CLAIMS

What is claimed is:

1. A method of producing liquefied natural gas (LNG) from a natural gas stream, the method comprising:

removing heavy hydrocarbons from the natural gas stream to thereby generate a separated natural gas stream;

partially condensing the separated natural gas stream in a first heat exchanger to thereby generate a partially condensed natural gas stream;

separating liquids from the partially condensed natural gas stream to thereby generate a pretreated natural gas stream;

compressing the pretreated natural gas stream in at least two serially arranged compressors to a pressure of at least 1,500 psia to form a compressed natural gas stream;

cooling the compressed natural gas stream to form a cooled compressed natural gas stream;

expanding, in at least one work producing natural gas expander, the cooled compressed natural gas stream to a pressure that is less than 2,000 psia and no greater than the pressure to which the at least two serially arranged compressors compress the pretreated natural gas stream, to thereby form a chilled natural gas stream;

separating the chilled natural gas stream into a refrigerant stream and a non-refrigerant stream;

warming the refrigerant stream through heat exchange with one or more process streams comprising the natural gas stream, the separated natural gas stream, the partially condensed natural gas stream, and the pretreated natural gas stream, thereby generating a warmed refrigerant stream; and

liquefying the warmed refrigerant stream and the non-refrigerant stream.

2. The method of claim 1, wherein the refrigerant stream is warmed through heat exchange with the separated natural gas stream.

3. The method of claim 1 or claim 2, wherein the heavy hydrocarbons are separated from the natural gas stream in a scrub column, and further comprising:

directing the separated liquids to the scrub column as a column reflux stream;

wherein the one or more process streams further comprise the column reflux stream.

4. The method of any one of claims 1-3, further comprising:

prior to compressing the pretreated natural gas stream, warming the pretreated natural gas stream through heat exchange with the separated natural gas stream in the first heat exchanger.

5. The method of any one of claims 1-4, wherein liquefying the chilled pretreated natural gas stream is performed in one or more single mixed refrigerant (SMR) liquefaction trains.

6. The method of claim 5, wherein liquefying the chilled pretreated natural gas stream is performed in at least three parallel SMR liquefaction trains.

7. The method of any one of claims 1-6, wherein liquefying the chilled pretreated natural gas stream is performed in one or more expander-based liquefaction modules, and wherein the expander-based liquefaction module is a nitrogen gas expander-based liquefaction module or a feed gas expander-based liquefaction module.

8. The method of any one of claims 1-7, wherein the at least two compressors compress the natural gas stream to a pressure greater than 3,000 psia, and wherein the work producing natural gas expander expands the cooled compressed natural gas stream to a pressure less than 2,000 psia.

~~9. The method of any one of claims 1-8, wherein the work producing natural gas expander is mechanically coupled to at least one compressor.~~

~~10. The method of any one of claims 1-9, wherein cooling the compressed natural gas stream comprises cooling the compressed natural gas stream in at least one heat exchanger that exchanges heat with an environment.~~

~~11. The method of any one of claims 1-10, wherein one of the at least two serially arranged compressors is driven by the natural gas expander.~~

~~12. The method of any one of claims 1-11, wherein the at least two serially arranged compressors comprise three serially arranged compressors, and wherein one of the three~~

~~serially arranged compressors is driven by the work producing natural gas expander.~~

~~13~~9. The method of any one of claims 1-~~12~~8, further comprising:

performing the removing, partially condensing, separating, compressing, cooling, expanding, separating, warming, combining, and liquefying steps on a topside of a floating LNG structure.

~~14~~10. The method of claim ~~13~~9, wherein the removing, partially condensing, separating, compressing, cooling, expanding, separating, warming, and combining steps are performed within a single module on the topside of the floating LNG structure.

~~15~~11. An apparatus for the liquefaction of natural gas, comprising:

a first separation device configured to remove heavy hydrocarbons from a natural gas stream to thereby generate a separated natural gas stream;

a first heat exchanger that partially condenses the separated natural gas stream, thereby forming a partially condensed natural gas stream;

a second separation device that separates liquids from the partially condensed natural gas stream to thereby generate a liquids stream and a pretreated natural gas stream;

at least two serially arranged compressors configured to compress the pretreated natural gas stream to a pressure greater than 1,500 psia, thereby forming a compressed natural gas stream;

a cooling element configured to cool the compressed natural gas stream, thereby forming a cooled compressed natural gas stream;

at least one work-producing expander configured to expand the cooled compressed natural gas stream to a pressure which is less than 2,000 psia and is no greater than the pressure to which the at least two serially arranged compressors compress the pretreated natural gas stream, to thereby form a chilled natural gas stream;

wherein the chilled natural gas stream is separated into a refrigerant stream and a non-refrigerant stream, and wherein the refrigerant stream is warmed through heat exchange in the first heat exchanger with one or more of the natural gas stream, the separated natural gas stream, the partially condensed natural gas stream, the pretreated natural gas stream, and the liquids stream, thereby generating a warmed refrigerant stream; and

at least one liquefaction train configured to liquefy the warmed refrigerant stream and the non-refrigerant stream.

~~16~~12. The apparatus of claim ~~15~~11, wherein the first separation device is a scrub column, and wherein the liquids stream is directed to the scrub column as a column reflux stream.

~~17~~13. The apparatus of ~~any one of~~ claim~~s~~ ~~15-16~~11 or 12, wherein, prior to compressing the pretreated natural gas stream, the pretreated natural gas stream is directed to the first heat exchanger to be warmed through heat exchange with the separated natural gas stream therein.

~~18~~14. The apparatus of any one of claims ~~15-17~~11-13, wherein the at least one liquefaction train comprises at least one single mixed refrigerant (SMR) liquefaction module or at least one expander-based liquefaction module.

~~19~~15. The apparatus of claim ~~18~~14, wherein the at least one liquefaction train comprises at least one expander-based liquefaction module that is one of a nitrogen gas expander-based liquefaction module and a feed gas expander-based liquefaction module.

~~20~~16. The apparatus of any one of claims ~~15-19~~11-15, wherein the at least two compressors compress the pretreated natural gas stream to a pressure greater than 3,000 psia.

~~21~~17. The apparatus of any one of claims ~~15-20~~11-16, wherein the natural gas expander is a work producing expander configured to expand the cooled compressed natural gas stream to a pressure less than 2,000 psia.

~~22. The apparatus of any one of claims 15-21, wherein the natural gas expander is mechanically coupled to at least one compressor.~~

~~23. The apparatus of any one of claims 15-22, wherein the cooling element comprises a heat exchanger configured to cool the compressed natural gas stream by exchanging heat with an environment.~~

~~24. The apparatus of any one of claims 15-23, wherein one of the at least two serially arranged compressors is driven by the natural gas expander.~~

~~25. The apparatus of any one of claims 15-24, wherein the at least two serially arranged~~

~~compressors comprise three serially arranged compressors, and wherein one of the three serially arranged compressors is driven by the natural gas expander.~~

~~26~~18. The apparatus of any one of claims ~~15-25~~11-17, wherein the first and second separation devices, the first heat exchanger, at least two serially arranged compressors, the cooling element, the at least one work-producing expander, and the liquefaction train are disposed on a floating LNG structure.

~~27~~19. The apparatus of claim ~~26~~18, wherein the at least two serially arranged compressors, the cooling element, the first heat exchanger, the first and second separation devices, and the at least one work-producing expander are disposed within a single module on a topside of the floating LNG structure.

~~28~~20. A floating LNG structure, comprising:

a first separation device configured to remove heavy hydrocarbons from a natural gas stream, to thereby generate a separated natural gas stream;

a first heat exchanger that partially condenses the separated natural gas stream, thereby forming a partially condensed natural gas stream;

a second separation device that separates liquids from the partially condensed natural gas stream to thereby generate a liquids stream and a pretreated natural gas stream;

at least two serially arranged compressors configured to compress the pretreated natural gas stream to a pressure greater than 1,500 psia, thereby forming a compressed natural gas stream;

a cooling element configured to cool the compressed natural gas stream, thereby forming a cooled compressed natural gas stream;

at least one work-producing expander configured to expand the cooled compressed natural gas stream to a pressure less than 2,000 psia and no greater than the pressure to which the at least two serially arranged compressors compress the natural gas stream, to thereby form a chilled natural gas stream;

wherein the chilled natural gas stream is separated into a refrigerant stream and a non-refrigerant stream, and wherein the refrigerant stream is warmed through heat exchange in the first heat exchanger with one or more of the natural gas stream, the separated natural gas stream, the partially condensed natural gas stream, the pretreated natural gas stream, and the liquids stream, thereby generating a warmed refrigerant stream; and

at least one liquefaction train configured to liquefy the warmed refrigerant stream and the non-refrigerant stream.

~~29~~21. A method of producing liquefied natural gas from a natural gas stream, the method comprising:

pretreating the natural gas stream to generate a pretreated natural gas stream;

compressing the pretreated natural gas stream in at least two serially arranged compressors to a pressure of at least 1,500 psia to form a compressed natural gas stream;

cooling the compressed natural gas stream to form a cooled compressed natural gas stream;

expanding, in at least one work producing natural gas expander, the cooled compressed natural gas stream to a pressure that is less than 2,000 psia and no greater than the pressure to which the at least two serially arranged compressors compress the pretreated natural gas stream, to thereby form a chilled natural gas stream;

separating the chilled natural gas stream into a refrigerant stream and a non-refrigerant stream;

in a heat exchanger, warming the refrigerant stream through heat exchange with one or more process streams associated with pretreating the natural gas stream, thereby generating a warmed refrigerant stream; and

liquefying the warmed refrigerant stream and the non-refrigerant stream.

~~30~~22. The method of claim ~~29~~21, wherein pretreating the natural gas stream comprises at least one of :

removing heavy hydrocarbons from the natural gas stream;

partially condensing the natural gas stream;

separating liquids from the partially condensed natural gas stream; and

cooling the natural gas stream.