CLAIMS

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

cooling at least a portion of the natural gas stream in a first heat exchanger to generate a cooled natural gas stream;

combining the cooled natural gas stream and any remaining portion of the natural gas stream to generate a combined natural gas stream;

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

partially condensing the separated natural gas stream in the 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 cold pretreated gas stream and a liquid stream;

warming the cold pretreated gas stream in the first heat exchanger to generate a pretreated natural gas stream;

compressing the pretreated natural gas stream in at least one compressor 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 one compressor compresses 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;

recycling the refrigerant stream to exchange heat in the first heat exchanger with one or more process streams comprising at least said at least a portion of the natural gas stream, the separated natural gas stream, and the cold pretreated gas stream, thereby generating a warmed refrigerant stream;

combining the warmed refrigerant stream and the non-refrigerant stream to form a chilled pretreated gas stream; and

liquefying the chilled pretreated natural gas stream to form LNG.

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

directing the liquid stream to the scrub column as a column reflux stream.

3. The method of claim 2, further comprising:

extracting liquids from the scrub column;

heating the liquids in a reboiler to generate a stripping gas; and

inserting the stripping gas into a lower portion of the scrub column.

4. The method of any one of claims 1-3, wherein the at least one compressor compresses 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.

5. The method of any one of claims 1-4, wherein the at least one compressor comprises at least two serially arranged compressors, and wherein one of the at least two serially arranged compressors is driven by the natural gas expander.

6. The method of any one of claims 1-5, further comprising:

reducing a pressure and a temperature of a portion of the refrigerant stream, to produce a further cooled refrigerant stream;

directing the further cooled refrigerant stream through the first heat exchanger to cool the one or more process streams, thereby producing a warmed side stream; and

combining the warmed side stream with the pretreated natural gas stream.

7. The method of any one of claims 1-6, wherein said at least a portion of the natural gas stream comprises all of the natural gas stream.

8. An apparatus for the liquefaction of a natural gas stream, comprising:

a first heat exchanger that cools a at least a portion of the natural gas stream to generate a cooled natural gas stream;

a first separation device configured to remove heavy hydrocarbons from a remaining portion of the natural gas stream, combined with the cooled natural gas stream, to thereby generate a separated natural gas stream, wherein the first heat exchanger partially condenses

the separated natural gas stream to form a partially condensed natural gas stream;

a second separation device that separates liquids from the partially condensed natural gas stream to thereby generate a cold pretreated gas stream and a liquid stream, wherein the cold pretreated gas stream is warmed in the first heat exchanger to generate a pretreated natural gas stream;

at least one compressor 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 one compressor compresses 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 recycled to exchange heat in the first heat exchanger with one or more process streams comprising the portion of the natural gas stream, the separated natural gas stream, and the cold pretreated natural gas stream, thereby generating a warmed refrigerant stream, and wherein the warmed refrigerant stream and the pretreated natural gas stream are combined to form a chilled pretreated gas stream; and

at least one liquefaction unit configured to liquefy the chilled pretreated gas stream.

9. The apparatus of claim 8, 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.

10. The apparatus of claim 8 or claim 9, wherein the at least one compressor comprises at least two serially arranged compressors, and wherein one of the at least two serially arranged compressors is driven by the natural gas expander.

11. The apparatus of any one of claims 8-10, further comprising:

a device for reducing a temperature and a pressure of a portion of the refrigerant stream, the device producing a further cooled refrigerant stream that is directed through the first heat exchanger to cool the one or more process streams, thereby producing a warmed side stream;

wherein the warmed side stream is combined with the pretreated natural gas stream.

12. The method of any one of claims 1-7, further comprising reducing a pressure of the cold pretreated gas stream.

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

cooling a portion of the natural gas stream in a first heat exchanger to generate a cooled natural gas stream;

combining the cooled natural gas stream and a remaining portion of the natural gas stream to generate a combined natural gas stream;

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

partially condensing the separated natural gas stream in the 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 cold pretreated gas stream and a liquid stream;

warming the cold pretreated gas stream in the first heat exchanger to generate a pretreated natural gas stream;

compressing the pretreated natural gas stream in at least one compressor 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 one compressor compresses the pretreated natural gas stream, to thereby form a chilled natural gas stream;

recycling the chilled natural gas stream through heat exchange with one or more process streams comprising the portion of the natural gas stream, the separated natural gas stream, and the cold pretreated gas stream, thereby generating a warmed refrigerant stream; and

liquefying the warmed refrigerant stream to form LNG.

14. The method of claim 13, wherein the heavy hydrocarbons are separated from the natural gas stream in a scrub column, and further comprising:

directing the liquid stream to the scrub column as a column reflux stream.

15. The method of claim 13 or claim 14, further comprising:

expanding and cooling the natural gas stream in a feed gas expander prior to the heavy hydrocarbons being removed from the natural gas stream; and

compressing the pretreated natural gas stream in a feed gas compressor prior to the pretreated natural gas stream being compressed in the at least one compressor.

16. The method of claim 15, further comprising:

powering the feed gas compressor by a power output of the feed gas expander.

17. An apparatus of the liquefaction of a natural gas stream, comprising:

a first heat exchanger that cools a portion of the natural gas stream to generate a cooled natural gas stream;

a first separation device configured to remove heavy hydrocarbons from the natural gas stream, combined with the cooled natural gas stream, to thereby generate a separated natural gas stream, wherein the first heat exchanger partially condenses the separated natural gas stream to form a partially condensed natural gas stream;

a second separation device that separates liquids from the partially condensed natural gas stream to thereby generate a cold pretreated gas stream and a liquid stream, wherein the cold pretreated gas stream is warmed in the first heat exchanger to generate a pretreated natural gas stream;

at least one compressor 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 one compressor compresses the pretreated natural gas stream, to thereby form a chilled natural gas stream;

wherein the chilled natural gas stream is recycled to exchange heat in the first heat exchanger with one or more process streams comprising the portion of the natural gas stream, the separated natural gas stream, and the cold pretreated gas stream, thereby generating a warmed refrigerant stream; and

at least one liquefaction unit configured to liquefy the warmed refrigerant stream to form LNG.

18. The apparatus of claim 17, wherein the heavy hydrocarbons are separated from the natural gas stream in the first separation device, and wherein the liquid stream is directed to the first separation device as a column reflux stream.

19. The apparatus of claim 17 or claim 18, further comprising:

a feed gas expander that expands and cools the natural gas stream prior to the heavy hydrocarbons being removed from the natural gas stream; and

a feed gas compressor that compresses the pretreated natural gas stream prior to the pretreated natural gas stream being compressed in the at least one compressor.

20. The apparatus of claim 19, wherein the feed gas compressor is powered by a power output of the feed gas expander.