
RAPHAEL SCHMUECKER
MEMORIAL
SOLAR-
HYDROGEN
SYSTEM

MY SOLAR HYDROGEN AND AMMONIA FUELED TRACTOR AND FERTILIZER SYSTEM

Jay Schmuecker

TOPICS

- Background
- System Description
- Hydrogen Storage
- Ammonia Generation
- System Controls
- System Schematic
- Tractor
- The Result

BACKGROUND

- Corn and soybeans are raised on our 320 acre farm.
- 3000 pounds of hydrogen is needed to replace the fossil fuels used.
  - A pound of hydrogen contains the energy of a little less than two quarts of gasoline.
- 175 pounds of nitrogen/acre is applied to the corn cropland each year.
  - A significant fraction Earth's population is dependent on nitrogen fertilized foods.
  - When ammonia is used, 4500 pounds of hydrogen is applied.

BACKGROUND

- As a memorial to my father, a hydrogen use advocate, on the Iowa farm where he was raised; we have the ability to make from only solar power, water, and air:
  - Hydrogen, for use as a fuel and to make:
  - Ammonia, for use as a fuel and fertilizer
- I'm also doing this to make the public, especially farmers, aware that as fossil energy costs increase, we will have to find other materials for use as farm fuels and fertilizers.
  - We are demonstrating an alternative.

SYSTEM DESCRIPTION

- Three two axis trackers, rated at 8.1 kw total, provide power to inverters.
- Unused power is fed to the grid.
- Short term peak power is drawn from the grid.

C-FREE RENEW

SYSTEM DESCRIPTION

- An electrolyzer rated to provide .2 lbs (40scf) of hydrogen/hr.
- 7kw is required to start the unit, then the output is throttled to match the solar array output.

SYSTEM DESCRIPTION

- Two 5 hp air compressors are used together or separately to drive the pumps.
- Air is routed through drying coils, refrigerant and desiccant dryers.

HYDROGEN STORAGE

- The produced hydrogen is stored at 200 psi in the 1000 gal staging tank at the rear.
- Then it is pumped into the 8 composite storage tanks.

HYDROGEN STORAGE

- Compressed air drives the storage pump that compresses hydrogen to 3600 psi in the storage tanks.
- After storage tank hydrogen has been bleed into the tractor, the tractor pump pumps hydrogen into the four tractor tanks.
- Hydrogen is available to flow to the ammonia generation subsystem

AMMONIA GENERATION

- The ammonia is made in a 9’ X 9’ vented steel enclosure called “The Shed”.

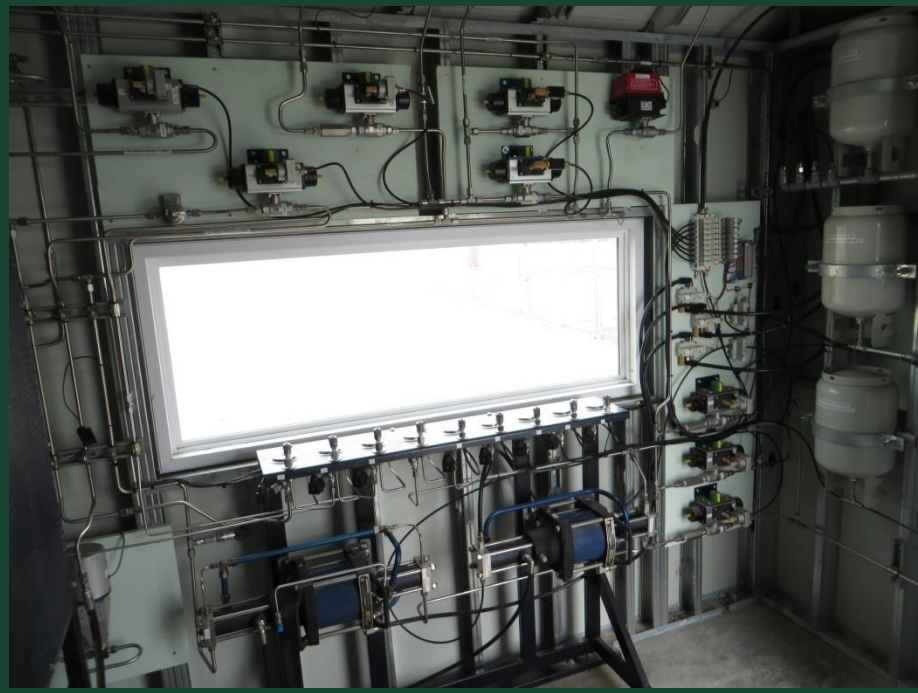
AMMONIA GENERATION

- Compressed air also drives:

  - The Air-Nitrogen pump pumps air into the nitrogen generator and then pumps the nitrogen into the nitrogen storage tank.

  - The Gas Mixture pump compresses nitrogen, hydrogen, and residual gases into the inlet and feed cylinders

- The air operated control valves are above the window.



AMMONIA GENERATION

- The nitrogen is separated from the air and pumped into the 1000 gallon nitrogen storage tank.
- Eye wash is provided, if needed.

AMMONIA GENERATION

- One part nitrogen, three parts hydrogen and residual gases are compressed in the six inlet and feed cylinders to 3500 psi.
- Condensed ammonia is collected in the tank at the bottom.
- The reactor is visible at the right.

AMMONIA GENERATION

- The reactor before being insulated and enclosed.
- Internal temperatures run 450 – 550 degrees C.

AMMONIA GENERATION

- Electrical heaters around the reactor and on the top incoming gas line heat the gases to start the reaction.
- Once the reaction is started, the inlet gases are routed in the bottom of the reactor where the exit gases preheat it.
- As the inlet cylinders are emptied, the high reactor pressure is maintained by the gas mixture pump and feed cylinder.

AMMONIA GENERATION

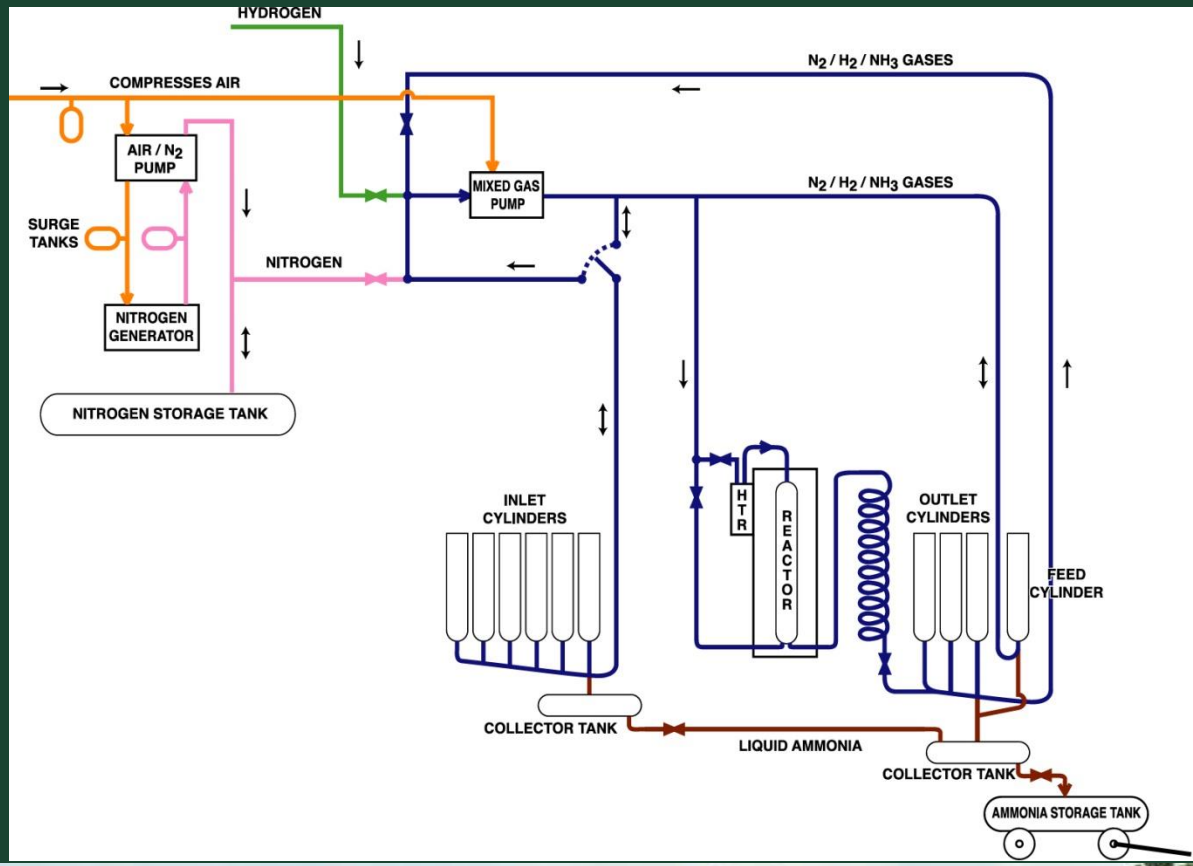
- The mixture flows through the cooling coil and into the three left outlet cylinders where the ammonia condenses.
- The right cylinder, the feed cylinder, is pumped to 3500 psi to maintain reactor efficiency as the inlet cylinder pressure falls to 350 psi.
- All ammonia is collected in the collector tank at the bottom.

AMMONIA GENERATION

- About 18 hours are needed to load the inlet cylinders, and about 11 hours to react the gases to make 6 gallons of ammonia.
- The liquid ammonia is bled from the collector tanks to the mini-nurse tank.
  - Ammonia is pumped into the tractor tank using special hoses.
  - The full nurse tank will fertilize 3 acres of corn cropland.

AMMONIA GENERATION

- System controlled by automated valves.
- Ammonia containing components can be vented through top Shed vent if needed.

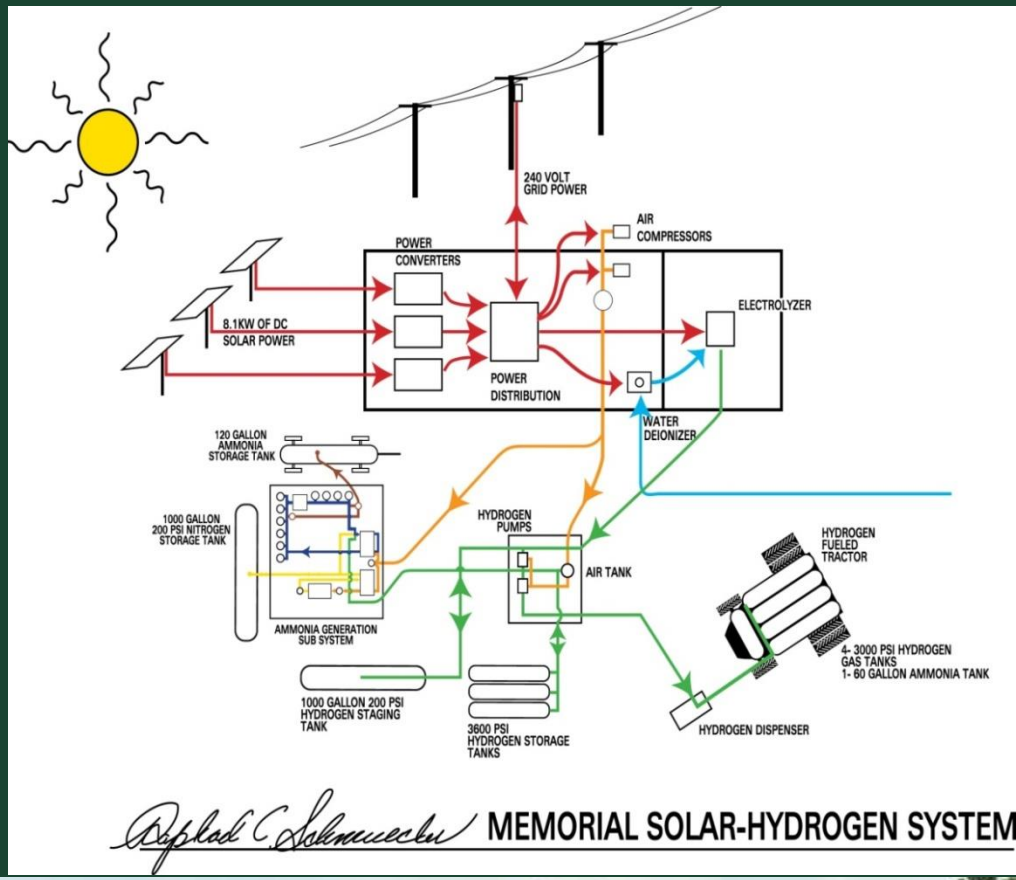


SYSTEM CONTROLS

- The automated Instrumentation and Control Subsystem monitors and controls all the components.
  - Solar array and component performance can be monitored remotely.

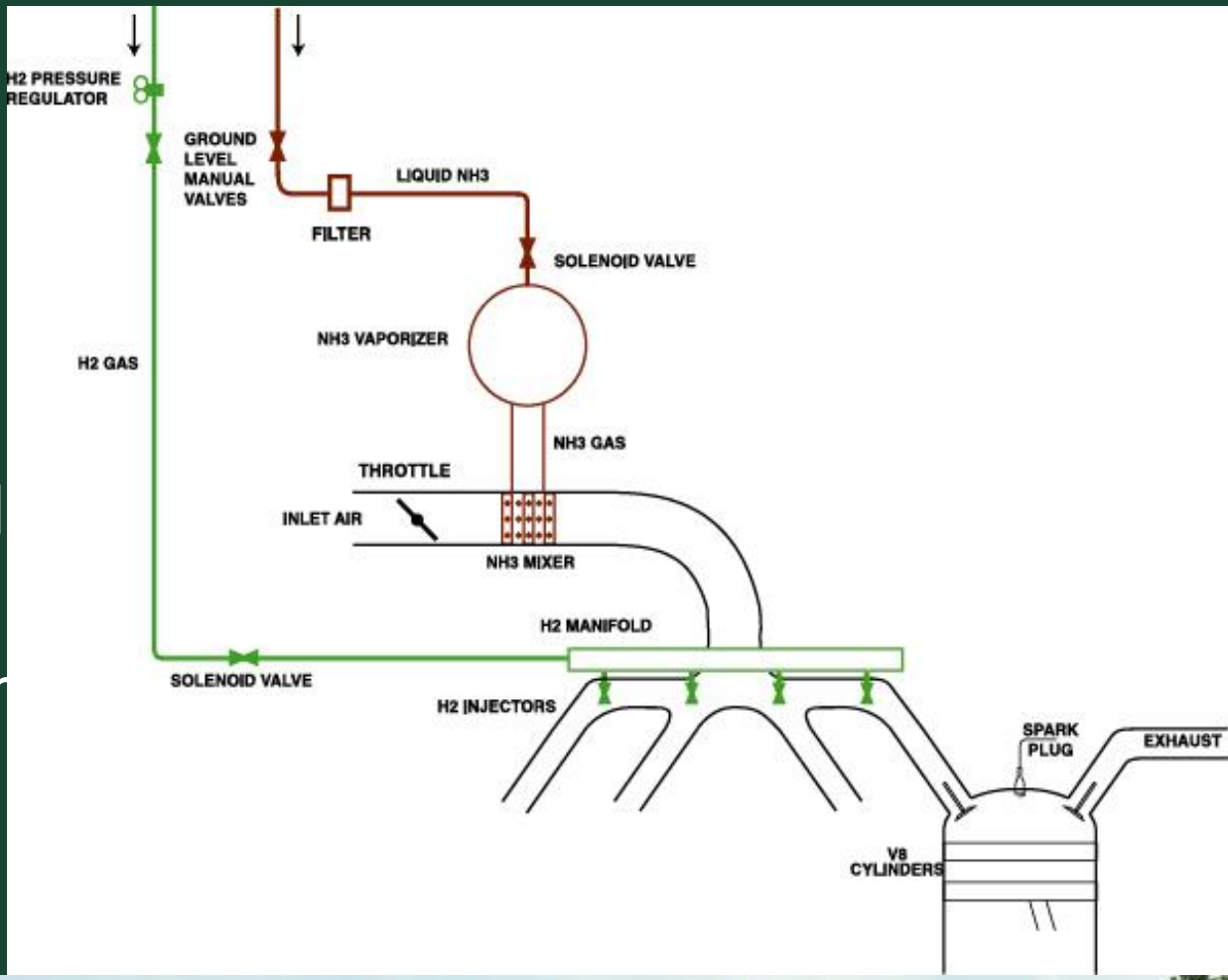
SYSTEM SCHEMATIC

- The generation and use of these on-site renewably made fuels and fertilizer are C-FREE RENEW (Carbon Emission Free Renewable) Technology



TRACTOR

- A Hydrogen Engine Center 572 cu. in. 13.5 to 1 compression ration V-8 engine is fueled by hydrogen or a mixture of hydrogen and ammonia.

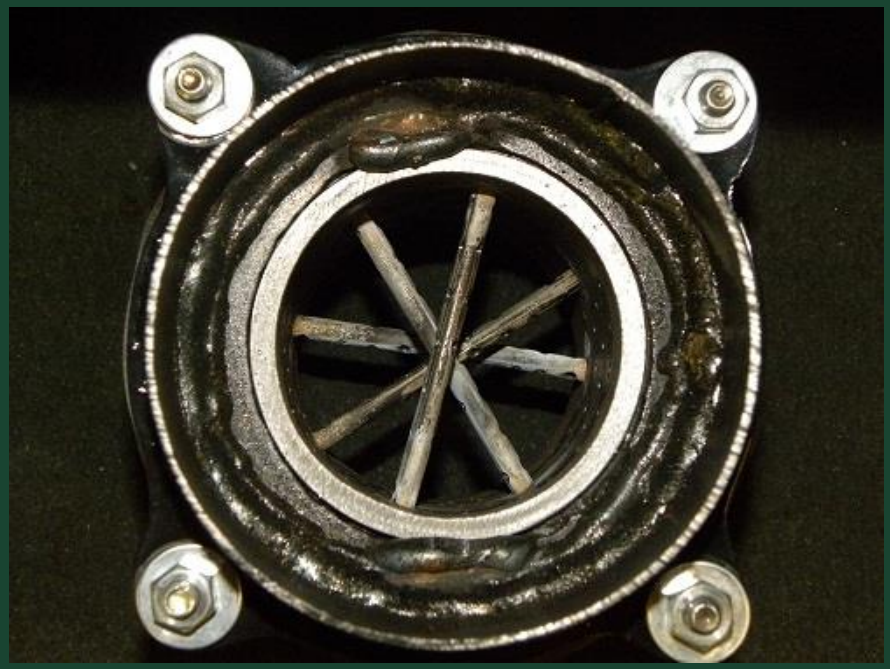


TRACTOR

- Hydrogen enters the engine through injectors in the intake manifold and it is ignited by spark plugs.

TRACTOR

- After the engine is started and before shutdown, a solenoid valve allows liquid ammonia into the vaporizer.
- The resulting gases flow through the mixer where they are blended with the engine intake air.



TRACTOR

- The energy contained in the 60 gallon ammonia tank is equivalent to that contained in two of the 21” X 10’ long 3000 psi hydrogen storage tanks.

THE RESULT:


C-FREE RENEW
Changing the way we think about farm fuels.