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# On Board Storage Technology Hurdles & Actions

October 9, 2006



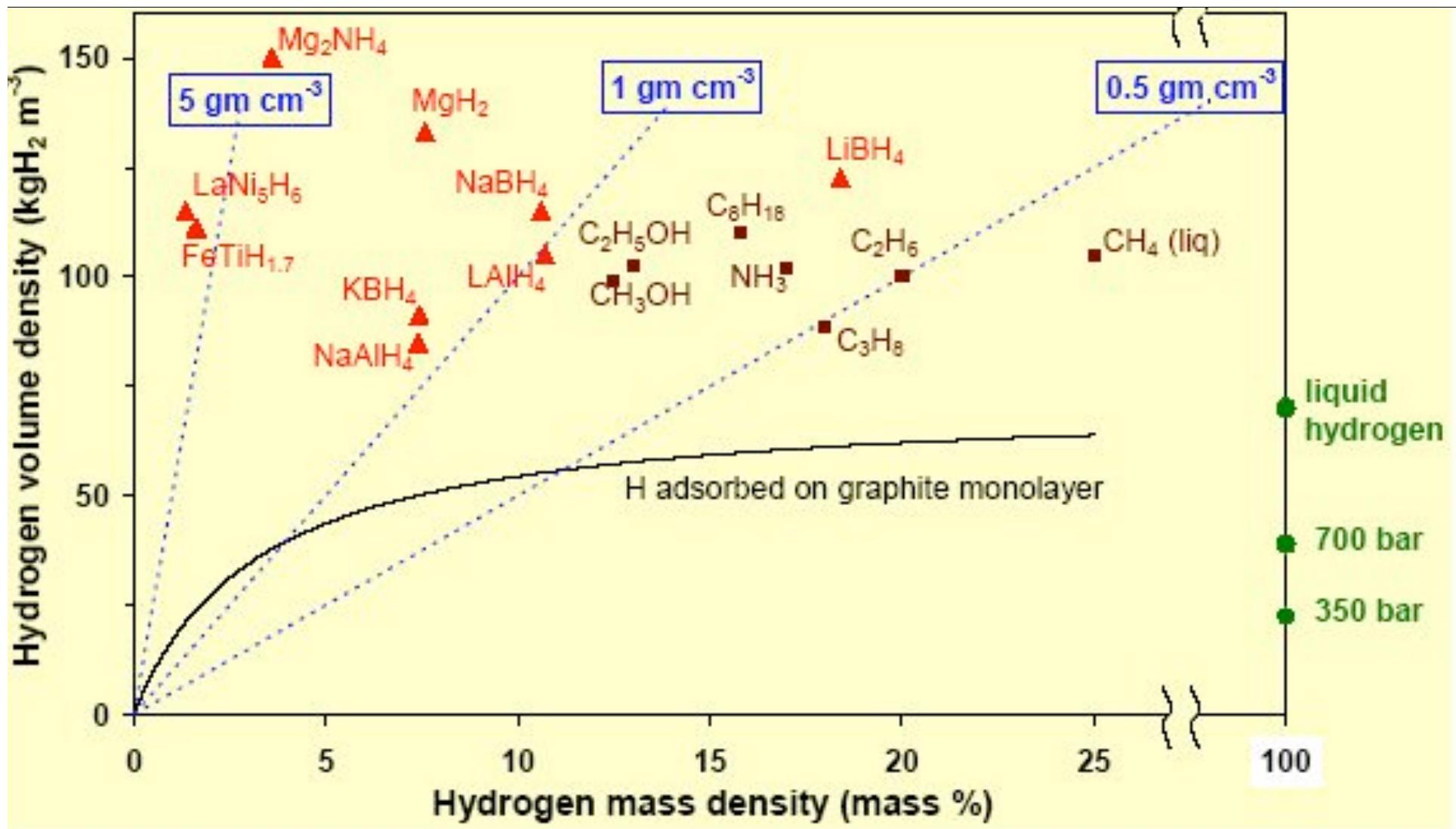
Since  
1959  
  
Ammonia  
Met  
Today's  
DOE  
Hydrogen  
Fuel  
Spec's

## The Biggest Hurdle

Alternative fuels that:

- Work with your engine now.
- Competitively priced
- Don't have to be widely available
- Plug in Hybrid's, not shown, work in your home.





**Basic Research Needs for the Hydrogen Economy**, Report on the Basic Energy Sciences Workshop on Hydrogen Production, Storage, and Use (DOE May 2003)

# Infrastructure –Problem Scale

- Domestic Gas Stations ~100,000 declining (Exxon 45,000 worldwide)
- Deliver >250,000 gallons gasoline per month\*. ~41 Ton NH3/day
- US gasoline consumption is ~6x world NH3 Capacity (KBR).
- US NH3 Pipeline Capacity 1MMTon/yr could supply 66 gas stations.

# Well to Wheels Efficiency

- Fuel Production efficiency
  - Refineries – 90% petroleum to gasoline
  - KAAP NH<sub>3</sub> Production 7GCal/MT >80%
- Electrolysis
  - Power Plant ~40%
  - Cell 56% to 73% (NREL)
- Automotive ICE 25%

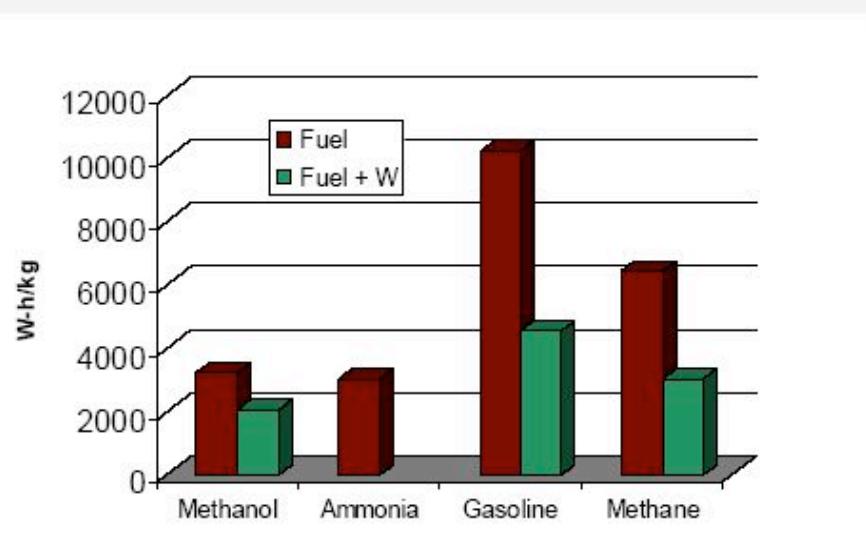
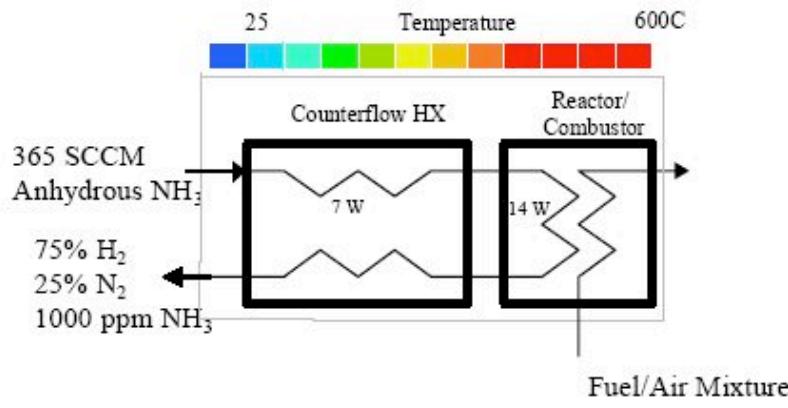
# Technology Hurdles

- Multi fuel capacity & ICEs
- Crackers weight, volume and quick start
- On board storage of fuels
- Real On board storage hydrogen density
- Well to Wheels Efficiency.
- Renewables

# Energy Storage Density

- Package and process weight & volume are important.
- Liquid processing generally simpler than solids.
- Thermolysis of solids generally yields higher energy density than hydrolysis and is easier to regenerate.

# Intelligent Energy Information



NH<sub>3</sub>-Based Hydrogen Generator



Microreactor  
for NH<sub>3</sub>  
Decomposition

Package & Process weight & volume - crucial issues

# Intelligent Energy Information



Fiber-composite tank formed with safe-storage material

## Challenges:

Design for Fast Fill

## Features:

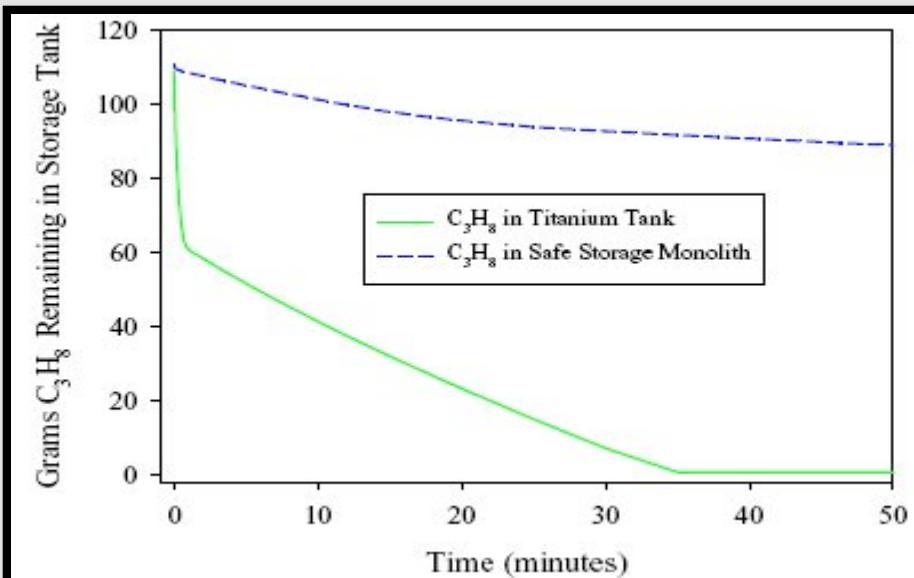
Kevlar foam filled Safe Tank.

120 gm tank stores 500gm NH<sub>3</sub>

NH<sub>3</sub> Energy Density 17.5% → 12%.

Withstands 1000 psig

200 kg/m<sup>3</sup> & 85% porosity → 75% NH<sub>3</sub> storage density

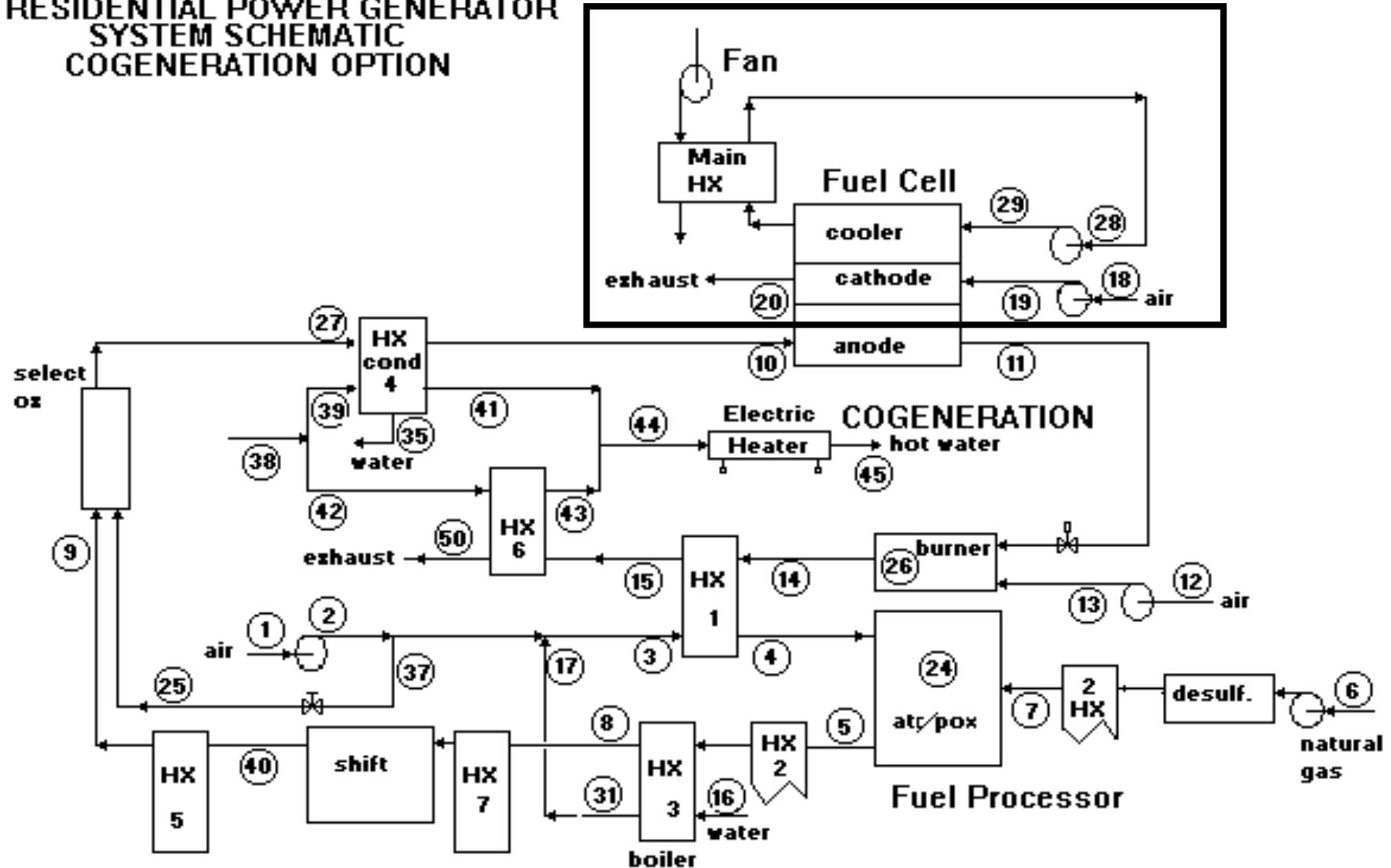


# Panel Members

- **Don Hagge**, Oregon Sustainable Energy - Guanidine--A Sustainable, Flexible Fuel and Safe Storage Material
- **Tue Johannessen**, Amminex A/S - “Solidified” ammonia as energy storage material for fuel cell applications
- **Patrick Desrochers**, University of Central Arkansas -Reversible Surface Storage of Ammonia

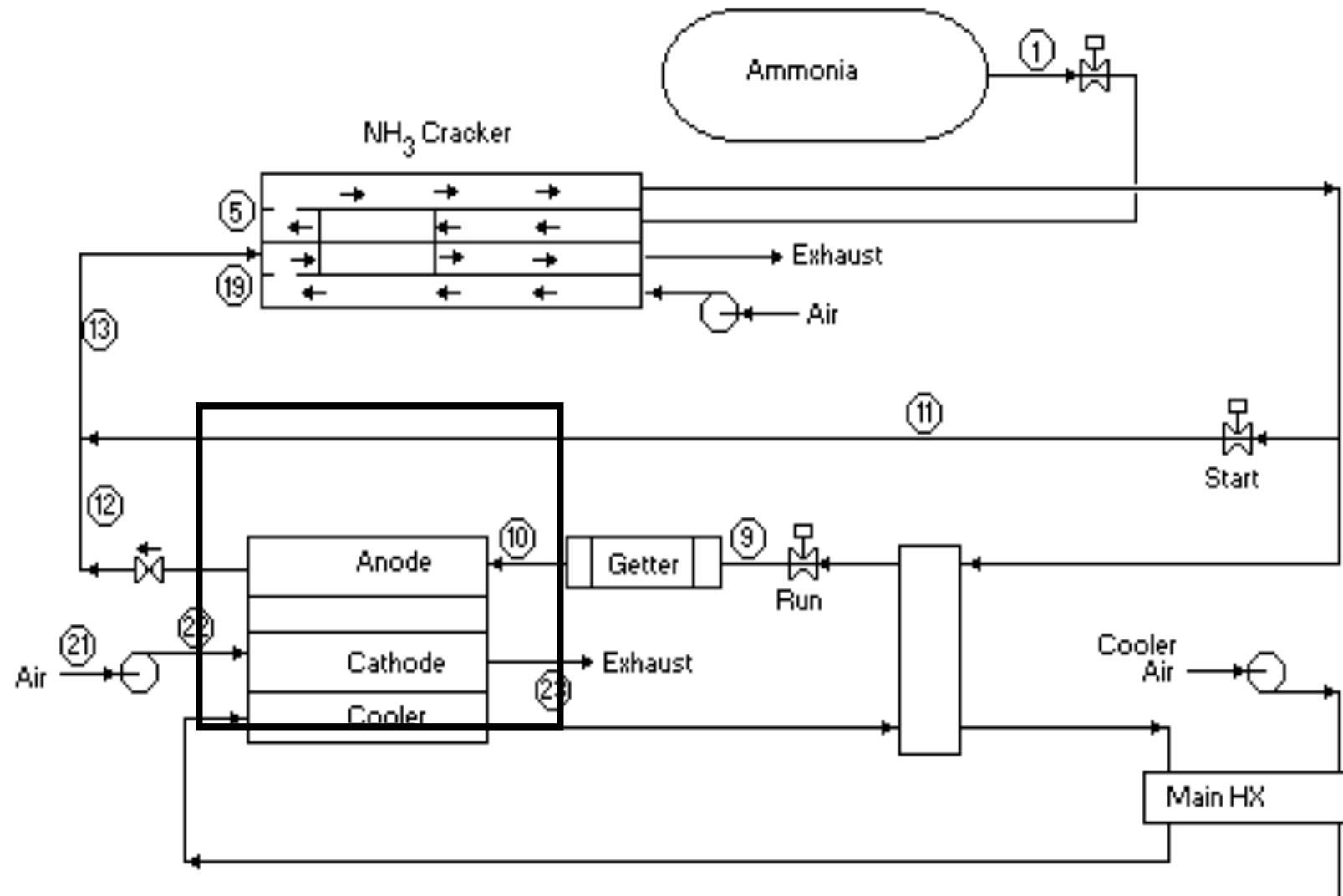
# Hydrocarbon Reformers are Complex

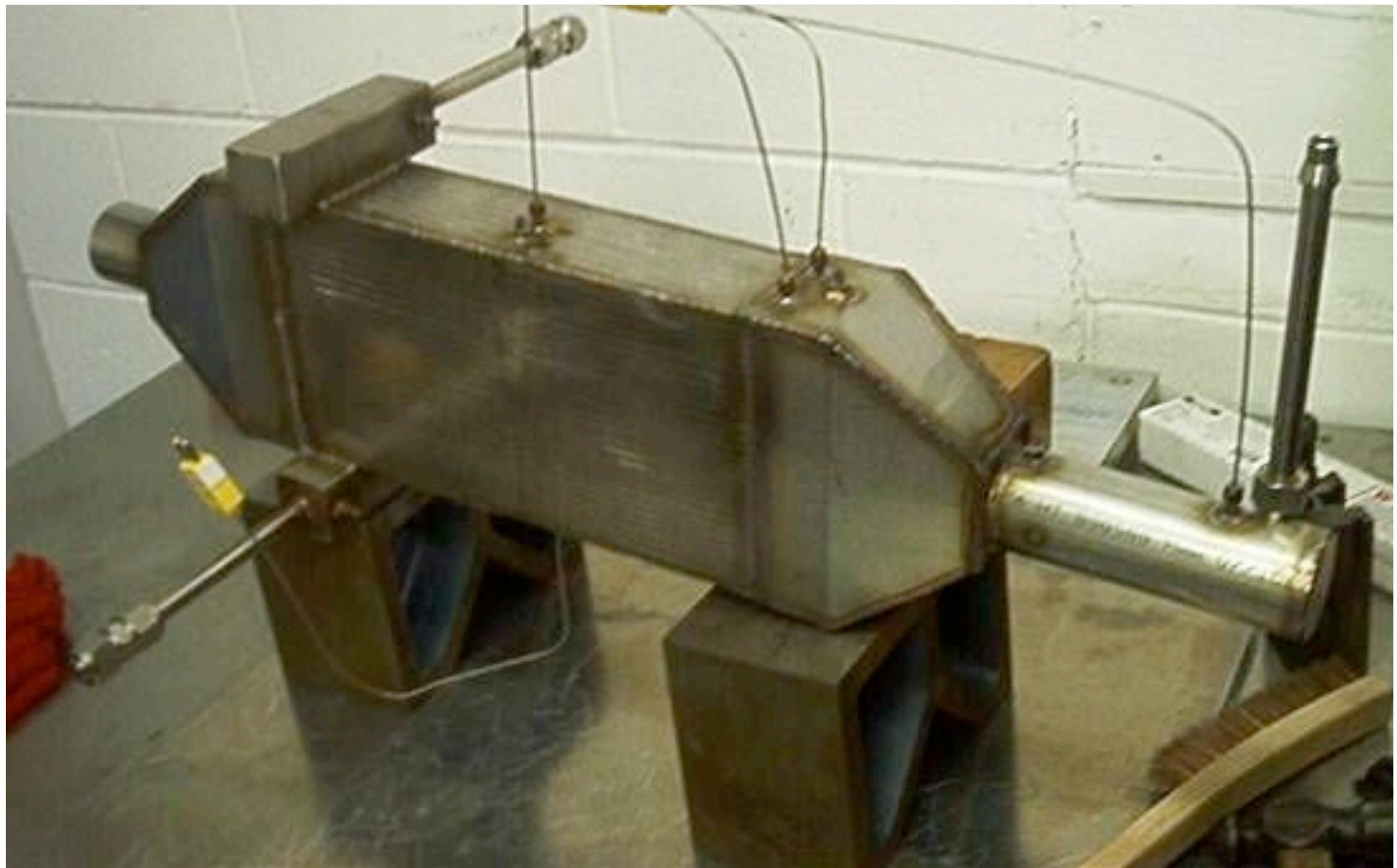
Analytic Energy Systems  
RESIDENTIAL POWER GENERATOR  
SYSTEM SCHEMATIC  
COGENERATION OPTION



# Crackers are Simple

## Ammonia Cracker Fuel Cell Power Plant





Analytic Power -All Brazed, Iron Catalyzed, 5kW Cracker