by LNG, PLNG and CNG systems and processes, the demanding economics of fringe area development of reserves dictate the need to increase cargo density, reduce process energy, and reduce containment vessel mass.

[007] Accordingly, it is desirable to provide systems and methods that facilitate economic development of remote or stranded reserves to be realized by a means not afforded by LNG, PLNG or CNG systems and utilize CGL systems and process for natural gas storage to realize increased cargo density, reduction of process energy, and reduction in containment vessel mass inherent.

Summary

[008] Embodiments provided herein are directed to systems and methods to both create and store a denser liquid phase mix of natural gas and light-hydrocarbon solvent under temperature and pressure conditions that facilitate improved volumetric ratios of the stored gas within containment systems of lighter construction. In a preferred embodiment, improved density of storage of natural gas, as compared to compressed natural gas (CNG) and pressurized liquid natural gas (PLNG) at the same temperature and pressure conditions, is enabled using hydrocarbon solvents such as light-hydrocarbon based solvents including ethane, propane and butane, a natural gas liquid (NGL) based solvent or a liquid petroleum gas (LPG) based solvent under overall temperature conditions from less than -80°F to about -120°F with overall pressure conditions ranging from about 300 psig to about 1800 psig, and under enhanced pressure conditions ranging from about 300 psig to less than 900 psig , or, more preferably, under enhanced pressure conditions ranging from about 500 psig to less than 900 psig.

[008a] In one embodiment, there is provided a process of mixing natural gas with a hydrocarbon solvent to yield a liquid medium suited for storage and transport at greater storage densities than compressed natural gas at the same storage conditions, comprising:

combining natural gas with a liquid hydrocarbon solvent into a single phase liquid medium comprising the natural gas absorbed in the hydrocarbon solvent, wherein combining natural gas with the liquid hydrocarbon solvent into a single phase liquid medium includes optimizing a ratio of the liquid hydrocarbon solvent to the natural gas to optimize the storage densities of the natural gas of the single phase liquid medium for pressures and temperatures at which the single phase liquid medium is set to be stored in the storage vessel,

cooling the single phase liquid medium to a storage temperature in a range between -80 F and -120 F, and compressing the single phase liquid medium to a storage pressure in a range between 500 psig and 900 psig, and

storing the single phase liquid medium in a storage vessel at a storage temperature of less than -80 F to about -120 F and a storage pressure between 500 psig and 900 psig, wherein the natural gas of the single phase liquid medium is stored at storage densities that exceed storage densities of compressed natural gas for the same pressure and temperatures.

[008b] In one embodiment, there is provided a gas transport vessel comprising

a cargo hold, and

a containment system located in the cargo hold and adapted to store a single phase liquid medium comprising natural gas absorbed in a hydrocarbon gas solvent at storage pressures and temperatures associated with storage densities for the natural gas in the single phase liquid medium that exceeds the storage densities of compressed natural gas (CNG) for the same storage pressures and temperatures, wherein the containment system is adapted to store the single phase liquid medium at temperatures in a range of -80 F to -120 F and at pressures in a range of 500 psig to 900 psig.

[008c] In one embodiment, there is provided a system for processing, storing and transporting natural gas from supply source to market, comprising

a production vessel comprising processing equipment modules configured to produce a single phase liquid medium comprising natural gas absorbed in a liquid hydrocarbon solvent by combining natural gas with a liquid hydrocarbon solvent into a single phase liquid medium comprising the natural gas absorbed in the hydrocarbon solvent while optimizing a ratio of the liquid hydrocarbon solvent to the natural gas to optimize the storage densities of the natural gas of the single phase

liquid medium for pressures and temperatures at which the single phase liquid medium is set to be stored in the storage vessel, wherein the production vessel is moveable between natural gas supply locations,

a marine transport vessel comprising a containment system configured to store the single phase liquid medium at storage pressures and temperatures associated with storage densities for the natural gas that exceeds the storage densities of compressed natural gas (CNG) for the same storage pressures and temperatures, wherein the marine transport vessel is configured to receive single phase liquid medium from the production vessel and load into the containment system, wherein the containment system is configured to store the single phase liquid medium at storage temperatures and pressures in the ranges of -80 F to -120 F and 500 psig to 900 psig, and

an offloading vessel comprising separation, fractionation and offloading equipment modules for separating the single phase liquid medium into its natural gas and solvent constituents and offloading natural gas to storage or pipeline facilities, wherein the offloading vessel is configured to receive single phase liquid medium from the marine transport vessel and wherein the offloading vessel is moveable between natural gas market offloading locations.

[008d] In one embodiment, there is provided, in a system for processing, storing and transporting natural gas from supply source to market, the system comprising

a production vessel comprising processing equipment modules configured to produce a single phase liquid medium comprising natural gas absorbed in a liquid hydrocarbon solvent by combining natural gas with a liquid hydrocarbon solvent into a single phase liquid medium comprising the natural gas absorbed in the hydrocarbon solvent while optimizing a ratio of the liquid hydrocarbon solvent to the natural gas to optimize the storage densities of the natural gas of the single phase liquid medium for pressures and temperatures at which the single phase liquid medium is set to be stored in the storage vessel, wherein the production vessel is moveable between natural gas supply locations, and

a marine transport vessel comprising a containment system configured to store the single phase liquid medium at storage pressures and temperatures associated with storage densities for the natural gas that exceeds the storage densities of compressed natural gas (CNG) for the same storage pressures and temperatures, wherein the marine transport vessel is configured to receive single phase liquid medium from the production vessel and load into the containment system, wherein the containment system is configured to store the single phase

liquid medium at storage temperatures and pressures in the ranges of -80 F to -120 F and 500 psig to 900 psig.

[008e] In one embodiment, there is provided, in a system for processing natural gas from supply source and producing, storing and transporting a single phase liquid medium comprising natural gas absorbed in a liquid hydrocarbon solvent to deliver natural gas to market, the system comprising

a marine transport vessel comprising a containment system configured to store the single phase liquid medium at storage pressures and temperatures associated with storage densities for the natural gas that exceeds the storage densities of compressed natural gas (CNG) for the same storage pressures and temperatures, wherein the marine transport vessel is configured to receive single phase liquid medium from the production vessel and load into the containment system, wherein the containment system is configured to store the single phase liquid medium at storage temperatures and pressures in the ranges of -80 F to -120 F and 500 psig to 900 psig, and

an offloading vessel comprising separation, fractionation and offloading equipment modules for separating the single phase liquid medium into its natural gas and solvent constituents and offloading natural gas to storage or pipeline facilities, wherein the offloading vessel is configured to receive single phase liquid medium from the marine transport vessel and wherein the offloading vessel is moveable between natural gas market offloading locations.

[008f] In one embodiment, there is provided a method for processing, storing and transporting natural gas from supply source to market, comprising

receiving natural gas on a production vessel comprising processing equipment modules configured to produce a single phase liquid medium comprising natural gas absorbed in a liquid hydrocarbon solvent, wherein the production vessel is moveable between gas supply locations,

producing a supply of single phase liquid medium for storage and transport by combining natural gas with a liquid hydrocarbon solvent into a single phase liquid medium comprising the natural gas absorbed in the hydrocarbon solvent while optimizing a ratio of the liquid hydrocarbon solvent to the natural gas to optimize the storage densities of the natural gas of the single phase liquid medium for pressures and temperatures at which the single phase liquid medium is set to be stored in the storage vessel,

cooling the single phase liquid medium to a storage temperature in a range between -80 F and -120 F, and compressing the single phase liquid medium to a storage pressure in a range between 500 psig and 900 psig,

loading the single phase liquid medium from the production vessel onto a marine transport vessel comprising a containment system configured to store the single phase liquid medium at storage pressures and temperatures associated with storage densities for the natural gas that exceeds the storage densities of compressed natural gas (CNG) for the same storage pressures and temperatures,

storing the single phase liquid medium in the containment system at storage temperatures and pressures in the ranges of -80 F to -120 F and 500 psig to 900 psig,

unloading the single phase liquid medium from the containment system on the marine transport vessel to an offloading vessel comprising separation, fractionation and offloading equipment modules for separating the single phase liquid medium into its natural gas and solvent constituents and offloading natural gas to storage or pipeline facilities, wherein the offloading vessel is moveable between gas market offloading locations,

separating the single phase liquid medium into its natural gas and solvent constituents, and

offloading the natural gas from the offloading vessel to storage or pipeline facilities.

[008g] In one embodiment, there is provided a method for processing, storing and transporting natural gas from supply source to market, comprising

receiving natural gas on a production vessel comprising processing equipment modules configured to produce a single phase liquid medium comprising natural gas absorbed in a liquid hydrocarbon solvent, wherein the production vessel is moveable between gas supply locations,

producing a supply of single phase liquid medium for storage and transport by combining natural gas with a liquid hydrocarbon solvent into a single phase liquid medium comprising the natural gas absorbed in the hydrocarbon solvent while optimizing a ratio of the liquid hydrocarbon solvent to the natural gas to optimize the storage densities of the natural gas of the single phase liquid medium for pressures and temperatures at which the single phase liquid medium is set to be stored in the storage vessel,

cooling the single phase liquid medium to a storage temperature in a range between -80 F and -120 F, and compressing the single phase liquid medium to a storage pressure in a range between 500 psig and 900 psig,

loading the single phase liquid medium from the production vessel onto a marine transport vessel comprising a containment system configured to store the single phase liquid medium at storage pressures and temperatures associated with

storage densities for the natural gas that exceeds the storage densities of compressed natural gas (CNG) for the same storage pressures and temperatures, and

storing the single phase liquid medium in the containment system at storage temperatures and pressures in the ranges of -80 F to -120 F and 500 psig to 900 psig.

[008h] In one embodiment, there is provided a method for processing natural gas from supply source and producing, storing and transporting a single phase liquid medium comprising natural gas absorbed in a liquid hydrocarbon solvent to deliver natural gas to market, comprising

storing a single phase liquid medium on a marine transport vessel comprising a containment system configured to store the single phase liquid medium at storage pressures and temperatures associated with storage densities for the natural gas that exceeds the storage densities of compressed natural gas (CNG) for the same storage pressures and temperatures, wherein the single phase liquid medium is stored at storage temperatures and pressures in the ranges of -80 F to -120 F and 500 psig to 900 psig, and

unloading the single phase liquid medium from the containment system on the marine transport vessel to an offloading vessel comprising separation, fractionation and offloading equipment modules for separating the single phase liquid medium into its natural gas and solvent constituents and offloading natural gas to storage or pipeline facilities, wherein the offloading vessel is moveable between gas market offloading locations,

separating the single phase liquid medium into its natural gas and solvent constituents, and

offloading the natural gas from the offloading vessel to storage or pipeline facilities.

[009] The embodiments described herein are also directed to a scalable means of receiving raw production (including NGLs) or semi-conditioned natural gas,