CLAIMS

1. A method for separating nitrogen from a pressurized LNG stream with a nitrogen concentration of greater than 1 mol %, comprising:

at a liquefaction facility, producing the pressurized LNG stream by liquefying natural gas, where the pressurized LNG stream comprises a nitrogen concentration of greater than 1 mol %;

receiving at least one liquid nitrogen (LIN) stream, the at least one LIN stream being produced at a different geographic location from the liquefaction facility;

directing the at least one LIN stream to a separation vessel;

directing the pressurized LNG stream to the separation vessel;

in the separation vessel, using the at least one LIN stream to separate the pressurized LNG stream into a vapor stream and a liquid stream, where the vapor stream has a nitrogen concentration greater than the nitrogen concentration of the pressurized LNG stream and the liquid stream has a nitrogen concentration less than the nitrogen concentration of the pressurized LNG stream;

using the vapor stream to liquefy a natural gas stream to form an additional pressurized LNG stream and a warm nitrogen vent stream; and

combining the additional pressurized LNG stream with the pressurized LNG stream upstream of the separation vessel.

2. The method of claim 1, wherein the liquid stream is an LNG stream with a nitrogen concentration of less than 2 mol %.

3. The method of claim 1, further comprising subcooling the LNG stream by indirect heat exchange with at least one of the one or more LIN streams.

4. The method of claim 1, wherein the vapor stream is a cold nitrogen vent stream with a hydrocarbon concentration of less than 2 mol %, and further comprising:

using the cold nitrogen vent stream to liquefy the natural gas stream to form the additional pressurized LNG stream and the warm nitrogen vent stream.

5. The method of claim 1, wherein the separation vessel is a first separation vessel, and further comprising directing LNG boil-off gas to a second separation vessel.

6. The method of claim 5, further comprising:

after separating the pressurized LNG stream into the vapor stream and the liquid stream, directing all or a portion of the vapor stream to the second separation vessel; and

directing another of the at least one LIN streams to the second separation vessel.

7. The method of claim 5, wherein the second separation vessel is a multi-stage separation column, and the boil-off gas is a stripping gas for the multi-stage separation column, the method further comprising:

condensing, in the multi-stage separation column, hydrocarbons within the boil-off gas; and

directing another of the at least one LIN streams to the multi-stage separation column.

8. The method of claim 1, wherein the separation vessel is a first separation vessel, the vapor stream is a first vapor stream and the liquid stream is a first liquid stream, and further comprising:

partially or fully condensing the first vapor stream by indirect heat exchange with another of the at least one LIN stream, to thereby form a condensed first vapor stream and a vaporized LIN stream; and

directing the first condensed vapor stream into a second separation vessel to form a second vapor stream and a second liquid stream.

9. The method of claim 8, further comprising directing the second liquid stream into the first separation vessel as a reflux stream to the first separation vessel.

10. The method of claim 8, further comprising directing another of the at least one LIN streams to the second separation vessel to condense a majority of hydrocarbon components present in the second separation vessel such that the second vapor stream is substantially free of hydrocarbons.

11. The method of claim 8, wherein the second vapor stream is a cold nitrogen vent stream with a hydrocarbon concentration of less than 2 mol % or less than 1 mol %.

12. The method of claim 1, further comprising subcooling the pressurized LNG stream by indirect heat exchange with one or more of the at least one LIN streams, to form a subcooled pressurized LNG stream and a vaporized LIN stream.

13. The method of claim 7, further comprising:

cooling inlet air to one or more turbines using the warm nitrogen vent stream.

14. The method of claim 1, further comprising:

after separating the pressurized LNG stream into the vapor stream and the liquid stream, partially or fully condensing the vapor stream by indirect heat exchange with one of the at least one LIN streams to form a condensed vapor stream and a warmed nitrogen gas stream, wherein the one of the at least one LIN streams has a pressure greater than 400 psia, wherein vapor separated from the condensed vapor stream is used to liquefy the natural gas stream to form the additional pressurized LNG stream;

reducing the pressure of the warmed nitrogen gas stream in at least one expander service to produce at least one additionally cooled nitrogen gas stream;

exchanging heat between the at least one additionally cooled nitrogen gas stream and the vapor stream to form a partially or fully condensed vapor stream and a warmed nitrogen gas stream; and

coupling the at least one expander service with at least one compressor used to compress the warmed nitrogen gas stream.

15. The method of claim 1, wherein the pressurized LNG stream has a temperature in the range of −100° C. to −150° C.

16. The method of claim 1, wherein the different geographic location is an LNG regasification facility, the method further comprising:

transporting the pressurized LNG to the regasification facility to produce a transported LNG stream;

regasifying the transported LNG stream at the LNG regasification facility;

producing the at least one LIN stream from nitrogen gas by exchanging heat with the transported LNG stream during regasification of the transported LNG stream.

17. The method of claim 1, further comprising expanding the pressurized LNG stream to produce a two-phase mixture with a vapor fraction of less than 40 mol %.

18. The method of claim 1, further comprising expanding the pressurized LNG stream to produce a two-phase mixture with a vapor fraction of less than 20 mol %.

19. The method of claim 1, wherein the liquefaction process used to produce the pressurized LNG stream is a single mix refrigerant process, a propane pre-cooled mixed refrigerant process, a cascade refrigerant process, a dual mixed refrigerant process, or an expander-based liquefaction process.

20. The method of claim 1, wherein the liquefaction process used to produce the pressurized LNG stream is a liquid nitrogen refrigeration process, where liquid nitrogen is substantially used as an open loop source of refrigeration in the liquid nitrogen refrigeration process.

21. A system for processing pressurized liquefied natural gas (LNG) produced at a liquefied natural gas (LNG) liquefaction facility, the pressurized LNG having a nitrogen concentration greater than 1 mol %, comprising:

a liquefied nitrogen (LIN) stream produced at a different geographic location from the LNG liquefaction facility;

a separation vessel into which the pressurized LNG stream and the LIN stream are directed, the separation vessel configured use the LIN stream to separate the pressurized LNG stream into a vapor stream and a liquid stream, where the vapor stream has a nitrogen concentration greater than the nitrogen concentration of the pressurized LNG stream and the liquid stream has a nitrogen concentration less than the nitrogen concentration of the pressurized LNG stream; and

a heat exchanger that uses the vapor stream to liquefy a natural gas stream to form an additional pressurized LNG stream and a warm nitrogen vent stream;

wherein the additional pressurized LNG stream is combined with the pressurized LNG stream upstream of the separation vessel.

22. The system of claim 21, wherein the vapor stream is a cold nitrogen vent stream with a hydrocarbon concentration of less than 2 mol % or less than 1 mol %.

23. The system of claim 21, wherein the separation vessel is a first separation vessel, and further comprising a second separation vessel to which LNG boil-off gas is directed;

wherein all or a portion of the vapor stream is directed to the second separation vessel, and wherein at least part of the LIN stream is directed to the second separation vessel.

24. The system of claim 22, further comprising:

a second heat exchanger that partially or fully condenses the vapor stream by indirect heat exchange with at least part of the LIN stream to form a condensed vapor stream and a warmed nitrogen gas stream, wherein the at least part of the LIN stream has a pressure greater than 400 psia;

an expander service configured to reduce the pressure of the warmed nitrogen gas stream to produce at least one additionally cooled nitrogen gas stream;

a third heat exchanger that exchanges heat between the at least one additionally cooled nitrogen gas stream and the vapor stream to form a partially or fully condensed vapor stream and a warmed nitrogen gas stream; and

a compressor coupled to the expander service, wherein the compressor is used to compress the warmed nitrogen gas stream.