 plan for a plurality of types of fuel including biomass having such properties to the plant operator.

[0027] (14) A plant operation assistance method according to at least one embodiment of the present invention is

a plant operation assistance method of determining a fuel procurement plan which is a plan related to procurement of a plurality of types of fuel used in a fuel combustion plant, the method including:

5 a plant operation plan acquisition step of acquiring an operation plan which is a plan related to operation of the fuel combustion plant operated by a plant operator;

a candidate fuel information acquisition step of acquiring candidate fuel information including at least one of a fuel property, an available amount, and a fuel cost of each of the plurality of types of fuel provided from a plurality of fuel suppliers;

10 a constituent device information acquisition step of acquiring device information of the at least one of devices that constitute the fuel combustion plant; and

a fuel procurement plan determination step of determining the fuel procurement plan capable of realizing the operation plan by determining a procurement amount in each prescribed period, of each of the plurality of types of fuel supplied from each of the plurality of fuel suppliers on the basis of the candidate fuel information, the operation plan, and the device information of the at least one of devices.

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[0028] According to the configuration of (14), the same advantages as those of (1) are obtained.

[0029] (15) In some embodiments, in the configuration of (14), the plant operation assistance method further includes:

20 a fuel procurement plan feedback step of transmitting at least part of information of the fuel procurement plan to at least one of the plurality of fuel suppliers.

According to the configuration of (15), the same advantages as those of (2) are obtained.

[0030] (16) In some embodiments, in the configuration of (15),

the fuel procurement plan feedback step involves acquiring adjustability information indicating whether the available amount of each of the plurality of types of fuel provided from the plurality of fuel suppliers can be adjusted and determining a destination fuel supplier to which at least part of information of the fuel procurement plan is transmitted on the basis of the adjustability information.

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According to the configuration of (16), the same advantages as those of (3) are obtained.

[0031] (17) In some embodiments, in the configuration of any one of (14) to (16),

a fuel use record acquisition step of acquiring a fuel use record obtained when the fuel combustion plant is operated according to the fuel procurement plan, the fuel use record including a combustion performance or a fuel use amount of at least one of the plurality of types of fuel; and

a fuel use record feedback step of transmitting at least part of information of the fuel use record to at least one of the fuel suppliers.

According to the configuration of (17), the same advantages as those of (4) are obtained.

10 [0032] (18) In some embodiments, in the configuration of (17),

the candidate fuel information acquisition step involves acquiring the candidate fuel information that the fuel supplier has corrected on the basis of the fuel use record.

According to the configuration of (18), the same advantages as those of (5) are obtained.

[0033] (19) In some embodiments, in the configuration of any one of (14) to (18), the plant operation assistance method further includes:

a maintenance plan determination step of determining a maintenance plan of the fuel combustion plant on the basis of the device information, the operation plan, and the fuel procurement plan.

According to the configuration of (19), the same advantages as those of (6) are obtained.

20 [0034] (20) In some embodiments, in the configuration of (19), the plant operation assistance method further includes:

an operation data record acquisition step of acquiring an operation data record obtained when the fuel combustion plant is operated according to the fuel procurement plan; and

a maintenance plan correction determination step of determining a correction of the maintenance plan on the basis of the operation data record.

According to the configuration of (20), the same advantages as those of (7) are obtained.

[0035] (21) In some embodiments, in the configuration of any one of (14) to (20),

the fuel procurement plan determination step involves determining a fuel usable in the

fuel combustion plant among the plurality of types of fuel included in the candidate fuel information on the basis of the candidate fuel information and the device information and calculating the fuel procurement plan on the basis of the candidate fuel information of the fuel determined to be usable, the device information, and the operation plan.

5 According to the configuration of (21), the same advantages as those of (8) are obtained.

[0036] (22) In some embodiments, in the configuration of any one of (14) to (21),

 the fuel procurement plan determination step involves determining the fuel procurement plan on the basis of the candidate fuel information, the operation plan, and the device information of the at least one of devices using a learning model created by machine-learning
10 a relationship between a past used fuel used in the past in the fuel combustion plant and a past operation record obtained by operating the fuel combustion plant using the past used fuel.

 According to the configuration of (22), the same advantages as those of (9) are obtained.

[0037] (23) In some embodiments, in the configuration of any one of (14) to (22),

 the candidate fuel information includes information on the fuel cost.

15 According to the configuration of (23), the same advantages as those of (10) are obtained.

[0038] (24) In some embodiments, in the configuration of any one of (14) to (23),

 the candidate fuel information includes information on the available amount.

 According to the configuration of (24), the same advantages as those of (11) are
20 obtained.

[0039] (25) In some embodiments, in the configuration of any one of (14) to (24),

 the candidate fuel information includes information on the fuel property.

 According to the configuration of (25), the same advantages as those of (12) are
obtained.

25 [0040] (26) In some embodiments, in the configuration of any one of (14) to (25),

 the plurality of types of fuel includes biomass.

 According to the configuration of (26), the same advantages as those of (13) are
obtained.

Advantageous Effects

[0041] According to at least one embodiment of the present invention, a plant operation assistance device that performs assistance for operations of a fuel combustion plant by determining a fuel combination to be provided from a plurality of fuel suppliers to a plant operator is provided.

BRIEF DESCRIPTION OF DRAWINGS

[0042] FIG. 1 is a diagram illustrating an entire system including a plant operation assistance device according to an embodiment of the present invention.

FIG. 2 is a diagram for describing an entire image of the content performed by the system of FIG. 1 according to an embodiment of the present invention.

FIG. 3 is a block diagram illustrating functions of the plant operation assistance device according to an embodiment of the present invention.

FIG. 4 is a diagram illustrating a fuel procurement plan according to an embodiment of the present invention.

FIG. 5 is a diagram illustrating the flow of determining a plurality of fuels defined in a fuel procurement plan according to an embodiment of the present invention.

FIG. 6 is a diagram for describing correction of a fuel production plan by a fuel supplier according to an embodiment of the present invention.

FIG. 7A is a diagram for describing a method of determining a fuel supplier serving as a feedback destination of the fuel procurement plan according to an embodiment of the present invention, in which the feedback destination is determined on the basis of adjustability information.

FIG. 7B is a diagram for describing a method of determining a fuel supplier serving as a feedback destination of the fuel procurement plan according to an embodiment of the present invention, in which the feedback destination is determined on the basis of adjustability information and a fuel cost.

FIG. 8 is a diagram illustrating a plant operation assistance method according to an embodiment of the present invention.

DETAILED DESCRIPTION

5 [0043] Embodiments of the present invention will now be described in detail with reference to the accompanying drawings. It is intended, however, that unless particularly specified, dimensions, materials, shapes, relative positions and the like of components described in the embodiments shall be interpreted as illustrative only and not limitative of the scope of the present invention.

10 For example, an expression of relative or absolute arrangement such as “in a direction”, “along a direction”, “parallel”, “orthogonal”, “centered”, “concentric” and “coaxial” shall not be construed as indicating only the arrangement in a strict literal sense, but also includes a state where the arrangement is relatively displaced by a tolerance, or by an angle or a distance whereby it is possible to achieve the same function.

15 For example, an expression of an equal state such as “same” “equal” and “uniform” shall not be construed as indicating only the state in which the feature is strictly equal, but also includes a state in which there is a tolerance or a difference that can still achieve the same function.

Furthermore, in the present specification, an expression of a shape such as a rectangular
20 shape or a cylindrical shape shall not be construed as only the geometrically strict shape, but also includes a shape with unevenness or chamfered corners within the range in which the same effect can be achieved.

Furthermore, in the present specification, an expression such as “comprise”, “include”, “have”, “contain” and “constitute” are not intended to be exclusive of other components.

25 [0044] FIG. 1 is a diagram illustrating an entire system including a plant operation assistance device 1 according to an embodiment of the present invention. FIG. 2 is a diagram for describing an entire image of the content performed by the system of FIG. 1 according to the embodiment of the present invention. In the following description, a boiler

plant 92 which is a plant including a boiler is described as an example of a fuel combustion plant. However, an application of the present invention is not limited to the boiler plant, and the present invention can be applied to a plant which procures and uses a plurality of fuels.

[0045] As illustrated in FIG. 1, a plant operator 9 that operates the boiler plant 92 (described above) receives provision (supply) of boiler fuel serving as various types of fuel such as fossil fuel (for example, coal, petroleum, gas, and the like) and biomass (for example, woody biomass) from a plurality of fuel suppliers 8 (described above) to operate the boiler plant 92. The fuel supplier 8 is a fuel producer (a fuel importer) that produces or imports the boiler fuel or a trading company that sells the fuel produced by the fuel producer to the plant operator 9 and handles at least one type of boiler fuel. In the present invention, the fuel supplier 8 and the plant operator 9 trade fuel via the plant operation assistance device 1.

[0046] The plant operation assistance device 1 is a device managed by an EPC vendor or the like who undertakes plant construction, for example, and in the embodiment illustrated in FIGS. 1 and 2, the plant operation assistance device 1 is owned and managed by an EPC vendor. The EPC vendor holds device information B such as specifications of various devices including a boiler that constitutes the boiler plant 92. Such device information B is information used for selecting fuel usable in a boiler and predicting the degree of progress of deterioration of a device when the boiler was operated using fuels having various properties. That is, in the present invention, the fuel supplier 8 and the plant operator 9 enable execution of fuel trading more preferable to both by using knowledge and knowhow of an EPC vendor having knowledge on the properties of the boiler plant 92.

[0047] Specifically, as illustrated in FIG. 2, the plant operation assistance device 1 (the EPC vendor or the like) makes an initial plan such as a fuel combination and a maintenance plan on the basis of various pieces of information provided from the fuel supplier 8 and the plant operator 9. The plant operation assistance device 1 receives a feedback of results when the boiler plant 92 was operated according to the initial plan to correct the initial plan and provides a feedback to the fuel supplier 8.

[0048] Hereinafter, the plant operation assistance device 1 that realizes the above-

described content will be described in detail with reference to FIGS. 3 to 5. FIG. 3 is a block diagram illustrating the functions of the plant operation assistance device 1 according to an embodiment of the present invention. FIG. 4 is a diagram illustrating a fuel procurement plan P according to an embodiment of the present invention. FIG. 5 is a diagram illustrating the flow of determining a plurality of fuels defined in the fuel procurement plan P according to an embodiment of the present invention.

[0049] The plant operation assistance device 1 is a device that determines a fuel procurement plan P which is a plan related to procurement of a plurality of types of fuel used in the boiler plant 92. As illustrated in FIG. 3, the plant operation assistance device 1 includes a device information storage unit 2, a plant operation plan acquisition unit 31, a candidate fuel information acquisition unit 32, a constituent device information acquisition unit 33, and a fuel procurement plan determination unit 4. These functional units will be described below.

[0050] The plant operation assistance device 1 is configured as a computer and includes a CPU (a processor) (not illustrated) and a storage device such as a memory (ROM and RAM). The CPU performs operations (calculation of data and the like) according to commands of a program (a plant operation assistance program) loaded on a main storage device whereby the functional units are realized. The plant operation assistance program may be stored in a computer-readable storage medium.

[0051] The device information storage unit 2 stores the device information B of devices that constitute the boiler plant 92. Generally, the boiler plant 92 is made up of various devices including a boiler. For example, in addition to the boiler, the boiler plant 92 includes various devices constituting a mill device that grinds the fuel of a boiler, a conveying device (a belt conveyer or the like) that conveys the fuel to the mill device, and a combustion device that supplies and combusts primary air or secondary combustion air for conveying the fuel grinded by the mill device to the boiler (a burner), various devices constituting various heat exchangers such as a superheater, a reheater, and an economizer installed in the boiler or a flue and an exhaust gas processing device such as a denitration device, an electric dust

collector, and a desulfurization device for processing exhaust gas, and various devices such as a generator driven by steam generated by the boiler. A necessary range of the device information B of these respective devices is stored in the device information storage unit 2 such as a database, for example.

5 [0052] The plant operation plan acquisition unit 31 acquires an operation plan D which is a plan related to operations of the boiler plant 92 operated by the plant operator 9. The operation plan D is a plan that defines the output (the amount of steam or the amount of power generation through operation of a boiler) of the boiler plant 92 in respective unit periods such as hours, days, weeks, months, quarters, and years over a prescribed period (for
10 example, a year) longer than the unit period and is similarly defined on the basis of a power generation plan or the like that defines the amount of power generation in respective unit periods over a prescribed period, for example. Although the plant operator 9 operates the boiler plant 92 according to the operation plan D, the operation plan D may be created by the plant operator 9 and may be created by another person (a vendor or the like).

15 [0053] The candidate fuel information acquisition unit 32 acquires information (hereinafter candidate fuel information F) on each of a plurality of types of fuel provided from a plurality of fuel suppliers 8. Each fuel supplier 8 provides at least one type of fuel. The candidate fuel information F includes at least one of a fuel property Fp, an available amount Fq, and a fuel cost Fc for each type of fuel. Fuels of different types have different fuel
20 properties Fp. Specifically, fossil fuel and biomass are different types of fuel, and coal, petroleum, and gas are of different fuel types. Biomass fuels may be said to be of the same type if the properties such as, for example, water contents or the calorific values of the fuels match within a prescribed range and may be said to be of different types if one of the raw materials such as tree species and the origins of the raw materials such as wood or
25 construction waste is different. In the case of coal fuels, high-grade coal and low-grade coal have different fuel types.

[0054] The information of the fuel property Fp is an index that quantizes and indicates fuel properties, and may include at least one properties among a moisture content (a water

content), a calorific value (MJ/kg or the like), a bulk density (kg/m³ or the like), an energy density (MJ/m³ or the like), a composition, an ash content (wt% or the like), and a fuel shape related to handlability such as a fuel type such as pellet, chip, palm kernel shell (PKS), or empty fruit bunches (EFB).

5 [0055] The information of the available amount F_q includes at least one of information on a fuel amount (excess fuel) for each fuel type which can be shipped immediately now such as a fuel in stock and a fuel that can be shipped in the near future. The latter (information on a fuel that can be shipped in the near future) is information such as a production plan (including the owner of a mountain) of a fuel supplier that the amount of supply (for example, tons per
10 month) from point B in country A will be increased from 10,000 to 20,000, a prediction that considering from weather conditions, the production amount of palm fruits will increase and the production amount of PKS will increase, and a prospect that new fuels will be developed. In the case of new fuels, it may be ascertained in advance whether the fuel can be used in the boiler plant 92. The information of the available amount F_q may include a supply plan of
15 each fuel supplier 8 for other countries and other boiler plants so that these pieces of information can be applied to the available amount F_q. Alternatively, the supply plan for other countries or boiler plants may be excluded in advance from the available amount F_q so that the information indicates the amount of fuel that can be provided to the boiler plant 92 which is a providing destination of the information of the available amount F_q.

20 [0056] The information of the fuel cost F_c may include at least one piece of information among the price (unit price) per unit amount (weight), a freight cost and an insurance fee for transporting fuel from the fuel supplier 8 to the boiler plant 92. For example, although a fuel cost (fuel price) of fuel is calculated by (unit price)×(supply amount) (purchase amount), which information will be included in the fuel cost F_c may be determined by the relative size
25 of candidate information in such a way that the fuel cost only is included if a freight cost or an insurance fee is negligibly small as compared to the fuel cost.

[0057] The constituent device information acquisition unit 33 acquires device information of at least one device constituting the boiler plant 92 from the device information storage unit

2. That is, the constituent device information acquisition unit 33 acquires device information on a necessary range of devices from the device information storage unit 2.

[0058] The fuel procurement plan determination unit 4 determines a fuel procurement plan P that can realize the operation plan D by determining a procurement amount in
5 respective prescribed periods of each of a plurality of types of fuel supplied from each of the plurality of fuel suppliers 8 on the basis of the candidate fuel information F, the operation plan D, and the device information B of at least one device. As illustrated in FIG. 4, the fuel procurement plan P defines one or a plurality of types of fuel procured from each of the plurality of fuel suppliers 8 and the amount of fuel of each type for each of a plurality of unit
10 periods constituting the prescribed period. By referring to the device information B, the amount of steam to be generated to obtain the amount of power to be generated is obtained from the amount of power generation (a power generation plan) or the like. The amount of energy (calorie) required to generate the amount of steam to be generated is obtained from the amount of steam. The required amount of fuel is obtained from the obtained amount of
15 energy and the fuel property Fp such as a calorific value of fuel.

[0059] Generally, the types and the amounts of fuel that can be supplied by the plurality of fuel suppliers 8 are not always the same. Even if the plurality of fuel suppliers 8 handle the same types of fuel, at least one of the unit cost, the freight cost, and the insurance fee is different, the fuel cost is generally different depending on from which fuel supplier 8 the fuel
20 will be procured. Therefore, the fuel procurement plan determination unit 4 determines the fuel procurement plan P which is a combination of a fuel supplier and a fuel type which can realize the operation plan D determined on the basis of an electricity demand, a power generation capacity of the boiler plant 92, and the like on the basis of the type of a device constituting the boiler plant 92, and an actual fuel supply capacity (the fuel type, a suppliable
25 amount, a cost, and the like included in the candidate fuel information F) of each of the plurality of fuel suppliers 8.

[0060] Until the fuel procurement plan determination unit 4 determines a final fuel procurement plan P, a fuel procurement draft plan obtained by repeating, at least once, a series

of steps of transmitting a fuel procurement draft plan determined temporarily to the plurality of fuel suppliers 8 and obtaining approval from each of the plurality of fuel suppliers 8 that supplies the fuel defined in the fuel procurement draft plan or obtaining approval by reflecting the requests from the fuel suppliers 8 on the fuel procurement draft plan may be determined as the fuel procurement plan P.

[0061] In the embodiment illustrated in FIG. 3, the fuel procurement plan determination unit 4 determines a fuel usable in the boiler plant 92 among a plurality of fuels included in the candidate fuel information F on the basis of the candidate fuel information F and the device information B and calculates the fuel procurement plan P on the basis of the candidate fuel information F related to the fuel determined to be usable, the device information B, and the operation plan D. For example, the usability of fuel may be determined from the viewpoint of the degree of detoxification of exhaust gas by an exhaust gas processing device and life such as corrosion or wear of a boiler and flue as well as whether fuel is conveyed appropriately by a conveying device that conveys fuel to a mill device, whether fuel is grinded appropriately by a mill device, and whether fuel can be combusted appropriately in a boiler. For example, there may be a limitation that chlorine (Cl) in the fuel used in a boiler needs to be 0.2% or smaller.

[0062] Although at least some of the fuels determined to be usable is employed by the fuel procurement plan P through the processing of the fuel procurement plan determination unit 4, the fuel procurement plan P may be determined by taking any one of the fuel cost F_c of the fuel, stable procurement of the fuel, and a maintenance cost or a running cost of the boiler plant 92 into consideration with highest priority. The prioritizing index (optimization policy) may be determined according to the needs of the plant operator 9, and the needs are input in advance and stored in a storage device or the like before the fuel procurement plan P is determined.

[0063] For example, when making the fuel procurement plan P that emphasizes the fuel cost F_c such as minimizing the fuel cost F_c , the candidate fuel information F must include information on the fuel cost F_c . The price of fuel itself (a fuel cost) can be calculated by

(unit price)×(amount of fuel). The fuel cost F_c may be a CIF price including a fuel cost (Cost), an insurance fee (Insurance), and a freight fee (Freight) and may be a cost including at least one of them. In this embodiment, in some embodiments, the candidate fuel information F may further include information of the available amount F_q . In this case, by making the fuel procurement plan P emphasizing the fuel cost F_c of the fuel within the range of the available amount F_q of each fuel which is presently available for each of the fuel suppliers 8, it is possible to determine the fuel procurement plan P emphasizing the fuel cost F_c while achieving stable supply of fuel. In some other embodiments, the candidate fuel information F may not include the information of the available amount F_q . In this case, it is possible to prompt adjustment of stock by the fuel supplier 8 at an early stage by providing a feedback to the fuel supplier 8 in the fuel procurement plan P .

[0064] When making the fuel procurement plan P emphasizing stable procurement of fuel, the candidate fuel information F must include information of the available amount F_q . That is, the operation plan D is determined within the range of the available amount F_q which is presently available for each of the fuel suppliers 8. In this case, in some embodiments, the candidate fuel information F may further include information of the fuel cost F_c . In this case, it is possible to determine the fuel procurement plan P emphasizing stable procurement of fuel while decreasing the fuel cost F_c similarly to the above.

[0065] When making the fuel procurement plan P emphasizing a maintenance cost or a running cost of the boiler plant 92, the candidate fuel information F must include information of the fuel property F_p . For example, since the ash generated by combustion of a fuel has a high adhesion property if the fuel contains a large amount of Na, K, Cl, or the like, it is necessary to operate a sootblower frequently accordingly to remove the ash (byproduct) adhering to a heat transfer surface of various heat exchangers inside the boiler (the running cost increases). When chemicals (as an example, aluminum chemicals that weaken the clinker adhering to a furnace wall to make it easier to peel off and chemicals used in an exhaust gas processing device or an exhaust water processing device may be used but there is no limitation thereto) for suppressing adhesion of ash and environmentally harmful

substances are supplied into the boiler, the running cost increases accordingly. A sootblower injects high-pressure air or compressed air to remove adhering ash, and since frictional force acts when removing the ash, wearing of a heat transfer pipe is accelerated as the number of injection times increases (the maintenance cost increases).

5 [0066] Particularly, the water content of biomass varies greatly, and if the moisture content (water content) does not fall within a defined range, it is difficult to use a conveying device that conveys fuel to a device that grinds or crushes the fuel or to secure grinding or crushing properties of the device that grinds or crushes the fuel, and the handlability deteriorates. On the other hand, the larger the calorific value (MJ/kg or the like), the bulk
10 density (kg/m^3 or the like), and the energy density (MJ/m^3 or the like), the higher the operation efficiency, which also has an influence on the life or the like of the boiler. In this manner, by emphasizing the information of the fuel property Fp, it is possible to determine the fuel procurement plan P emphasizing the maintenance cost or the running cost.

[0067] However, the present invention is not limited to the above-described embodiment.
15 In some other embodiments, as illustrated in FIG. 5, the fuel procurement plan determination unit 4 may derive the fuel procurement plan P using various learning models created by machine-learning past operation records. More specifically, the fuel procurement plan determination unit 4 determines the fuel procurement plan P from the candidate fuel information F, the operation plan D, and the device information B of at least one device using
20 a learning model 71 created by machine-learning a relationship between the fuel (past used fuel) used in the past in the fuel combustion plant and an operation record (a past operation record) obtained by operating the fuel combustion plant using the past used fuel.

[0068] For example, a relationship among a past used fuel, a fuel cost, and an operation result such as an output, for example, may be machine-learned on the basis of the past
25 operation record provided from the plant operator 9 and stored in a past DB 7 (database), the learning model 71 that derives (outputs) a fuel combination having the best power generation efficiency ((output) $\div$ (fuel cost)) may be created from the candidate fuel information F, the operation plan D, and the device information B, and the fuel procurement plan P in which a

fuel type is selected (determined) emphasizing a fuel cost may be determined using the learning model 71.

Similarly, a relationship among a past used fuel, an ash generation amount, and an ash processing cost may be machine-learned on the basis of the past operation record, the learning
5 model 71 that derives a fuel combination with the lowest ash processing cost may be created from the candidate fuel information F, the operation plan D, and the device information B, and the fuel procurement plan P in which a fuel type is selected (determined) emphasizing a byproduct processing cost may be determined using the learning model 71.

[0069] Alternatively, a relationship between a past used fuel and a trouble record of the
10 used fuel may be machine-learned on the basis of the past operation record, and a repair cost prediction model that machine-learns a relationship between the trouble record and a repair cost record and derives the repair cost from troubles as well as a trouble prediction model (the learning model 71) that predicts troubles from the used fuel may be created. In this way, it is possible to predict troubles by inputting the record of fuel having been used in the fuel
15 combustion plant to the trouble prediction model and to calculate a repair cost by inputting the predicted troubles to the repair cost prediction model. Therefore, the fuel procurement plan P in which a fuel type is selected (determined) emphasizing the maintenance cost may be determined by finding a fuel combination that best suppresses the repair cost (a lost profit during a stopping period may be taken into consideration) from the candidate fuel information
20 F, the operation plan D, and the device information B using these models.

[0070] The fuel type may be selected by finding a fuel combination that best suppresses a total cost of at least two items among the fuel cost, the byproduct processing cost, and the maintenance cost. For example, an optimal fuel combination that best suppresses an operation cost (running cost) of the boiler plant 92 by finding a fuel combination that best
25 suppresses the total cost of the three items. The past DB may store information of plants different from the target boiler plant 92 of the fuel procurement plan P.

[0071] On the other hand, a relationship between a past used fuel and an operation result may be machine-learned on the basis of the past operation record, the learning model 71 that

derives a fuel combination providing the most stable operation may be created from the candidate fuel information F, the operation plan D, and the device information B, and the fuel procurement plan P in which a fuel type is selected (determined) emphasizing stable operation may be determined using the learning model 71.

5 Similarly, a relationship among a past used fuel, a trouble occurrence record, and a plant stopping period associated therewith may be machine-learned on the basis of the past operation record, the learning model 71 that derives (outputs) a fuel combination providing the fewest troubles may be created from the candidate fuel information F, the operation plan D, and the device information B, and the fuel procurement plan P in which a fuel type is selected
10 (determined) emphasizing fewer occurrence of troubles may be determined using the learning model 71. The fuel procurement plan P in which a fuel type is selected (determined) best emphasizing stable operation among the two plans which emphasize stable operation and fewer occurrences of troubles. After that, from which fuel supplier 8 the determined fuel combination will be procured is determined by taking viewpoints such as the fuel cost and the
15 stable procurement of fuel into consideration.

[0072] In the embodiment illustrated in FIG. 5, conditions for determining a fuel usable in the boiler plant 92 are acquired on the basis of the device information B of devices constituting the boiler plant 92, which one of the plurality of types of fuel listed up in the candidate fuel information F can be usable is determined, and the fuel procurement plan P is
20 determined under the above-described optimization policy set separately. Specifically, in the embodiment illustrated in FIG. 5, the usable fuel is determined on the basis of handlability (fuel shape), a water content, and a fuel component (S51), and for example, candidate fuels are narrowed down from a plurality of fuels on the basis of values of pellet, a water content of a% or smaller, and a chlorine content of b% or smaller (S52). On the other hand, the
25 optimization policy includes a fuel cost reduction policy, a byproduct processing cost reduction policy, a maintenance cost reduction policy, an output stabilization (stable fuel procurement) policy, and a trouble-zero (high-quality fuel use) policy, and the fuel procurement plan P is determined using the learning model 71 according to at least one of

these policies (S53).

[0073] According to the configuration, the plant operation assistance device 1 is a device closely associated with an EPC vendor, for example, that holds the device information B such as specifications of devices constituting the boiler plant 92 and determines the fuel procurement plan P related to a plurality of types of fuel appropriate for the device information B and the operation plan D planned by the plant operator 9 using the fuels scheduled to be held by each of the plurality of fuel suppliers 8 as candidates. By determining the fuel procurement plan P in this manner, it is possible to determine which type of fuel is to be supplied from which fuel supplier in which amount from the viewpoint of the operation cost and the stability of fuel supply of the boiler plant 92 and to propose the fuel procurement plan P optimal for realizing the operation plan D to the plant operator 9.

[0074] In some embodiments, the plant operation assistance device 1 may send a feedback related to the determined fuel procurement plan P to the fuel supplier 8. That is, in some embodiments, as illustrated in FIG. 3, the plant operation assistance device 1 further includes a fuel procurement plan feedback unit 51 that transmits at least part of information of the fuel procurement plan P to at least one of the plurality of fuel suppliers 8. The plant operation assistance device 1 acquires the candidate fuel information F by receiving the provision of information from the plurality of fuel suppliers 8 when determining the fuel procurement plan P. However, by sending a feedback of the fuel procurement plan P, each fuel supplier 8 can review the fuel production plan according to the fuel demand defined in the fuel procurement plan P (see FIG. 6).

[0075] FIG. 6 is a diagram for describing correction of the fuel production plan by the fuel supplier 8 according to an embodiment of the present invention. For example, it is assumed that the initial fuel production plan provided from the plurality of fuel suppliers 8 to the plant operation assistance device 1 is that illustrated in FIG. 6(a). In FIG. 6, it is assumed that Fuel [1] and Fuel [2] are of different types but have the same fuel quality (fuels usable as alternative fuels). For simplicity of description, it is assumed that the required procurement amount of the boiler plant 92 is 40 in total for Fuel [1] and Fuel [2] in spring, summer,

autumn, and winter, respectively, and the plant operator 9 trades fuel with Company A (producer of Fuel [1]) and Company B (producer of Fuel [2]) which are fuel suppliers 8. Moreover, it is assumed that Fuel [1] is a fuel of which the production period is limited (rice husks of harvested grains and the like) and Fuel [2] is a fuel of which the production period is easily adjusted and the production is easily increased (wood processing scraps or the like).

[0076] In the initial production plan of FIG. 6(a), Company A which is the fuel supplier 8 plans to produce 40 tons of Fuel [1] in spring and summer, respectively and do not produce Fuel [1] in autumn and winter, and Company B plans to produce 20 tons of Fuel [2] in spring, summer, autumn, and winter, respectively. Therefore, looking at Companies A and B as a whole, the demand in spring and summer is 40 tons whereas the supply is 60 tons, which is oversupply, and the demand in autumn and winter is 40 tons whereas the supply is 20 tons, which is undersupply. However, by feeding back the fuel procurement plan P, the initial production plan can be corrected so that Company B decrease production of Fuel [2] of which the production is easily adjusted (from 20 to 0) in spring and summer in which oversupply occurs and increases the production (from 20 to 40) in autumn and winter in which undersupply occurs. By correcting the production plan in this manner, it is possible to meet the demand of the plant operator 9.

[0077] In this manner, the plant operator 9 can stably maintain the best fuel combination. An EPC vendor or the like can avoid such a situation where undersupply occurs and does not need to spot-procure more expensive fuels from other fuel suppliers 8. As for the fuel supplier 8 (Company B), it is not necessary to take over an excess stock and concentrate production in autumn and winter so that time and effort are not wasted.

[0078] The entire fuel procurement plan P may be fed back to the fuel supplier 8, and a required range of information may be fed back, for example, a required amount in each period (each season) of Fuel [1] for Company A and a required amount in each period of Fuel [2] for Company B. Alternatively, for example, the content (Fuel [2] in FIG. 6(b)) of correction of the production plan may be created by the plant operation assistance device 1 and be fed back to the fuel supplier 8 as a proposal to Company B. In the embodiment illustrated in FIG. 5,

although the fuel suppliers 8 are two companies, even when the fuel supplier 8 of one company produces a plurality of fuels, the production amounts of the plurality of types of fuel may be corrected similarly using the fed-back fuel procurement plan P.

[0079] In the embodiment illustrated in FIG. 6, a case in which Company B only handles
5 a fuel of which the production period is easily adjusted and the production is easily increased has been described. However, in some other embodiments, the plant operation assistance device 1 may have the fuel cost F_c and the adjustability information indicating whether each fuel supplier 8 can adjust the fuel amount, and the plant operation assistance device 1 may feed the fuel procurement plan P back to only a minimal group of fuel suppliers 8 determined
10 on the basis of the adjustability information and the fuel cost F_c . The fuel procurement plan P is based on the plant operation plan D and can be said to be management information of the plant operator 9 (that is, highly confidential information). Therefore, there is little need to feed such a fuel procurement plan P back to the fuel supplier 8 of which the fuel amount cannot be adjusted. Therefore, by narrowing a feedback destination of the fuel procurement
15 plan P to the fuel supplier 8 of which the fuel amount can be adjusted, it is possible to prevent information from spreading more than necessary.

[0080] Specifically, the fuel procurement plan feedback unit 51 acquires adjustability information indicating whether a fuel amount of each of a plurality of types of fuel provided from the plurality of fuel suppliers 8 can be adjusted and determines a destination fuel
20 supplier 8 to which at least a portion of the fuel procurement plan P will be transmitted on the basis of the adjustability information (see FIGS. 7A to 7B). The adjustability information may be included in the candidate fuel information F. In this way, the plant operation assistance device 1 can understand whether the fuel amount for each fuel type of the fuel supplier 8 can be adjusted by acquiring the candidate fuel information F. Alternatively, the
25 adjustability information may be generated on the basis of a difference in each prescribed period between the available amount F_q for each fuel supplier 8 and each of the plurality of fuel types included in the candidate fuel information F and the procurement amount for each fuel supplier 8 and each of the plurality of fuel types included in the fuel procurement plan P.

In this case, it may be determined that the fuel amount of a fuel of which the procurement amount is not 0 and of which the procurement amount and the available amount F_q are different can be adjusted. By determining whether a fuel having the difference is a fuel of which the fuel amount can be easily adjusted depending on the type of fuel included in the candidate fuel information F on the basis of prescribed information, it may be determined that the fuel amount of the fuel can be adjusted when the fuel has a fuel type of which the fuel amount can be adjusted and has the difference.

[0081] FIG. 7A is a diagram for describing a method of determining the fuel supplier 8 serving as a feedback destination of the fuel procurement plan P according to an embodiment of the present invention. In the embodiment illustrated in FIG. 7A, first, the plant operation assistance device 1 determines an adjustable range S which is a period in which the fuel amount can be adjusted on the adjustability information for each fuel supplier 8 and each fuel type. As a result, in the example of FIG. 7A, it is determined that the time (period) at which the fuel amount for Companies A, B, and C which are the fuel supplier 8 that can provide Fuel [1] can be adjusted is after period III for Company A, after period II for Company B, and after period IV for Company C. Therefore, since the feedback destination of the fuel procurement plan P is the fuel supplier 8 of which the fuel amount can be adjusted in each period (the fuel supplier 8 of which the period overlaps the adjustable range S), the feedback destination is no company in period I, Company B in period II, at least one of Companies A and B in period III, and at least one of Companies A, B, and C in periods IV to V.

[0082] As illustrated in FIG. 7B, since the information of the fuel cost F_c is known for each period, each fuel supplier 8, and each fuel type, the feedback destination of the fuel procurement plan P can be further narrowed down. FIG. 7B is a diagram for describing a method of determining the fuel supplier 8 serving as a feedback destination of the fuel procurement plan P according to an embodiment of the present invention, in which the feedback destination is determined on the basis of the adjustability information and the fuel cost F_c . Such information of the fuel cost F_c can be acquired since the candidate fuel information F includes the information of the fuel cost F_c for each of the plurality of types of

fuel. Numbers 1 to 3 in the table of FIG. 7B are information of the fuel cost F_c , and indicates that the fuel cost F_c increases in the order of 1, 2, and 3. In the embodiment illustrated in FIG. 7B, although the fuel cost F_c is a unit fuel price, the fuel cost F_c may be at least one of a unit fuel price, an insurance fee, and a freight cost and may be the sum of at least two fees. The adjustable range S in FIG. 7B is the same as that of FIG. 7A.

[0083] In the example of FIG. 7B, the supply of Fuel [1] is excessive in periods I to II and IV and is deficient in periods III and V. The excess or deficiency is determined on the basis of a difference obtained, for each fuel type, by subtracting the total procurement amount for each fuel type included in the fuel procurement plan P and the total for each fuel type of the production plan of each fuel supplier 8. When the fuel amount is excessive, the fuel procurement plan P may be fed back to the fuel supplier 8 having the highest fuel cost F_c among the fuel suppliers 8 supplying the same type of fuel to prompt reduction in fuel production. On the contrary, when the fuel amount is insufficient, the fuel procurement plan P may be fed back to the fuel supplier 8 having the lowest fuel cost F_c among the fuel suppliers 8 supplying the same type of fuel to prompt increase in fuel production.

[0084] Therefore, in the example of FIG. 7B, although the fuel amount of Fuel [1] is excessive in period I, since the fuel amount of Companies A to C cannot be adjusted, the fuel procurement plan P is not transmitted to Companies A to C. On the other hand, since the fuel amount is excessive in period II and the fuel amount of Company B only can be adjusted, the fuel procurement plan P is transmitted to Company B. Although the fuel amount is insufficient in period III and the fuel amount of Companies A and B can be adjusted, since the fuel cost F_c of Company A is the lowest, the fuel procurement plan P is transmitted to at least Company A. Although the fuel amount is excessive in period IV and the fuel amount of Companies A, B, and C can be adjusted, since the fuel cost F_c of Company B is the highest, the fuel procurement plan P is transmitted to at least company B. On the contrary, although the fuel amount is insufficient in period V and the fuel amount of Companies A, B, and C can be adjusted, since the fuel cost F_c of Company C is the lowest, the fuel procurement plan P is transmitted to at least Company C.

[0085] In the embodiment illustrated in FIGS. 7A to 7B, the destination of the fuel procurement plan P is one company. When the destination of the fuel procurement plan P is one company, adjustment can always be performed for only one company in each period, it is possible to perform complex adjustment.

5 [0086] By determining the destination of the fuel procurement plan P in the above-described manner, it is possible to reduce a procurement cost by feeding the fuel procurement plan P back to the fuel supplier 8 having a low fuel cost F_c to prompt increase in fuel production when the fuel amount is insufficient. On the other hand, it is possible to reduce the cost of the fuel supplier 8 by feeding the fuel procurement plan P back to the fuel supplier
10 8 having a high fuel cost F_c to prompt reduction in fuel production when the fuel amount is excessive.

[0087] According to the above-described configuration, since the fuel procurement plan P is fed back to the fuel suppliers 8, each fuel supplier 8 can perform adjustment such as increasing the production of fuel of the fuel type that has a demand or reducing the production
15 of fuel of the fuel type that does not have a demand. Therefore, it is possible to optimize fuel production and stock of the fuel supplier 8.

[0088] In some embodiments, as illustrated in FIG. 3, the plant operation assistance device 1 may further include a fuel use record acquisition unit 52 that acquires a fuel use record R_f obtained when the operation of the boiler plant 92 is executed according to the fuel
20 procurement plan P, the fuel use record R_f including the combustion performance or the fuel use amount of at least one of a plurality of types of fuel defined in the fuel procurement plan P, and a fuel use record feedback unit 53 that transmits at least part of information of the fuel use record R_f to at least one fuel supplier 8 such as at least one fuel supplier 8 that provided any one of the plurality of types of fuel defined in the fuel procurement plan P. The fuel use
25 record R_f is transmitted to the fuel supplier 8 that provided the fuel included in the fuel use record R_f . The combustion performance is a calorific value, for example, and is information that can be used for predicting the fuel amount defined in the fuel procurement plan P as described above. Since the boiler plant 92 is operated according to the operation plan D, if

the calorific value is smaller than expected, for example, more fuel is required for compensating for the deficient amount. On the contrary, if the calorific value is larger than expected, since it is not necessary to use an amount of fuel corresponding to the excess amount, a surplus occurs in the fuel amount defined in the fuel procurement plan P, which
 5 results in increase in the stock of the fuel supplier 8.

[0089] Generally, for example, woody biomass fuel is produced from wood (raw wood) produced directly from forests such as thinned wood and industrial waste such as wood scraps, wood chips, and building demolition materials produced by wood processing. The properties such as a water content of biomass fuel vary greatly and the combustion
 10 performance is likely to vary in such a way that a water content or the like is affected by the origin, tree species, a storage method, and the like. The combustion performance of fossil fuel such as coal may differ depending on a production site or the like. Therefore, the combustion performance of a fuel supplier may be different from an actual combustion performance when fuel was actually used. If the combustion performance is different, the
 15 fuel use amount may deviate from a planned value.

[0090] Such a deviation may lead to unplanned increase or shortage of stock for the fuel supplier 8. It may be a hindrance for the plant operator 9 in operating the boiler plant 92 according to the operation plan D. Therefore, the plant operation assistance device 1 acquires the fuel use record R_f from the plant operator 9, for example, and feeds the same
 20 back to the fuel supplier 8. In this way, the fuel supplier 8 can take quick countermeasures when there is a deviation from the planned value of an initial fuel procurement plan P by correcting the information of the candidate fuel information F used when making the initial fuel procurement plan P to a more appropriate value.

[0091] According to the above-described configuration, the fuel use record R_f obtained
 25 by using a plurality of types of fuel supplied on the basis of the fuel procurement plan P in operation of the boiler plant 92 is fed back to the fuel supplier 8 that provided the fuel via the plant operation assistance device 1. In this way, the fuel supplier 8 can optimize the fuel production of the fuel supplier 8 such as production adjustment and stock adjustment by

increasing or reducing the production of required fuel and can stably supply fuel to the plant operator 9 more reliably.

[0092] In the above-described embodiment, in some embodiments, after the fuel use record R_f is fed back to the fuel supplier 8, the candidate fuel information acquisition unit 32
5 may acquire candidate fuel information F' corrected by the fuel supplier 8 on the basis of the fuel use record R_f. That is, the plant operation assistance device 1 creates the fuel procurement plan P again as described above using the corrected candidate fuel information F' as the candidate fuel information F. The new fuel procurement plan P may be transmitted to the plant operator 9 and may be received by the plant operator 9 so that the initial fuel
10 procurement plan P is switched to the new fuel procurement plan P at an appropriate timing. Such a loop ((2) to (5) in FIG. 2) may be repeated at least once.

[0093] According to the above-described configuration, it is possible to determine a more accurate fuel procurement plan P on the basis of more accurate candidate fuel information F on which the fuel use record R_f is reflected.

15 [0094] Next, some embodiments related to the maintenance plan M will be described.

In some embodiments, as illustrated in FIG. 3, the plant operation assistance device 1 may further include a maintenance plan determination unit 61 that determines the maintenance plan M of the boiler plant 92 on the basis of the device information B, the operation plan D, and the fuel procurement plan P. The maintenance plan M defines a
20 scheduled time or the like (scheduled maintenance date) for performing maintenance when the fuel defined in the fuel procurement plan P is used.

[0095] The present inventors have found that problems such as, for example, blockage and wear of the heat transfer pipes, occurring in the boiler plant 92 are correlated with specifications of devices constituting the boiler plant 92 and the properties (a composition, an
25 ash content, a moisture content, and the like) of the used fuel. Therefore, a guaranteed operating time of the boiler is obtained from the fuel properties by examining a relationship among problem cases, an operating time, and a used fuel (fuel properties) for each device, for example, from the past failure cases and examination results in periodic inspections, for

example. By doing so, it is possible to plan an appropriate time as a scheduled maintenance date before and after the guaranteed operating time elapsed from the start of using the fuel on the basis of the device information B, the operation plan D, and the guaranteed operating time, for example. In this way, it is possible to prevent increase in the operation stopping period of the boiler plant 92 due to execution of premature maintenance.

[0096] According to the above-described configuration, the maintenance plan M of the boiler plant 92 is determined on the basis of the fuel procurement plan P including the information on used fuel. For example, an ash content in woody biomass fuel is different depending on a fuel type such as bark, wood chips, and waste wood. The ash content and the adhesion property of coal or the like are different depending on a fuel type such as high-grade coal or low-grade coal. The tolerance to failures is different depending on the specification of a device constituting the boiler plant 92. Therefore, it is possible to determine an appropriate maintenance plan M by taking the specifications (the device information B) of the boiler plant 92, the operation plan D, and the used fuel type into consideration.

[0097] In some embodiments, as illustrated in FIG. 3, the plant operation assistance device 1 may further include an operation data record acquisition unit 62 that acquires the operation data record Rd obtained by operating the boiler plant 92 according to the fuel procurement plan P and a maintenance plan correction determination unit 63 that determines correction of the maintenance plan M on the basis of the operation data record Rd. The operation data record Rd is various pieces of information which may affect the maintenance plan M. For example, the operation data record Rd may include information such as various state quantities and presence/absence of troubles acquired through measurement or the like to check the operation state during operation of the boiler plant 92. Examples of the state quality include a fuel use amount, the amount of ash generated, the amount of used utilities such as chemicals or industrial water, and the pressure, the flow rate, and the like in the pipe measured by a permanent monitor (sensors).

[0098] Specifically, by monitoring the pressure and the flow rate in the pipe measured by

the monitor, when the monitoring result shows such a trend that the pressure increases in a situation in which the same amount of fuel flows in from the inlet of the pipe, for example, it is expected that the clogging (blockage) of the pipe progresses. When the monitoring result shows such a trend that the pressure decreases in the same situation, it is expected that the thinning (wearing) of the pipe progresses. In this way, by monitoring the measurement values of the monitor, it is possible to monitor the thickness state of the pipe.

[0099] It is determined whether the initial maintenance plan M determined in advance is appropriate by predicting a damage state occurring with the elapse of an operating time such as the thickness state of a pipe on the basis of the operation data record Rd to predict the life thereof. When it is determined that the maintenance plan M is not appropriate, it is possible to update the maintenance plan M to a more appropriate one by advancing or delaying the next scheduled maintenance date.

[0100] When information such as periodic inspections and repairs, variations in power generation output, changes in co-combustion rate, and changes in power generation portfolio is also included in the operation data record Rd, it is possible to predict the fuel use amount of each fuel through these pieces of information and to update the fuel procurement plan P to a more appropriate one. By analyzing the operation data record Rd, it is possible to propose that the fuel use amount can be reduced and the co-combustion rate of fuel with poor fuel properties (for example, low-grade coal or biomass relative to high-grade coal) can be improved. In addition, the operation data record Rd can be fed back to a device design concept or the like.

The plant operation assistance device 1 may acquire the fuel use record Rf and the operation data record Rd automatically and continuously from the plant operator 9 via a network.

[0101] According to the above-described configuration, the correction of the maintenance plan M is determined on the basis of the operation data record Rd obtained by operating the boiler plant 92. By determining the correction of the maintenance plan M at that time point according to the operation record, it is possible to update the maintenance plan M to a plan

appropriate for the type of used fuel.

[0102] Hereinafter, a plant operation assistance method corresponding to the processing executed by the plant operation assistance device 1 will be described with reference to FIG. 8.

FIG. 8 is a diagram illustrating a plant operation assistance method according to an embodiment of the present invention.

[0103] The plant operation assistance method is a method of determining a fuel procurement plan P which is a plan related to procurement of a plurality of types of fuel used in the boiler plant 92. As illustrated in FIG. 8, the plant operation assistance method includes a plant operation plan acquisition step (S11), a candidate fuel information acquisition step (S12), a constituent device information acquisition step (S13), and a fuel procurement plan determination step (S2). The plant operation assistance method may be executed by the plant operation assistance device 1 and may be executed manually.

The plant operation assistance method will be described in the order of the steps of FIG. 8.

[0104] In the embodiment illustrated in FIG. 8, a device information storing step is executed in step S0 of FIG. 8. The device information storing step (S0) is a step of storing the device information B of devices constituting the boiler plant 92 in the device information storage unit 2 or the like serving as a database, for example. In the present embodiment, by executing the step (S0), the device information B is managed in the database or the like in a centralized manner, acquisition (reference) of the device information B is facilitated.

[0105] In step S1 of FIG. 8, the operation plan D, the candidate fuel information F, and the device information B are acquired. Specifically, the plant operation plan acquisition step (S11) is executed in step S11, the candidate fuel information acquisition step (S12) is executed in step S12, and the constituent device information acquisition step (S13) is executed in step S13. The plant operation plan acquisition step (S11) is a step of acquiring the operation plan D of the boiler plant 92. The candidate fuel information acquisition step (S12) is a step of acquiring the candidate fuel information F. The constituent device information acquisition step (S13) is a step of acquiring the device information of at least one

device constituting the boiler plant 92 from the device information storage unit 2 or the like. These steps (S11 to S13) are similar to the contents of the processing executed by the plant operation plan acquisition unit 31, the candidate fuel information acquisition unit 32, or the constituent device information acquisition unit 33, and the details thereof will be omitted. In the embodiment illustrated in FIG. 8, the operation plan D is acquired from the plant operator 9, the candidate fuel information F is acquired from the plurality of fuel suppliers 8, and the device information B is acquired from the device information storage unit 2. These steps (S11 to S13) may be executed in an order different from that of FIG. 8.

[0106] In step S2, the fuel procurement plan determination step is executed. The fuel procurement plan determination step (S2) is a step of determining the fuel procurement plan P that can realize the operation plan D by determining a procurement amount in each prescribed period, of each of the plurality of types of fuel supplied from each of the plurality of fuel suppliers 8 on the basis of the candidate fuel information F, the operation plan D, and the device information B of at least one device acquired in step S1. The fuel procurement plan determination step (S2) is similar to the content of processing executed by the fuel procurement plan determination unit 4, and the details will be omitted.

[0107] According to the above-described configuration, it is possible to determine the fuel procurement plan P optimal for realizing the operation plan D and propose the fuel procurement plan P to the plant operator 9.

[0108] In some embodiments, as illustrated in FIG. 8 (see S3), the plant operation assistance method may further include a maintenance plan determination step of determining the maintenance plan M (described above) of the boiler plant 92 on the basis of the device information B, the operation plan D, and the fuel procurement plan P. The maintenance plan determination step is similar to the content of processing executed by the maintenance plan determination unit 61, and the details thereof will be omitted. In the embodiment illustrated in FIG. 8, although the maintenance plan determination step is executed in step S3, the maintenance plan determination step may be executed earlier than the fuel procurement plan determination step (S2).

[0109] According to the above-described configuration, it is possible to determine an appropriate maintenance plan M by taking the specifications (the device information B) of the boiler plant 92, the operation plan D, and the used fuel type into consideration.

[0110] In some embodiments, as illustrated in FIG. 8 (see S4), the plant operation
5 assistance method may further include a fuel procurement plan feedback step of transmitting at least part of information of the fuel procurement plan P to at least one of the plurality of fuel suppliers 8. The fuel procurement plan feedback step is similar to the content of processing executed by the fuel procurement plan feedback unit 51, and the details thereof will be omitted. In the embodiment illustrated in FIG. 8, the fuel procurement plan feedback
10 step is executed in step S4.

[0111] According to the above-described configuration, since the fuel procurement plan P is fed back to the fuel suppliers 8, each fuel supplier 8 can perform adjustment such as increasing the production of fuel of the fuel type that has a demand or reducing the production of fuel of the fuel type that does not have a demand. Therefore, it is possible to optimize
15 fuel production and stock of the fuel supplier 8.

[0112] In some embodiments, as illustrated in FIG. 8 (see S5), the plant operation assistance method may further include a fuel use record acquisition step of acquiring the fuel use record Rf and a fuel use record feedback step of transmitting at least part of information of the fuel use record Rf to at least one fuel supplier 8 that provided the plurality of types of
20 fuel. The fuel use record acquisition step and the fuel use record feedback step are similar to the contents of processing executed by the fuel use record acquisition unit 52 and the fuel use record feedback unit 53, respectively, and the details thereof will be omitted. In the embodiment illustrated in FIG. 8, although the fuel use record acquisition step and the fuel use record feedback step are executed in step S5, the steps may be performed in any step as long
25 as the steps are performed later than the fuel procurement plan determination step (S2).

[0113] In this case, in some embodiments, the candidate fuel information acquisition step (S12) may acquire the candidate fuel information F corrected by the fuel supplier 8 on the basis of the fuel use record Rf. In this way, such a loop ((2) to (5) in FIG. 2) as illustrated in

FIG. 2 is repeated at least once, and it is possible to determine a more accurate fuel procurement plan P on the basis of more accurate candidate fuel information F on which the fuel use record R_f is reflected.

[0114] According to the above-described configuration, since the fuel use record R_f is fed back to the fuel supplier 8 that has provided fuel, the fuel supplier 8 can optimize the fuel production of the fuel supplier 8 such as production adjustment and stock adjustment by increasing or reducing the production of required fuel and can stably supply fuel to the plant operator 9 more reliably.

[0115] In some embodiments, as illustrated in FIG. 8 (see S6), the plant operation assistance method may further include an operation data record acquisition step of acquiring the operation data record R_d and a maintenance plan correction determination step of determining a correction of the maintenance plan M on the basis of the operation data record R_d. The operation data record acquisition step and the maintenance plan correction determination step are similar to the contacts of processing executed by the operation data record acquisition unit 62 and the maintenance plan correction determination unit 63, respectively, and the details thereof will be omitted. In the embodiment illustrated in FIG. 8, although the operation data record acquisition step and the maintenance plan correction determination step are executed in step S6, the steps may be performed in any step as long as the steps are performed later than the maintenance plan determination step (S3).

[0116] According to the above-described configuration, by determining the correction of the maintenance plan M according to the operation data record, it is possible to update the maintenance plan M to a plan appropriate for the type of used fuel.

[0117] The present invention is not limited to the above-described embodiments and includes forms obtained by modifying the embodiments and forms obtained by appropriately combining these forms.

Reference Signs List

[0118]

	1	Plant operation assistance device
	2	Device information storage unit
	31	Plant operation plan acquisition unit
	32	Candidate fuel information acquisition unit
5	33	Constituent device information acquisition unit
	4	Fuel procurement plan determination unit
	51	Fuel procurement plan feedback unit
	52	Fuel use record acquisition unit
	53	Fuel use record feedback unit
10	61	Maintenance plan determination unit
	62	Operation data record acquisition unit
	63	Maintenance plan correction determination unit
	7	Past DB
	71	Learning model
15	8	Fuel supplier
	9	Plant operator
	92	Boiler plant
	B	Device information
	D	Operation plan
20	F	Candidate fuel information
	Fc	Fuel cost
	Fp	Fuel property
	Fq	Available amount
	P	Fuel procurement plan
25	M	Maintenance plan
	Rd	Operation data record
	Rf	Fuel use record
	S	Adjustable range

CLAIMS

1. A plant operation assistance device that determines a fuel procurement plan which is a plan related to procurement of a plurality of types of fuel used in a fuel combustion plant, the
5 device comprising:

a device information storage unit configured to store device information related to devices that constitute the fuel combustion plant;

a plant operation plan acquisition unit configured to acquire an operation plan which is a plan related to operation of the fuel combustion plant operated by a plant operator;

- 10 a candidate fuel information acquisition unit configured to acquire candidate fuel information including at least one of a fuel property, an available amount, and a fuel cost of each of the plurality of types of fuel provided from a plurality of fuel suppliers;

a constituent device information acquisition unit configured to acquire the device information of the at least one of devices that constitute the fuel combustion plant from the
15 device information storage unit; and

a fuel procurement plan determination unit configured to determine the fuel procurement plan capable of realizing the operation plan by determining a procurement amount in each prescribed period, of each of the plurality of types of fuel supplied from each of the plurality of fuel suppliers on the basis of the candidate fuel information, the operation
20 plan, and the device information of the at least one of devices.

2. The plant operation assistance device according to claim 1, further comprising:

a fuel procurement plan feedback unit configured to transmit at least part of information of the fuel procurement plan to at least one of the plurality of fuel suppliers.

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3. The plant operation assistance device according to claim 2, wherein

the fuel procurement plan feedback unit acquires adjustability information indicating whether the available amount of each of the plurality of types of fuel provided from the

plurality of fuel suppliers can be adjusted and determines a destination fuel supplier to which at least part of information of the fuel procurement plan is transmitted on the basis of the adjustability information.

- 5 4. The plant operation assistance device according to any one of claims 1 to 3, further comprising:

 a fuel use record acquisition unit configured to acquire a fuel use record obtained when the fuel combustion plant is operated according to the fuel procurement plan, the fuel use record including a combustion performance or a fuel use amount of at least one of the
10 plurality of types of fuel; and

 a fuel use record feedback unit configured to transmit at least part of information of the fuel use record to at least one of the fuel suppliers.

5. The plant operation assistance device according to claim 4, wherein
15 the candidate fuel information acquisition unit acquires the candidate fuel information that the fuel supplier has corrected on the basis of the fuel use record.

6. The plant operation assistance device according to any one of claims 1 to 5, further comprising:

20 a maintenance plan determination unit configured to determine a maintenance plan of the fuel combustion plant on the basis of the device information, the operation plan, and the fuel procurement plan.

7. The plant operation assistance device according to claim 6, further comprising:
25 an operation data record acquisition unit configured to acquire an operation data record obtained when the fuel combustion plant is operated according to the fuel procurement plan; and

 a maintenance plan correction determination unit configured to determine a correction

of the maintenance plan on the basis of the operation data record.

8. The plant operation assistance device according to any one of claims 1 to 7, wherein
the fuel procurement plan determination unit determines a fuel usable in the fuel
5 combustion plant among the plurality of types of fuel included in the candidate fuel
information on the basis of the candidate fuel information and the device information and
calculates the fuel procurement plan on the basis of the candidate fuel information of the fuel
determined to be usable, the device information, and the operation plan.
- 10 9. The plant operation assistance device according to any one of claims 1 to 8, wherein
the fuel procurement plan determination unit determines the fuel procurement plan on
the basis of the candidate fuel information, the operation plan, and the device information of
the at least one of devices using a learning model created by machine-learning a relationship
15 between a past used fuel used in the past in the fuel combustion plant and a past operation
record obtained by operating the fuel combustion plant using the past used fuel.
10. The plant operation assistance device according to any one of claims 1 to 9, wherein
the candidate fuel information includes information on the fuel cost.
- 20 11. The plant operation assistance device according to any one of claims 1 to 10, wherein
the candidate fuel information includes information on the available amount.
12. The plant operation assistance device according to any one of claims 1 to 11, wherein
the candidate fuel information includes information on the fuel property.
- 25 13. The plant operation assistance device according to any one of claims 1 to 12, wherein
the plurality of types of fuel includes biomass.

14. A plant operation assistance method of determining a fuel procurement plan which is a plan related to procurement of a plurality of types of fuel used in a fuel combustion plant, the method comprising:

5 a plant operation plan acquisition step of acquiring an operation plan which is a plan related to operation of the fuel combustion plant operated by a plant operator;

a candidate fuel information acquisition step of acquiring candidate fuel information including at least one of a fuel property, an available amount, and a fuel cost of each of the plurality of types of fuel provided from a plurality of fuel suppliers;

10 a constituent device information acquisition step of acquiring device information of the at least one of devices that constitute the fuel combustion plant; and

a fuel procurement plan determination step of determining the fuel procurement plan capable of realizing the operation plan by determining a procurement amount in each prescribed period, of each of the plurality of types of fuel supplied from each of the plurality of fuel suppliers on the basis of the candidate fuel information, the operation plan, and the
15 device information of the at least one of devices.