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(71) Applicant *(for all designated States except US)*: **UPM-KYMMENE CORPORATION** [FI/FI]; Eteläesplanadi 2, FI-00130 Helsinki (FI).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **ANTTILA, Tero** [FI/FI]; Mielikintie 10, FI-37600 Valkeakoski (FI). **HUJO, Samuli** [FI/FI]; Jukolankuja 1 E 1, FI-13720 Parola (FI). **LAAKKONEN, Perttu** [FI/FI]; Könömäentie 69, FI-13720 Parola (FI).

(74) Agent: **TAMPEREEN PATENTTITOIMISTO OY**; Hermiankatu 1 B, FI-33720 Tampere (FI).

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(54) **Title**: A METHOD AND A SYSTEM FOR OPTIMIZING THE TIME OF TRANSPORTATION AND/OR USE OF BIOFUEL

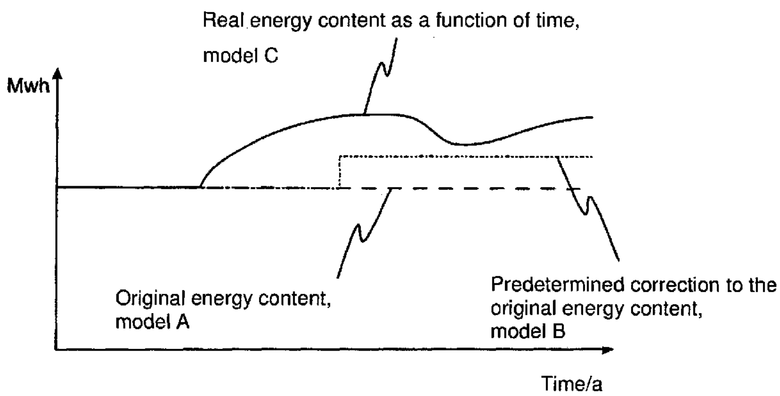

Fig. 3

(57) **Abstract**: The invention relates to a method for optimizing the time of transportation and/or use of biofuel. The method comprises measuring the moisture content of biofuel stored in a storage location, measuring one or more properties of the vicinity of the storage location, entering the measurement result on the moisture content and the measurement result on the property of the vicinity in a mathematical model estimating the energy content of the biofuel, and running the mathematical model for determining an estimate on the energy content of the biofuel. Furthermore, the invention relates to a system for optimizing the time of transportation and/or use of biofuel, as well as a method for optimizing the time of transportation and/or use of biofuel, the method comprising generating a mathematical model.

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A METHOD AND A SYSTEM FOR OPTIMIZING THE TIME OF TRANSPORTATION AND/OR USE OF BIOFUEL

Field of the invention

The invention relates to a method and a system for optimizing the time of transportation and/or use of biofuel.

Background of the invention

The procurement of biofuels, such as logging residue, small-dimensioned wood and stumps, has increased to a great extent while new power plants driven by biofuel have been constructed. Biofuel is unique material which is particularly heterogeneous. Typically, it is not dried by machine, in spite of the fact that it will be used in a state drier than the dry content at the time of harvesting, but it typically dries in stacks in its storage by the effect of heat (the sun) and/or wind. The biofuel storage is often located in the vicinity of the place of harvesting the material, on the terrain. There are several storage places, and the composition and the size of each storage vary. The time duration of the supply chain of biofuels varies from weeks to several years.

Brief summary of the invention

It is an aim of this invention to present a new solution for optimizing the time of transporation and/or use of biofuel. The aim of an embodiment according to an example is to provide a solution for estimating the energy content of biofuel in a biofuel storage and applying it for optimizing the time of transportation and/or use of the biofuel.

The overall management of the biofuel supply chain involves several challenges. The elements relating to the management and stock bookkeeping of the supply chain of conventional merchantable wood (saw timber, pulpwood) are in only some respects suitable for the management of the supply chain of biofuel. Essential differences include the effects of the time of building up the storage, the duration and time of storage on the properties of the material in the storage. In time, both desired and undesired changes take place in the biofuel. A desired change is, for example, drying of the material. The properties of the biofuel can also be changed by biological mechanisms, such as undesired decay. For example, so-called fermentation possibly taking place in a stack of wood chips is, however, not typical of fuel wood.

From the point of view of efficiency of a power plant, the most essential property of biofuel is its energy content. Well-known laboratory methods have been available for determining the energy content. However, it has turned out to be challenging to know the energy content stored in each existing biofuel storage. It is possible to present a very general estimate on the energy content to be obtained from biofuel in a storage, the estimate being typically based on the average energy content of the product. Typically, it can be assumed, for example, that about 1 m^3 of small-dimensioned wood contains about 2 MWh of energy. Furthermore, the energy content of biofuel storages can be corrected by calculations, for example by estimating a possible increase in the energy content resulting from drying; in practice, this is done by increasing the energy content by a given constant value, such as 10% per year. However, this estimate typically corresponds poorly to the real situation. Normally, in deliveries of biofuel, monitoring and payments are done by volume (m^3) and/or weight (kg), as well as “common” energy contents (MWh) of each type of goods.

The energy content can be measured, which is, in practice, often done by taking a sample, that is, a given quantity of the product to be measured, and by measuring the moisture content of the product in question. However, this method is laborious and uncertain, and it typically cannot provide an estimate of the energy content of the whole biofuel storage, because the sample seldom corresponds to the material distribution and conditions of the whole storage.

By implementing the management of the biofuel supply chain according to the prior art, the effect of long-time storage of *e.g.* biofuel does not, irrespective of the storage conditions, influence the value of the biofuel, although the real quality of the biofuel and the energy to be obtained from the biofuel change during the storage. Therefore, the value and the properties of the product purchased can change during the storage in a way that has not been predictable.

In an embodiment according to an example of the invention, it is determined how the need for auxiliary biofuel can be predicted. Thus, it is estimated how much energy is contained in the biofuel storages at each moment of time and how much auxiliary energy is needed, for example to achieve a target amount of energy within a given predetermined time.

The method according to the invention for optimizing the time of transportation and/or use of biofuel is presented in claims 1 and 11. The system according to the invention for optimizing the time of transportation and/or use of biofuel is presented in claim 7.

According to an advantageous example, the solution according to the present invention first includes modeling of the behavior of biofuel during storage, which can be done by generating a mathematical model by means of a computer program. Here, different conditions which vary according to the storage location and according to the fuel source are preferably taken into account.

Advantageously, in the method according to the invention, one or more measuring devices are used to measure previously modeled data, such as variable factors in the vicinity of the biofuel and/or the storage location of the biofuel. Preferably, in the solution according to the invention for optimizing the time of transportation and/or use of biofuel, technology functioning under terrain conditions is utilized for taking measurements.

In an example, variable factors to be measured in the close vicinity of the biofuel storage location include air temperature and/or air moisture content. An example of a variable factor of the biofuel is the moisture content of the biofuel. According to an advantageous example, the biofuel storage and/or its close vicinity is provided with one or more measuring devices for measuring both the moisture of the biofuel and the air moisture content and/or the air temperature in the close vicinity of the biofuel storage. Advantageously, at least the temperature and/or moisture content of the biofuel storage are measured. In a solution according to an advantageous example of the invention for optimizing the time of transportation and/or use of biofuel, position data is utilized, that is, conditions relating to the location of the biofuel storage.

The method according to the invention for optimizing the time of transportation and/or use of biofuel preferably comprises at least the following steps:

- Measuring the moisture content of biofuel stored in a storage location.
- Measuring one or more properties in the close vicinity of the storage location.
- Entering the measurement result of the moisture content and the measurement result of the property of the close vicinity in a mathematical model for estimating the energy content of the biofuel.
- Running the mathematical model for determining an estimate on the energy content of the biofuel.

With the invention, several advantages can be obtained. By means of the invention, it is possible to measure the properties of the biofuel storage, such as the moisture content and the properties of the environment, so that it is possible to take the measurement results into account in such a way that it is possible to estimate the energy content of the biofuel at each moment of time.

Time is an essential factor relating to the optimization of the time of transportation and/or use of the biofuel, because in time the biofuel can be exposed to variable conditions, such as moisture, temperature variations, the effect of wind, *etc.*, which may affect the properties of the biofuel. In general, biofuel material is the more suitable for energy production, the drier it is. Therefore, the time taken for drying of the material may become a critical factor in view of the cost efficiency of a power plant. Furthermore, the purity of the biofuel material is a crucial factor on the usability.

In an embodiment according to the invention, data on the amount of energy of biofuel estimated on the basis of measurements at each moment of time is utilized in different steps of the process, preferably from the moment of building up the biofuel storage all the way to the power plant. Thanks to the invention, it is possible to utilize stock bookkeeping in a way, in which the storage amount, that is, the energy content MWh to be obtained from the biofuel, is taken into account according to the variable conditions. In the method, it is possible to utilize one or more mathematical models and/or different methods of optimization.

By the method according to the invention, it is possible to measure and estimate the energy content of biofuel, which has hardly been possible previously, because the methods used for determining the energy content of conventional merchantable wood (saw timber, pulpwood) are not suitable for determining the energy content of material used as biofuel, due to the different structure of the material. By the method according to the invention, data on the amount of energy contained in energy storages can be updated, for example, on the basis of the weather, the storage duration and time in such a way that it is possible to take into account the change in the properties of the material under said conditions.

The method according to the invention makes it possible to optimize the deliveries of bioenergy and the running of a power plant by taking into account the properties and usability of biofuel energy storages. The invention can also make it possible to predict the "storage behaviour" of bioenergy in such a way that it can be deduced, for example, how the amount of energy to be obtained from fuel wood is changed during storage and when it is profitable to implement the transportation and burning.

One advantage of the invention is to optimize the time of storage and/or transportation of the biofuel and thereby to avoid unnecessary transportation and/or burning of water in the biofuel. Thanks to the invention, it is thus possible to transport and/or to use bioenergy at the right time, that is, in such a way that it does not need to be stored in a storage "to be sure", that is, to let it dry after the product is already sufficiently dry. In spite of this, thanks to the invention it is possible to make sure that the product is not used too early in view of energy efficiency and/or transportation costs, for example when the moisture content of the product is still unnecessarily high. Thanks to the optimization, as a result of the solution according to the invention, it may be possible to produce more energy from the same amount of biofuel.

Description of the drawings

In the following, the invention will be described in more detail with reference to the appended drawings, in which

Fig. 1 shows a chart on a method according to an embodiment for optimizing the time of transportation and/or use of biofuel,

Fig. 2 shows a chart on a system according to an embodiment for optimizing the time of transportation and/or use of biofuel,

Fig. 3 shows an example of the real change in the amount of energy in biofuel as a function of time, compared with a stock bookkeeping value according to the prior art, and

Fig. 4 shows a control device according to an advantageous embodiment of the invention.

Detailed description of the invention

In the present application, the term "biofuel" or "biofuel material" refers to any materials of biologic origin, which are suitable for use in the production of biofuel or as fuel for a boiler. Biofuel typically comprises virgin materials or waste materials originating from plants, such as wood. In particular, biofuel comprises wood-based materials, that is, so-called forest fuel. Forest fuels include, for example, wood, bark, wood chips, logging residue obtained from thinning, clearance and harvesting of merchantable wood, small-dimensioned wood, stumps, branches, and brushwood. In the present application, instead of using the term “forest fuel”, the term fuel wood is also used, both terms referring to the same concept in the present application.

In this application, the term "non-combustible material" refers to any material that is non-combustible in normal boilers, such as metal and mineral soil (for example rock, sand, gravel, and clay).

The term "biofuel storage" refers to biofuel stored in a storage location, for example, in a forest, on a field, by a road, or in a storage area, such as a so-called terminal storage.

The term "close vicinity of the biofuel storage" refers to the environment which is within a range of 2 km, 1.5 km or 1 km from the biofuel storage, more advantageously within a range of 800 m or within a range of 600 m from the biofuel storage, more preferably within a range not longer than 500 m or 250 m or 100 m from the biofuel storage, and most preferably within a range not longer than 70 m from the biofuel storage.

The determination of the energy content in prior art does not make it possible for the whole supply chain to operate in a cost-efficient way and/or in scuh a way the deliveries of biofuels could be made in a reliable way and on the basis of sufficiently accurate data. Consequently, incorrect data and/or assumptions form an unnecessary burden on the whole biofuel supply chain. The invention deviates from the approach of prior art, according to which the same volume of a given type of wood provides essentially the same amount of energy at a power plant. Instead, the approach has been changed to better correspond to the reality.

In an advantageous example according to the invention, one or more measuring devices for measuring predetermined parameters are applied together with a predictive mathematical model to estimate the amount of energy contained in a given biofuel storage at each moment of time in the modeling. According to an advantageous example, an accuracy of at least 50% is thus achieved in estimating said amount of energy, and more advantageously, an accuracy of about 80% is achieved. It has been found that even modeling at an accuracy of 50% means a significant improvement in the present practice in such a way that the cost efficiency of the procurement of biofuel is essentially increased. As a result, thanks to the method according to the invention, it is possible to substantially increase the efficiency of the biofuel supply chain.

In the solution according to the invention, the energy content of the biofuel storage is estimated at a given moment of time and/or within a given period, which may be the present time and/or a given period in the past and/or a given period in the future. Furthermore, data is preferably maintained on the energy content of one or more biofuel storages as a function of time. The estimated energy content of a biofuel storage is utilized for optimizing the time of transportation and/or use of the biofuel, for example for determining the optimal time of transportation of the biofuel in a given biofuel storage, and/or its optimal time of use in a power plant. The measurements according to the invention can be taken by measuring devices of prior art.

In an advantageous example, a mathematical model is generated for estimating the real energy content of the biofuel. In generating the mathematical model, at least the same measurements are taken as in the method for optimizing the time of transportation and/or use of biofuel. After this, said mathematical model is applied in combination with one or more measurements included in the model, for estimating the real energy content of one or more biofuel storages as a function of time.

Figures 1 and 2 illustrate, in a chart, a system according to one embodiment for optimizing the time of transportation and/or use of biofuel. The figures show how it is possible, on the basis of measurements taken on the biofuel by a second measuring device 2, data 3 relating to the location of the biofuel, and/or first measurements 1 taken on the close vicinity of the biofuel by a measuring device, to estimate the energy content of the biofuel at a given time and to apply this estimate for optimizing the time of transportation and/or use of biofuel. Figure 2 shows a first measuring device 1 for measurements to be taken on the environment, a second measuring device 2 for measurements to be taken on the biofuel, data 3 relating to the location of the biofuel, a control system 4 containing a block comprising a mathematical model, and data for optimizing the time of transportation and/or use of biofuel, preferably comprising a control signal.

Figure 3 shows a graph according to an example on the energy content of biofuel as a function of time. It also illustrates the storage bookkeeping value according to prior art in relation to the real energy content.

The graph shown in Fig. 3 illustrate three different approaches to the energy content. Model A shows a model typically used, in which it is assumed that the energy content of biofuel remains constant from the time of building up the storage up to the time of use of the storage. Model B is another commonly used model, in which the aim is to correct the approach of model A on the energy content of the biofuel storage in a one-time manner by a constant factor. This change made by a constant factor, which may be for example +10%, can be done for example once a year from the time of building up the storage to the time of use of the storage. Model C represents a new approach according to the invention, in which the energy content of the storage is determined in time on the basis of measurements and a mathematical model.

Figure 5 illustrates the advantageous feature of the time of use of the storage in relation to the combined effect of the energy content and economic profitability.

The upper graph in Fig. 5 illustrates the predicted amount of energy in relation to the limit of profitability (technological-economical limit). It is thus possible to estimate when it is profitable to transport the biofuel storage for use. The forecast of the amount of energy is updated on the basis of new measurement results. Furthermore, the data on the expected sales price of the energy, shown in the lower graph, is advantageously taken into account. On the basis of the energy sales price and the amount of energy in the storage, it is possible to create a forecast on when it is profitable to take the biofuel into use.

In Fig. 5, the storage value refers to the capital tied up in the storage. Typically, costs are related to the storage, such as possible rent, interest on the tied-up capital, *etc.* In other words, if the storage is used, for example, after two years from the time of building up the storage, its value should have been increased sufficiently from the starting time so that the storage would have been economically profitable.

Figure 4 shows a control system 40 according to a preferred embodiment of the present invention in a reduced block chart. The control system 40 preferably comprises a control block 41, such as a processor or the like, whose operation can be controlled by means of program commands. The control system also comprises receiving means 42 for receiving data, such as measurement results, for example from the first and/or second measuring devices 1, 2, and a memory 43 for storing data. The control system 40 may also comprise a display 45 for displaying data, so that the user of the control system can monitor, for example, changes in a graph of energy content of biofuel as a function of time, and a keyboard 46 for entering data, control commands *etc.* in the control system. The data defined in the control block can also be stored, for example, in the memory 43 of the control system, or in the memory of another device (not shown). Furthermore, the control system 40 may comprise, *inter alia*, data transmission means 44 for transmitting data defined in the control block further to, for example, an energy production plant. For generating and implementing the mathematical model according to the invention, it is possible to apply, for example, a computer program which comprises program commands for controlling the operation of the control system 40, so that the measurement results can be used for forming the necessary initial data, such as said graph on the energy content of biofuel. The computer program, the program commands, and the mathematical model can be stored, for example, in the memory 43 of the control system. This is represented by block 47 in Fig. 4.

In an example of the method, a mathematical model is generated by applying at least the following measurement results:

- the moisture content of biofuel stored in a storage location at measured moments of time, and
- one or more properties of the close vicinity of the storage location at measured moments of time.

Thus, the method preferably comprises entering said measurement results on the moisture content and said measurement results on one or more properties of the vicinity in a computer program, for generating a mathematical model estimating the energy content of biofuel, and generating the mathematical model for determining an estimate on the energy content of the biofuel.

In the solution according to the invention for optimizing the time of transportation and/or use of biofuel, measurements are taken in such a way that at least one second measuring device 2 measures at least one property, preferably the moisture content, of biofuel in a biofuel storage. Furthermore, one or more properties relating to the location of the biofuel storage and/or another property externally affecting the biofuel in another way are taken into account. In practice, it is thus possible to attach one or more first and/or second measuring devices 1, 2 to the vicinity of the biofuel storage and/or to the biofuel. The second measuring device 2 may be based on one of the following measuring methods: infrared, radiometric, impedance, capacitive, microwave, or nuclear magnetic resonance (NMR) measuring method. The moisture content can be measured, for example, by chipping the biofuel sample and by taking the measurement from the chips, but preferably the moisture measurement is taken by measuring the moisture directly from the biofuel material.

In an advantageous example, at least one first measuring device 1 is used per one biofuel storage, for measuring the external conditions which may have an effect on the biofuel. These measurements on the vicinity of the biofuel storage are taken at each storage location in question or its immediate vicinity. This improves the reliability of the measurements, because the external conditions may be changed as a result of the ground profile *etc.* essentially even in adjacent land areas. In other words, the microatmosphere and possible changes in it can be essential factors in estimating the energy content of the biofuel and in generating and/or applying a mathematical model for estimating the energy content of the biofuel. Thus, according to an advantageous example, the mathematical model used takes into account the location of the biofuel and the environmental conditions at a sufficient accuracy, containing for example the shapes of the terrain surface and/or the soil type. Common weather data, for example according to the municipality, is typically not sufficient when applying a mathematical model for optimizing the time of transportation and/or use of biofuel. Measuring devices can be placed in the vicinity of the biofuel storage, for example at the stage of harvesting and/or storage and/or short distance haul of the biofuel.

According to an example, when estimating the energy content of small biofuel storages for optimizing the supply of the biofuel storage, it may in some cases be sufficiently cost efficient to define the energy content of the biofuel storage merely by monitoring the mathematical model. However, for biofuel storages, it is typically advantageous to use measuring devices in parallel with the mathematical model to confirm the estimate on the energy content of the storage.

In an example, the solution according to the invention for optimizing the time of transportation and/or storage of biofuel comprises a control system 40. According to an example, the measuring device transmits measurement results taken on the biofuel storage or its vicinity, which can also take place in a wireless manner, to the control system 4, 40, wherein the data transmission can take place in real time or substantially in real time. In addition to or instead of this, it is possible to transmit stored data intermittently to the control system. Thus, the control system 4, 40 preferably combines one or more measurement results and/or one or more items of data on the harvesting and storage area (for example, soil, storage location, harvesting time) and/or one or more items of data on the weather in the area, and combines said data with the mathematical model used. It is thus possible to estimate the energy content of said biofuel storage at the time in question and/or to predict the development of the energy content of said biofuel storage. In an advantageous example, the system for optimizing the time of transportation and/or use of biofuel optimizes the best time for transportation to a power plant or to a so-called terminal storage located in the vicinity of the power plant, according to the biofuel material storage.

In the invention, at least one remote readable measuring device and/or at least one storing first and/or second measuring device 1, 2 are preferably used. The same measuring device 1, 2 can be used as both a storing and a remote readable measuring device. The transmission of the measurement results from the measuring device to the control system 4, 40 and/or to another storage unit can be implemented, for example, after each measurement, a few times per day, once a day, a few times per week, once a week, 1 to 4 times per month, or less frequently. Advantageously, the measurements are transmitted once to four times a month, or more frequently.

In an example of the method according to the invention, at least one storing first and/or second measuring device 1, 2 is used. Thus, the results of the measurements taken by the measuring device are stored and they are read and/or transmitted at desired intervals. The interval of transmission and/or reading of the results of the storing measuring device can be even several months. In an example of the method according to the invention, at least one remote readable measuring device is used, which is a storing measuring device. Thus, in an advantageous example, one or more automobiles, such as biofuel delivery trucks, are equipped with a device for reading said remote readable measuring device, wherein according to an advantageous example, the numerical values measured by the measuring device are arranged to be stored in the storage system of said one or more delivery trucks for biofuel or merchantable wood, when said delivery truck drives past the biofuel storage in question.

In an example, the mathematical model used for estimating the energy content of the biofuel storage is updated on the basis of a relatively accurate measurement result obtained from the power station and/or the biofuel measuring device, such as a so-called fuelwood measuring device. Thus, adjustment measures can be taken on said mathematical model, if necessary.

When estimating and/or predicting the energy content of the biofuel, the following factors are measured and/or preferably taken into account:

- weather data,
- evaporation,
- wood growth conditions,
- forest type,
- point of time of forest haulage,
- point of time of harvesting of the biofuel (*inter alia*, soil moisture content, frost in the ground) and the initial time of storage,
- method of harvesting,

- processing before the storage, such as shaking, preliminary storage, preliminary crushing, crushing, and/or debarking,
- storage quality,
- is the storage covered,
- is the storage subjected to wind or in a windless place,
- location of the storage in relation to shade/sunshine,
- structure of the storage (width, height, tightness),
- orientation of the storage assembly in relation to the points of compass,
- data measured by one or more measuring devices 1, 2 on the biofuel storage and/or its vicinity,
- fuelwood type (for example free length wood, stump pieces, crushed stumps, small-dimensioned wood) and method of processing (for example delimbed, non-delimbed),
- biofuel type,
- data on growing stock,
- type of soil in the location of harvesting and/or storage,
- geographical location of the storage site (coordinates, height from sea level) and the relating climatic conditions,
- topography of the storage location (in Geographic Information, GI), and/or
- duration of time that the biofuel is allowed to dry for example spread in the cutting area (drying is typically slowed down in a large stack).

Furthermore, one or more features relating to the planning of the deliveries are taken into account. Advantageously, the following factors are taken into account in the planning of the deliveries:

- demand of the energy type,
- storage limitations (in time) and storage cost,
- optimization of the sales margin,
- the status of other energy types and fuels (for example availability and/or price),
- tied-up capital,
- management of storages (forest, terminal, place of use),
- transportation capacity,
- receiving capacity, and/or

- alternative points of delivery.

These are preferably taken into account on predetermined periods of time in the vicinity of the biofuel storage.

The weather data comprises, for example, one or more of the following:
- precipitation (snow, water),
- air humidity,
- air temperature, and
- wind velocity.

Evaporation is a calculated value influenced by, among other things, the weather and the density of trees in said location.

The growth conditions of a tree are influenced by, among other things, forest treatments and other vegetation.

The effect of the time of forest haulage is based on, among other things, the storage period. Furthermore, the ambient conditions during the storage period should be taken into account.

The biofuel harvesting time refers to, among other things, the season and the related conditions, such as the weather in said season.

The storage quality refers, among other things, to the way how efficiently the biofuel dries. This is influenced, among other things, by the fact if the biofuel storage is covered with a rain shield.

The energy type refers to whether the biofuel comprises, for example, logging residue, small-dimensioned wood, stumps, brushwood, or another energy type. In an example, the biofuel comprises stumps of merchantable wood and energy wood. Thus, said stumps can be pre-crushed and/or crushed before and/or during the storage, which is preferably taken into account when estimating the energy content of the biofuel. The crushing of stumps typically affects the properties influencing the energy content, for example changes in the moisture content, and it may also affect the content of non-combustible material in the stumps.

The type of biofuel refers to, among other things, the wood species. For example, small-dimensioned wood dries in different ways, depending on whether it is spruce, pine, birch, aspen, or another wood species. When energy wood is used, the wood species is significant, because for example a spruce stump is different from a pine stump in its energy properties. The wood species differ, for example, so that the moisture contents of different wood species may be different, and furthermore, the method of drying of different wood species may be different.

The data on the soil type can be obtained as location data. The soil types include, for example, mineral soil types and organic soil types. The soil type can be specified with additional attributes which indicate how the soil types deviate from their basic type. The mineral soil types include, for example, boulder soil and cobbly soil, gravel soil, morainic soil, sandy soil, fine-sand soil, silty soil, and clay soil. The organic soil types include, for example, slimy and muddy soil, as well as humus soil, consisting of top soil or peaty soil type.

The soil type may have a substantial importance, for example, in view of the impurities (non-combustible material) in the biofuel, particularly in energy wood. If the harvesting of the biofuel is performed, for example, in fine soil at dry weather, the soil comes off, for example, small-dimensioned wood and branches. Similarly, when stumps are lifted up, the soil comes easily off the roots of the tree. However, when the harvesting is performed in fine soil at moist weather, non-combustible material is typically left adhering to the biofuel, such as the roots of trees. Thus, said non-combustible material can come off after the drying. If the harvesting of the biofuel is, in turn, performed in gravelly soil, the gravel normally drops off the biofuel, irrespective of the moisture. When the harvesting of the biofuel is performed, for example, in peat soil, it is usually the better, for example in view of energy saving, the more peat is left adhering to the energy wood. Consequently, the aim is typically not to remove peat from the energy wood.

For predicting the energy content of energy wood, both the mathematical model and said at least one first and/or second measuring device are used. For the mathematical model, one or more of the above-mentioned variables are suitably selected. The mathematical model is preferably implemented by taking into account measurement results from both the biofuel and the environment. Furthermore, facts are preferably taken into account, which are normally not substantially changed as a function of time (during the storage of the biofuel), for example data relating to the location of the biofuel storage, such as the soil type and/or the topography and/or the geographical location.

In an example, the mathematical model is adjusted on the basis of realized quality data obtained from the production plant. Thus, it is possible to take into account, for example:

- the real energy content,
- the real moisture content,
- the content of non-combustible material,
- the effect of the location data, and/or
- the effect of one or more items of condition data.

By means of the invention, it is possible to optimize the time of storage and/or transportation and/or use of the biofuel. In other words, by means of the invention, the drying and the energy content of the biofuel can be optimized in such a way that the biofuel is delivered from storage locations to the power plant at the best possible moment of time, and even in such a way that the composition and quality of the biofuel supplied to the power plant yield the best possible amount of energy. It is thus possible to reduce the content of water in the biofuel to be burnt and thereby to obtain more energy from the same amount of biofuel at the power plant, because less energy is used for heating the water than when using more moist biofuel. Furthermore, it is possible to reduce the content of water carried entrained in the biofuel and thereby to reduce the costs of transportation of the biofuel.

<u>Example</u>

In a forest according to an example, clear cutting was performed in week 40 in 2011, and stump harvesting work was performed in week 19 in 2012. 90 %

of the wood consisted of spruce and 10% of pine. Before the storage, the stumps were cleaved into four pieces, and they were subjected to normal shaking of prior art.

The biofuel was stored in two storages, the first storage (plot) being located in the same place as the clear cutting, and the second storage (by the road) being located in the vicinity of the clear cutting location. The first storage was a stack of biofuel which was not covered and which is subjected to sunshine at sunny weather. The second storage by the road was loosely piled and covered, and it is subjected to sunshine at sunny weather.

The biofuel was first stored to the plot storage in week 19, at the same time when the stumps were lifted up and cleaved. The storage by the road was taken into use in week 22 when the biofuel was moved to said storage. During the time between the weeks 19 and 22, cleaning of the stump pieces took place, for example as a result of drying of the soil material adhered to the stump pieces, as well as drying of the stump pieces. During the whole storage period, both biofuel storages are subjected to variable weather conditions, such as air humidity, temperature, rainfall, and wind velocity. Variable conditions of the biofuel storage include, for example, temperature and humidity. Sensors installed inside/in the vicinity of the storages are used for measuring the changes.

In connection with the biofuel storages, first measuring devices were installed for measuring the properties of the vicinity: air humidity, air temperature, rainfall, and wind velocity of said vicinity during the storage. These measuring devices are common to both the storages close to each other. In addition, moisture content of the stored biofuel is measured.

For optimizing the time of transportation, the measuring results taken by the measuring devices are applied into a mathematical model. Furthermore, in said model, the planning of deliveries, the demand, and the variation of sales prices are taken into account.

As a result of the method according to the invention, a predicted development of the energy content of the storage is obtained, which is updated on the basis of the measuring results. Furthermore, an economical prognosis of the time of use of the storage is obtained. In addition, the combined effect of the above-mentioned factors provide a view on the optimal storage and use of the storage. The data obtained by the method according to the invention can be used in such a way that the intrinsic data on the biofuel storage, such as its energy content, can be predicted by taking the variable conditions into account. Furthermore, data which are continuously obtained can be utilized for making the model more accurate.

The invention is not limited solely to the examples presented in the drawings and the above description, but it may be modified within the scope of the appended claims.

Claims:

1. A method for optimizing the time of transportation and/or use of biofuel, the method comprising

- measuring
  - one or more properties of the vicinity of a storage location by a first measuring device, and
  - the moisture content of biofuel stored in the storage location by a second measuring device,

  of which measuring devices at least one first and/or second measuring device (1, 2) is a remote readable measuring device and/or a storing measuring device;
- entering the measurement result of the moisture content and one or more measurement results of the property of the close vicinity in a mathematical model for estimating the energy content of the biofuel; and
- running the mathematical model for determining an estimate on the energy content of the biofuel, on the basis of at least the moisture content of the biofuel stored in the storage location and said at least one property of the vicinity.

2. The method according to claim 1, wherein one or more properties of the vicinity are measured within the range of 2 km from said storage location, more advantageously within the range of 1.5 km from said storage location.

3. The method according to claim 1 or 2, **characterized** in that said one or more properties of the vicinity of the storage location comprises at least one item of weather data, which is preferably selected from:

- air temperature,
- air humidity,
- wind velocity, and
- precipitation.

4. The method according to any of the preceding claims, **characterized** in that also one or more items of data relating to the location of the biofuel stor-

age are entered in said mathematical model, the data being preferably selected from:

- the soil type,
- the topography, and
- the geographical location.

5. The method according to any of the preceding claims, **characterized** in that the method comprises

- optimizing the best time of transportation of said biofuel to a power plant or a so-called terminal storage.

6. The method according to any of the preceding claims, **characterized** in that said biofuel is fuelwood.

7. A system for optimizing the time of transportation and/or use of biofuel, the system comprising

- one or more first measuring devices (1) for measuring one or more properties of the vicinity of the biofuel, and for forming one or more first measurement results, as well as one or more second measuring devices (2) for measuring the moisture content of the biofuel and for forming one or more second measurement results, of which measuring devices at least one first and/or second measuring device (1, 2) is a remote readable measuring device and/or a storing measuring device; and
- a control system (4) comprising a mathematical model and arranged
    - to receive at least said first measurement results and second measurement results, and
    - to generate, on the basis of at least said first measurement results and second measurement results, an estimate on the energy content of the biofuel.

8. The system according to claim 7, **characterized** in that at least one first measuring device (1) measuring the vicinity of biofuel is arranged to measure at least one item of weather data, preferably within a range of 2 km from the location of storage of said biofuel.

9. The system according to any of the preceding claims 7 to 8, **characterized** in that the control system (4) is arranged to optimize the best time of transportation of said biofuel to a power plant or a so-called terminal storage.

10. The system according to any of the preceding claims 7 to 9, **characterized** in that said biofuel is fuelwood.

11. A method for optimizing the time of transportation and/or use biofuel, the method comprising creating a mathematical model by applying at least the following measurement results:

- the moisture content of biofuel stored in a storage location at measured moments of time, and
- one or more properties of the close vicinity of the storage location at measured moments of time;

and the method comprising

- entering said measurement results on the moisture content and said measurement results on one or more properties of the vicinity in a computer program, for generating a mathematical model estimating the the energy content of the biofuel, and
- generating the mathematical model for determining an estimate on the energy content of the biofuel.

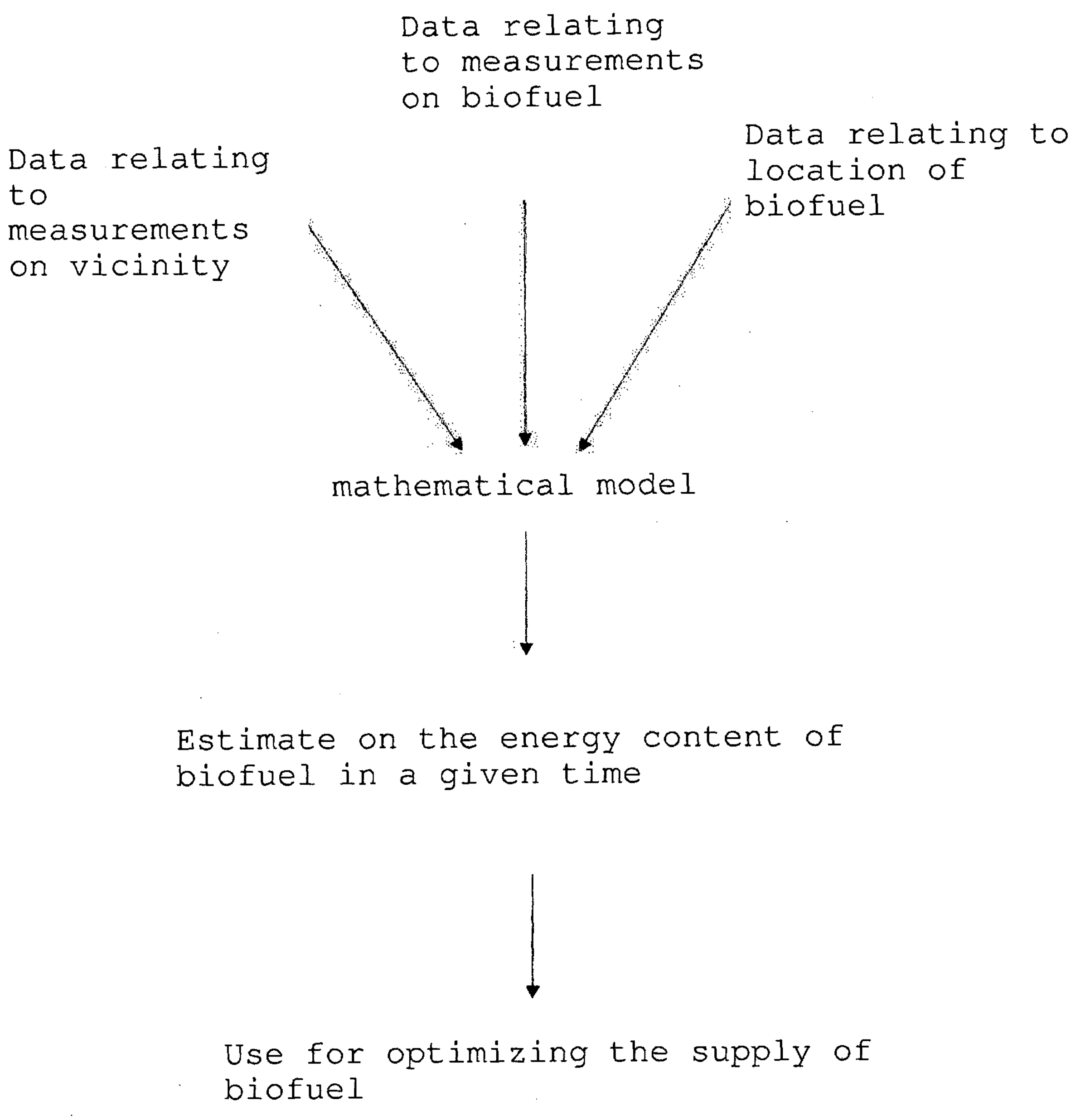
Data relating to measurements on biofuel
Data relating to measurements on vicinity
Data relating to location of biofuel
mathematical model
Estimate on the energy content of biofuel in a given time
Use for optimizing the supply of biofuel

Fig. 1

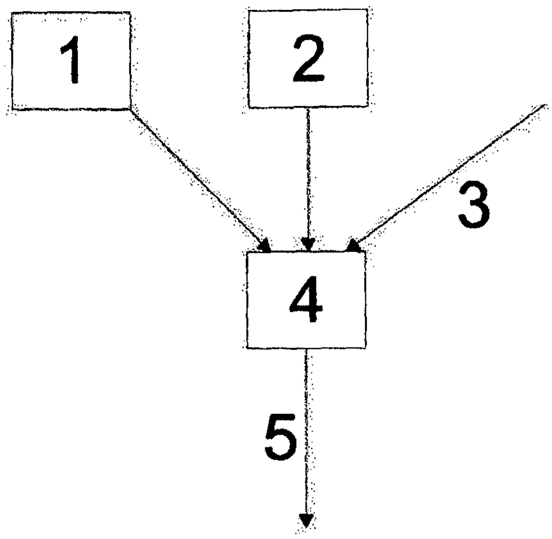

Fig. 2

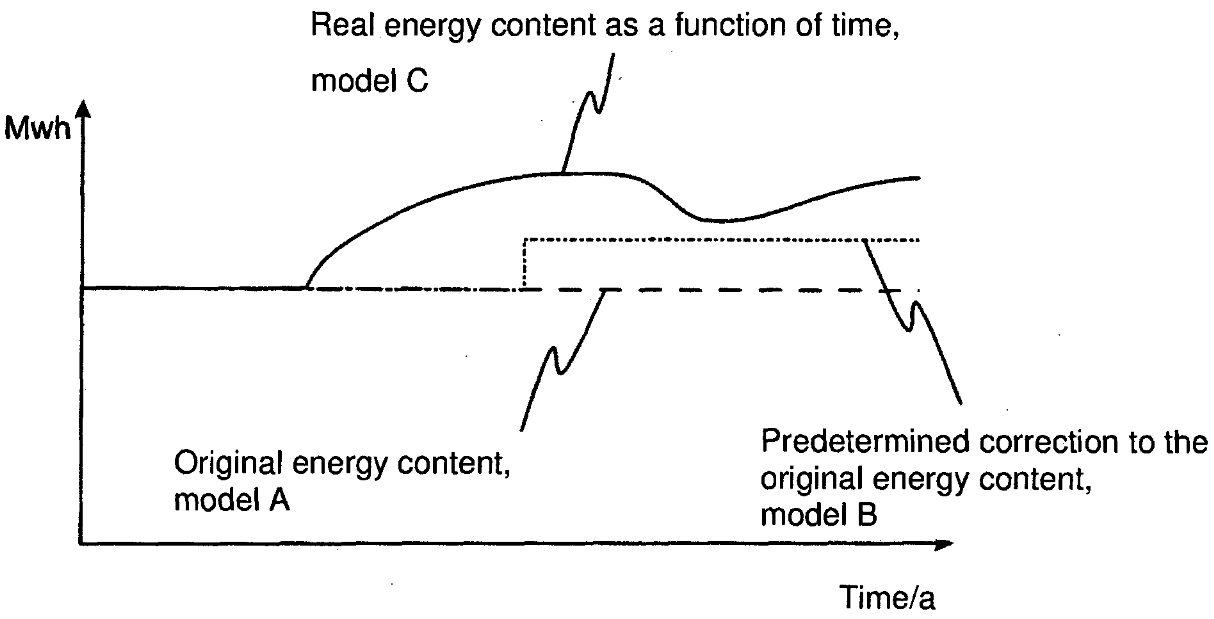
Real energy content as a function of time,
model C
Mwh
Original energy content,
model A
Predetermined correction to the
original energy content,
model B
Time/a

Fig. 3

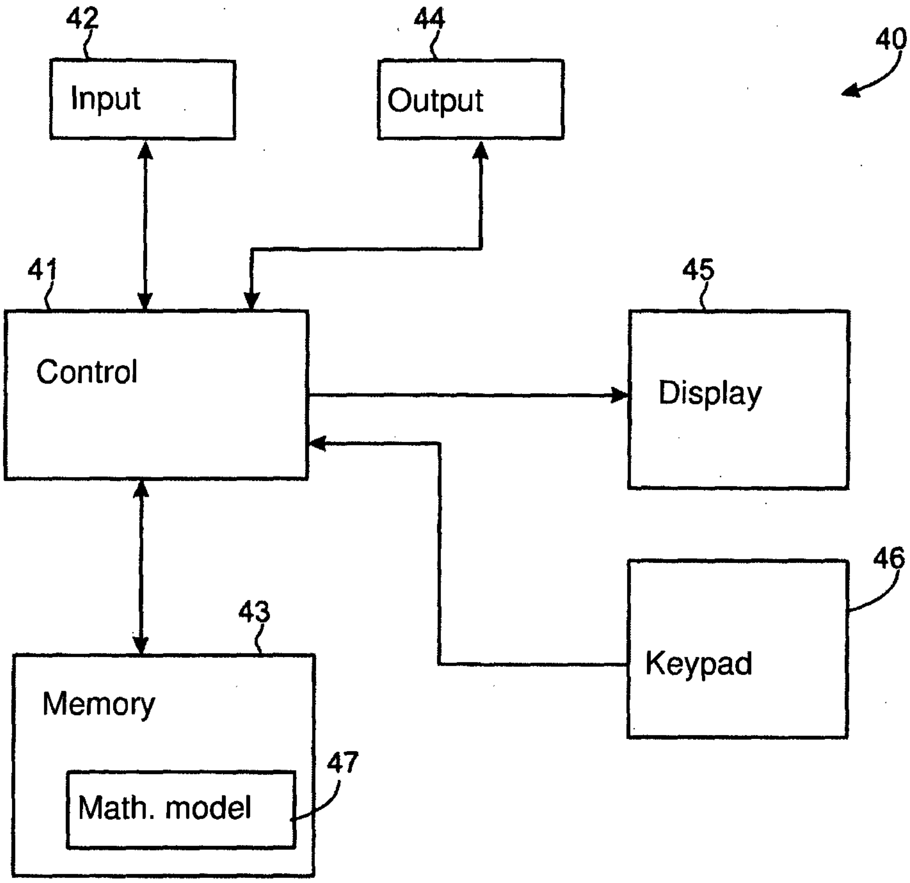
42
44
40
Input
Output
41
45
Control
Display
46
43
Keypad
Memory
47
Math. model

Fig. 4

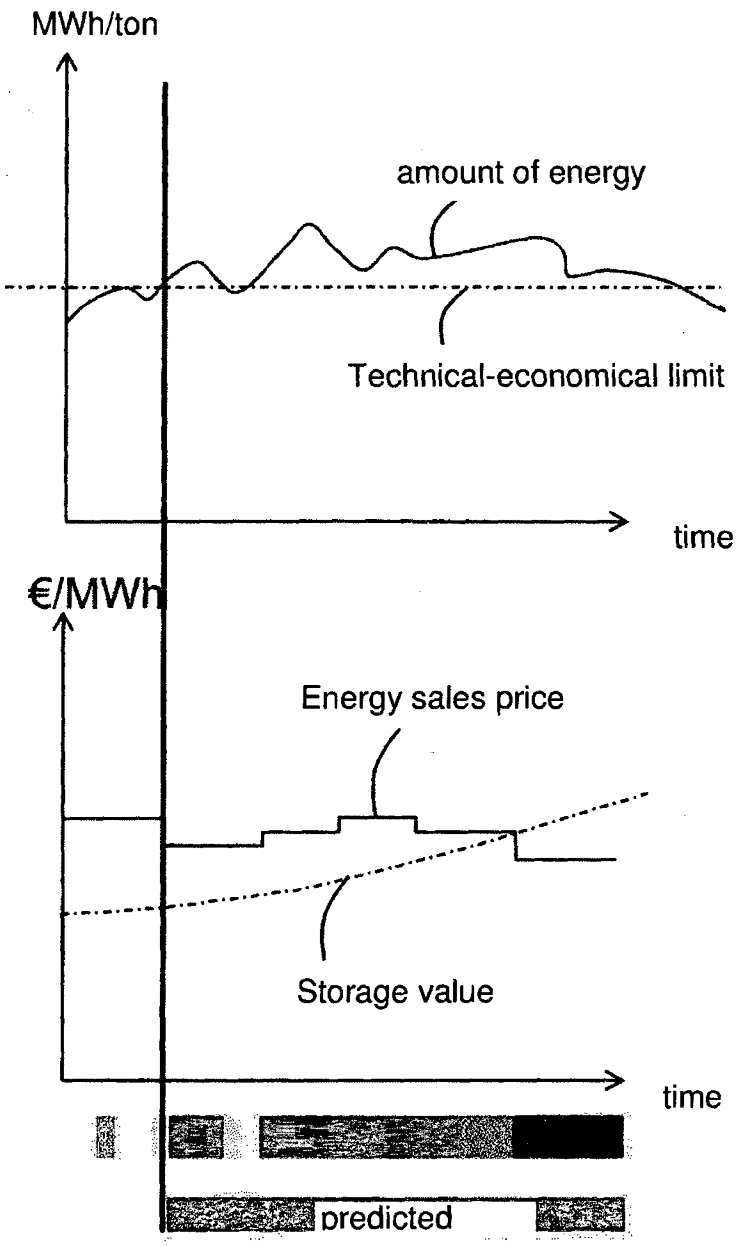
MWh/ton
amount of energy
Technical-economical limit
time
€/MWh
Energy sales price
Storage value
time
predicted

Fig. 5