

Description

Title: Method for liquefying and/or solidifying a gas rich in carbon dioxide

The present invention relates to a process for liquefying and/or solidifying a carbon dioxide-rich gas. The gas which is liquefied is a carbon dioxide-rich gas containing more than 30 mol% of carbon dioxide, such as a waste gas from a PSA that produces a gas enriched in hydrogen or flue gases.

It is known from "Integrating hydrogen liquefaction with steam methane reforming and CO₂ liquefaction processes using techno-economic perspectives" by Lee et al., Energy Conversion and Management 245 (2021), to use the cold energy from a vaporization of liquefied natural gas to liquefy CO₂ and hydrogen.

The present invention provides a process for liquefying and/or solidifying a carbon dioxide-rich gas, i.e. a gas containing at least 30 mol% of carbon dioxide, or even at least 50 mol% of carbon dioxide, and preferably at least 90 mol% of carbon dioxide. The gas also contains at least one of the following gases: nitrogen, oxygen, hydrogen, methane, NO_x, argon and carbon monoxide.

JP H06 63699, US2019151789 and FR2969404 describe the use of an intermediate cycle for transferring cold from an LNG flow to a flow of CO₂ to be liquefied. JP H06 63699, published in 1990, describes an intermediate cycle using ethylene, in which the ethylene is vaporized using the heat from the CO₂ flow.

One subject of the invention is that of improving the exchange diagram of the process, in order to avoid large differences in temperature at the hot end of a heat exchanger used for liquefying a CO₂-rich gas.

In order to make a process more efficient from an energy perspective, it is necessary to avoid large differences in temperature, especially for the case where the heat exchanger is an exchanger of brazed-plate-and-fin exchanger type.

Provision is also made to use an intermediate fluid cycle without phase change for transferring cold from the natural gas, liquefied or otherwise, to the gas to be liquefied.

According to one subject of the invention, there is provided a process for liquefying and/or solidifying a carbon dioxide-rich gas in which at least some of the cold energy

for the liquefaction and/or solidification is provided by a low-temperature methane-rich fluid, characterized in that:

- a) the methane-rich fluid is a methane-rich liquid, for example liquefied natural gas, or methane-rich gas at a temperature of less than -50°C ; the methane-rich fluid cools an intermediate fluid at a pressure between 5 and 40 bara down to a first temperature between -30°C and -100°C ,
- b) the intermediate fluid is compressed in gaseous form before or after being cooled down to the first temperature, and is sent to a heat exchanger at a second temperature between -30°C and -80°C , preferably between -50°C and -55°C , where it is heated by indirect heat exchange with the carbon dioxide-rich gas, which condenses at least partially and/or solidifies,
- c) the intermediate fluid heated in the heat exchanger is divided into two, one portion of the fluid leaving the heat exchanger at a temperature which differs by at most 10°C from the dew point temperature of the carbon dioxide-rich gas to be at least partially condensed and which is at least 15°C lower than the temperature at which the carbon dioxide-rich gas enters the heat exchanger at a first end thereof, this portion constituting at least 50%, or even at least 70%, of the intermediate fluid entering the heat exchanger, and
- d) the portion constituting at least 50% of the intermediate fluid is not heated in the heat exchanger and
 - i) is not heated outside of the heat exchanger or
 - ii) is heated outside of the heat exchanger by cooling a refrigerant and/or the carbon dioxide-rich gas,
- e) another portion of the intermediate fluid is heated up to the first end of the heat exchanger, and
- f) the portion constituting at least 50% of the intermediate fluid and the other portion are mixed and returned to be cooled by the methane-rich fluid of step a), the intermediate fluid remaining gaseous during the heat exchange with the methane-rich fluid and the intermediate fluid cycle not comprising a phase change.

According to other optional characteristics:

- at least a portion of the intermediate fluid that has been compressed and heated in the exchanger is expanded in a turbine to a temperature between -30°C and -80°C , preferably between -50°C and -55°C , and returned to the heat exchanger in order to be heated and divided into two according to step c).
- intermediate fluid expanded in the turbine is heated in the heat exchanger and then expanded in another turbine to a temperature between -30°C and -80°C , preferably between -50°C and -55°C , and returned to the heat exchanger in order to be heated and divided into two according to step c).
- the CO_2 -rich gas is a waste gas from a pressure swing adsorption process that produces a gas enriched in hydrogen relative to the gas feeding the adsorption process and the waste gas depleted in hydrogen relative to the gas feeding the adsorption process.
- the intermediate fluid is contains at least 90 mol% of nitrogen or methane or is a mixed refrigerant comprising at least nitrogen, methane and ethane and/or ethylene.
- the flow rate of intermediate fluid is between 10D/L and 25D/L, where D is the flow rate of carbon dioxide-rich gas sent to the heat exchanger in Nm^3/l and L is the number of streams of intermediate fluid in the heat exchanger.
- the carbon dioxide-rich gas is compressed in a compressor upstream of the heat exchanger having at least two stages and an interstage cooler cooled either by a/the portion of intermediate fluid or by the water which has been cooled by the portion of intermediate fluid.
- the inlet temperature of the intermediate fluid compressor is less than 0°C .
- an interstage cooler cooled by a/the portion of intermediate fluid at less than -55°C cools a carbon dioxide-rich gas at a pressure of less than 5.1 bar abs.
- the carbon dioxide-rich gas is cooled in a cooler and then purified of water upstream of the heat exchanger and the portion of the intermediate fluid is used to cool the carbon dioxide-rich gas.
- a flow having the same composition as the intermediate fluid is cooled down to a temperature between -120°C and -160°C and provides cold to a liquefaction or

separation unit operating at a temperature between -120°C and -160°C , for example an air separation apparatus or a hydrogen liquefier.

- a flow having the same composition as the intermediate fluid is cooled down to a temperature between -135°C and -155°C and provides cold to a liquefaction or separation unit operating at a temperature between -135°C and -155°C , in order to solidify a portion of liquefied carbon dioxide-rich gas.
- the methane-rich fluid is a methane-rich liquid which is preheated before cooling the intermediate fluid of step a) by heat exchange with at least one other flow of intermediate fluid or glycol water.
- the compression of step b) raises the pressure of the intermediate fluid such that the intermediate fluid which is heated in the heat exchanger leaves the exchanger and is divided while it is at a pressure substantially equal to that of the fluid upstream of the compression of step b).
- the intermediate fluid is a gas, the heat exchanger is a brazed-plate-and-fin exchanger.
- the heat exchanger has a first end (hot end) and a second end (cold end).
- the difference in temperatures of the heat exchanger at the first end thereof, operating at a hotter temperature than the second end, is between 2 and 10°C .
- the difference in temperatures of the heat exchanger does not exceed 25°C .

The invention will be described in more detail with reference to the figures, in which: [FIG. 1] represents a process for liquefying and/or solidifying a carbon dioxide-rich gas according to the invention.

[FIG. 2] represents a process for liquefying and/or solidifying a carbon dioxide-rich gas according to the invention.

[FIG. 3] represents a process for liquefying and/or solidifying a carbon dioxide-rich gas according to the invention.

[FIG. 4] represents a process for liquefying and/or solidifying a carbon dioxide-rich gas and for liquefying hydrogen according to the invention.

In [FIG. 1], in a process for liquefying and/or solidifying a carbon dioxide-rich gas in which at least some of the cold energy for the liquefaction is provided by a low-temperature methane-rich fluid. The gas contains at least 30 mol% of carbon dioxide,

or even at least 50 mol% of carbon dioxide, and preferably at least 90 mol% of carbon dioxide. The gas also contains at least one of the following gases: nitrogen, oxygen, hydrogen, methane, NO_x, argon and carbon monoxide.

The methane-rich fluid is a methane-rich liquid 1, for example liquefied natural gas or else methane-rich gas at a temperature of less than -50°C. Here, a liquid pressurized by a pump is heated, or even vaporizes, in a heat exchanger E1 via indirect heat exchange with a single fluid which is an intermediate fluid 5 at a pressure between 5 and 40 bara up to a first temperature between -30°C and -100°C.

The intermediate fluid cooled to the first temperature, for example -70°C, is compressed in a compressor C just enough to compensate for the pressure drop in the heat exchanger E1, this pressurization possibly varying between 200 mbar and several bar, depending on the technology of the exchanger E1. The compressed fluid 7 is sent to the cold end of a heat exchanger E2 at a second temperature between -30°C and -80°C, preferably between -50°C and -55°C, for example -55°C having been heated by the compression. It is heated in the exchanger E2 by indirect heat exchange with the carbon dioxide-rich gas 13, which condenses at least partially, leaving the cold end in this example in two-phase form and being separated in a separator S, forming a liquid 17 and a gas 15 which is heated in the exchanger E2. The intermediate fluid 7 heated in the heat exchanger is divided into two, one portion 11 of the fluid leaving the heat exchanger at a temperature which differs by at most 10°C from the dew point temperature of the carbon dioxide-rich gas 13 to be at least partially condensed and which is at least 15°C lower than the temperature at which the carbon dioxide-rich gas 13 enters the heat exchanger E2. The portion 11 may leave the exchanger E2 at -20°C. This portion 11 constitutes at least 50%, or even at least 70%, of the intermediate fluid 7 entering the heat exchanger E2. The portion 11 constituting at least 50% of the intermediate fluid is

- i) returned in a closed circuit in order to be cooled by the methane-rich fluid in step a) and/or
- ii) used to cool another refrigerant and/or
- iii) treated in another way.

The remainder 9 of the intermediate fluid continues to be heated up to the hot end of the heat exchanger E2, for example at 10°C, and then passes through a valve V1 and is remixed with the flow 11 which has not been heated. The valves V1, V2 regulate the percentages of the flows 9, 11.

The flow rate of intermediate fluid 7 is between 10D/L and 25D/L, where D is the flow rate of carbon dioxide-rich gas 13 sent to the heat exchanger E2 in Nm³/l and L is the number of streams of intermediate fluid in the heat exchanger (in this case just one). The fact that only a portion 9 of the intermediate fluid (at most 50%, or even at most 30% of the flow 7) arrives at the hot end of the heat exchanger E2 makes it possible to reduce the difference in temperature at the hot end, thus making it possible to use an exchanger such as a brazed-plate-and-fin exchanger as exchanger E2.

Of course, the cold of the portion 11 can be cleverly exploited, as illustrated in figures 2 and 3.

The liquefaction may be replaced at least partially by solidification.

In [FIG. 2], which is a variant of [FIG. 1], the intermediate fluid is heated in the exchanger E2 up to an intermediate temperature of less than -20°C, is sent to be expanded in a turbine T to a temperature between -30°C and -80°C, preferably between -50°C and -55°C, is sent at a temperature between -30°C and -80°C, preferably between -50°C and -55°C, to the cold end of the exchanger E2 and is heated. It is then divided into two, one portion 11 of the fluid leaving the heat exchanger at a temperature which differs by at most 10°C from the dew point temperature of the carbon dioxide-rich gas 13 to be at least partially condensed and which is at least 15°C lower than the temperature at which the carbon dioxide-rich gas 13 enters the heat exchanger E2. The portion 11 may leave the exchanger E2 at -20°C. This portion 11 constitutes at least 50%, or even at least 70%, of the intermediate fluid 7 entering the heat exchanger E2. The portion 11 constituting at least 50% of the intermediate fluid is used to cool the water 19 in the heat exchanger E3 downstream of the valve V2. The water thus cooled 19 may be a product of the process.

The liquefaction process may comprise or be replaced by a process of solidification by solidifying the flow 13.

The remainder 9 of the intermediate fluid continues to be heated up to the hot end of the heat exchanger E2, for example at 10°C, and then passes through a valve V1 and is remixed with the flow 11 which has been heated in the exchanger E3.

The water 19 can be used to cool the gas 13 upstream of a step of purification for removing the water contained therein. Otherwise, the water 19 can cool an interstage cooler of a compressor for the gas 13 upstream of the heat exchanger E2 having at least two stages. For example, the interstage cooler may be cooled by a/the portion 11 of intermediate fluid at less than -55°C in order to cool a carbon dioxide-rich gas at a pressure of less than 5.1 bar abs.

The flow rate of intermediate fluid 7 is between 10D/L and 25D/L, where D is the flow rate of carbon dioxide-rich gas 13 sent to the heat exchanger E2 in Nm³/l and L is the number of streams of intermediate fluid in the heat exchanger (in this case two, the flows before and after expansion in the turbine T).

The flow 7 can be expanded in two turbines T in series such that the number of streams is three, since one non-expanded flow and two expanded flows are heated in the exchanger E2.

This makes it possible to operate with a reduced flow rate of liquefied natural gas 1 compared to that of Fig. 1.

In this example, all of the intermediate fluid is sent to the turbine. However, it could be envisaged to expand just a portion of the flow in the turbine, to heat it up to the hot end of the exchanger E2, to pass it into the exchanger E1 and to introduce it inter-stage into the compressor C.

In [FIG. 3], which is a variant of [FIG. 2], it can be seen that the exchanger E3 sends cooled water 19 to the exchanger E6 in order to cool the carbon dioxide-rich gas upstream of a dryer P and downstream of the compression in the compressors V1, V2. The water 19 or the portion 11 of intermediate gas can be sent to cool the interstage cooler E4 of the compressor V1, V2, driven by a motor M.

This figure shows a variant of the liquefaction process using a refrigeration cycle with a fluid 27 and two compressors V3, V4.

The carbon dioxide-rich gas 13 is compressed in the compression stages V1, V2, cooled with water in the exchangers E5, E6, dried in the dryer P and then cooled in

the exchanger E2, cold compressed in the compressor V5, cooled in the heat exchanger E2 where it partially condenses, forming a liquid 17 and a gas 15 in the separator S, the gas 15 being cold compressed in the compressor V6, cooled in the heat exchanger E2 where it partially condenses, forming a liquid 21 and a gas 25 in the separator S1. The liquid 21 is expanded and sent to the separator S. The gas 25 is heated in the exchanger E2.

The invention also applies to a case as illustrated in the patent application FR2200982 filed on 4 February 2022, in which there is provided a process for cooling, or even at least partially condensing, gaseous carbon dioxide and for cooling, or even at least partially liquefying, gaseous hydrogen, said process comprising

- i) a step of compressing a first intermediate flow and a step of compressing a second intermediate flow,
- ii) a step of indirect heat exchange, preferably in a first heat exchanger, between a first flow of liquefied natural gas or with a flow of natural gas at a temperature of less than -50°C and at least the first and the second intermediate flows compressed in step i) in order to cool the first intermediate flow down to a temperature T_1 between -30°C and -100°C , or even between -30°C and -80°C , preferably between -25°C and -60°C , and in order to cool the second intermediate flow down to a temperature of less than T_1 , preferably between -130°C and -150°C , and in order to form a first flow of heated, or even vaporized, liquefied gas or a flow of heated natural gas,
- iii) a step of sending the first intermediate flow, which has been cooled down to a temperature between -30°C and -100°C , to a second indirect heat exchanger, where it cools a carbon dioxide-rich flow, which preferably condenses at least partially,
- iv) a step of sending the second intermediate flow, which has been cooled down to between -130°C and -150°C , to a third indirect heat exchanger, where it cools a flow of hydrogen and optionally a cycle fluid, and
- v) a step of cooling, or even at least partially liquefying, the flow of hydrogen cooled in step iv).

According to the present invention, the process described above is adapted so that a portion of the first intermediate flow is heated up to the hot end of the second heat

exchanger and another portion of the first intermediate flow is not heated up to the hot end of the second heat exchanger.

The liquefaction may be replaced by a step of solidifying the CO₂.

Fig. 4 illustrates an integrated process for cooling gaseous carbon dioxide, for cooling gaseous hydrogen and for vaporizing liquefied natural gas. The vaporization apparatus 100 for vaporizing liquefied natural gas optionally comprises a pump P if the liquefied natural gas 1 is not at the required pressure. The liquefied natural gas 1 is divided into two portions, one portion being sent to a plate-and-fin heat exchanger E1, for example a brazed aluminum plate-and-fin exchanger. The liquid flows through the entire exchanger, from the cold end to the hot end, and is vaporized therein. The remainder 5 of the liquid 1 is sent via the valve V1 to a heat exchanger E4, in which it exchanges heat and is vaporized by a flow 7 of cycle gas. The two gases vaporized in the exchangers E1, E4 are mixed in order to form the vaporized natural gas 45. Preferably, the vaporized natural gas 3 exits the exchanger E1 at a temperature greater than 0°C.

The liquefied natural gas 1, 3 may be replaced by natural gas at less than -50°C. The carbon dioxide liquefier 500 comprises a compressor C3 for compressing the gaseous carbon dioxide 450. The compressed gas 13 is cooled, purified of water and optionally of methanol, then compressed in a compressor C4, cooled and then compressed in a compressor C5. The gas compressed in the compressor C5 partially condenses in a plate-and-fin heat exchanger E2, for example a brazed aluminum plate-and-fin exchanger. The gas 13 is rich in carbon dioxide and contains at least 90 mol% of carbon dioxide, or even at least 95% of carbon dioxide. The two-phase fluid formed is sent to a phase separator S1, which produces a gas 17 that is heated in the exchanger E2 and rejoins the gas to be compressed in the compressor C5. The liquid from the phase separator is partially returned as liquid 21, which is vaporized in the exchanger E2 and rejoins the gas to be compressed in the compressor C5. The remainder 17 of the liquid from the separator S1 is sent to a stripping column R, of which the bottom liquid 550, which is purified of light impurities, constitutes the liquefied CO₂. The gas from the column R is heated in the exchanger E2.

The gas 13 may be solidified in order to provide a solid product or the solid may be vaporized in order to form a gas or a liquid.

If the gas 13 is sufficiently pure, the column R will not be needed.

The cold energy needed for this liquefaction in the liquefier E2 is at least partially recovered by a closed cycle. The first intermediate fluid, cycle gas 11, is heated in the heat exchanger E2, is compressed in a compressor C1, and then is optionally divided into two. A portion of the cycle gas arrives in the hottest portion of the heat exchanger E1 and is cooled down to an intermediate temperature of the exchanger E2. The remainder of the cycle gas is cooled in the exchanger E4 and the two cooled fluids are mixed in order to form the cycle gas 11.

The compressor C1 may compress the cycle gas 11 just enough to overcome the pressure losses or else may be associated with a turbine that expands the cycle gas. The hydrogen liquefier 300 comprises two heat exchangers, one precooling heat exchanger E3 and one final heat exchanger E5.

The hydrogen to be liquefied 250 is cooled first of all in the exchanger E3, then in an exchanger E6 and finally in the exchanger E5 in order to form the liquefied hydrogen 350.

Another closed cycle constituted by a second intermediate fluid transfers cold energy from the liquefied natural gas toward the heat exchanger E3. The cycle gas 39 is compressed in a compressor C2, then flows through the exchanger E1, from the hot end to the cold end, before being divided into two. A portion 41 of the gas 39 is expanded in a turbine T1. The remainder 43 is sent to the cold end of the exchanger E3, where it partially condenses, and then is sent to a phase separator 37. The separator gas mixed with the turbine flow 41 becomes the gas 39 that is heated in the exchanger E3, by flowing through it from the cold end to the hot end.

The liquid 35 from the separator is vaporized in an exchanger E6 and rejoins the separator 37.

The molar flow rate D of the second intermediate fluid 39 and the molar flow rate D1 of the fraction 3 of the first intermediate fluid exchanging heat with the first flow of liquefied natural gas are selected such that $0.9D < D1 < 1.3D$.

The first and/or the second intermediate fluid(s) 9, 39 contain(s) at least 50 mol% of nitrogen, indeed even at least 90 mol% of nitrogen, or even 99 mol% of nitrogen.

The first and/or the second intermediate fluid(s) 9, 39 remain(s) in the gaseous state throughout any cooling in the process.

A flow 41, 43 having the same composition as the intermediate fluid 9, 11 is cooled down to a temperature between -120°C and -160°C and provides cold to a liquefaction or separation unit operating at a temperature between -120°C and -160°C , for example an air separation apparatus or a liquefier E3 for hydrogen 27. A flow having the same composition as the intermediate fluid is cooled down to a temperature between -135°C and -155°C and provides cold to a liquefaction or separation unit operating at a temperature between -135°C and -155°C , in order to solidify a portion of liquefied carbon dioxide-rich gas.

The methane-rich fluid 1 is a methane-rich liquid which may be preheated before cooling the intermediate fluid 5 of step a) by heat exchange with at least one other flow of intermediate fluid or glycol water.

For all the figures, the difference in temperatures of the heat exchanger E2 at the hot end is between 2 and 10°C and the difference in temperatures of the heat exchanger E2 preferably does not exceed 25°C .

The intermediate fluid cycle does not comprise a phase change for transferring cold from the natural gas, liquefied or otherwise, to the gas to be liquefied. Thus, the intermediate fluid remains gaseous throughout the cycle and in particular the intermediate fluid remains gaseous during the exchange of heat with the methane-rich fluid and does not condense.

Claims

1. A process for liquefying a carbon dioxide-rich gas (13) in which at least some of the cold energy for the liquefaction is provided by a low-temperature methane-rich fluid (1), wherein:
 - a) the methane-rich fluid is a methane-rich liquid, for example liquefied natural gas, or methane-rich gas at a temperature of less than -50°C ; the methane-rich fluid cools an intermediate fluid (5) at a pressure between 5 and 40 bara down to a first temperature between -30°C and -100°C ,
 - b) the intermediate fluid is compressed (C, C1) in gaseous form before or after being cooled down to the first temperature, and is sent to a heat exchanger (E2) at a second temperature between -30°C and -80°C , preferably between -50°C and -55°C , where it is heated by indirect heat exchange with the carbon dioxide-rich gas, which condenses at least partially,
 - c) the intermediate fluid heated in the heat exchanger is divided into two, one portion (11) of the fluid leaving the heat exchanger at a temperature which differs by at most 10°C from the dew point temperature of the carbon dioxide-rich gas to be at least partially condensed and which is at least 15°C lower than the temperature at which the carbon dioxide-rich gas enters the heat exchanger at a first end thereof, this portion constituting at least 50%, or even at least 70%, of the intermediate fluid entering the heat exchanger, and the portion constituting at least 50% of the intermediate fluid is not heated in the heat exchanger and
 - i) is not heated outside of the heat exchanger or
 - ii) is heated outside of the heat exchanger by cooling a refrigerant (19) and/or the carbon dioxide-rich gas,
 - e) another portion of the intermediate fluid (9) is heated up to the first end of the heat exchanger, and
 - f) the portion constituting at least 50% of the intermediate fluid and the other portion are mixed and returned to be cooled by the methane-rich fluid of step a), the intermediate fluid remaining gaseous during the heat exchange with the methane-rich fluid and the intermediate fluid cycle not comprising a phase change.

2. The process as claimed in claim 1, wherein at least a portion of the intermediate fluid that has been compressed and heated in the exchanger is expanded in a turbine (T) to a temperature between -30°C and -80°C , preferably between -50°C and -55°C , and returned to the heat exchanger (E2) in order to be heated and divided into two according to step c).
3. The process as claimed in claim 2, wherein intermediate fluid expanded in the turbine (T) is heated in the heat exchanger (E2) and then expanded in another turbine to a temperature between -30°C and -80°C , preferably between -50°C and -55°C , and returned to the heat exchanger in order to be heated and divided into two according to step c).
4. The process as claimed in one of the preceding claims, wherein the CO_2 -rich gas (13) is a waste gas from a pressure swing adsorption process that produces a gas enriched in hydrogen relative to the gas feeding the adsorption process and the waste gas depleted in hydrogen relative to the gas feeding the adsorption process.
5. The process as claimed in one of the preceding claims, wherein the intermediate fluid (9, 11) contains at least 90 mol% of nitrogen or methane or is a mixed refrigerant comprising at least nitrogen, methane and ethane and/or ethylene.
6. The process as claimed in one of the preceding claims, wherein the flow rate of intermediate fluid (5) is between 10D/L and 25D/L , where D is the flow rate of carbon dioxide-rich gas (13) sent to the heat exchanger (E2) in Nm^3/h and L is the number of streams of intermediate fluid in the heat exchanger.
7. The process as claimed in one of the preceding claims, wherein the carbon dioxide-rich gas is compressed in a compressor (V1, V2, C3, C4, C5) upstream of the heat exchanger having at least two stages and an interstage cooler (E5) cooled either by a/the portion of intermediate fluid or by the water (19) which has been cooled by the portion (11) of intermediate fluid.
8. The process as claimed in claim 7, wherein an interstage cooler (E5) cooled by a/the portion of intermediate fluid (11) at less than -55°C cools a carbon dioxide-rich gas at a pressure of less than 5.1 bar abs.
9. The process as claimed in one of the preceding claims, wherein the carbon dioxide-rich gas (13) is cooled in a cooler (E6) and then purified of water (P) upstream

of the heat exchanger (E2) and the portion of the intermediate fluid (11) is used to cool the carbon dioxide-rich gas.

10. The process as claimed in one of the preceding claims, wherein a flow having the same composition (41, 43) as the intermediate fluid is cooled down to a temperature between -120°C and -160°C and provides cold to a liquefaction or separation unit (300) operating at a temperature between -120°C and -160°C , for example an air separation apparatus or a hydrogen liquefier (27).

11. The process as claimed in one of the preceding claims, wherein a flow having the same composition (41, 43) as the intermediate fluid is cooled down to a temperature between -135°C and -155°C and provides cold to a liquefaction or separation unit operating at a temperature between -135°C and -155°C , in order to solidify a portion of liquefied carbon dioxide-rich gas (27).

12. The process as claimed in one of the preceding claims, wherein the methane-rich fluid is a methane-rich liquid (1) which is preheated before cooling the intermediate fluid (5) of step a) by heat exchange with at least one other flow of intermediate fluid or glycol water.

13. The process as claimed in one of the preceding claims, wherein the compression (C, C1) of step b) raises the pressure of the intermediate fluid such that the intermediate fluid which is heated in the heat exchanger (E2) leaves the exchanger and is divided while it is at a pressure substantially equal to that of the fluid upstream of the compression of step b).

14. The process as claimed in one of the preceding claims, wherein the intermediate fluid (5) is a gas and is not condensed by heat exchange with the methane-rich fluid (1).

15. The process as claimed in one of the preceding claims, wherein the heat exchanger (E2) is a brazed-plate-and-fin exchanger.