## CLAIMS

1. A system, comprising:

an acid gas treatment unit operable to treat an acid gas stream comprising hydrogen sulfide, the acid gas treatment unit comprising:

a fuel reactor operable to receive the acid gas stream and calcium oxide, the fuel reactor further operable to react the hydrogen sulfide with the calcium oxide to produce calcium sulfide and a first gas stream comprising water vapor and carbon dioxide;

an oxidizer reactor operable to receive the calcium sulfide and a first air stream, the oxidizer reactor further operable to produce calcium sulfate and an oxygen-lean second air stream, the oxygen-lean air stream comprising no more than 15 % by weight oxygen: and

a calciner reactor operable to receive the oxygen-lean second air stream and calcium carbonate, the calciner reactor further operable to produce the calcium oxide and a second gas stream, the second gas stream comprising carbon dioxide.

2. The system of claim 1, comprising one or more heat exchangers operable to receive at least one of the first gas stream, the second gas stream, and the oxygen-lean second air stream, the one or more heat exchangers further operable to produce steam using heat from the first gas stream, the second gas stream, the oxygen-lean second air stream, or any combination thereof.

3. The system of claim 2, wherein the one or more heat exchangers are further operable to heat the first air stream using heat from the first gas stream, the second gas stream, or a combination thereof.

4. The system of claim 2, wherein the one or more heat exchangers are further operable to heat the acid gas stream before the fuel reactor receives the acid gas stream.

5. The system of claim 2, comprising a power generation unit operable to receive the steam from the one or more heat exchangers and produce power and reduced pressure steam.

6. The system of claim 5, wherein the reduced pressure steam is provided to regeneration column of an acid gas removal unit.

7. The system of claim 1, comprising an acid gas removal unit operable to receive a sour gas stream and produce the acid gas stream, the acid gas removal unit comprising an absorption column and a regeneration column.

8. The system of claim 7, comprising one or more heat exchangers operable to transfer heat from the oxidizer reactor to the regeneration column.

9. The system of claim 1, comprising a selective membrane module disposed between a sour gas stream and an acid gas removal unit operable to produce the acid gas stream, the selective membrane operable to produce a permeate stream having an increased concentration of carbon dioxide and hydrogen sulfide as compared to the sour gas stream and a retentate stream having a reduced concentration of carbon dioxide and hydrogen sulfide as compared to the sour gas stream.

10. The system of claim 9, wherein the permeate stream is mixed with the acid gas stream before being received by the fuel reactor and the acid gas removal unit is operable to receive the retentate stream.

11. The system of claim 1, wherein the oxidizer reactor comprises a fast riser reactor.

12. The system of claim 1, wherein the calciner reactor comprises a fluidized bed reactor.

13. A method, comprising:

receiving an acid gas stream and calcium oxide at a fuel reactor of an acid gas treatment unit, the acid gas stream comprising hydrogen sulfide;

operating the fuel reactor to react the hydrogen sulfide with calcium oxide to produce calcium sulfide and a first gas stream comprising water vapor and carbon dioxide;

operating an oxidizer reactor of the acid gas treatment unit to receive the calcium sulfide and a first air stream to produce calcium sulfate and an oxygen-lean second air stream, the oxygen-lean air stream comprising no more than 15 % by weight oxygen; and

operating a calciner reactor to receive the oxygen-lean air stream and calcium carbonate and produce the calcium oxide and a second gas stream, the second gas stream comprising carbon dioxide.

14. The method of claim 13, comprising operating one or more heat exchangers to receive at least one of the first gas stream, the second gas stream, and the oxygen-lean second air

stream to produce steam using heat from the first gas stream, the second gas stream, the oxygen-lean second air stream, or any combination thereof.

15. The method of claim 14, comprising operating the one or more heat exchangers heat the acid gas stream before receiving the acid gas stream and calcium oxide at the fuel reactor of the acid gas treatment unit.

16. The method of claim 13, comprising operating a power generation unit to receive the steam from the one or more heat exchangers and produce power and reduced pressure steam.

17. The method of claim 15, comprising providing the reduced pressure steam to a regeneration column of an acid gas removal unit.

18. The method of claim 13, wherein the acid gas stream is received from an acid gas removal unit.

19. The method of claim 13, comprising operating a selective membrane module disposed between a sour gas stream and an acid gas removal unit to produce a permeate stream having an increased concentration of carbon dioxide and hydrogen sulfide as compared to the sour gas stream and retentate stream having a reduced concentration of carbon dioxide and hydrogen sulfide as compared to the sour gas stream.

20. The method of claim 19, comprising mixing the permeate stream with the acid gas stream before being received by the fuel reactor.

21. The method of claim 13, comprising removing the water vapor from the first gas stream to produce a $CO_2$ stream when the acid gas stream does not include hydrocarbons.

22. The method of claim 13, comprising operating the oxidizer reactor of the acid gas treatment unit to receive the first gas stream when the first gas stream comprises an amount of carbon monoxide below a first threshold amount and an amount of hydrogen below a second threshold amount.

23. The method of claim 13, wherein operating the fuel reactor comprises operating the fuel reactor at a temperature in the range of 600°C to 900°C.

24. The method of claim 13, wherein operating the oxidizer reactor comprises operating the oxidizer reactor at a temperature in the range of 800°C to 1100°C.

25. The method of claim 13, wherein operating the calciner reactor comprises operating the oxidizer reactor at a temperature in the range of 800°C to 1000°C.

26. A system, comprising:

an acid gas treatment unit operable to treat an acid gas stream comprising hydrogen sulfide, the acid gas treatment unit comprising:

a fuel reactor operable to receive the acid gas stream and calcium carbonate, the fuel reactor further operable to:

produce carbon dioxide and calcium oxide from the calcium carbonate; and

react the hydrogen sulfide with the calcium oxide to produce calcium sulfide and a first gas stream comprising water vapor and carbon dioxide; and

an oxidizer reactor operable to receive the calcium sulfide and a first air stream, the oxidizer reactor further operable to produce calcium sulfate and an oxygen-lean second air stream, the oxygen-lean air stream comprising no more than 15 % by weight oxygen.

27. The system of claim 26, comprising one or more heat exchangers operable to receive the first gas stream and the oxygen-lean second air stream, the one or more heat exchangers further operable to produce steam using heat from the first gas stream, the oxygen-lean second air stream, or a combination thereof.

28. The system of claim 27, wherein the one or more heat exchangers are further operable to heat the first air stream using heat from the first gas stream, the oxygen-lean second air stream, or a combination thereof.

29. The system of claim 26, wherein the one or more heat exchangers are further operable to heat the acid gas stream before the fuel reactor receives the acid gas stream.

30. The system of claim 27, comprising a power generation unit operable to receive the steam from the one or more heat exchangers and produce power and reduced pressure steam.

31. The system of claim 30, wherein the reduced pressure steam is provided to regeneration column of an acid gas removal unit.

32. The system of claim 26, comprising an acid gas removal unit operable to receive a sour gas stream and produce the acid gas stream, the acid gas removal unit comprising an absorption column and a regeneration column.

33. The system of claim 26, comprising a selective membrane module disposed between a sour gas stream and an acid gas removal unit operable to produce the acid gas stream, the selective membrane operable to produce a permeate stream having an increased concentration of carbon dioxide and hydrogen sulfide as compared to the sour gas stream and retentate stream having a reduced concentration of carbon dioxide and hydrogen sulfide as compared to the sour gas stream.

34. The system of claim 33, wherein the permeate stream is mixed with the acid gas stream before being received by the fuel reactor and the acid gas removal unit is operable to receive the retentate stream.

35. The system of claim 26, wherein the oxidizer reactor comprises a fast riser reactor.

36. A method, comprising:

receiving an acid gas stream and calcium carbonate at a fuel reactor of an acid gas treatment unit, the acid gas stream comprising hydrogen sulfide;

operating the fuel reactor to produce carbon dioxide and calcium oxide from the calcium carbonate and react the hydrogen sulfide with the calcium oxide to produce calcium sulfide and a first gas stream comprising water vapor and carbon dioxide; and

operating an oxidizer reactor of the acid gas treatment unit to receive the calcium sulfide and a first air stream to produce calcium sulfate and an oxygen-lean second air stream, the oxygen-lean air stream comprising no more than 15 % by weight oxygen.

37. The method of claim 36, comprising operating one or more heat exchangers to receive at least one of the first gas stream and the oxygen-lean second air stream to produce steam using heat from the first gas stream, the oxygen-lean second air stream, or a combination thereof.

38. The method of claim 37, comprising operating the one or more heat exchangers to heat the acid gas stream before receiving the acid gas stream at the fuel reactor of the acid gas treatment unit.

39. The method of claim 37, comprising operating a power generation unit to receive the steam from the one or more heat exchangers and produce power and reduced pressure steam.

40. The method of claim 39, comprising providing the reduced pressure steam to a regeneration column of an acid gas removal unit.

41. The method of claim 36, comprising operating a selective membrane module disposed between a sour gas stream and an acid gas removal unit to produce a permeate stream having an increased concentration of carbon dioxide and hydrogen sulfide as compared to the sour gas stream and retentate stream having a reduced concentration of carbon dioxide and hydrogen sulfide as compared to the sour gas stream.

42. The method of claim 41, comprising mixing the permeate stream with the acid gas stream before being received by the fuel reactor.

43. The method of claim 36, comprising removing the water vapor from the first gas stream to produce a $CO_2$ stream when the acid gas stream does not include hydrocarbons.

44. The method of claim 36, comprising operating the oxidizer reactor of the acid gas treatment unit to receive the first gas stream when the first gas stream comprises an amount of carbon monoxide below a first threshold amount and an amount of hydrogen below a second threshold amount.

45. The method of claim 36, wherein operating the fuel reactor comprises operating the fuel reactor at a temperature in the range of 800°C to 900°C.

46. The method of claim 36, wherein operating the oxidizer reactor comprises operating the oxidizer reactor at a temperature in the range of 850°C to 1100°C.