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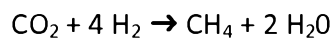
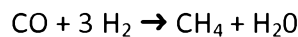
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Technical field of the invention

The present invention relates to a device and method for producing substitute natural gas and a network comprising same. It applies, in particular, to industrial methanation and the cogeneration of thermal energy and methane.

Prior art

Methanation is an industrial process of catalytic conversion of hydrogen and carbon monoxide or dioxide to methane. Depending on the nature of the carbon-based compound, the formula of the methanation reaction changes. This formula is, as the case may be:



Usually, a biomethane production device whose main input is a biomass, has three main elements. The first element is a means of gasification of biomass into synthetic gas (also called "syngas"). This syngas is essentially composed of incondensable gases, such as H₂, CO, CO₂ or CH₄. For certain processes, in addition to the syngas produced, the gasification means produce condensable gases of a tar type, hereinafter called "tars", and solid residues of the "char" type, i.e. a solid part resulting from pyrolysis of a solid fuel.

The gasification means are associated with a combustion means in which the solid residues, such as chars, are burned to maintain the temperature of the gasification means. These combustion means are usually in the form of a transported or circulating bed reactor. This fluidised medium preferably comprises olivine catalyst particles and, more generally, of a heat-transfer solid such as sand, for example. This fluidised medium facilitates the withdrawal of residual chars unreacted in the gasification means and facilitates the transport of these chars to the combustion means.

The second main element is the catalytic methanation of the gasified biomass, wherein this methanation comprises converting H_2 and CO into CH_4 (SNG for "Synthetic Natural Gas").

5 The third main element is the specification of the residual SNG, i.e. the elimination of residual H_2 , CO , H_2O and CO_2 in order to produce an SNG that is as close as possible to the injection specifications on the natural gas network, in particular in terms of gross calorific value, called "GCV" and the Wobbe index. The Wobbe index makes it possible to evaluate the interchangeability capacity between gases, fuel oils or motor fuels.

10 M. Saric et al.: "Power-to-Gas coupling to biomethane production", published on 1 September 2013, describes the use of a natural gas network as a means of storing excess electricity by producing synthetic methane.

The main disadvantage of the current systems stems from the lack of optimisation in the yield of SNG at the output of the system because of the many
15 carbon and energy losses throughout the chain described above.

Object of the invention

The present invention aims to remedy all or part of these drawbacks.

To this end, the present invention aims, in a first aspect, to provide an integrated device for producing substitute natural gas, which comprises:

- 20
- a gasifier configured to produce a gaseous compound from a biomass, comprising:
 - an inlet for biomass;
 - an inlet for an oxidizing agent, and
 - an outlet of the gaseous compound comprising carbon
25 monoxide;
 - a first methanation means for carbon monoxide, disposed downstream of the gasifier, for producing a compound comprising natural gas from the gaseous compound leaving the gasifier, wherein the carbon monoxide methanation means comprises at least one

inlet for water and one inlet for the gaseous compound from the gasifier,

- 5 - downstream of the first means for methanation of carbon monoxide, a carbon dioxide separator for supplying a second means of carbon dioxide methanation to carbon dioxide,
- the second means for methanation of carbon dioxide to produce a compound comprising substitute natural gas comprising at least one inlet for water and one inlet for carbon dioxide from the separator,
- a means for producing dihydrogen from water and electric current, 10 comprising:
 - a power supply,
 - an inlet for water and
 - an outlet for dihydrogen supplying the second means for methanation of carbon dioxide.

15 It is noted that "gasifier" is the accepted term.

By virtue of these arrangements, the carbon dioxide present at the outlet of the carbon monoxide methanation means is converted to SNG via the carbon dioxide methanation means, thereby increasing the carbon conversion efficiency of the device as a whole. In addition, the presence of water electrolysis means 20 allows for applications of the "power-to-gas" type. Power-to-gas applications consist in converting unused electrical energy, for example produced at night by a nuclear power station, into substitute gas that may be consumed later to regenerate electrical energy.

In the embodiments, the device that is the subject of the present 25 invention, further comprises a combustion means, comprising:

- an inlet for a solid part resulting from the pyrolysis of a non-gasified solid fuel, also called "char", from the gasifier and transported by a heat transfer medium,
- an inlet for combustion air,

- a means of combustion of the non-gasified char to heat the heat transfer medium,
- an outlet for the heat transfer medium connected to a heat medium inlet of the gasifier, and
- 5 - a smoke outlet.

The advantage of these embodiments is that they make it possible to increase the efficiency of the gasifier using non-carbonated carbonaceous waste in order to generate heat for the gasifier. The combustion of this carbonaceous waste furthermore makes it possible to heat the transfer medium transporting the
10 carbonaceous waste.

In the embodiments, the dihydrogen generating means are configured to perform electrolysis of water having an oxygen output supplying the oxidiser inlet of the combustion means.

These embodiments have the advantage of drastically increasing the
15 yield of substitute natural gas by avoiding the injection of a portion of the synthetic gas from the gasifier into the combustion means to make combustion possible.

In particular, these embodiments make it possible to maximise the efficiency of a power-to-gas application by using all the water electrolysis products and by optimizing the yield of substitute natural gas.

20 In the embodiments, the device which is the subject of the present invention comprises, between the gaseous compound outlet of the gasifier and the gaseous compound inlet of the carbon monoxide methanation means, a separator that is designed to separate the gases from the solids and/or or tars in the gaseous compound and to transmit the solids and/or tars separated by the
25 combustion means.

The first advantage of these embodiments is that they make it possible to purify the synthetic gas leaving the gasifier by removing solids that can be carried with the gas.

The second advantage of these embodiments is that they make it possible to recycle the solids by using them in the combustion means, thus increasing the efficiency of the combustion means.

In the embodiments, the device which is the subject of the present invention, comprises a means for recycling a portion of the smoke, at the outlet of the combustion means and comprising oxygen, to an oxidant inlet of the combustion means. These embodiments make it possible to increase the efficiency of the combustion means by recycling part of the products of the combustion means. These embodiments allow, for a given apparatus, the ability to operate both in air-fuel combustion and oxy-fuel combustion. For a process initially designed to operate in air-fuel combustion, switching to oxy-fuel combustion leads to a drastic drop in speed and leads to the cessation of the circulation of the heat transfer fluid and therefore the production of gas. In this case, in order to switch to oxy-fuel combustion, it is necessary to arrange either for a new combustion means with a smaller diameter to achieve sufficient transport speeds, or for recirculation of the smoke to compensate for the absence of nitrogen in the oxidant. The choice of smoke is certainly the most relevant because it is a product of the same system.

In the embodiments, the device of the present invention comprises, downstream of the smoke outlet of the combustion means, a carbon dioxide separator that is designed to supply the carbon dioxide methanation means with carbon dioxide.

These embodiments make it possible to increase the yield of the carbon dioxide methanation means.

In the embodiments, the device of the present invention comprises a dihydrogen separator downstream of the carbon monoxide methanation means for supplying the carbon monoxide methanation means with dihydrogen.

These embodiments make it possible to increase the yield of the carbon monoxide methanation means. These embodiments are preferred in the case

where the Wobbe index or the higher heating value of the synthesis gas, does not comply with the requirements of the gas transport network to which the synthetic gas is supplied.

In the embodiments, the device that is the subject of the present invention comprises, downstream of the carbon monoxide methanation means, a carbon dioxide separator for supplying the carbon dioxide methanation means.

These embodiments make it possible to separate the methane at the outlet of the carbon monoxide methanation means from the carbon dioxide for supplying the carbon dioxide methanation means. Thus, the input gas of the carbon dioxide methanation means is more concentrated in carbon dioxide, thereby increasing the yield of the carbon dioxide methanation means.

In the embodiments, an outlet of the carbon dioxide methanation means is connected to an outlet of the carbon monoxide methanation means.

These embodiments make it possible to minimise the number of devices required between the outlets of each methanation means and a substitute natural gas outlet of the device.

In the embodiments, the device of the present invention comprises, downstream of the carbon monoxide methanation means and/or the combustion means, a condenser that is designed to condense water contained in the vapors and to supply the water electrolysis means.

These embodiments make it possible to increase the yields of the electrolysis means.

According to a second aspect, the present invention aims to provide a network, which comprises at least one device object of the present invention.

As the aims, advantages and characteristics of the network are identical to those of the device object of the present invention, they are not repeated here.

In the embodiments, the network object of the present invention comprises a multi-energy management means for controlling:

- the production, with at least one device object of the present invention, and the storage of methane during periods of excess electricity production, and
- the production of electricity with methane stored outside these periods.

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These embodiments make it possible to optimise the amount of energy available in the network during the periods when the electricity produced is not in excess of requirements.

In the embodiments, the network object of the present invention comprises gas distribution pipes, wherein the storage of methane to generate electricity is achieved by overpressure beyond the nominal pressure of the pipes.

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These embodiments make it possible to store at a lower cost the methane produced by the device object of the present invention.

According to a third aspect, the present invention relates to

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- a process for producing substitute natural gas, which comprises:
 - a gasification step for producing a gaseous compound from a biomass, comprising:
 - an inlet step of the biomass;
 - an inlet step of an oxidizing agent, and
 - an outlet step of the gaseous compound comprising carbon monoxide;
- a first step of methanation of the carbon monoxide, downstream of the gasification step, to produce a compound comprising substitute natural gas from the gaseous compound resulting from the gasification step, wherein the carbon monoxide methanation step comprises at least one inlet step for water and for the gaseous compound from the gasifier,

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25

- downstream of the first carbon monoxide methanation step, a carbon dioxide separation step to feed a second carbon dioxide methanation step with carbon dioxide,
- 5 - a second carbon dioxide methanation step to produce a compound comprising substitute natural gas comprising at least one inlet step for water and one inlet for carbon dioxide from the separation step,
- a step for producing dihydrogen from water and electric current, comprising:
 - 10 - a step of power supply,
 - an inlet step for water and
 - an outlet step for dihydrogen used during the carbon dioxide methanation step.

As the aims, advantages and characteristics of the network are identical to those of the device object of the present invention, they are not repeated here.

15 **Brief description of the figures**

Other advantages, aims and particular characteristics of the invention will become apparent from the following nonlimiting description of at least one particular embodiment of the device and method for producing substitute natural gas and the network comprising the device object of the present invention, with
20 reference to the accompanying drawings, wherein:

Fig. 1 represents, schematically, a particular embodiment of the device for producing substitute natural gas object of the present invention,

25 Fig. 2 represents, schematically, a particular embodiment of the network object of the present invention and

Fig. 3 represents a logic diagram of steps of a particular embodiment of the method object of the present invention.

Description of examples of inventive embodiments

The present description is given in a non-limiting manner.

It is to be noted that the figures are not to scale.

Fig. 1 shows one embodiment of the integrated natural gas production device of the present invention. This device comprises:

- a gasifier 102, comprising:
 - 5 – an inlet 104 for biomass;
 - an inlet 106 for an oxidizing agent, and
 - an outlet 108 for synthetic gas comprising carbon monoxide;
- a separator 138 designed to transmit separated solids and tars to the combustion means 124,
- 10 - a means 110 for methanation of the carbon monoxide leaving the gasifier 102 comprising at least one inlet 112 for water and for synthetic gas from the gasifier 102, supplying methane and carbon dioxide,
- a hydrogen separator 144,
- 15 - a first carbon dioxide separator 146,
- a carbon dioxide methanation means 114 comprising at least one inlet 116 for water and for carbon dioxide originating from the carbon monoxide methanation means supplying methane,
- a water electrolysis means 118 comprising:
 - 20 – an electrical power supply 176;
 - an inlet 120 for water;
 - an outlet 136 for oxygen, and
 - an outlet 122 for dihydrogen and
- a combustion means 124, comprising:
 - 25 – an inlet 126 for a non-gasified char transported by a heat transfer medium from the gasifier 102;
 - three inlets 128;
 - a means 130 for combustion of non-gasified char, tars and syngas to heat the heat transfer medium;

- an outlet 132 for the heat transfer medium connected to a heat medium inlet of the gasifier 102, and
- an outlet 134 for smoke
- an inlet 168 of ungasified char and for tars separated from the gas leaving the gasifier 102. and
- a means 140 for recycling part of the smoke at the outlet of the combustion means 124,
- a second carbon dioxide separator 142, and
- two condensers 148,
- three cooling means 150,
- two heating means 172,
- a first inlet 152 of water vapor,
- an oxygen outlet 158,
- an outlet 160 of ash and solid residues,
- a first water outlet 154,
- a second water outlet 162,
- an outlet 164 of gases unused by the device,
- a second water vapor inlet 166, and
- an outlet 170 for substitute natural gas.

20 The gasifier 102 is, for example, a reactor in which the fed biomass undergoes a thermochemical conversion to form a synthetic gas (also called "syngas") containing hydrogen, carbon monoxide, carbon dioxide, water, tars or generally any type of carbon compound. This gasifier 102 has a biomass inlet 104 which is, for example, a valve, a metering screw or a hopper for introducing biomass into the reactor. This gasifier 102 further comprises an inlet 106 for an oxidizing agent which is, for example, a valve for introducing water vapor into the reactor. Upstream of this oxidizing agent inlet 106, a heating means 172 is so placed that the incoming oxidant does not disturb the thermal equilibrium inside the gasifier 102.

The gasifier 102 further comprises an outlet (not shown) for non-gasified char which is, for example, a conduit in which a heat-transfer fluidised medium may be conveyed. This heat-transfer fluidised medium is, for example, made of olivine or sand and provides the energy necessary for the thermochemical
5 conversion of the biomass. This gasifier 102 also comprises an inlet (not shown) for fluidised medium. This gasifier 102 finally comprises an outlet 108 for synthetic gas which is, for example, a pipe connected to the reactor.

In order to heat the gasifier 102, the device comprises a means 124 for combustion. This combustion means 124 is, for example, a reactor. This
10 combustion means 124 comprises an inlet 126 for non-gasified char transported by a coolant medium from the gasifier 102 which is, for example, a pipe connecting the gasifier 102 to the combustion means 124. This combustion means 124 also comprises three inlets 128 for oxidant which are, for example, valves connected to pipes for introducing oxidant into the combustion means 124. An inlet 128
15 allows insertion into the combustion means 124 air, nitrogen or oxygen or the mixture of all of them, such as oxygen-enriched air. An optional means 172 for heating the oxidant may be placed upstream of this inlet 128 in such a way that the input oxidiser does not disturb the internal thermal equilibrium of the combustion means 124. Another inlet 128 allows insertion of dioxygen into the
20 combustion means 124 from the water electrolysis. The final inlet 128 allows insertion of an oxidiser, as necessary, as a thermal auxiliary in the case where char and tars are not sufficient, in the means 124 for burning synthetic gas from the gasifier 102.

In these variants, these oxidiser inlets 128 may be combined into two, or
25 only one, oxidiser inlet(s). The combustion means 124 performs the combustion of the non-gasified char and/or tars from the inlet 168 in order to heat the heat transfer medium, wherein this heat transfer medium leaves the combustion means 124 via an heat transfer medium outlet 132 connected to a coolant medium inlet of the gasifier 102 which is, for example, a pipe connecting the combustion

means 124 and the gasifier 102. The combustion means 124 further comprises a smoke outlet 134 which is, for example, a pipe connected to the combustion means 124.

5 The use of oxygen as an oxidant improves the energy efficiency of the combustion means 124. The use of oxygen allows, in particular, a drastic reduction of the synthetic gas at the outlet of the gasifier 102 to be reused as an oxidiser. The excess oxygen produced by the electrolysis means 118 may also be exploited in other ways. Furthermore, the greater the oxygen content in the oxidant, the greater is the improvement in the efficiency of the separation chain comprising
10 the condenser 148 and the carbon dioxide separator.

The composition of the synthetic gas generated by the gasifier 102 changes under the action of water vapor or of another oxidizing agent, such as for example oxygen or air, which enters the reactor due to the thermochemical equilibria and the production of compounds by heterogeneous gasification of
15 char. For this reason, the synthetic gas produced generally contains pollutants harmful to the service life of a catalyst contained in the carbon monoxide methanation means 110. For this reason, a means 150 for cooling, or heat recovery, is placed at the outlet of the gasifier 102 and, at the outlet of this means 150 for cooling, a separator 138 designed to transmit the solids and tars separated
20 by the combustion means 124. This cooling means 150 is, for example, a heat exchanger. This cooling means 150 makes it possible to perform heat exchange, wherein the heat is recovered for re-use elsewhere in the device.

The separator 138 is, for example, a filter designed to retain the solid compounds coupled to an absorption to retain the tars. This separator 138
25 supplies the means 124 for burning the solids thus separated via, for example, a pipe. The solids thus retained may be organic compounds, or inorganic such as tars, hydrogen sulphide, carbon monoxide sulphide or a large part of the water and solids transported with the gas stream. Part of the gas at the outlet of the separator 138 may be supplied, if necessary, to the combustion means 124.

Similarly, the smoke at the outlet of the combustion means 124 is treated analogously via a means 150 for cooling, or heat recovery, such as, for example, a heat exchanger cooling the fumes, and a gas/solids separator 174 designed to transfer the filtered solids to an outlet 160 of ash and elutriated solids. Part of the
5 gas, containing oxygen, at the outlet of this separator 174 may be supplied, if necessary, to combustion means 124 as an oxidiser.

The device comprises a means 110 for methanation of the carbon monoxide leaving the gasifier 102 which is, for example, a catalytic methanation reactor. This catalytic methanation reactor may be, for example, a fixed-bed
10 reactor, a fluidised-bed reactor or an exchanger type reactor. This catalytic methanation reactor converts carbon monoxide, dihydrogen and water into carbon dioxide and methane. This carbon monoxide methanation means 110 comprises an inlet 112 for water and for synthetic gas from the gasifier 102. This inlet 112 is, for example, a valve for inserting water vapor and synthetic gas into
15 the carbon monoxide methanation means 110.

Water vapor enters the device through a first water inlet 152 which feeds the inlet 112 for water and for synthetic gas. The addition of water vapor makes it possible to ensure the adjustment of the ratio of dihydrogen to carbon monoxide close to stoichiometry by the reaction of water gas shift ($\text{CO} + \text{H}_2\text{O} = \text{H}_2 + \text{CO}_2$), and
20 thus avoid a premature deactivation of the catalyst by deposit of coke. The carbon monoxide methanation means 110 produces methane and carbon dioxide at the outlet.

The gaseous mixture at the outlet of the methanation means 110 is cooled by a cooling means 150 which are, for example, in the form of a heat
25 exchanger. The synthetic gas output is dehydrated by a condenser 148. This condenser 148 may employ all water reduction techniques or their combinations, such as thermal condensation, adsorption or absorption. The water thus recovered is transmitted to a water outlet 154. The water thus discharged may be removed from the device or fed by electrolysis means 118.

The gaseous mixture at the outlet of the condenser 148 is injected into a carbon dioxide separator 146. The carbon dioxide separator 146 may utilise all known methods or combinations thereof, such as, for example, the use of cryogenics, absorption or adsorption. Those skilled in the art will retain the solution of their choice provided that this solution makes it possible to obtain carbon dioxide with a purity greater than 85% by volume. An excessively large volume of carbon monoxide together with carbon dioxide promotes the carbon monoxide methanation reaction to the detriment of the carbon dioxide methanation reaction in a methanation reactor 114.

Alternatively, the recovered carbon dioxide is treated by a complementary purification means designed to remove the carbon monoxide present by carbon dioxide. Beyond conventional solutions, such as adsorption or absorption, the mixture containing the carbon dioxide separated by the separator 146 may undergo thermal oxidation in the combustion means 124. It should be noted that the thermal oxidation may be envisaged only if the combustion means 124 operates with pure oxygen, or if the device comprises a carbon dioxide separator at the outlet of the combustion means 124.

Alternatively, the device may comprise a finishing carbon monoxide methanation means upstream of the means 114 for the carbon dioxide methanation.

The device comprises a means 114 for methanation of the carbon dioxide leaving the gasifier 102 which may be, for example, a catalytic methanation reactor. This catalytic methanation reactor may be, for example, a fixed-bed reactor, a fluidised-bed reactor or an exchanger type reactor. This catalytic methanation reactor converts carbon dioxide, dihydrogen and water into carbon dioxide and methane. These carbon dioxide methanation means 114 comprise an inlet 116 for water and for synthetic gas from the separator 146. This inlet 116 is, for example, a valve for inserting water vapor and synthetic gas into the carbon dioxide methanation means 114. Water vapor enters the device through a first

water inlet 166 which feeds the inlet 116 for water and for synthetic gas. The carbon dioxide methanation means 114 produces methane and water at the outlet.

In addition to the carbon dioxide separated at the outlet of the carbon
5 monoxide methanation means 110, carbon dioxide is recovered from the smoke
at the outlet of the methanation means 124. To do this, the device comprises at
the outlet of the gas-solid separator 174 at the outlet of the methanation means
124, a condenser 148 designed to dehydrate the smoke output from the separator
174. The recovered water is transferred to a water outlet 162 allowing the
10 evacuation of water from the device, or the transfer of this water to the water
electrolysis means 118.

At the outlet of this condenser 148, the remaining gaseous mixture
enters a carbon dioxide separator 142 similar to the carbon dioxide separator 146
at the outlet of the carbon monoxide methanation means 110. The gases
15 separated from the carbon dioxide are fed by the device to an outlet 164 for
unused gases. The carbon dioxide separated by the separator 142 is supplied to
the inlet of the carbon dioxide methanation means 114.

The outlet 156 of methane and water of the carbon dioxide methanation
means 114 is connected to the outlet (not shown) of the carbon monoxide
20 methanation means 110 downstream of the cooling means 150.

Downstream of the carbon dioxide separator 146, the device comprises
a dihydrogen separator 144. This dihydrogen separator 144 makes it possible to
set the specifications of the synthetic gas to the characteristics of the natural gas.
This dihydrogen separator 144 may employ any of the usual methods or their
25 combination. The separated dihydrogen is supplied at the inlet of the carbon
monoxide methanation means 110 via a line 156.

The synthetic gas at the outlet of the dihydrogen separator 144 is fed to
a synthetic gas outlet 170 of the device.

The device comprises a water electrolysis means 118 designed to transform water into oxygen and hydrogen. This electrolysis means 118 are in the form, for example, of an electrolytic cell comprising two electrodes immersed in water, each of which is connected to an opposite pole of a source 176 of direct current. This electrolysis means 118 comprises a water inlet 120 which is, for example, a valve for injecting water into the electrolysis means 118. This electrolysis means 118 also comprise an outlet 122 for dihydrogen supplying the carbon dioxide methanation means 114. In addition, these electrolysis means 118 comprise an oxygen outlet 136 supplying an inlet 128 for the oxidiser of the combustion means 124. This device finally comprises an outlet 158 for oxygen to evacuate the excess oxygen of the device.

Fig. 2 shows one embodiment of the network that is the subject of the present invention. This network comprises:

- a device 205 for producing substitute natural gas as described in Fig. 1.
- a means 210 for multi-energy management,
- a pipe 215 for transporting or distributing gas,
- a means 220 for converting gas into electricity, and
- a generator 225 for direct current.

The multi-energy management means 210 are in the form, for example, of a switch that controls:

- the production, by the device 205, and the storage of methane during periods of excess electricity production, and
- the production of electricity with the methane stored outside these periods.

The excess power generation periods may be predetermined in the system or come from an external source of information, such as a server.

When the multi-energy management means 210 identifies an excess power generation period, this management means 210 controls the production of

methane. To do this, excess electricity is used by the generator 225 of direct current to supply by electrolysis means (not shown) the device 205 to produce substitute natural gas. In parallel, biomass and an oxidizing agent is inserted into the gasifier of the device 205 in order to produce synthetic gas. The device 205
5 produces, at the outlet, substitute natural gas stored at overpressure, beyond the nominal pressure of the pipes, in a gas distribution pipe 215. This excess pressure is, for example, of the order of 10%.

When the multi-energy management means 210 identify a period during which the power generation is not in excess, these management means 210
10 control the production of electricity by means of 220 of the conversion of gas into electricity. The means 220 for converting gas into electricity is, for example, a gas thermal power plant consuming the substitute natural gas stored by overpressure in the pipe 215, in order to produce electricity.

Fig. 3 shows a logic diagram of steps of a particular embodiment of the
15 method that is the object of the present invention. This method comprises:

- a gasification step 305 for producing a synthetic gas, comprising:
 - a biomass input step 310;
 - an oxidizing agent input step 315, and
 - an output step 320 for synthetic gas comprising carbon
20 monoxide;
- a step 325 for methanation of the carbon monoxide resulting from the gasification step 305 comprising an input step 330 for water and for synthetic gas resulting from the gasification step 305 and a methane and carbon dioxide supply step 335;
- 25 - a carbon dioxide methanation step 340 comprising an input step 345 for water and for carbon dioxide originating from the carbon monoxide methanation step 325 and a methane supply step 350,
- a water electrolysis step 355 for converting water into dioxygen and dihydrogen comprising:

- a power supply step 370,
- a water input step 360, and
- an output step 365 for dihydrogen used during the carbon dioxide methanation step 340.

5 The gasification step 305 is carried out, for example, by the use of a gasifier which is a reactor in which supplied biomass undergoes a thermochemical conversion to form a synthetic gas (also called "syngas") containing dihydrogen, carbon monoxide, carbon dioxide, water, tars or generally any type of carbon compound. The gasification step 305 comprises a biomass input step 310 that is
10 carried out, for example, by the implementation of a biomass supply valve in the gasifier. The gasification step 305 also comprises an oxidizing agent input step 315 that is carried out, for example, by the use of an oxidant supply valve to the gasifier. The gasification step 305 further comprises an output step 320 for synthetic gas comprising carbon monoxide produced, for example, by the use of a
15 pipe connected to the gasifier.

 The method comprises a step 325 for methanation of the carbon monoxide from the gasification step 305 carried out, for example, by the implementation of a fluidised bed carbon monoxide methanation means. This carbon monoxide methanation step 325 comprises a step 330 for the input of
20 water and for synthetic gas resulting from the gasification step 305 carried out, for example, by the implementation of a valve for the carbon dioxide methanation means. The carbon monoxide methanation step 325 comprises a step 335 for supplying methane and carbon dioxide + H₂O that is carried out, for example, by the implementation of a pipe at the outlet of the carbon monoxide methanation
25 means.

 The method comprises a carbon dioxide methanation step 340 that is carried out, for example, by the implementation of a fluidised bed carbon dioxide methanation means. The carbon dioxide methanation step 340 comprises an input step 345 for water and for carbon dioxide from the carbon monoxide methanation

step 325 carried out, for example, by the implementation of an insertion valve for water and carbon dioxide from the carbon dioxide methanation means. The carbon dioxide methanation step 340 comprises a methane supply step 350 carried out, for example, by the implementation of a pipe at the outlet of the
5 carbon dioxide methanation means.

The method comprises a water electrolysis step 355 for converting water into dioxygen and dihydrogen that is carried out, for example, by the implementation of two electrodes immersed in water and each connected to a different pole of a DC generator. The electrolysis step 355 comprises a water inlet
10 step 360 carried out, for example, by the implementation of a water injection pipe between the two electrodes used during the electrolysis step 355. The power supply step 370 is performed, for example, by connecting the two electrodes to a DC power source. The electrolysis step 355 comprises an output step 365 for dihydrogen used during the carbon dioxide methanation step 340 that is carried
15 out, for example, by the implementation of a pipe.

Alternatively, the method 30 may further comprise a combustion step comprising:

- an input step for a solid part resulting from the pyrolysis of a solid fuel, also called "char", which is not gasified by the gasifier and is
20 transported by a heat transfer medium,
- an oxidant input stage,
- a stage of combustion of the non-gasified char for heating the heat transfer medium,
- a heat transfer medium output step connected to a heat-medium
25 input of the gasifier, and
- a smoke output step.

Alternatively, the step of producing dihydrogen may carry out water electrolysis comprising an output step for oxygen supplying the combustion input of a combustion means implemented during the combustion step.

Alternatively, the method 30 may comprise, between the gaseous compound output step of the gasifier and the gaseous compound input step of the carbon monoxide methanation step, a gas separation step for the solids and and/or tars in the gaseous compound, and a step for transmitting the solids and/or
5 tars separated by combustion means implemented during the combustion step.

Alternatively, the method 30 may comprise a step of recycling part of the smoke comprising dioxygen, at the output of the combustion step, to an oxidant input of the combustion means implemented during the combustion step.

Alternatively, the method 30 may comprise, downstream of the smoke
10 output step of the combustion step, a step of separating carbon dioxide feeding carbon dioxide to the carbon dioxide methanation means, implemented by the carbon dioxide methanation step.

Alternatively, the method 30 may comprise, a step of dihydrogen separation downstream of the carbon monoxide methanation step to feeding
15 dihydrogen to the carbon monoxide methanation means, implemented during the carbon monoxide methanation step.

The method 30 comprises, downstream of the carbon monoxide methanation step, a step of separating carbon dioxide to feed the carbon dioxide methanation means implemented during the carbon dioxide methanation step.

Alternatively, an output step of the carbon dioxide methanation step is
20 joined to an output step of the carbon monoxide methanation step. Alternatively, the method 30 may comprise, downstream of the carbon monoxide methanation step and/or the combustion step, a step for condensing the water contained in the vapors and feeding the water electrolysis step.

Patentkrav

1. Integreret indretning til produktion af naturgaserstatning, **kendetegnet ved, at** den har:

- 5 - en forgasser (102), der er udformet til at producere en gasformig sammensætning ud fra en biomasse, omfattende:
 - en indgang (104) for biomassen;
 - en indgang (106) for et oxidationsmiddel og
 - en udgang (108) for den gasformige sammensætning indeholdende carbonmonoxid;
- 10 - et første middel (110) til methanisering af carbonmonoxid anbragt nedstrøms for forgasseren (102) til at producere en sammensætning indeholdende naturgaserstatning ud fra den gasformige sammensætning, der forlader forgasseren, idet midlet (110) til methanisering af carbonmonoxid har mindst en indgang (112) for vand og en indgang for
- 15 den gasformige sammensætning, der stammer fra forgasseren (102),
 - nedstrøms for det første middel (110) til methanisering af carbonmonoxid, en carbondioxidseparator (146) til at forsyne et andet middel (114) til methanisering af carbondioxid med carbondioxid,
 - det andet middel (114) til methanisering af carbondioxid til at producere
 - 20 en sammensætning indeholdende naturgaserstatning med mindst en indgang (116) for vand og en indgang for det carbondioxid, der kommer fra separatoren (146),
 - et middel (118) til produktion af dihydrogen ud fra vand og elektrisk strøm omfattende:
 - 25 - en strømforsyning,
 - en indgang (120) for vand og
 - en udgang (122) for dihydrogen, der forsyner det andet middel (114) til methanisering af carbondioxid.
- 30 **2.** Indretning ifølge krav 1, som desuden omfatter et forbrændingsmiddel (124) med:
 - en indgang (126) for en fast del, der stammer fra en pyrolyse af et uforgasset brændbart fast stof, også betegnet "trækul", der stammer fra forgasseren (102) og transporteres af et varmeoverføringsmedium,
 - 35 - en indgang (128) for en oxygenbærer,

- et middel (130) til forbrænding af uforgasset trækul til opvarmning af varmeoverføringsmediet,
 - en udgang (132) for varmeoverføringsmediet, der er forbundet med en indgang for forgasserens varmeoverføringsmedium (102) og
- 5 - en udgang (134) for røg.

3. Indretning ifølge krav 2, i hvilken midlet (118) til produktion af dihydrogen er udformet til at foretage en elektrolyse af vand omfattende en udgang (136) for dioxygen, der forsyner indgangen (128) med forbrændingsmidlets oxygenbærer.

10

4. Indretning ifølge et af kravene 2 eller 3, som mellem udgangen (108) for den gasformige sammensætning fra forgasseren (102) og indgangen (112) for den gasformige sammensætning fra det første middel (110) til methanisering af carbonmonoxid har en separator (138), der er udformet til at adskille gasserne fra

15 de faste stoffer og/eller tjærer i den gasformige sammensætning og til overføre de fraskilte faste stoffer og/eller tjærer til forbrændingsmidlet (124).

5. Indretning ifølge et af kravene 2 til 4, som omfatter et middel (140) til tilbageføring af en del af røgen, omfattende dioxygen, der forlader

20 forbrændingsmidlet (124), til en indgang (128) for forbrændingsmidlets oxygenbærer.

6. Indretning ifølge et af kravene 2 til 5, som nedstrøms de udgangen (134) for røg fra forbrændingsmidlet (124) har en carbondioxidseparator (142), der er

25 udformet til af forsyne det andet middel (114) til methanisering af carbondioxid med carbondioxid.

7. Indretning ifølge et af kravene 1 til 6, som har en separator (144) for dihydrogen nedstrøms for det første middel (110) til methanisering af

30 carbonmonoxid til af forsyne første middel (110) til methanisering af carbonmonoxid med dihydrogen.

8. Indretning ifølge et af kravene 1 til 7, i hvilken en udgang for sammensætningen omfattende naturgaserstatningen fra det andet middel (114)

35 til methanisering af carbondioxid, er forbundet med en udgang for den

sammensætning, der indeholder naturgaserstatningen fra det første middel (110) til methanisering af carbonmonoxid.

5 **9.** Indretning ifølge et af kravene 1 til 8, som nedstrøms for midlet (110) til methanisering af carbonmonoxid og/eller forbrændingsmidlet (124) har en kondensator (148), der er udformet til kondensere i dampene indeholdt vand og til at forsyne elektrolysemidlet (118) med vand.

10 **10.** Net, **kendetegnet ved, at** det omfatter mindst et indretning (205) ifølge et af kravene 1 til 9.

11. Net ifølge krav 10, som omfatter et multi-energiforvaltningsmiddel (210) til at styre:

- 15
- produktion med mindst en indretning (205) ifølge et af kravene 1 til 9 og oplagring af metan i perioder med overskydende elektricitetsproduktion og
 - produktion af elektricitet med den uden for disse perioder oplagrede metan.

20 **12.** Net ifølge krav 11, som omfatter rørledninger (215) til distribution af gas, idet oplagringen af metan til at frembringe elektricitet foretages ved overtryk ud over rørledningernes nominelle tryk.

25 **13.** Fremgangsmåde til produktion af naturgaserstatning, **kendetegnet ved, at** den omfatter:

- et trin til forgasning (305) til at producere en gasformig sammensætning ud fra en biomasse, omfattende:
 - et indgangstrin (310) for biomassen;
 - et indgangstrin (315) for et oxidationsmiddel og
 - 30 - et udgangstrin (320) for den gasformige sammensætning indeholdende carbonmonoxid;
- et første trin (325) til methanisering af carbonmonoxid nedstrøms for forgasningstrinnet til at producere en sammensætning indeholdende naturgaserstatning ud fra den gasformige sammensætning, der stammer
- 35 fra forgasningstrinnet, idet trinnet (325) til methanisering af

- carbonmonoxid omfatter mindst et indgangstrin (330) til vand og til den gasformige sammensætning, der stammer fra forgasseren,
- nedstrøms for det første trin til methanisering af carbonmonoxid, et trin til fraskillelse af carbondioxid for at forsyne et andet trin til methanisering af carbondioxid med carbondioxid,
 - et andet trin (340) til methanisering af carbondioxid for at producere en sammensætning indeholdende naturgaserstatning med mindst et indgangstrin (345) for vand og en indgang for carbondioxid, der kommer fra adskillelsestrinnet,
 - et trin (355) til produktion af dihydrogen ud fra vand og elektrisk strøm omfattende:
 - et trin (370) til strømforsyning,
 - et trin (360) til indgang for vand og
 - et trin (365) til udgang for dihydrogen, der under det andet trin anvendes til methanisering af carbondioxid.

14. Fremgangsmåde ifølge krav 13, som desuden omfatter et forbrændingstrin med:

- et indgangstrin til en indgang for en fast del, der stammer fra pyrolyse af et uforgasset brændbart fast stof, også betegnet "trækul", der kommer fra forgasseren og transporteres af et varmeoverføringsmedium,
- et indgangstrin for oxygenbærer,
- et trin til forbrænding af uforgasset trækul til opvarmning af varmeoverføringsmediet,
- et udgangstrin for varmeoverføringsmediet forbundet til en indgang for forgasserens varmeoverføringsmedium og
- et udgangstrin for røg.

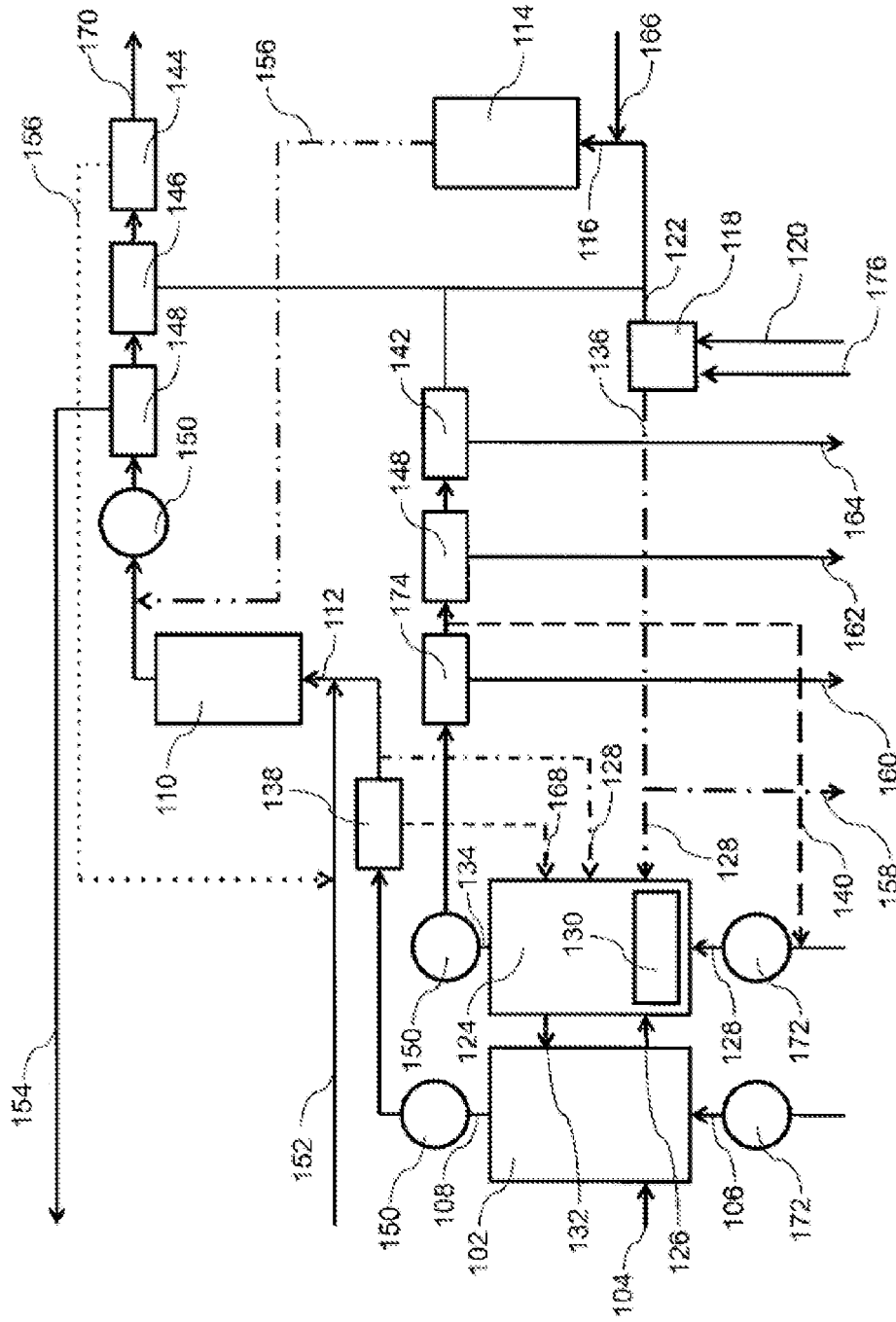


Figure 1

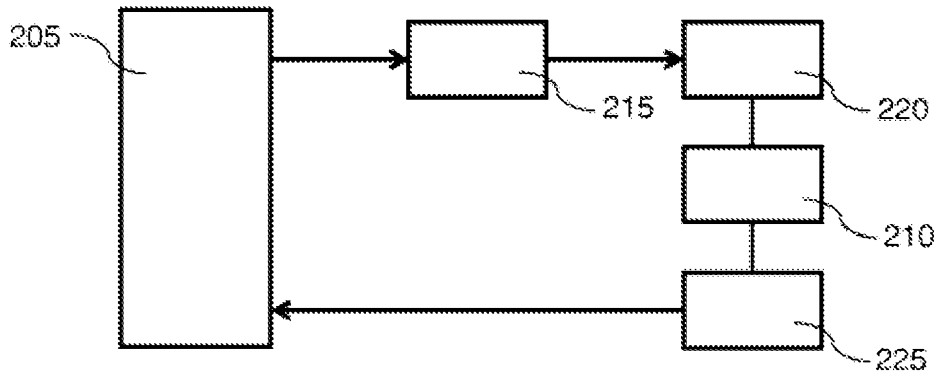


Figure 2

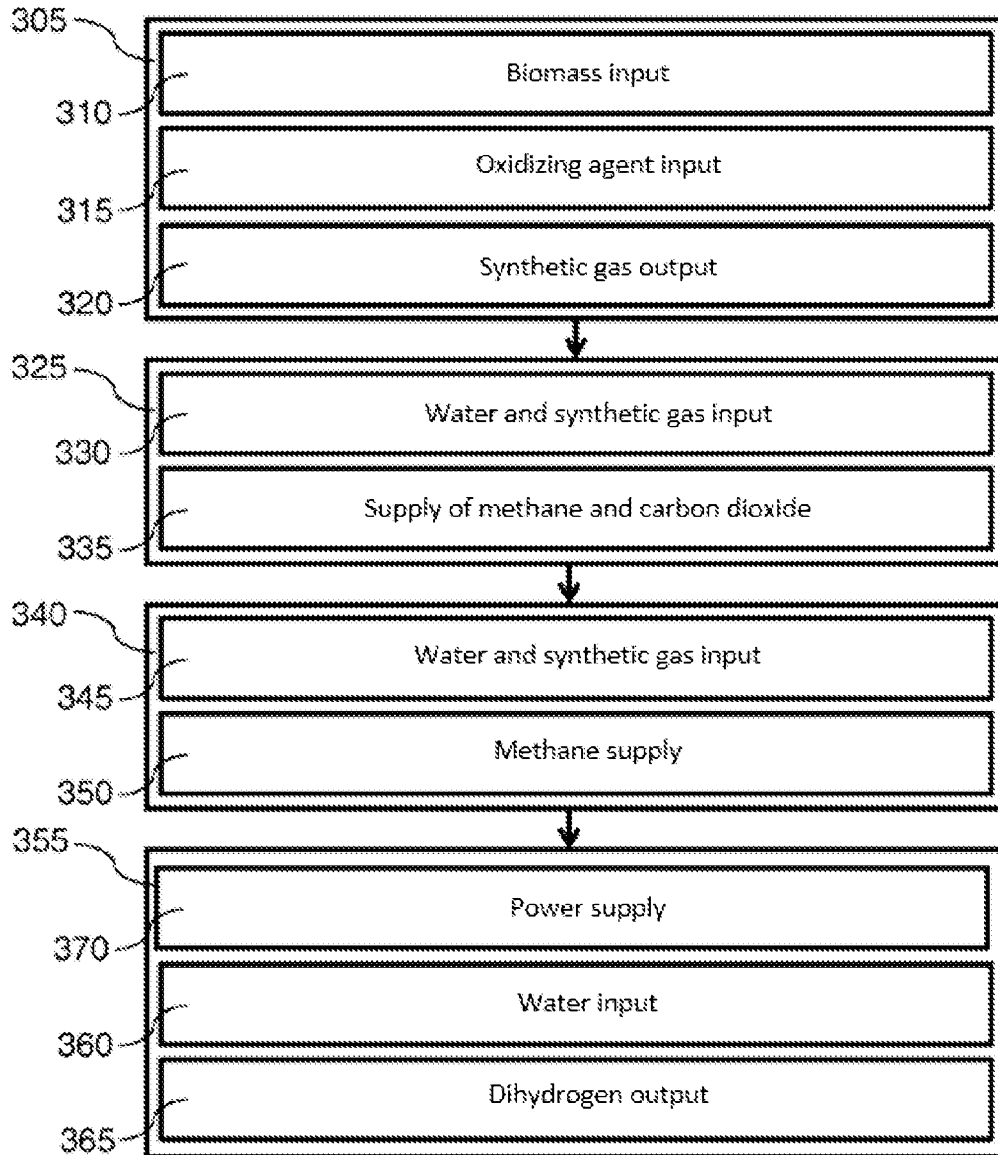


Figure 3