

PROCESSES FOR BLENDING TWO OR MORE STREAMS OF LIQUIFIED HYDROCARBONS

Field of the Invention

[0001] The present specification generally relates to the field of blending of hydrocarbons, and more specifically, to processes to blend two or more streams of liquefied hydrocarbons.

Background of the Invention

[0002] This section is intended to introduce various aspects of the art, which may be associated with exemplary embodiments of the present invention. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present invention. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of any prior art.

[0003] Generally, it is commercially important to cryogenically liquefy natural gas so as to produce LNG for more convenient storage and transport. A fundamental reason for the liquefaction of natural gas is that liquefaction results in a volume reduction, thereby making it possible to store and transport large volumes the liquefied gas in containers at low or even atmospheric pressure, in an economical manner, and thereby to provide a technically sound and safe solution, in situations where pipeline transport is not practical or economically feasible.

[0004] Blending of an LNG product, which comprises mainly methane with another component, such as light hydrocarbons, such as ethane, propane, or butane, to increase the LNG heating value to meet market demands is known. For instance, US20140338393 discloses a method for producing a blended mixture of liquefied natural gases to meet the particular requirements of an operator at a production facility, application site or a fueling station by blending together a lean liquefied natural gas and a rich liquefied natural gas. In another example, WO2005093017 discloses compositions comprising mixtures of natural gas and synthetic light hydrocarbons, such as C2 to C5 paraffins, olefins and mixtures thereof, obtained via a hydrocarbon synthesis reactions, which are suitable for use as fuel compositions, and particularly to blends of such synthetic light hydrocarbons and a natural gas derived from LNG produced in an LNG process. In yet another example, US8381544 discloses altering the heating value of a liquefied natural gas by adding higher heating value components by using the LNG to cool the higher heating value component stream prior to combining the higher heating value components with the LNG.

[0005] In addition, US 11416012 discloses in-line mixing of hydrocarbon liquids from a plurality of tanks into a single pipeline, where the hydrocarbon liquids are generally those that exist in a liquid state at atmospheric conditions, such as hydrocarbons that exists as a viscous liquid in underground geological formations and at the surface, gasoline, crude oils, pyrolysis oil, etc. As such, this patent reference does not address the challenges of blending liquefied hydrocarbons.

[0006] These disclosures, however, do not address potential challenges associated with blending of two liquified hydrocarbon streams that have different properties, such as density. As such, it would be desirable to have an improved process to blend two or more liquified hydrocarbon streams. These and other objectives will become apparent from the disclosure provided herein.

Summary of the Invention

[0007] There is provided a method for blending two or more liquified hydrocarbon streams between at least two vessels, where the first vessel comprises a first storage container for storing a first liquified hydrocarbon, optionally the first liquified hydrocarbon is liquefied natural gas and wherein the second vessel comprises a second storage container for storing a second liquified hydrocarbon, optionally the second liquified hydrocarbon is selected from a group consisting of liquified ethane, liquified butane, liquified propane, and any combination thereof. The method comprises: (a) providing a network of conduits between the at least two vessels, and the network of conduits comprises: (i) a first blending point that is optionally a part of a liquid manifold of the second vessel, (ii) a first conduits segment that is optionally part of a liquid manifold of the first vessel to provide fluid communication between the first storage container and the first blending point, (iii) a second conduits segment that is optionally part of a liquid manifold of the second vessel to provide fluid communication between the second storage container and the first blending point, and (iv) combined conduits to provide fluid communication downstream of the first blending point and back to an inlet of the first storage container. The combined conduits comprise a final valve immediate upstream of said inlet of the first storage container. The method further comprises (b) pumping a first liquified hydrocarbon stream from the first storage container to the first blending point via the first conduits segment; (c) pumping a second liquified hydrocarbon stream from the second storage container to the first blending point via the second conduits segment; (d) combining the first and second liquified hydrocarbon streams at the first blending point in a volumetric ratio in a range from 1:500, preferably from 1:100, and up to 500:1 to provide a combined stream; (e) providing at least a portion, including all, of the combined stream from the

first blending point back to the first storage container via the combined conduits, thereby providing a combined product to the first storage container, and (f) while the combined stream is between a segment of the combined conduits between the first blending point and the final valve, providing the combined stream with an operating pressure above (preferably at least 0.1 bar above, more preferably at least 0.5 bar above, most preferably at least 1.2 bar above) a saturation pressure of the combined stream.

[0008] Optionally, in some embodiments, the combined conduits further comprise a first subsequent blending point downstream of the first blending point, and optionally upstream of the final valve 126. In such embodiment, the method can further comprise: (g) providing a second stream of the first liquified hydrocarbon from a source of the first liquified hydrocarbon, which is optionally the first storage container, to the first subsequent blending point; and (h) combining the combined stream and the second stream of the first liquified hydrocarbon at the first subsequent blending point in a volumetric ratio in a range from 25:1, preferably 50:1, and up to 500:1, wherein the first stream of the first liquified hydrocarbon and the stream of the second liquified hydrocarbon ethane stream are combined in a volumetric ratio in a range from 1:500, preferably 1:100, and up to 50:1 at the first blending point. Optionally, the combined conduits can further comprise a second subsequent blending point located downstream of the first subsequent blending point, either upstream or downstream of the final valve, and upstream of the inlet of the first storage container. In such embodiment, the method can further comprise: (i) providing a third stream of the first liquified hydrocarbon from a source of the first liquified hydrocarbon, optionally the first storage container, to the second subsequent blending point; and (j) combining the combined stream and the third stream of the first liquified hydrocarbon at the second subsequent blending point in a volumetric ratio in a range from 25:1, preferably 50:1, and up to 150:1, wherein the first liquified hydrocarbon stream and second liquified stream are combined in a volumetric ratio in a range from 1:500, preferably 1:100, and up to 50:1 at the first blending point and wherein the combined stream and the second stream of the first liquified hydrocarbon are combined in a volumetric ratio in a range from 100:1, preferably 150:1, and up to 500:1 at the first subsequent blending point.

[0009] Optionally, in some embodiments, the combined conduits further comprise a subsequent blending point located downstream of the final valve and upstream of the inlet of the first storage container. In such embodiment, the method can further comprise: (g) providing another stream of the first liquified hydrocarbon from a source of the first liquified hydrocarbon

to the subsequent blending point, optionally wherein said source is the first storage container; and (h) combining the combined stream and the other stream of the first liquified hydrocarbon at the subsequent blending point in a volumetric ratio in a range from 25:1, preferably 50:1, and up to 500:1, and wherein the first stream of the first liquified hydrocarbon and the stream of the second liquified hydrocarbon are combined in a volumetric ratio in a range from 1:500, preferably 1:100, and up to 50:1 at the first blending point.

[0010] Optionally, in some embodiments, the combined stream downstream of the final valve and downstream of any subsequent blending point comprises a volumetric ratio of the first liquified hydrocarbon, preferably LNG, to the second liquified hydrocarbon, preferably liquified ethane, of at least 2:1, preferably at least 3:1, and more preferably at least 4:1.

[0011] Optionally, in some embodiments, the network of conduits can further comprise at least one of a drop-down line and an in-tank spray header to introduce the combined stream from the combined conduits 116 to the first storage tank. Optionally, the drop-down line and/or in-tank spray header further comprises its respective final valve immediately upstream of its outlet. In such embodiment, the method can further comprise providing a segment of conduits between the combined conduits and respective final valve of the drop-down line and/or in-tank spray header with an operating pressure that is above (preferably at least 0.1 bar above, more preferably at least 0.5 bar above, most preferably at least 1.2 bar above) the saturation pressure of the combined stream.

[0012] Optionally, in some embodiments, the method can further comprise providing the network of conduits with an overall operating pressure of at least 2 barg.

[0013] Optionally, in some embodiments, the method can further comprise: providing the first storage container with an operating pressure higher, preferably at least 5% higher, more preferably at least 50%, and most preferably at least 100% higher, than the saturation pressure of the combined stream) the saturation pressure of the combined stream.

[0014] Optionally, in some embodiments, the method can further comprise: continuously performing steps (a) – (e) and as applicable, steps (f) – (j) until a desired amount of the first liquified hydrocarbon and/or the second liquified hydrocarbon has been combined. Optionally, the method can further comprise returning the operating pressure of the network of conduits to a standard operating pressure, and returning the operating pressure of the first storage container to a standard operating pressure.

[0015] Optionally, in some embodiments, the method can further comprise: providing the combined product from the first storage container to another storage container on the first vessel

[0016] Optionally, in some embodiments, the method can further comprise storing the combined product in the first storage container as inventory.

Brief Description of the Drawings

[0017] FIG. 1 depicts a diagram of an exemplary embodiment of a system for use in blending two or more liquified hydrocarbon streams according to aspects disclosed in the present disclosure.

[0018] FIG. 2 depicts a diagram of an exemplary embodiment of another system for use in blending two or more liquified hydrocarbon streams according to aspects disclosed in the present disclosure.

[0019] FIG. 3 depicts a diagram of an exemplary embodiment of yet another system for use in blending two or more liquified hydrocarbon streams according to aspects disclosed in the present disclosure.

[0020] FIG. 4 depicts a diagram of an exemplary embodiment of yet another system for use in blending two or more liquified hydrocarbon streams according to aspects disclosed in the present disclosure.

Detailed Description of the Invention

[0021] The present invention will now be described in detail with reference to embodiments thereof as illustrated in the accompanying drawings. References to “one embodiment,” “an embodiment,” “an example embodiment,” etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described. Other suitable modifications and adaptations of the variety of conditions and parameters normally encountered in the field, and which would be apparent to those skilled in the art, are within the spirit and scope of the invention.

[0022] Although the description herein provides numerous specific details that are set forth for a thorough understanding of illustrative embodiments, it will be apparent to one skilled in the art that embodiments may be practiced without some or all of these specific details. In other instances,

well known process steps and/or structures have not been described in detail in order to not unnecessarily obscure the present invention. The features and advantages of embodiments may be better understood with reference to the drawings and discussions that follow.

[0023] In addition, when like elements are used in one or more figures, identical reference characters will be used in each figure, and a detailed description of the element will be provided only at its first occurrence. Some features or components of the systems or processes described herein may be omitted in certain depicted configurations in the interest of clarity.

[0024] A general concern when blending an LNG product with lighter hydrocarbons is the potential formation of stratified liquid layers (or stratification) of different density, in a storage tank. Typically, heat leaking into the blended-LNG product via the storage tank walls, will slowly warm the blend-LNG in contact with the tank walls and bottom plate. This warmer blended LNG has a lower density, which increases its buoyancy, slowly leading the warmer blended LNG to ascend in the bulk LNG inventory. At the top of the liquid column (liquid vapor interface), the warmer LNG releases the accumulated excess heat through vaporization, becoming cooler and denser, which in turn decreases its buoyancy, slowly leading the cooler blended LNG to descend in the bulk LNG inventory. This natural convection currents will occur uninterrupted, as long as, the difference in density within the blended LNG bulk inventory is less than 1%. In situations where the density in the bulk is greater than 1%, different LNG layers will form, interrupting the natural convection of the bulk LNG. When there is a potential for LNG blends with different density to be introduced in the same tank, particularly such as in this case at least 10% difference in density between the lean LNG (methane) and liquified ethane, it is essential to maintain the homogeneity and mitigate stratification. Once stratified liquid layers are formed, a rollover can occur when the density difference between the two layers becomes sufficiently small that the natural convection currents from the bottom layer come to the free surface. The subsequent mixing of these layers is accompanied by a large increase in the normal vaporization rate, which will be proportional to the amount of superheat accumulated in the bottom layer. This physical phenomenon associated with the mixing of stratified layers of LNG is commonly and descriptively referred to as “rollover”. A rollover of high intensity can result, however, in vapor release in excess of the designed vapor handling capabilities of the tank and can thus overpressure and possibly rupture the tank.

[0025] Although the present disclosure often refers to LNG and ethane as the two streams of liquefied hydrocarbons that benefit from the blending methods described herein, it is understood that the principles provided by the present disclosure can be applied to blend other streams of liquefied hydrocarbons, such as (i) LNG and liquified propane, or (ii) LNG and a mixture of liquified ethane, liquified propane, liquified butane, and any combination thereof.

[0026] As used herein, the term “hydrocarbon” has its ordinary meaning, which includes molecules comprised of carbon and hydrogen in various combinations, and may be of fossil (e.g., natural gas) or biogenic origin (e.g., biomethane). The term “liquified hydrocarbons” refers to hydrocarbons that occur as gases at atmospheric pressure and temperature, and due to a reduction of temperature and/or an increase of pressure, or a combination of both, will change state and become liquids at the new pressure and temperature conditions. In some cases (as it is the case of natural gas liquefaction) this phase change can also be coupled with a subsequent lowering of the operating pressure to meet downstream processes (e.g., atmospheric storage of LNG), further lowering the liquefied hydrocarbon stream temperature. The specific combination of pressures and temperatures at which the gases liquefy vary by the type of hydrocarbons. Furthermore, hydrocarbons may be described as being light or heavy according to the number of carbon atoms and hydrogen atoms in a molecule. Examples of liquified hydrocarbons include alkanes (or paraffins) (such as methane – CH_4 , ethane — C_2H_6 , propane— C_3H_8 , butanes: normal butane and isobutane— C_4H_{10} , natural gasoline or pentanes plus— C_5H_{12} and heavier); and alkenes (or olefins) (such as ethylene— C_2H_4 , propylene— C_3H_6 , normal butylene and isobutylene— C_4H_8).

[0027] The present disclosure provides methods for conducting a blending operation of two streams of liquefied hydrocarbons to produce a liquefied natural gas with desired composition at a floating facility, namely by using a combination of floating assets for at least storing and transporting liquified hydrocarbons, such as an LNG vessel operating in combination with a vessel carrying another liquified hydrocarbon, such as an ethane compatible multigas carrier, or an LNG FSRU operating in combination with a vessel carrying another liquified hydrocarbon, as well as any floating facility capable of handling liquefied hydrocarbons and any floating facility capable of handling LNG. In addition, certain embodiments of the methods described herein can be suitably adapted for blending of lean LNG with liquified ethane to meet desired LNG and/or natural gas specifications (such as the Wobbe Index (WI), Lower Heating Value (LHV), Methane

Number (MN), or the Incomplete Combustion Factor (ICF)) at various LNG facilities or sites using existing infrastructure of the respective site.

[0028] FIGS. 1 - 4 depict various arrangements of two vessels, each carrying a respective liquified hydrocarbon component for blending. For instance, vessel 100 comprises of a storage container 102 to store a first liquefied hydrocarbon, preferably LNG, a second vessel 104 that comprises a storage container 114 to store a second liquified hydrocarbon, preferably ethane, and a network of conduits in fluid communication with both the storage container 102 and the second vessel 114.

[0029] Liquified natural gas (LNG) is natural gas (predominantly methane) that has been cooled down and liquified. LNG can be stored in container 102 at a temperature lower than -110 °C, depending on the application, and more typically lower than -145 °C, such as between -159 °C and -162 °C. Generally speaking, “lean” LNG has a relatively lower calorific value whereas “rich” LNG contains a greater proportion of heavier hydrocarbons which gives it a higher calorific value. Lean LNG can be further enriched, such as by methods described herein, to meet various market quality specifications, such as the Wobbe Index (WI), Lower Heating Value (LHV), Methane Number (MN), or the Incomplete Combustion Factor (ICF).

The network of conduits comprises a first blending point, which may preferably be referred to as an LNG-ethane blending point 108 as a reference to a preferred embodiment, first conduits segment 110 (which may be referred to as LNG conduits 110 for a preferred embodiment where the first liquified hydrocarbon is LNG), and second conduits segment 112 (which may be referred to as ethane conduits 112 for a preferred embodiment where the second liquified hydrocarbon is ethane). First conduits segment 110 provides fluid communication between the first storage container 102 and first blending point 108. Second conduits segment 112 provides fluid communication between the second storage container 114 and the first blending point 108. The first blending point 108 is a fluid conduit junction between the first conduits segment 110 and the second conduits segment 112. Preferably, the first blending point 108 is a junction at the crossover between the liquid manifold of the first vessel 100 and the liquid manifold of the second vessel 104. The various conduits can be segregated to route the various liquids as described herein. Suitable examples of blending point 108 include a tee junction, Y-shape junction, a mixing tee, a wye pipe fitting, and any combination thereof. Examples of suitable first conduits segment 110 and second conduits segment 112 can be applicable segments from the liquid manifold of the first

vessel 100 and the second vessel 104, respectively. For instance, optionally, the first blending point 108 can be part of a liquid manifold of the second vessel 104; the first conduits segment 110, optionally, can be part of a liquid manifold of the first vessel 100 and the transfer system (not shown) between the first and second vessels; and the second conduits segment 112, optionally, can be part of a liquid manifold of the second vessel 104.

[0030] Liquefied ethane can be stored at a temperature lower than -30°C , depending on the application, and more typically lower than -75°C , such as between -80°C to -89°C . Although FIG. 1 depicts the ethane source 114 as on onshore storage container, it is understood that ethane source 114 suitably can additionally or alternatively be storage on a vessel (liquefied ethane carrier) as known by one of ordinary skill. The network of conduits further comprises combined conduits 116 to provide fluid communication downstream of the first blending point 108 and back to storage container 102. The combined stream can enter container 102 from combined conduits 116 via the drop-down line 105, or the in-tank spray header 107, or through a combination of both. As known to one of ordinary skill, the combined stream can be routed to container 102 for distribution to other suitable storage containers (not shown) on the first vessel 100.

[0031] Suitable storage for liquefied hydrocarbons like LNG, liquefied ethane, and others that are noted herein, are known to one of ordinary skill. For example, suitable examples can include single containment systems that typically have an inner wall or primary container that holds the refrigerated liquid and can be self-supporting. The inner container can be surrounded by an outer wall, thereby forming an annular space, which can hold insulation. The single containment system can be further insulated, such as the base and roof, and external insulation. Another suitable example includes double containment systems which typically adds to the single containment system, a secondary wall that is capable of containing both liquid and vapor.

[0032] A first stream of a first liquefied hydrocarbon, preferably liquefied natural gas (LNG), is pumped through the first portion 110 of conduits, preferably LNG conduits 110, from the storage container 102 to the first blending point 108. Referring to FIG. 1, the pumping of the LNG stream can be done at least by pump equipment 120. A liquefied ethane stream is pumped through ethane conduits 112 from the ethane source 114 to the LNG-ethane blending point 108. As used herein, the term “liquefied ethane”, “liquid ethane” or “ethane” refers to a liquefied hydrocarbon stream comprising at least 50 mol%, preferably at least 95 mol%, of ethane. As noted elsewhere in the present disclosure, liquefied hydrocarbons other than LNG and liquefied ethane can be blended

using the methods described herein. For instance, if LNG is being blended with liquified propane, then the liquified hydrocarbon stream that is liquified propane comprises at least 50 mol%, preferably at least 95 mol% propane; and if liquified butane, then the stream comprises at least 50 mol% butane, preferably at least 95 mol%. Optionally, if the liquified hydrocarbon stream does not consist essentially of the component of its namesake (for instance, the liquified ethane stream is not essentially all ethane), the remaining portion of that stream be selected from a group consisting of ethane, methane, propane, butane, and any combination thereof, as applicable. For instance, an example of a mixture of liquefied hydrocarbons as defined herein can be LPG, which stands for liquefied petroleum gas, which includes mixes that are mostly propane, mostly butane, or mostly a mixture of both propane and butane.

[0033] Referring to FIG. 1, the pumping of the liquified ethane stream can be done at least by pump equipment 118. The first LNG stream and the ethane stream are combined at the LNG-ethane blending point 108 in a volumetric blending ratio of LNG to ethane in a range from 1:500 and up to 500:1, preferably 1:100 and up to 500:1, and more preferably 1:10 and up to 500 to 1, to provide a combined stream. It is understood that one of ordinary skill can select a suitable flow rate for the first LNG stream and the liquified ethane stream to achieve a desired blending ratio in the range described herein, taking into consideration various factors, such as the specifications and safe operating envelope (SOE) of the equipment and infrastructures involved in the blending operation (e.g., network of conduits, pumps, storage containers, valves, etc.). The suitable number of pumps and types of pumps to implement the methods as described herein are known to one of ordinary skill. Additionally or alternatively, the pump equipment may be part of the existing infrastructure and equipment of the vessels, such as a LNG storage vessel and an ethane multi carrier.

[0034] The combined stream is provided back to the storage container 102 via at least combined conduits 116 from the first blending point 108. The storage tank 102 in the vessel 100, can comprise multiple storage tanks (not shown) to which the combined stream can be provided via combined conduits 116 individually and/or from one storage container, such as container 102. For instance, for each storage container that is to receive the combined stream directly, it can include its respective drop-down line 105 and/or in-tank spray header 107, which are in fluid communication with the combined conduits 116. Additionally or alternatively, the combined stream can enter a storage container, such as 102, and subsequently be distributed to other storage

containers, preferably via existing infrastructure on vessel 100 that are used for normal operation outside of blending. Preferably, the flow rate of the LNG stream and the flow rate of the ethane stream, by the respective pumps, provide suitable force to move the combined stream to the blended-product storage 102 without needing additional pump equipment.

[0035] The network of conduits can comprise a plurality of valves as known by one of ordinary skill to control the flow of various streams. For instance, referring to FIG. 1, optionally, LNG conduits 110 can comprise a valve (not shown) to control the flow of the first LNG stream flowing from storage container 102 to the LNG-ethane blending point 108. Ethane conduits 112 can comprise of a series of valves (not shown) to control the flow of the liquified hydrocarbon from container 114 to the LNG-ethane blending point 108. The combined conduits 116 comprise a final valve, which is the last valve that the combined stream flows through prior to entering its destination, such as container 102, drop-down line 105, and/or spray header 107. As shown in FIGS. 1 – 4, a final valve for combined conduits 116 is final valve 126. For embodiments that employ drop-down line 105 and/or spray header 107 to provide the combined stream from the combined conduits 116 to container 102, the drop-down line 105 and spray header 107 each comprises its respective final valve (not shown) immediately upstream to the outlet.

[0036] At least while the first LNG stream and the liquified ethane stream are being continuously combined at the blending point 108 and continuously provided back to LNG storage container 102, combined conduits 116 have an operating pressure due at least to the force exerted by the flow of the combined stream through combined conduits 116, as well as any available flow control devices in the conduits, such as the final valve 126. While the combined stream is being provided back to the LNG storage container 102, the operating pressure in combined conduits 116 between the LNG-ethane blending point 108 and final valve 126 is at a pressure that is higher than the saturation pressure of the combined stream, preferably at least 0.1 bar, more preferably at least 0.5 bar, and most preferably at least 1.2 bar above the saturation pressure of the combined stream. An operating pressure of at least 1.2 bar higher than the saturation pressure of the combined stream is most preferred because it provides a most preferred buffer to accommodate fluctuations in pressure conditions along conduits 116, and optionally drop-down line 105 and/or spray header 107, although embodiments with a lower operating pressure that is higher than the saturation pressure of the combined stream can still provide benefits described herein. The saturation pressure of the combined stream can change as it travels through conduits 116 back to storage

container 102, at least due to heat transfer from the environment and/or equipment. Generally, the saturation pressure of the combined stream increases as it travels through the combined conduits 116 toward container 102. Either the operating pressure of the combined conduits 116 between the LNG-ethane blending point 108 and final valve 126 is adjusted frequently, preferably in response to the monitoring, to accommodate the increase in saturation pressure and/or the saturation pressure of the combined stream can be reduced to ensure that the operating pressure remains higher than the saturation pressure of the combined stream as the saturation pressure changes. In addition to other benefits described elsewhere in the present disclosure, by providing an operating pressure that is higher than the saturation pressure of the combined stream in the combined conduits 116 portion between blending point 108 and final valve 126, the methods described herein mitigates two phase flow formation in that portion of the combined conduits 116 (whether localized or sustained two phase flow formation). Thus, the methods described herein can minimize operational disturbances and equipment damage (e.g., cavitation driven erosion of valves) as known by one of ordinary skill. The term “saturation pressure” has its ordinary meaning and includes the definition of the pressure at which the fluid exists both as a vapor and liquid, and the rate of evaporation equals its rate of condensation for a given temperature. In this scenario, the saturation pressure of the combined stream is the pressure at which the combined stream exhibits both a vapor and liquid phase, which are in thermodynamic equilibrium at the temperature of the combined stream. The saturation pressure of the combined stream while in the combined conduits 116 between the LNG-ethane blending point 108 and final valve 126 can be suitably determined by one of ordinary skill, based on the temperature of the combined stream and blending ratio (both of which can be measured by sensors). The network of conduits can comprise suitable sensors known to one of ordinary skill to provide the relevant data to implement the methods as described herein. Examples of suitable sensors include hydrometers, gravimeters, densitometers, density measuring sensors, gravity measuring sensors, pressure transducers, temperature sensors, flow meters, mass flow meters, Coriolis meters, other measurement sensors to determine a density, gravity, or other variable as will be understood by those skilled in the art, or some combination thereof. The determination of the saturation pressure of the combined stream can be done manually, or autonomously using a computer or other similar process control systems such that subsequent corrective action (e.g., increase of the system operating pressure, increase of blending ratio, or other) may be implemented as desired. The methods described herein provide

an operating pressure in the combined conduits 116 between the LNG-ethane blending point 108 and final valve 126 that is higher than the saturation pressure of the combined stream, preferably at least 0.1 bar, more preferably at least 0.5 bar, and most preferably at least 1.2 bar above the saturation pressure of the combined stream. Providing such operating pressure that is higher than the saturation pressure of the combined stream enables the combined stream to remain in the liquid phase while flowing through these segments of conduits, despite varying pressure conditions along such conduits segments.

[0037] Suitably, the operating pressure of the combined stream in the combined conduits, as well as other parts of the network of conduits, can be monitored as known by one of ordinary skills, such as by sensors. The monitoring can allow for continuous monitoring of the operating conditions of the combined stream to ensure that the operating pressure in combined conduits 116 stays above (preferably at least 0.1, 0.5, or 1.2 bar above) the saturation pressure of the combined stream. Optionally and preferably, an operating pressure of the combined stream upstream of the final valve 126 that is higher than the saturation pressure of the combined stream can be provided by adjusting the opening percentage of the final valve 126 to provide the desired operating pressure upstream of valve 126. The opening percentage of the final valve 126 can be adjusted continuously as needed during the blending operation to provide the desired operating pressure at or above the saturation pressure of the combined stream as described herein.

[0038] Optionally, additionally or alternatively, the operating pressure of the combined stream 116 can also be influenced by operating conditions of downstream systems, such as adjustments to the operating pressure of a storage container, such as 102 or one or more containers (not shown), including by adjustments to pressure setpoint of a corresponding boil off gas management system pressure setpoint, as understood by one of ordinary skill.

[0039] Optionally, additionally or alternatively, the saturation pressure of the combined stream can be reduced by adjusting the volumetric ratio of the first LNG stream and liquefied ethane at the LNG-ethane blending point 108, and/or along the combined conduits 116 by providing additional blending points. In general, additional blending point(s) allows for more LNG to be added to the combined stream, which lowers the saturation pressure of the combined stream, thereby providing another option to ensure achieving of an operating pressure of the combined stream that is higher than the saturation pressure of the combined stream. For instance, referring to FIG. 2, combined conduits 116 further comprises subsequent blending point 208 located

upstream of the final valve 126 and downstream of the LNG-ethane blending point 108. As can be seen in FIG. 2, the network of conduits further comprises another conduits segment 216 (which may be referred to as second LNG conduits 216 for a preferred embodiment) to provide fluid communication between storage container 102 (or a second suitable source of LNG, which is not depicted in FIG. 2) and subsequent blending point 208. In scenarios where the second LNG stream comes from storage container 102, second LNG conduits 216 can provide fluid communication between the subsequent blending point 208 and container 102 via a connection with LNG conduits 110 or another conduits segment (not shown) that provide fluid communication between container 102 and the conduit 216. When desired, a second stream of the first liquified hydrocarbon, preferably LNG, can be provided to subsequent blending point 208 from storage container 102 (or a second source of LNG) via second LNG conduits 216. Optionally and preferably, second LNG conduits 216 can further comprise valve 222 to control the flow of the second LNG stream through the second LNG conduits 216. For instance, valve 222 can be closed when blending at subsequent blending point 208 is not desired and opened when blending of additional LNG to the combined stream is desired. The opening of valve 222 can be adjusted to achieve a desired blending ratio at subsequent blending point 208. In FIG. 2, the combined stream and the second LNG stream are combined in a ratio in a range from 25:1, preferably 50:1, and up to 500:1 at the subsequent blending point 208 and the first LNG stream and ethane stream are combined in a ratio in a range from 1:100 and up to 50:1 at the LNG-ethane blending point 108. Because an additional blending point is provided, the ratio of LNG and ethane at the LNG-ethane blending point 108 can be less than if there is only a single blending point (i.e., 108). For instance, in a single-blending point scenario, the ratio of LNG to ethane at the LNG-ethane blending point is in a range from 1:500 and up to 500:1 versus a multi-blending-points scenario as depicted in FIG. 2, the ratio is in a range from 1:500, preferably from 1:100, and up to 50:1 of LNG to ethane at the LNG-ethane blending point 108 and from 25:1, preferably from 50:1, and up to 500:1 of combined stream to second LNG stream at the subsequent blending point 208. The provided blending ratio ranges, for a multi-blending-points scenario can be extended or changed, to suit asset and/ or process specific requirements, as understood by one of ordinary skill. For example, the first blending points may have a blending ratio of 1:1, while the second blending point may have a blending ratio of 47:1.

[0040] Optionally, additionally or alternatively, there can be a different blending point downstream of final valve 126. For instance, referring to FIG. 3, combined conduits 116 further

comprises subsequent blending point 308 located downstream of the final valve 126 and upstream of the container 102. Optionally and alternatively, subsequent blending point 308 can be located upstream of the final valve 126, depending on the particular arrangement of the existing infrastructure of the plant at which the blending operation is carried out. As can be seen in FIG. 3, the network of conduits further comprises a third LNG conduits 316 to provide fluid communication between a source of the first liquified hydrocarbon, such as LNG (which source can be storage container 102 as depicted or another suitable source that is not shown) and subsequent blending point 308. When desired, another LNG stream can be provided to subsequent blending point 308. As shown, conduits 316 can further comprise a valve to control the flow of the LNG stream therethrough. In FIG. 3, the combined stream and the LNG stream from conduits 316 are combined in a ratio in a range from 25:1, preferably from 50:1, and up to 500:1 at the subsequent blending point 208 and the first LNG stream and ethane stream are combined in a ratio in a range preferably from 25:1, preferably 50:1, and up to 500:1 at the LNG-ethane blending point 108. For a multi-blending-points scenario depicted in FIG. 3, the blending ratio of LNG to ethane at the LNG-ethane blending point 108 is in a range from 1:500, preferably from 1:100, and up to 50:1, and at the subsequent blending point 308, the ratio of the combined stream to the LNG stream from conduits 316 is in a range from 25:1, preferably from 50:1, and up to 500:1.

[0041] Optionally, additionally or alternatively, both additional blend points can be present along with the LNG-ethane blend point 108. For instance, referring to FIG. 4, combined conduits 116 comprises both subsequent blending point 208 and subsequent blending point 308 as described in FIGS. 2 and 3, respectively. For the multi-blending-points scenario depicted in FIG. 4, the blending ratio of (i) LNG to ethane at the LNG-ethane blending point 108 is in a range from 1:500, preferably from 1:100, and up to 50:1, (ii) the combined stream to the second LNG stream at the subsequent blending point 208 is in a range from 25:1, preferably from 50:1, and up to 150:1, and (iii) the combined stream to the LNG stream from conduits 316 at the subsequent blending point 308 is in a range from 100:1, preferably from 150:1, and up to 500 to 1. . While it is not shown, it is understood that on an asset basis, additional blending points and opportunities may be present, although not specified in the provided pictures.

[0042] Optionally and preferably, various blending scenarios (such as single or multi blending point) and blending ratio within the provided ranges can be selected to achieve the volumetric blending ratio of LNG to ethane of at least 2:1, preferably at least 3:1, more preferably at least 4:1,

in the combined stream that is downstream of final valve 126 (for a scenario involving a single blending point and/or multi-blending points with the subsequent blending point 208) or downstream of subsequent blending point 308 (for the scenarios that include blending point 308).

[0043] It is understood that a BOG management system (not shown) for vessel 100 can be present in all figures. This can be an onboard system, or a BOG management system of onshore, in case of a Vessel-to-Vessel operation at a jetty as known to one of ordinary skill,

[0044] Optionally and preferably, the first LNG stream is pumped to the LNG-ethane blending point 108 at a volumetric flow rate and pressure, which may be adjusted throughout the blending operation to meet the relevant process requirements. Although the flow rate and pressure of the first LNG stream pumped to blending point 108 may be adjusted, it is preferred to minimize the rate of change in the operation of the first LNG stream to a reasonable and/or practical extent. Meanwhile, the volumetric flow rate and pressure of the liquified ethane stream in ethane conduits 112 may be suitably adjusted, as known to one of ordinary skill, to meet the desired blending ratio at the LNG-ethane blending point 108, in a range from 1:500, preferably from 1:100 to 500:1 of LNG to liquefied ethane, for a single blending point, or the various ranges of blending ratios at other blending points in scenarios that include multi-blending points as described herein.

[0045] Embodiments described in the present disclosure provide options for implementation, such as a selection between a single-point blending operation or a multi-point process, to allow for consideration of various factors in optimizing the blending operation as desired. For instance, at a facility with hydraulic limitations in a conduits segment that is upstream of the first blending point 108 (such as at least a portion of conduits 110 leading to the first blending point having a reduced inner diameter, such as one that is 12 inches or smaller or one that is smaller than the diameter of conduits 116 and/or conduits 112). A multi-point blending operation may be more suitable for such a scenario because such limitations can limit a single-point blending operation, such as in terms of flow rate and blending ratio possibilities (including a reduction of the amount of the second liquified hydrocarbon that can be blended) and higher operational costs. In addition, a multi-point blending operation allows for improve control and flexibility of the overall operation.

[0046] Referring to FIGS. 1 - 4, combined conduits 116 continue through final valve 126 to provide the combined stream (which can be from single or multi blending point(s)) to container 102, which is downstream of final valve 126. The conduits segments associated with drop-down line 105 and in-tank spray header 107 between the final valve 126 and an outlet of 105 and 107

have certain length, shape, and size (such as diameter) and may include flow control devices not depicted in FIGS. 1-4, that contribute to specific operational parameters, which should be considered. Optionally, additionally or alternatively, the operating pressure of the storage container 102 is another potential factor for consideration, as noted elsewhere in the present disclosure. Optionally and preferably, the operating pressure of the combined stream downstream of final valve 126 can be influenced by manipulating the operating pressure of the respective storage container 102. Suitable ways to manipulate the operating pressure of a storage container is known to one of ordinary skill, such as by adjusting the pressure setpoint of the associated BOG management system.

[0047] Optionally, the blending operation can be further improved, such as a reduction in the amount of time to complete the blending operation, by providing a receiving storage container (a storage container to which the combined stream is being provided, such as container 102) with an operating pressure that is higher than the saturation pressure of the combined stream. It is understood that the higher operating pressure is subject to limitations imposed by the safety operating parameters of the respective storage container. Preferably, the operating pressure of the container receiving the combined stream is at least 5% higher, more preferably at least 50%, and most preferably at least 100% higher than the saturation pressure of the combined stream. A suitable way to provide such tank with the operating pressure higher than the saturation pressure of the combined stream is to adjust the BOG pressure setpoint as known to one of ordinary skill.

[0048] The option to provide a receiving storage container with a higher operating pressure than the saturation pressure of the combined stream, is subject to limitations imposed by safety operating parameters of the respective storage container, is not typical in standard operational practice (primarily storage of liquified hydrocarbon for transport) for these storage tanks, and it can be exercised as desired. If employed, the higher operating pressure is temporarily provided to the respective storage container during part or all of the duration of the blending operation, or even maintained after the blending operation, as desired.

[0049] Generally, for storage, it is desirable to maintain the operating pressure relatively low, preferably as low as possible within the relevant technical and contractual constraints, to maintain the temperature of the product in the storage container correspondingly low, thereby optimizing the volumetric capacity of the storage container and reducing BOG formation. Long term, the lower operating pressure is further desirable because it can help minimize changes in LNG quality

over time. It is understood that the standard practice of keeping a low operating pressure for the receiving storage tank is also available as an option for selection during part or all of the blending operation. Implementing a desired operating pressure for a particular receiving tank is achieved primarily by managing the BOG of the respective tank, which is typically done through the associated BOG management system. By providing the applicable storage container(s) with a higher operating pressure during the blending operation, the flashing of the combined stream when it enters the respective storage container is reduced or even potentially eliminated, thereby minimizing or even eliminating the rate of boil off gas formation associated with the blending operation. A minimal or zero BOG formation rate during blending operation relaxes the constraints on the boil off gas management, which decreases the operational time. Once the blending operation is completed, the operating pressure of the respective tank may be reduced to return it to the standard operating pressure, or optionally maintained as per the relevant technical and contractual constraints impose to the vessel and its cargo. The BOG can be managed using standard operating procedures after blending operation, thereby allowing the blending operation to proceed without any time delays associated with the BOG management.

[0050] The methods of the present disclosure address certain negative impacts of in-tank blending two different liquified hydrocarbons, such as stratification, by promoting the inline blending of two different liquified hydrocarbons in a conduit under an operating pressure that is higher than the saturation pressure of the combined stream. Because the saturation pressure of the combined stream can vary throughout its journey from the blending point 108 to its destination, such as back to container 102, reference to the “saturation pressure of the combined stream” is generally in the context of a particular segment of conduits. Adjusting the blending ratios and/or providing additional blending points as described herein are some suitable ways of manipulating the operating pressure of a relevant segment of conduits and/or influencing the saturation pressure of the combined stream in the relevant segment to achieve the desired level of operating pressure that is higher than the saturation pressure of the combined stream to ensure it stays in liquid state.

[0051] Additionally, the methods described herein further provide an option to minimize the BOG management requirements during the blending operation, thereby decreasing operational time of the blending operation, by providing the respective receiving storage container with an operating pressure that is higher than the saturation pressure of the combined stream to minimize flashing of the combined stream as it enters the respective storage container.

[0052] As noted in the present disclosure, the methods herein can be employed to conduct a blending operation of two streams of liquefied hydrocarbons, such as LNG and liquefied ethane, particularly at existing facility using the infrastructure already being used in standard operations, such as loading and storage equipment. For instance, if it is desired to produce “rich” LNG to meet the requirements of a particular end market or application, the methods described herein can be used to add liquefied ethane (or another lighter hydrocarbon or composition of light hydrocarbons) to the LNG from the LNG vessel, while making use of the combined infrastructure (such as pumps, conduits, valves, control systems, boil off gas management system, etc.) of both the first and second vessels, and in certain embodiments, as well as the infrastructure of the jetty of a LNG import or export facility. It is known to one of ordinary skill that the LNG vessel may be represented by an LNG vessel (barge or ocean-going vessel) or an LNG FSRU, or that the LNG import facility may also be represented by an LNG FSRU or that the LNG export facility may also be represented by an LNG floating and production facility. When the blending operation is desired, certain operating parameters of the facility can be changed to implement the methods described herein.

[0053] During standard operation, the LNG floating facility is operated under its standard parameters to handle its LNG cargo and cargo management operations, such as Boil Off Gas management. Before the blending operation begins, the product in storage container 102 is typically lean LNG that can be further enriched with another liquified hydrocarbon. Prior to combining the lean LNG with another liquified hydrocarbon, such as ethane, the lean LNG from the storage container 102 is preferably recirculated over the LNG vessel conduit 110 and returned back to the tank 102 to enable the piping cooldown procedure, as part of standard loading/unloading operation or otherwise, to minimize the temperature difference between the combined stream and the conduits. The larger the difference in temperature, the greater the negative impact on the blending operation, including vapor formation. A similar recirculation of the second liquified hydrocarbon, such as ethane, also preferably takes place on the second vessel 104 in preparation for cargo transfer and the blending operation. Before the second liquified hydrocarbon stream is provided to the first blending point 108, the lean LNG from storage container 102 is preferably provided first to the blending point 108 and returned to the container 102 via conduits 116 to ensure cooling of the blending pathway for at least the combined stream. The circulation of the various applicable streams as described can be suitably facilitated by various pump equipment

as known by one of ordinary skill, such as pumps 120 (or other pumps at the LNG vessel and not depicted in Fig. 1-4), and 120. After circulation of the first liquified hydrocarbon is established, the second liquified hydrocarbon stream can be pumped from the second container 114 according to aspects described in the present disclosure to begin the blending operation. The combined stream is provided back to the storage container 102 according to aspects described herein, including being provided to container 102 at an operating pressure higher than the saturation pressure of the combined stream.

[0054] The operating parameters of the blending operation as described herein impacts the operating pressure of the network of conduits as compared to standard operating parameters. Optionally and preferably, the network of conduits is provided with an operating pressure of at least 2 bar g (bar gauge) to accommodate the impacts from the blending operation while meeting operational parameters. Suitable methods to provide the network of conduits with such operating pressure are known to one of ordinary skill. Once the blending operation is completed, such as when the storage container 102 has reached a desired specification, the liquified ethane stream is ramped down and stopped. Standard operation resumes, including returning the operating pressure of the network of conduits to its standard parameters. For embodiments in which the operating pressure of the respective storage container, such as 102, has been increased to be above the saturation pressure of the combined stream, the operating pressure of the respective container is also reduced to its standard parameters. After the blending operation, the blended product in container 102 can be stored as inventory, or otherwise managed, such as distribution pursuant to contractual obligations.

[0055] The methods described herein can be carried out continuously over a period of time until the blended product in container 102 has desired specifications, such as a certain heating value, and/or a desired amount of the second liquified hydrocarbon, such as liquified ethane, has been blended. During or after the blending operation, the properties of the product in container 102 can be monitored pursuant to standard operation of the facility to determine whether desired specifications have been achieved. It is understood that vessels (100 and 104) can comprise multiple storage containers (102 and 114, respectively), and the embodiments of the methods described herein can be employed on various combinations of such storage containers on these vessels.

[0056] In applications where the combined stream may be recirculated or distributed amongst various storage tanks (not shown) on the vessel 100 such that at least a portion, including all, of the combined stream, is provided to a blending point as if it were lean LNG, accumulation of the second liquified hydrocarbon (such as liquified ethane) may occur. That is, as the blending operation is performed for a period of time, the first liquified hydrocarbon stream that is pumped to the first blending point 108 comprises an increasing amount of the second liquified hydrocarbon over time. Such accumulation can be accounted for by adjusting the blending ratio at LNG-ethane blending point 108. LNG floating facilities typically include equipment to continuously monitor the properties of the LNG flowing through the network of conduits, including sensors (e.g., flow). Continuous monitoring allows for continuous adjustment of flow of the respective streams, preferably the liquified ethane stream, to achieve desired blending ratios.

[0057] Optionally and preferably, the flow of the combined stream in the part of the combined conduits 116 upstream of final valve 126 is preferably carried out under turbulent flow regime.

[0058] The methods provided herein, which include in-line mixing of the first LNG stream and the liquified ethane stream, particularly under turbulent flow regime, can maximize mixing of the LNG and liquified ethane in the combined stream, thereby enabling the combined stream to exhibit a homogenous composition and characteristics (e.g., density), such that it can be provided to the blended-product storage container 102 in homogenous condition, which mitigates the risks associated with a stratified stream entering the storage container. In-line blending operations, however, can introduce partial vaporization with two-phase flow formation due to the difference in specific enthalpy of the lean LNG and liquid ethane streams, which can lead to the undesirable risk of excessive piping vibrations that lead to stress and fatigue of the pipes. The methods described herein address the potential two-phase flow formation by maintaining the operating pressure in the combined stream to be above the combined stream saturation pressure.

[0059] While not shown, it is understood that a computer program can be used to control and/or implement some, including all, aspects of the methods described herein. This computer program may be referred to as a controller. For instance, the computer program can be used to control the pump discharge pressure and flow, the system operating pressure via the manipulation of the flow control valve opening percentage, among others. A suitable computer program includes one that is executed by a data processor. As used herein, reference to a computer program is intended to be equivalent to a reference to a program element and/or a computer readable medium containing

instructions for controlling a computer system to coordinate the performance of the above described method. The computer program may be implemented as computer readable instruction code by use of any suitable programming language, such as, for example, JAVA, C++, and may be stored on a computer-readable medium (removable disk, volatile or nonvolatile memory, embedded memory/processor, etc.). The instruction code is operable to program a computer or any other programmable device to carry out the intended functions. The computer program may be available from a network, such as the World Wide Web, from which it may be downloaded. The various aspects described herein may be realized by means of a computer program respectively software; however, they may also be realized by means of one or more specific electronic circuits respectively hardware. Furthermore, the invention may also be realized in a hybrid form, i.e. in a combination of software modules and hardware modules. Additionally or alternatively, any or all aspects of the methods described herein can be performed manually by one or more human operator with relevant operational knowledge of the facility.

[0060] While specific embodiments have been described herein, it is understood that such descriptions are not intended to limit the described embodiments. Instead, any combination of the features and elements provided above, whether related to different embodiments or not, is contemplated to implement and practice contemplated embodiments. Furthermore, although embodiments disclosed herein may achieve advantages over other possible solutions or over the prior art, whether or not a particular advantage is achieved by a given embodiment is not limiting of the scope of the present disclosure. Thus, the aspects, features, embodiments and advantages described herein are merely illustrative and are not considered elements or limitations of the appended claims except where explicitly recited in a claim(s).

CLAIMS

1. A method for blending two or more liquified hydrocarbon streams between at least two vessels, wherein the first vessel (100) comprises a first storage container (102) for storing a first liquified hydrocarbon, optionally the first liquified hydrocarbon is liquefied natural gas and wherein the second vessel (104) comprises a second storage container (114) for storing a second liquified hydrocarbon, optionally the second liquified hydrocarbon is selected from a group consisting of liquified ethane, liquified butane, liquified propane, and any combination thereof, wherein the method comprises:

(a) providing a network of conduits between the at least two vessels, wherein the network of conduits comprises:

i. a first blending point (108), optionally wherein the first blending point being part of a liquid manifold of the second vessel 104

ii. a first conduits segment (110), optionally wherein the first conduits segment being part of a liquid manifold of the first vessel to provide fluid communication between the first storage container (102) and the first blending point (108),

iii. a second conduits segment (112) to provide fluid communication between the second storage container (114) and the first blending point (108), optionally wherein the second conduits segment being part of a liquid manifold of the second vessel;

iv. combined conduits (116) to provide fluid communication downstream of the first blending point (108) and back to an inlet of the first storage container (102), wherein the combined conduits (116) comprise a final valve (126) immediate upstream of said inlet of the first storage container,

wherein the method comprises:

(b) pumping a first liquified hydrocarbon stream from the first storage container (102) to the first blending point (108) via the first conduits segment (110);

(c) pumping a second liquified hydrocarbon stream from the second storage container (114) to the first blending point (108) via the second conduits segment (112);

(d) combining the first and second liquified hydrocarbon streams at the first blending point (108) in a volumetric ratio in a range from 1:500, preferably from 1:100, and up to 500:1 to provide a combined stream; and

- (e) providing at least a portion, including all, of the combined stream from the first blending point (108) back to the first storage container (102) via the combined conduits (116), thereby providing a combined product to the first storage container, and
- (f) while the combined stream is between a segment of the combined conduits (116) between the first blending point (108) and the final valve (126), providing the combined stream with an operating pressure above (preferably at least 0.1 bar above, more preferably at least 0.5 bar above, most preferably at least 1.2 bar above) a saturation pressure of the combined stream.

2. The method of claim 1 wherein the combined conduits (116) further comprise a first subsequent blending point (208) downstream of the first blending point (108), and optionally upstream of the final valve 126, wherein the method further comprises:

- (g) providing a second stream of the first liquified hydrocarbon from a source of the first liquified hydrocarbon, optionally the first storage container (102), to the first subsequent blending point (208);
- (h) combining the combined stream and the second stream of the first liquefied hydrocarbon at the first subsequent blending point (208) in a volumetric ratio in a range from 25:1, preferably 50:1, and up to 500:1, wherein the first stream of the first liquefied hydrocarbon and the stream of the second liquified hydrocarbon ethane stream are combined in a volumetric ratio in a range from 1:500, preferably 1:100, and up to 50:1 at the first blending point (108).

3. The method of claim 2, wherein the combined conduits (116) further comprise a second subsequent blending point (308) located downstream of the first subsequent blending point (208), either upstream or downstream of the final valve (126) and upstream of the inlet of the first storage container (102), wherein the method comprises:

- (i) providing a third stream of the first liquified hydrocarbon from a source of the first liquified hydrocarbon, optionally the first storage container (102), to the second subsequent blending point (208);
- (j) combining the combined stream and the third stream of the first liquified hydrocarbon at the second subsequent blending point (308) in a volumetric ratio in a range from 25:1, preferably 50:1, and up to 150:1, wherein the first liquified hydrocarbon stream and second liquified hydrocarbon stream are combined in a volumetric ratio in a range from 1:500, preferably 1:100,

and up to 50:1 at the first blending point (108) and wherein the combined stream and the second stream of the first liquified hydrocarbon are combined in a volumetric ratio in a range from 100:1, preferably 150:1, and up to 500:1 at the first subsequent blending point (208).

4. The method of claim 1, wherein the combined conduits (116) further comprise a subsequent blending point (308) located downstream of the final valve (126) and upstream of the inlet of the first storage container (102), wherein the method comprises:

(g) providing another stream of the first liquified hydrocarbon from a source of the first liquified hydrocarbon to the subsequent blending point (308), optionally wherein said source is the first storage container (102);

(h) combining the combined stream and the other stream of the first liquified hydrocarbon at the subsequent blending point (308) in a volumetric ratio in a range from 25:1, preferably 50:1, and up to 500:1, and wherein the first stream of the first liquified hydrocarbon and the stream of the second liquified hydrocarbon are combined in a volumetric ratio in a range from 1:500, preferably 1:100, and up to 50:1 at the first blending point (108).

5. The method of any prior claims, wherein the combined stream downstream of the final valve (126) and downstream of any subsequent blending point (308) comprises a volumetric ratio of the first liquified hydrocarbon, preferably LNG, to the second liquified hydrocarbon, preferably liquified ethane, of at least 2:1, preferably at least 3:1, and more preferably at least 4:1.

6. The method of any prior claims wherein the network of conduits further comprises at least one of a drop-down line (105) and an in-tank spray header (107) to introduce the combined stream from the combined conduits 116 to the first storage tank (102).

7. The method of any prior claims, wherein the drop-down line (105) and/or in-tank spray header (107) further comprises its respective final valve immediately upstream of its outlet, wherein the method further comprises providing a segment of conduits between the combined conduits and respective final valve of the drop-down line and/or in-tank spray header with an operating pressure that is above (preferably at least 0.1 bar above, more preferably at least 0.5 bar above, most preferably at least 1.2 bar above) the saturation pressure of the combined stream.

8. The method of any prior claim further comprising: providing the network of conduits with an overall operating pressure of at least 2 barg.
9. The method of any prior claim, further comprising: providing the first storage container (102) with an operating pressure higher, preferably at least 5% higher, more preferably at least 50%, and most preferably at least 100% higher, than the saturation pressure of the combined stream) the saturation pressure of the combined stream.
10. The method of any prior claims further comprising: continuously performing steps (a) – (e) and as applicable, steps (f) – (h) until a desired amount of the first liquified hydrocarbon and/or the second liquified hydrocarbon has been combined.
11. The method of claim 10, further comprises: returning the operating pressure of the network of conduits to a standard operating pressure, and returning the operating pressure of the first storage container (102) to a standard operating pressure.
12. The method of any prior claims, further comprising: providing the combined product from the first storage container (102) to another storage container on the first vessel.
13. The method of any prior claims, further comprising: storing the combined product in the first storage container (102) as inventory.