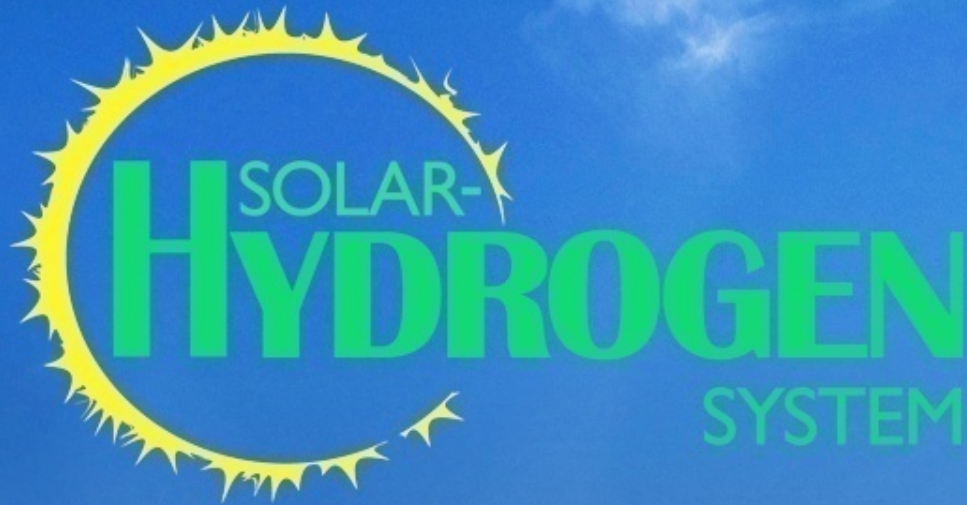


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MEMORIAL



# ADVANCES IN MAKING HIGH PURITY NITROGEN FOR SMALL SCALE AMMONIA GENERATION

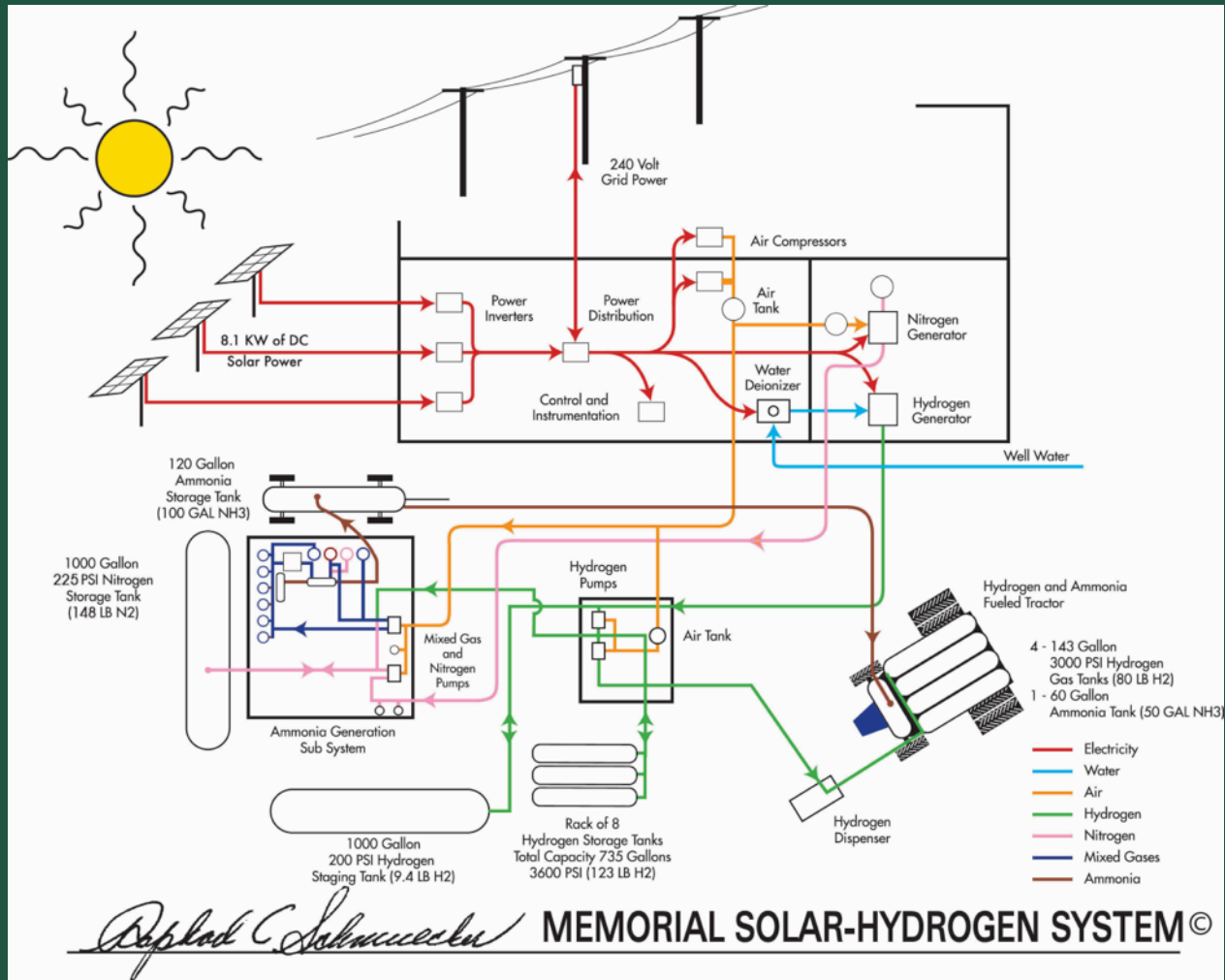
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Jay Schmuecker, Co-Author,  
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# SYSTEM OVERVIEW

- We have installed on an Iowa farm the ability to generate demonstration amounts of Hydrogen, Nitrogen and Ammonia from Solar Power, Water and Air.
- The hydrogen and ammonia fuel a modified John Deere tractor.
- The ammonia can fertilize corn cropland.



# SYSTEM SCHEMATIC





# SYSTEM DESCRIPTION

- Tractor is in storage building
- Low pressure 200 psi H<sub>2</sub> storage tank
- H<sub>2</sub> storage and fueling pumps hut
- Eight 3600 psi H<sub>2</sub> composite storage tanks
- Tractor fueling dock



# SYSTEM DESCRIPTION

- 8 Kw of solar arrays
- N<sub>2</sub> stored in 1000 gallon tank at 235 psi max
- Ammonia generation building
- Inverters, controls and H<sub>2</sub> and N<sub>2</sub> generator in tractor storage building.





# NITROGEN GENERATION

- A modified Dual Bed, Pressure Swing Absorption (PSA) unit generates Nitrogen
- 140 psi compressed air is routed through the PSA unit.
- The generator makes 2.7 lbs/hour.
- It takes 16.5 hours to make enough nitrogen to generate a 10 gallon ammonia batch.



# NITROGEN PURIFICATION

- Residual oxygen in nitrogen gas contaminated the ammonia reactor.
- Installed a nitrogen purification unit containing a catalyst bed and desiccant container.
  - Small amounts of  $H_2$  are mixed with the purified  $N_2$  and the catalyst bed forms  $H_2O$  water vapor that is removed by the desiccant.

# NITROGEN PURITY SENSING

- Measure the purity of the nitrogen being generated by the Pressure Swing Absorber unit.
- When N2 Low Purity Sensor shows purity down to 300 ppm, stop venting from PSA.
- Add H2 and flow through purification unit until High N2 Purity Sensor shows level down to less than 5 ppm.
- Then flow nitrogen to the storage tank.

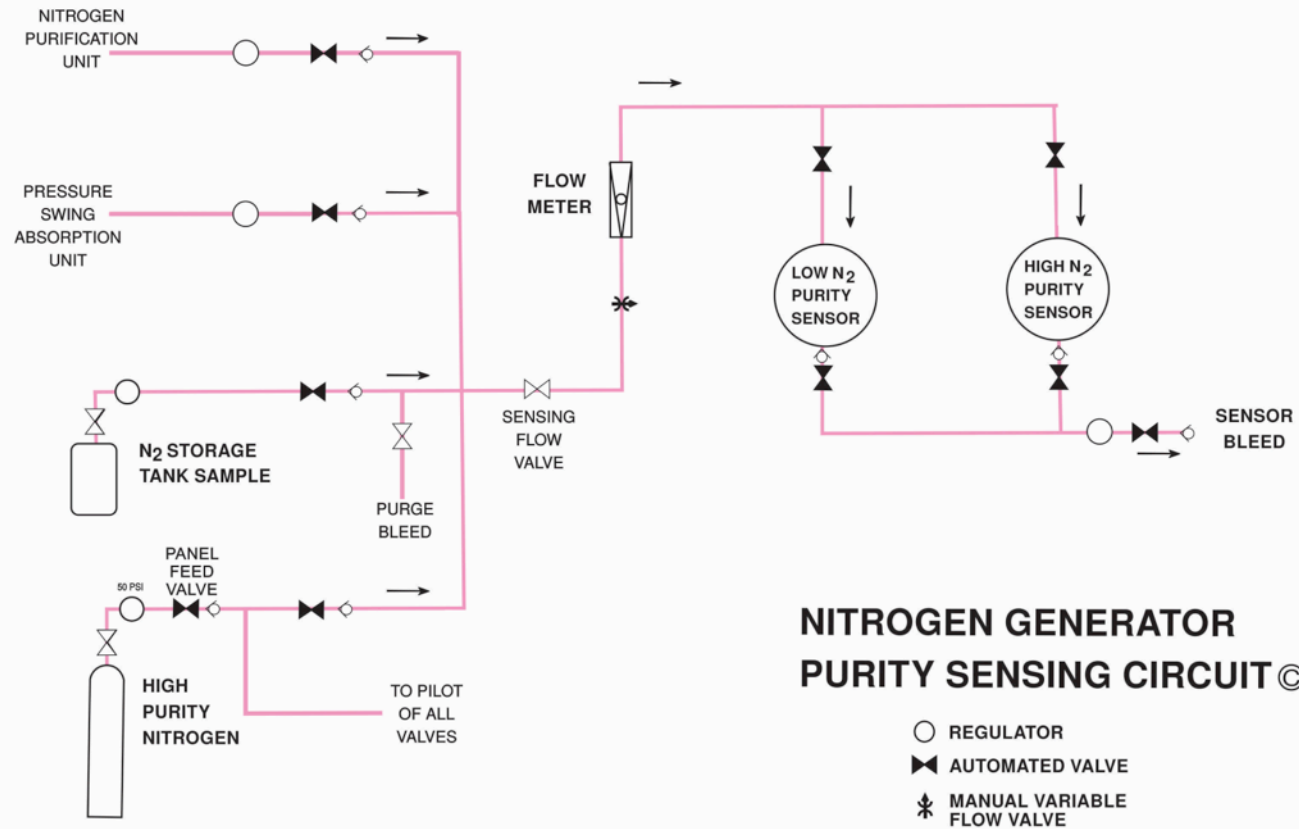


**NITROGEN GENERATION ©**

○ REGULATOR  
 ▲ AUTOMATED VALVE  
 \* MANUAL VARIABLE FLOW VALVE

The diagram illustrates the Nitrogen Generation process. Air enters an AIR TANK, then passes through PRESSURE SWING ABSORPTION TUBES. The output goes to an N<sub>2</sub> TANK. From the N<sub>2</sub> TANK, the gas flows through a FLOW METER and a MANUAL VARIABLE FLOW VALVE. It then splits into two paths: one to a VENT and another to a LOW PURITY SENSOR. The gas from the LOW PURITY SENSOR enters a NITROGEN PURIFICATION UNIT, which includes a CATALYST BED, a HEAT EXCHANGER, and a DESICCANT. The output of the Purification Unit goes to a HIGH PURITY SENSOR and then to N<sub>2</sub> STORAGE. A Hydrogen (H<sub>2</sub>) source is also shown entering the system through a FLOW METER and a MANUAL VARIABLE FLOW VALVE, joining the main gas line before the CATALYST BED.

# NITROGEN PURITY SENSING



# CONCLUSION

- Have demonstrated that super pure nitrogen can be generated for use in intermittent batches for making ammonia.
- More at [SolarHydrogenSystem.com](http://SolarHydrogenSystem.com)