CLAIMS

1. An oxycombustion system with thermally integrated ammonia synthesis, the oxycombustion system comprising:

an air separation unit that separates an air feed stream into an oxygen stream and a nitrogen stream;

an ammonia synthesis unit that synthesizes ammonia from a hydrogen feed stream and the nitrogen stream from the air separation unit to form a crude ammonia stream containing the ammonia and, optionally, unreacted nitrogen and hydrogen;

an ammonia separation unit that condenses at least a portion of the crude ammonia stream formed in the ammonia synthesis unit and separates the ammonia from any unreacted nitrogen and hydrogen to form a purified ammonia stream;

an oxycombustion reactor that combusts a fuel from a fuel feed stream in the presence of the oxygen stream from the air separation unit to produce combustion heat;

a flue-gas treatment system that treats a flue gas formed by the combustion of the fuel in the oxycombustion reactor; and

thermal integrations comprising a reactor thermal linkage of the ammonia synthesis unit with the oxycombustion reactor and a separator thermal linkage of the air separation unit with the ammonia separation unit,

wherein the purified ammonia stream is in fluidic communication with the flue-gas treatment system and at least a portion of the ammonia separated in the ammonia separation unit is used in the flue-gas treatment system to remove pollutants from the flue gas.

2. The oxycombustion system of claim 1, wherein the reactor thermal linkage of the ammonia synthesis unit with the oxycombustion reactor comprises a boiler loop that transfers combustion heat to the ammonia synthesis unit from the oxycombustion reactor, from flue gas formed in the oxycombustion reactor, from hot water or steam that has been heated from the combustion heat, or a combination thereof.

3. The oxycombustion system of claim 1, wherein the separator thermal linkage of the air separation unit with the ammonia separation unit comprises a

separator loop that transfers heat to the air separation unit from the ammonia separation unit.

4. The oxycombustion system of claim 1, wherein the flue-gas treatment system outputs carbon dioxide, the oxycombustion system further comprising a carbon dioxide capture unit that captures the carbon dioxide generated in the flue-gas treatment system.

5. The oxycombustion system of claim 4, further comprising at least one capture-unit thermal integration chosen from an air-separator capture-unit thermal linkage between the air separation unit and the carbon dioxide capture unit, an ammonia-separator capture-unit thermal linkage between the ammonia separation unit and the carbon dioxide capture unit, or both.

6. The oxycombustion system of claim 4, further comprising a urea synthesis unit that synthesizes urea to produce a urea stream from carbon dioxide captured in the carbon dioxide capture unit and the ammonia in the ammonia stream.

7. The oxycombustion system of claim 6, wherein the urea stream is in fluidic communication with the flue-gas treatment system and at least a portion of the urea in the urea stream is used to remove pollutants from the flue gas in the flue-gas treatment system.

8. The oxycombustion system of claim 6, further comprising at least one additional thermal integration chosen from an air-separator capture-unit thermal linkage between the air separation unit and the carbon dioxide capture unit, an ammonia-separator capture-unit thermal linkage between the ammonia separation unit and the carbon dioxide capture unit, a urea synthesis thermal linkage between the urea synthesis unit and the oxycombustion reactor, or combinations thereof.

9. The oxycombustion system of claim 1, wherein the fuel that is combusted in the oxycombustion reactor is a fossil fuel or a biomass.

10. A method for performing oxycombustion with thermally integrated ammonia synthesis, the method comprising:

separating an air feed stream with an air separation unit into an oxygen stream and a nitrogen stream;

flowing the oxygen stream to an oxycombustion reactor;

flowing the nitrogen stream to an ammonia synthesis unit;

combining the nitrogen stream in the ammonia synthesis unit with a hydrogen feed stream to synthesize ammonia and form a crude ammonia stream containing the ammonia and, optionally, unreacted nitrogen or hydrogen;

condensing at least a portion of the crude ammonia stream in an ammonia separation unit;

separating the ammonia in the crude ammonia stream from any unreacted nitrogen or hydrogen in the crude ammonia stream, to form a purified ammonia stream;

combining a fuel from a fuel stream with the oxygen stream to form a fuel mixture;

combusting the fuel mixture in the oxycombustion reactor to generate combustion heat; and

transferring thermal energy through thermal integrations while the fuel mixture is being combusted and the ammonia is being synthesized, the thermal integrations comprising a reactor thermal linkage of the ammonia synthesis unit with the oxycombustion reactor and a separator thermal linkage of the air separation unit with the ammonia separation unit; and

treating in a flue-gas treatment system, a flue gas formed by the combustion of the fuel in the oxycombustion reactor to remove pollutants from the flue gas, wherein treating the flue gas comprises using at least a portion of the ammonia in the purified ammonia stream to remove the pollutants from the flue gas.

11. The method of claim 10, wherein:

the reactor thermal linkage of the ammonia synthesis unit with the oxycombustion reactor comprises a boiler loop that transfers combustion heat to the ammonia synthesis unit from the oxycombustion reactor, from flue gas formed in the

oxycombustion reactor, from at least a portion of the hot water or steam formed in the oxycombustion reactor, or a combination thereof; and

transferring the thermal energy comprises circulating a heat transfer fluid through the boiler loop while the fuel mixture is being combusted and the ammonia is being synthesized.

12. The method of claim 10, wherein:

the separator thermal linkage of the air separation unit with the ammonia separation unit comprises a separator loop that transfers heat to the air separation unit from the ammonia separation unit; and

transferring the thermal energy comprises circulating a heat transfer fluid through the separator loop while the fuel mixture is being combusted and the ammonia is being synthesized.

13. The method of claim 10, wherein:

the reactor thermal linkage of the ammonia synthesis unit with the oxycombustion reactor comprises a boiler loop that transfers combustion heat to the ammonia synthesis unit from flue gas formed in the oxycombustion reactor, from hot water or steam that has been heated by the combustion heat, or a combination thereof; and

the separator thermal linkage of the air separation unit with the ammonia separation unit comprises a separator loop that transfers heat to the air separation unit from the ammonia separation unit; and

transferring the thermal energy comprises circulating a first heat transfer fluid through the boiler loop and circulating a second heat transfer fluid through the separator loop while the fuel mixture is being combusted and the ammonia is being synthesized.

14. The method of claim 10, wherein the treating of the flue gas in the flue-gas treatment system outputs carbon dioxide, the method further comprising:

capturing the carbon dioxide in a carbon dioxide capture unit;

combining at least a portion of the carbon dioxide captured in the carbon dioxide capture unit with the ammonia in the ammonia stream to form a urea reactant mixture;

synthesizing urea from the urea reactant mixture in a urea synthesis unit.

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15. The method of claim 14, wherein treating the flue gas in the flue-gas treatment system comprises using at least a portion of the urea in the urea stream, to remove the pollutants from the flue gas.