

AN ENERGY RECOVERY SYSTEM

TECHNICAL FIELD

5 This invention relates generally to an energy recovery system and an energy recovery method.

Background

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but commonly including varying amounts of other higher alkanes, and sometimes a small percentage of carbon dioxide, nitrogen, hydrogen sulfide, or helium. Natural gas is a fossil fuel used as a source of energy for heating, cooking, and electricity generation. It is also used as a fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other commercially important organic chemicals. Natural gas is often informally referred to simply as "gas", especially when compared to other energy sources such as oil or coal. However, it is not to be confused with gasoline, especially in North America, where the term gasoline is often shortened in colloquial usage to gas.

Liquefied natural gas (LNG) is a composition of methane and some mixture of ethane used to convert natural gas to liquid form for ease and safety of storage transport. It is cooled to approximately -256 degrees Fahrenheit so that it can be transported from countries with a large supply of natural gas to countries that demand more natural gas than they produce. In its liquid state, natural gas takes up 1/600th of the space, making it much easier to ship and store when pipeline transport is not feasible. Liquefied natural gas is primarily used to transport natural gas from one source to another. The main method of transportation is storage tanks ashore to vessel tanks. Once the cargo is delivered, the natural gas is allowed to expand and convert back to its gaseous form. Regasification terminals are used to help convert temperatures back to a natural gas state.

However, regasification of the LNG usually results in an increase in pipeline pressure which are often kept in check through the use of strategically positioned and rated pressure relief

valves and step-down convertors. Although use of the pressure relief valves and step-down convertors is necessary for safety reasons, this always results in the loss of energy through pressure reduction. Therefore, there exists a need for a system for addressing the foregoing energy loss problem.

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Summary

In accordance with a first aspect of the invention, there is disclosed an energy recovery system comprising a storage system operable for providing vapourised natural gas, and a generator assembly for receiving the vapourised natural gas from the storage system and enabling passage of the vapourised natural gas therethrough to thereby generate energy therefrom. The vapourised natural gas is for discharge from the generator assembly to a downstream system.

In accordance with a second aspect of the invention, there is disclosed an energy recovery method comprising drawing vapourised natural gas from a storage system for provision to a generator assembly, and passing the vapourised natural gas through the generator assembly to thereby generate energy therefrom. The vapourised natural gas is for discharge from the generator assembly to a downstream system, and the pressure of the vapourised natural gas entering the generator assembly is higher than the pressure of the vapourised natural gas exiting the generator assembly.

Brief Description of the Drawings

FIG. 1 shows an exemplary system diagram of an energy recovery system in accordance with an aspect of the invention; and

FIG. 2 shows an exemplary process flow diagram for an energy recovery method utilizing the energy recovery system of FIG. 1.

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Detailed Description

An exemplary embodiment of the present invention, an energy recovery system 20, is described hereinafter with reference to FIG. 1 and FIG. 2. The energy recovery system 20 may utilize an energy recovery method 100 as herein described. The energy recovery system 20 comprises a storage system 22 for storing and being operable for providing vapourised natural gas, and a generator assembly 24. Utilising the energy recovery method 100, vapourised natural gas is drawn from the storage system 22 for provision to the generator assembly 24 in a step 102 before passaging the vapourised natural gas through the generator assembly 24 to thereby generate energy therefrom in a step 104. The vapourised natural gas is for discharge from the first generator assembly 24 to a downstream system 26. Preferably, the pressure of the vapourised natural gas entering the generator assembly 24 is higher than the pressure of the vapourised natural gas exiting the generator assembly 24. Preferably, the downstream system 26 comprises at least one of a downstream manifold, a natural gas operated system and a natural gas processing system, and a natural gas consuming system

In an implementation of the energy recovery system 20 with the energy recovery method 100, the generator assembly 24 comprises a first generator 28, a heat exchanger 30 and a second generator 32. In the step 104, mechanical energy is generated from the vapourised natural gas received by the first generator 28 to thereby reduce pressure of the vapourised natural gas to a first pressure level in a step 112. Next, temperature of the vapourised natural gas is increased during heat exchange through the heat exchanger 30 to thereby increase the pressure of the vapourised natural gas to a second pressure level in a step 114. Mechanical energy is then generated from the vapourised natural gas received by the second generator 32 from the heat exchanger 30 to thereby reduce pressure of the vapourised natural gas to a third pressure level in a step 116. Preferably, the second pressure level is between the first pressure level and the third pressure level.

Preferably, the temperature of the vapourised natural gas provided by the storage system 22 is reduced to a first temperature level by the first generator 28 when the pressure thereof

reaches the first pressure level. Temperature of the vapourised natural gas exiting the first generator 28 is increased to a second temperature level by the heat exchanger 30 to achieve the second pressure level before being reduced to a third temperature level by the second generator 32 when the pressure thereof reaches the third pressure level.

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Preferably, the heat exchanger 30 is for enabling heat exchange between the vapourised natural gas and ambient air. Further preferably, each of the first generator 28 and the second generator 32 is a turbine generator for converting the pressure potential of the vapourised natural gas into mechanical energy and further for converting the mechanical energy into electrical energy.

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The energy recovery system 20 may comprise more than two generators and more than one heat exchanger. Further, the generators may not require a heat exchange between them if the pressure of the vapourised natural gas exiting one of the generator is sufficient to power the generator configured downstream therefrom.

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In an example of implementation of more than one heat exchanger and more than two generators, the energy recovery system 20 further comprises an additional heat exchanger 34 and a third generator 36.

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Preferably, temperature of the vapourised natural gas exiting the second generator 32 is increased during heat exchange through the additional heat exchanger 34 to thereby increase the pressure of the vapourised natural gas to a fourth pressure level in a step 118. Mechanical energy is then generated from the vapourised natural gas received by the third generator 36 from the additional heat exchanger 34 to thereby reduce pressure of the vapourised natural gas to a fifth pressure level in a step 120. Preferably, the fourth pressure level is between the third pressure level and the fifth pressure level. Preferably, the additional heat exchanger 34 is for enabling heat exchange between the vapourised natural gas and ambient air. Further preferably, the third generator 36 is a turbine generator for

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converting the pressure potential of the vapourised natural gas into mechanical energy and further for converting the mechanical energy into electrical energy.

In another implementation of the energy recovery system 20 with the energy recovery method 100, the generator assembly 24 comprises the first generator 28 and a priming heat exchanger 38, with the priming heat exchanger 30 configuratively interposing the storage system 22 and the first generator 28. In this configuration, the vapourised natural gas provided from the storage system 22 is passaged through the priming heat exchanger 38 before being provided to the first generator 28. Hence, in the step 104, the priming heat exchanger 38 increases the temperature and consequently increases the pressure of the vapourised natural gas passing therethrough prior to provision of the vapourised natural gas to the first generator in a step 130. The first generator 28 then receives the vapourised natural gas from the storage system 22 via the priming heat exchanger 38 to generate mechanical energy therefrom to thereby reduce the pressure of the vapourised natural gas to a pre-defined pressure which system requirements and/or system configuration dictates, in a step 132.

In this implementation of the energy recovery system 20, the generator assembly 24 may be extended to include the configuration of the previous implementation. Therefore, the energy recovery system can further comprise, in addition to the priming heat exchanger 38 and the first generator 28, the first generator 28, the heat exchanger 30, the second generator 32, the additional heat exchanger 34 and the third generator 36 in the relative configuration and function as described in the previous implementation, and in accordance with step 112 to step 120.

An example of this implementation provides that each of the first generator 28, the second generator 32 and the third generator 36 are 68kW turbine generators. The storage system 22 will provide the vapourised natural gas at -168 °C and at 1 bar to be fed to the priming heat exchanger 38 which will increase the temperature of the vapourised natural gas to 20 °C to thereby increase the pressure thereof to 15 bar. The vapourised natural gas will then be fed

from the priming heat exchanger 38 to the first generator 28 which will generate mechanical energy and, in tandem, electrical energy therefrom. In the process, the pressure of the vapourised natural gas will be reduced to the exemplary first pressure level of 1 bar and the exemplary first temperature level of -100 °C. Next, the heat exchanger 30 will increase the temperature and consequently the pressure of the vapourised natural gas to the second temperature level and the second pressure level respectively. The second generator 32 will generate mechanical and electrical energy from to vapourised natural gas which will reduce the pressure thereof to the third pressure level and the temperature thereof to the exemplary third temperature level of -50 °C. Next, the additional heat exchanger 34 will increase the temperature and consequently the pressure of the vapourised natural gas to the fourth temperature level and the fourth pressure level respectively. The third generator 36 will generate mechanical and electrical energy from to vapourised natural gas which will reduce the pressure thereof to the fifth pressure level and the temperature thereof to the exemplary fifth temperature level of 0 °C for provision to the downstream system 26.

The storage system 22 can comprise one or more large storage tanks, for example liquid natural gas (LNG) vessels of 20ft (18,000L) or (36,000L) where vapour is drawn from such large storage tanks in the form of the vapourised natural gas. The use of an external vapouriser is not precluded from the energy recovery system for interposing the storage system 22 and the generator assembly 24. However, in practical implementation, the large storage tanks may be provided with internal vapourisers to enable vapour to be drawn therefrom. Alternatively, the storage system 22 may comprise one or more insulative vessels with less than 1000 litres in storage capacity for the liquefied natural gas stored in each thereof. More specifically, each of the one or more insulative vessels has less than or substantially 210 litres in storage capacity for liquefied natural gas. Preferably, each of the one or more insulative vessels is a cryogenic storage dewar. For clarity, only vapor, specifically the vaporized natural gas, is drawn from each of the one or more insulative vessels. Therefore, use of an external vapouriser is excluded when the one or more insulative vessels are used.

Aspects of particular embodiments of the present disclosure address at least one aspect, problem, limitation, and/or disadvantage associated with existing energy recover systems. While features, aspects, and/or advantages associated with certain embodiments have been described in the disclosure, other embodiments may also exhibit such features, aspects, and/or advantages, and not all embodiments need necessarily exhibit such features, aspects, and/or advantages to fall within the scope of the disclosure. It will be appreciated by a person of ordinary skill in the art that several of the above-disclosed structures, components, or alternatives thereof, can be desirably combined into alternative structures, components, and/or applications. In addition, various modifications, alterations, and/or improvements may be made to various embodiments that are disclosed by a person of ordinary skill in the art within the scope of the present disclosure, which is limited only by the following claims.

Claims

1. An energy recovery system comprising:

a storage system operable for providing vapourised natural gas; and

- 5 a generator assembly for receiving the vapourised natural gas from the storage system and enabling passage of the vapourised natural gas therethrough to thereby generate energy therefrom,

wherein the vapourised natural gas is for discharge from the generator assembly to a downstream system.

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2. The energy recovery system as in claim 1, wherein the pressure of the vapourised natural gas entering the generator assembly is higher than the pressure of the vapourised natural gas exiting the generator assembly.

- 15 3. The energy recovery system as in claim 1, the generator assembly comprising:

a first generator for receiving the vapourised natural gas from the storage system and for generating mechanical energy from the vapourised natural gas to thereby reducing pressure of the vapourised natural gas to a first pressure level;

- 20 a heat exchanger for receiving the vapourised natural gas from the first generator and for increasing the temperature of the vapourised natural gas during heat exchange to thereby increase the pressure of the vapourised natural gas to a second pressure level; and

- 25 a second generator for receiving the vapourised natural gas from the heat exchanger and for generating mechanical energy from the vapourised natural gas to thereby reducing pressure of the vapourised natural gas to a third pressure level,

wherein the second pressure level is between the first pressure level and the third pressure level.

4. The energy recover system as in claim 3, the temperature of the vapourised natural gas being reduced to a first temperature level by the first generator when the pressure
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thereof reaches the first pressure level, increased to a second temperature level by the heat exchanger to achieve the second pressure level, and reduced to a third temperature level by the second generator when the pressure thereof reaches the third pressure level.

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5. The energy recovery system as in claim 3, the heat exchanger for enabling heat exchange between the vapourised natural gas and ambient air.

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6. The energy recovery system as in claim 3, each of the first generator and the second generator being a turbine generator for converting the pressure potential of the vapourised natural gas into mechanical energy.

7. The energy recovery system as in claim 3, the turbine generator further for converting the mechanical energy into electrical energy.

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8. The energy recovery system as in claim 1, the generator assembly comprising:
an additional heat exchanger for receiving the vapourised natural gas from the second generator and for increasing the temperature of the vapourised natural gas during heat exchange to thereby increase the pressure of the vapourised natural gas to a fourth pressure level; and

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a third generator for receiving the vapourised natural gas from the additional heat exchanger and for generating mechanical energy from the vapourised natural gas to thereby reducing pressure of the vapourised natural gas to a fifth pressure level,

wherein the fourth pressure level is between the third pressure level and the fifth pressure level.

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9. The energy recovery system as in claim 1, the downstream system comprising at least one of a downstream manifold, a natural gas operated system and a natural gas processing system, and a natural gas consuming system

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10. The energy recovery system as in claim 1, the storage system comprising:

a first insulative vessel and a second insulative vessel, each of the first
insulative vessel and the second insulative vessel having an internal vapourizer and a
gas outlet;

a gas withdrawal valve; and

a pipe assembly for removably intercoupling and fluid communicating the first
insulative vessel, the second insulative vessel and the gas withdrawal valve,

wherein each of the first insulative vessel and the second insulative vessel is
for storing liquefied natural gases and the internal vapouriser is for vapourizing the
liquefied natural gas into vapourised natural gas at the gas outlet thereof for provision
to the pipe assembly, the pipe assembly for providing the vapourised natural gas for
dispensing from the gas withdrawal valve.

11. The energy recovery system as in claim 1, the generator assembly comprising:

a first generator for receiving the vapourised natural gas from the storage
system and for reducing the pressure of the vapourised natural gas to a predefined
pressure level to thereby generate mechanical energy therefrom.

12. The energy recovery system as in claim 11, the generator assembly further
comprising:

a priming heat exchanger for inter-coupling the first generator and the storage
system, the priming heat exchanger for increasing the temperature and consequently
increase the pressure of the vapourised natural gas passaging therethrough prior to
provision of the vapourised natural gas to the first generator.

13. An energy recovery method comprising:

drawing vapourised natural gas from a storage system for provision to a generator assembly; and

5 passaging the vapourised natural gas through the generator assembly to thereby generate energy therefrom,

 wherein the vapourised natural gas is for discharge from the generator assembly to a downstream system, and the pressure of the vapourised natural gas entering the generator assembly is higher than the pressure of the vapourised natural gas exiting the generator assembly.

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14. The energy recovery method as in claim 13, passaging the vapourised natural gas through the generator assembly to thereby generate energy therefrom comprising:

 generating mechanical energy from the vapourised natural gas received by a first generator to thereby reduce pressure of the vapourised natural gas to a first pressure level;

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 increasing the temperature of the vapourised natural gas during heat exchange through a heat exchanger to thereby increase the pressure of the vapourised natural gas to a second pressure level; and

20 generating mechanical energy from the vapourised natural gas received by a second generator from the heat exchanger to thereby reduce pressure of the vapourised natural gas to a third pressure level,

 wherein the second pressure level is between the first pressure level and the third pressure level, and the generator assembly comprising the first generator and the second generator.

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15. The energy recovery method as in claim 13, passaging the vapourised natural gas through the generator assembly to thereby generate energy therefrom comprising:

generating mechanical energy from the vapourised natural gas received from a first generator to thereby reduce pressure of the vapourised natural gas to a pre-defined pressure level; and

increasing the temperature and consequently increasing the pressure of the vapourised natural gas passaging through a priming heat exchanger prior to provision of the vapourised natural gas to the first generator, the priming heat exchanger inter-coupling the first generator and the storage system.

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