RAPHAEL SCHMUECKER MEMORIAL

SOLAR-HYDROGEN SYSTEM

SOLAR HYDROGEN AND AMMONIA SYSTEM STATUS

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TOPICS

- Objectives
- System Overview
- Chronology
- Tractor Utilization
- Tractor in Operation
- Recent Developments
- Ammonia Reactor Venting
- New Ammonia Reactor
- Future Plans
- Questions

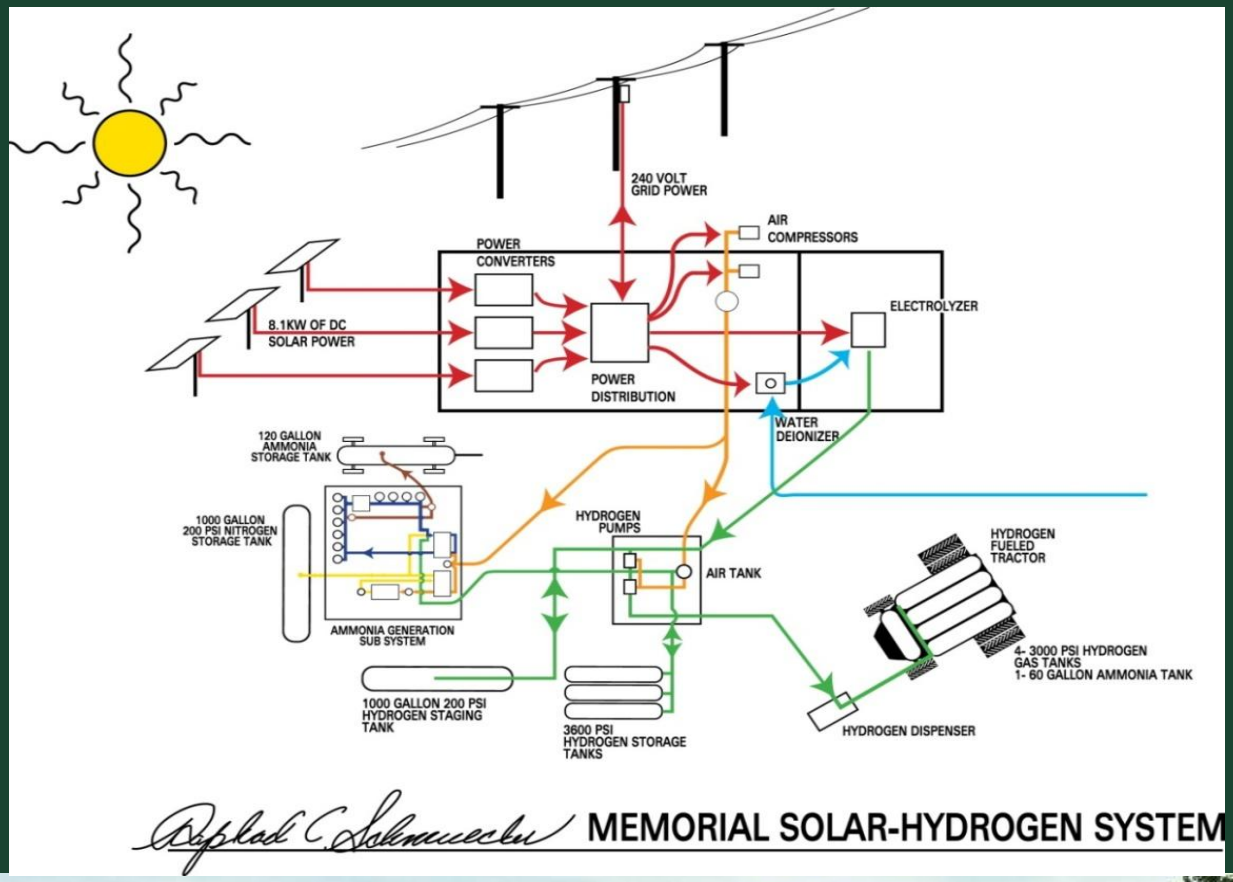
OBJECTIVES

- We are not selling a product.
- Demonstrate a system of generation, storage and transportability of clean energy in the form of ammonia; made from solar.
- Demonstrate that we have current technology to produce clean (non-CO2 producing), renewable, fuel and fertilizer to run a farm.

SYSTEM OVERVIEW

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

- Fuel and fertilizer from sunlight, water and air.



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CHRONOLOGY

- Design started in 2009
- Hydrogen production started in 2012
- Tractor delivered in December 2014
- Ammonia capability design began 2014
- Ammonia production started mid 2015
- High purity Nitrogen generator installed 2016
- Improved Ammonia production process with better conversion mid 2016
- Plan to install a new cold shell reactor by year end

TRACTOR UTILIZATION

- Demonstrations
- Ammonia vaporizer materials change
- Field Use
- Dyno Testing showed 85 net hp

FIELD USE OF THE TRACTOR

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RECENT DEVELOPMENTS

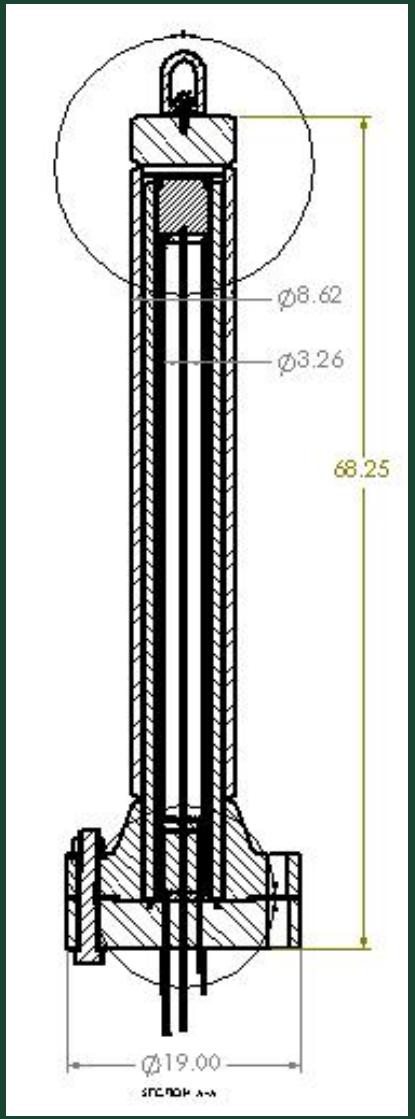
- New nitrogen generator capable of 99.995% purity.
- Reconfiguration of the ammonia subsystem compression pumps resulted in nearly doubling their flow output, reducing the batch charge time and energy requirement per ammonia batch.
- Ammonia system flow path and process control improved providing lower energy usage and a higher conversion rate.
  Approximately 12 gallons produced per batch.
  Approximately 12 hours to charge and 8 hours to produce a batch.
- Ammonia reactor venting

REACTOR VENTING

- Excess heat on the pressure vessel shell with high pressure in the reactor caused a pressure wall breach and vent, with fire.
- Non-explosive fire
- Safety factors designed and built into the system prevented any significant damage to anything except the reactor.

NEW REACTOR

- Cold shell design with internal catalyst preheaters and an external gas heat exchanger
- Safer design, heat is contained using internal preheaters
- More efficient operation
- Serviceability
- Three phases:
  initial compression,
  reaction concurrent with
  maintaining reactor pressure
  by recirculation of gases
  and heat recapture



FUTURE PLANS

- Finalize the ammonia reactor design, fabricate, and install
- Optimize the system efficiency and gather statistical data
- Install a wind power generator
  - To enable the current system to be powered longer
- Better fuel control for tractor engine in development
- Continue educating the public of the need to
  - Develop other energy sources to replace the declining supply of fossil fuels
  - Use renewable energy for farmers in a co-operative environment
  - Use in remote areas and third world countries.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QUESTIONS