MY SOLAR POWERED AMMONIA GENERATION SYSTEM

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TOPICS

- My and System Background
- Current Solar Hydrogen System
- Ammonia Subsystem Background
- Ammonia Subsystem Design
- Expected Performance
- Conclusion

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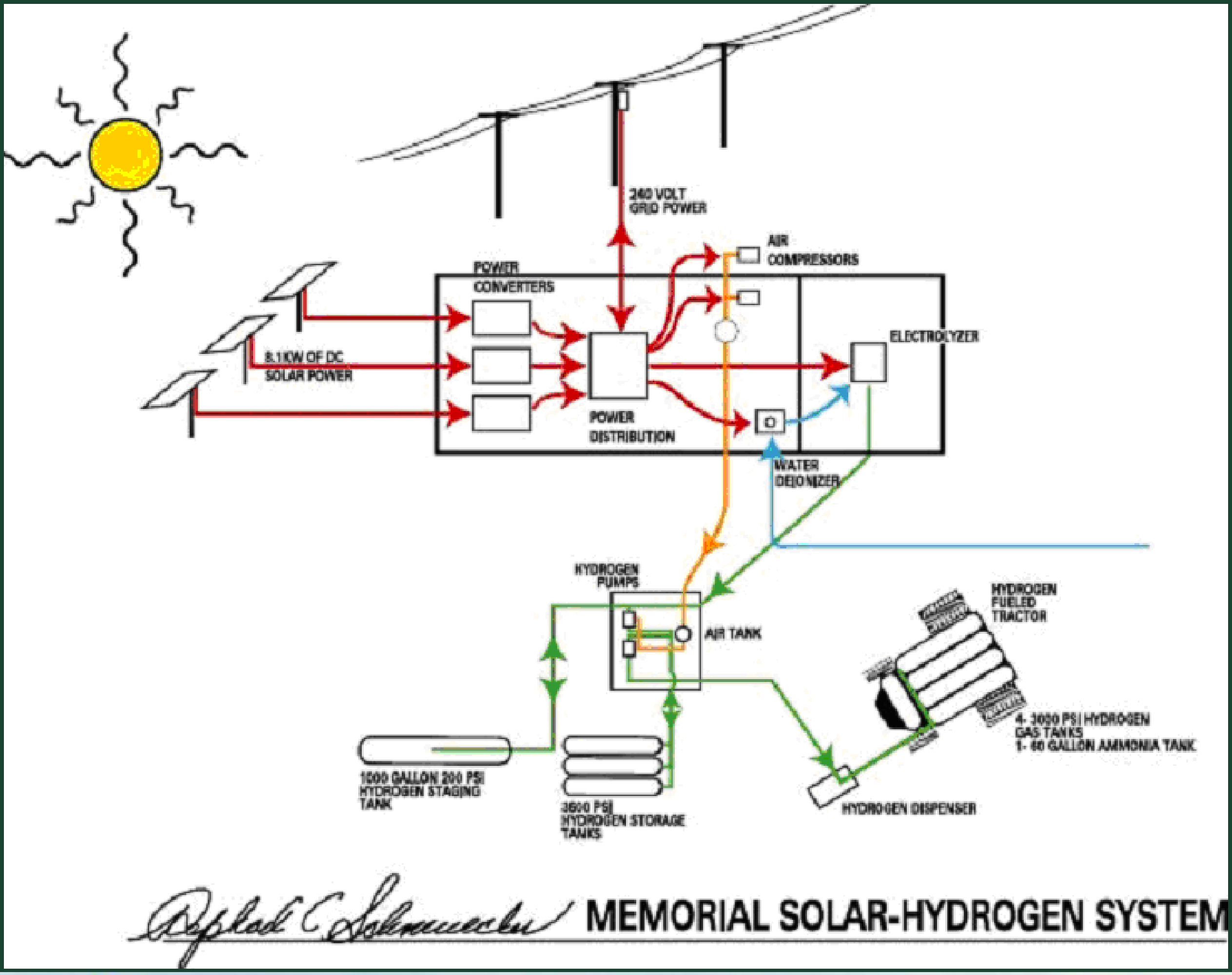
MY BACKGROUND

- 50 year working career at Caltech’s Jet Prop Lab.
    - Do things that haven’t been done before.
- Own farm near Blairstown on which my father was raised.
- System is a memorial to my Father, an advocate for using hydrogen to replace fossil fuels.

SYSTEM BACKGROUND

- 1 Kg of hydrogen = energy in a gallon of gasoline.
- Determined that 3000 lbs of hydrogen needed annually to farm 320 acre farm growing corn and soybeans.
- Farm operator estimated half of fuel used in spring and half in fall for harvest.
- Needed to generate 1500 lbs over 150 day growing season: 10 lbs a day.
- Needed 77 kw of solar panels and 80 10 ft long composite tanks to store the hydrogen at 3600 psi.
- Built a 10% demonstration system.

CURRENT SOLAR HYDROGEN SYSTEM



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CURRENT SOLAR HYDROGEN SYSTEM

- 8.1 kw of two axis solar arrays.
- On the average solar power is available 5 hours a day.
- Electrolyzer makes .2 lb of hydrogen/hour
- 1000 gallon staging tank holds 9.4 lbs at 200 psi.
- 5 hp air compressor provides air to hydrogen pumps at 50 to 100 psi.
- Hydrogen pumped into storage tanks at about .45 lbs/hour.

CURRENT SOLAR HYDROGEN SYSTEM

- 8 tanks hold 124 lbs of hydrogen at 3600 psi
- Second hydrogen pump pumps hydrogen into tractor tanks
- Tractor hydrogen tanks hold 80 lbs at 3000 psi.
- Enough to power the tractor at full power for 4 hours.
- Instrumentation and Control Subsystem manages when electrolyzer, compressors and pumps operate.
- Dependent on solar power level and pressures in staging and storage tanks.

CURRENT SOLAR HYDROGEN SYSTEM

AMMONIA SUBSYSTEM BACKGROUND

- After last year's meeting, Bill Ayers put me in touch with Doug Carpenter.
- Doug had a method of making small quantities of NH3 using available H2 and N2.
- Once H2 is available, the rest of ammonia generation is adaptable to the use of solar energy.
- Ammonia containing of 5400 lbs of hydrogen is applied annually to the 145 acres of corn land.
- Without ammonia corn yield would be about 100 bu/acre instead of 200.

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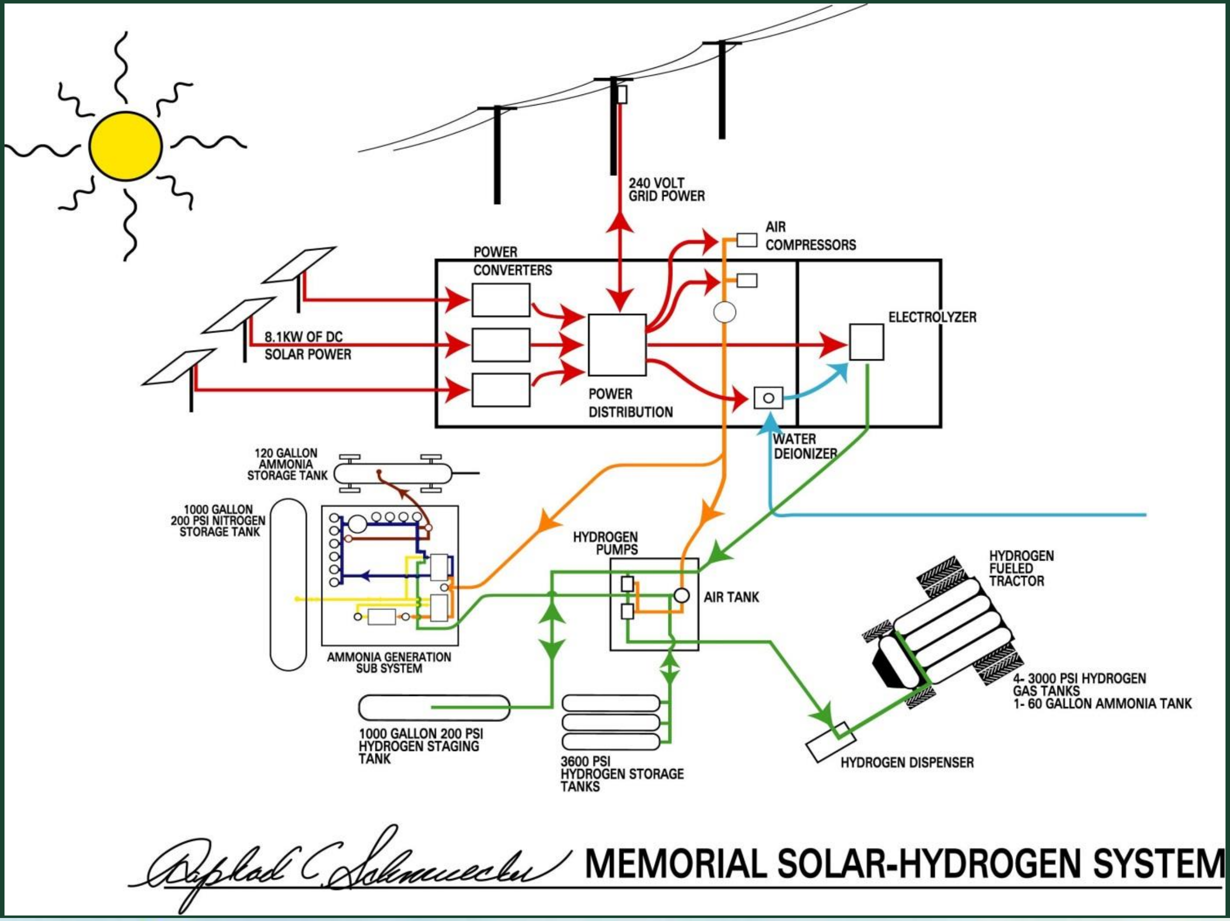
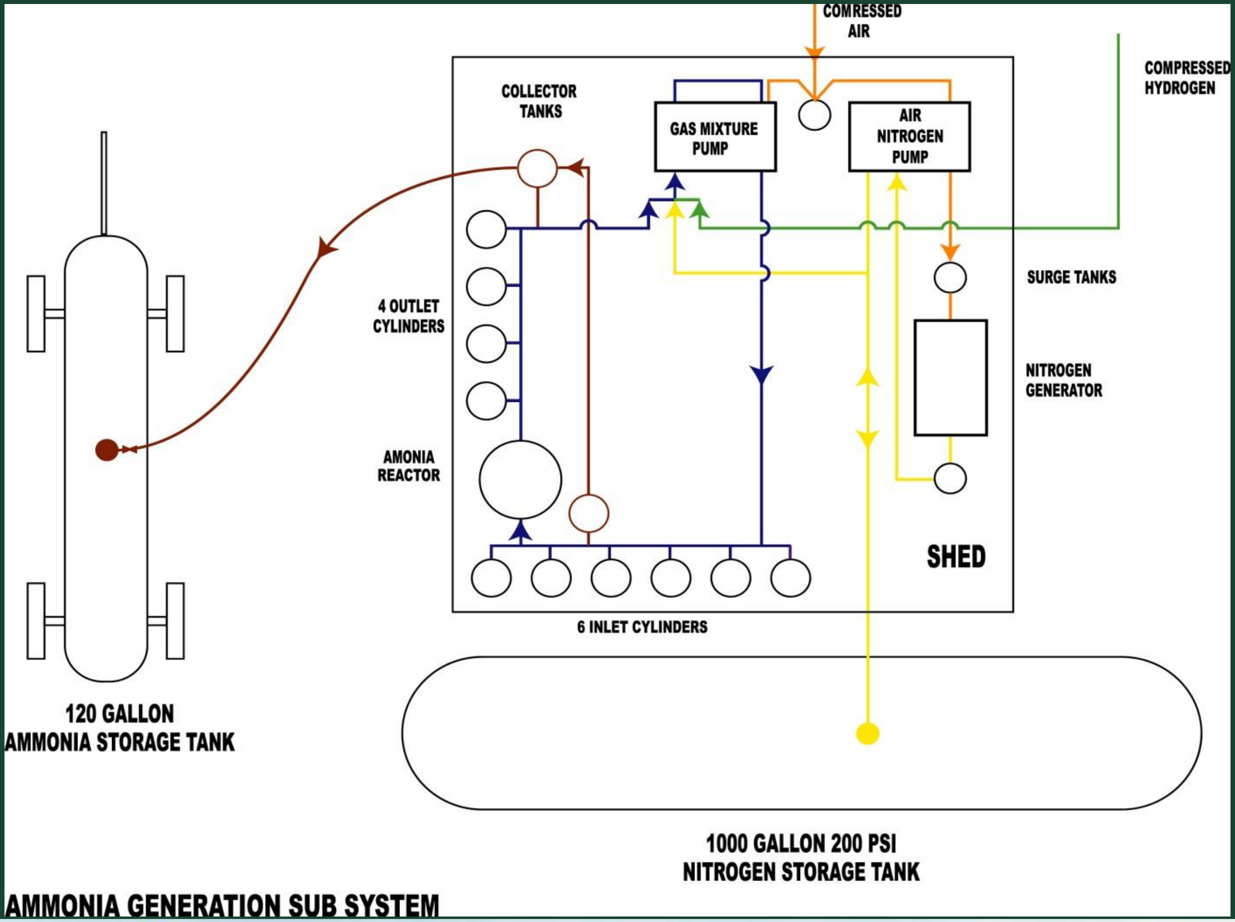
AMMONIA SUBSYSTEM DESIGN



AMMONIA SUBSYSTEM DESIGN



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AMMONIA SUBSYSTEM DESIGN

- 1000 gallon nitrogen storage tank is behind shed, and mobile NH3 storage tank is on near side
- Other hydrogen related components are in background
- NH3 subsystem components are in shed

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AMMONIA SUBSYSTEM DESIGN

- Nitrogen and gas mixture pumps and control valves
- 1st stage of N2 pump compresses air to N2 generator, 2nd stage compresses N2 for storage.
- Gas mixture pump compresses residual gases, N2, and H2 to 3500 psi in inlet cylinders.

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AMMONIA SUBSYSTEM DESIGN

- N2 generator takes 200 psi air and outputs as much a 100 scf/hour.
- Ammonia control box controls pumps and ammonia reactor via sensors and valves.

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AMMONIA SUBSYSTEM DESIGN

- 6 inverted 6000 psi T cylinders hold compressed
  - residual gas
  - nitrogen (29 % of remainder)
  - hydrogen (71% of remainder)

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AMMONIA SUBSYSTEM DESIGN

- A valve allows mixed gases to enter the ammonia reactor where a 300 watt heater initiates the reaction.
- After a short while it is turned off and two valves allow the inlet cylinder gas to flow through the reactor.

AMMONIA SUBSYSTEM DESIGN

- The ammonia vapors and residual gases flow into the outlet cylinders where the NH_3 condenses and flows into a collector tank that is near the floor.

AMMONIA SUBSYSTEM DESIGN

- When the collector tank is full, a valve allows the NH_3 to flow into the 120 gallon ammonia storage tank.
- A full tank will fertilize 3 acres of corn cropland.

AMMONIA SUBSYSTEM DESIGN

- The Instrumentation and Control Assembly monitors the ammonia reactor and cylinder pressures and temperatures, nitrogen and hydrogen pressures, and collector tank levels to control the operation of the air compressor, two pumps, and valves.
- Solar power is used:
  - To operate the Instrumentation and Control Assembly and valve controls.
  - To compress the air driving the pumps.
  - To power the reactor heater.

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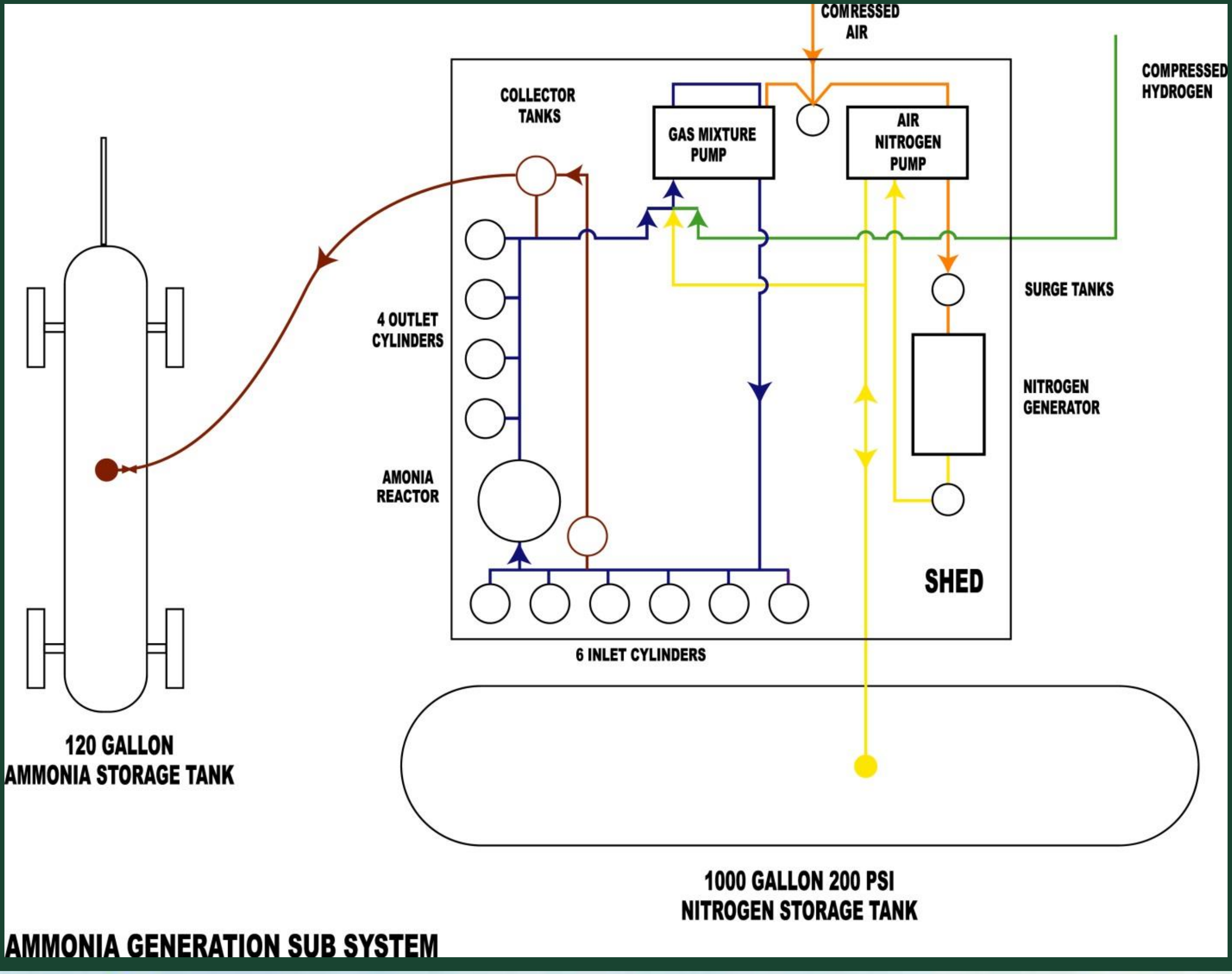
AMMONIA SUBSYSTEM DESIGN



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EXPECTED PERFORMANCE

- The compression of the N2/H2/residual gases to 3500 psi is estimated take 20 hours
- Once the gases are pressurized, the power required is so low that the ammonia generation process can be done any time of day.
- The gases flow through the Ammonia Reactor at 350 degrees C and drops to 1000 psi in about 8 hours.
- We estimate it will take another 12 hours for the ammonia to condense and cylinders to cool to room temperature at 800 psi.
- 4 to 5 gallons will be made per pass.

CONCLUSION

- 100 years ago my grandfathers used horses to farm the land
- My objective: AWARENESS by farmers and the public that
  - Fossil fuels, if available, will be expensive
  - Replacement energy sources will be needed for farming within the next 100 years.
- The generation and use of “C-Free Renew” fuel and fertilizer demonstrates one answer.

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