HEC

Hydrogen Engine Center, Inc.

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Ammonia Fuel Network

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HEC

Oxx Power

Topic for Discussion

Electrical support for
small scale
distributed ammonia production

Issues to be discussed

- Electrical energy requirements
- Hydrogen gas for fuel
  - hydrogen from electrolysis
  - hydrogen from Industrial processes
  - hydrogen from well
- Ammonia waste gas recovery for fuel
- System performance

Electrical energy requirements

- 90 kW electrical power is required for a 5 ton per day plant
  - Electrical power needed is 480V 3 phase 60 hz
- The main power requirement is for compression
- The second power requirement is for the system controls

Hydrogen fuel from electrolysis

- Electrolysis is often considered for hydrogen generation and has been used to store wind and solar energy
- Hydrogen is very pure and is stored under high pressure.
- University of Minnesota has used this technique in their ammonia from wind project. They returned the power to the grid and did not use the waste gases.

Hydrogen fuel from electrolysis

- Picture of University of Minnesota unit
  - “eat more chikin”

Hydrogen fuel from industrial processes

- Many industrial processes have waste hydrogen. The most notable is the chlor-alkali industry
- The hydrogen is not pure. Typical gas composition is 97% H_2 , 3% O_2 and some chlorine
- Hydrogen pressure is very low
- The hydrogen must be compressed to at least 30 psi for fuel injection use
- 4 to 10 MW can be generated from waste hydrogen at the average chlor-alkali plant

Hydrogen fuel from industrial processes

- Picture of gensets for chlor-alkali industry

Hydrogen from a hydrogen well

- **YES**, hydrogen wells exist. Unicorns?
- Denis Joseph Briere, P. Eng., Chapman Petroleum
  - Please take a bow
- Discovered in Mali, home of Timbuktu, aka Tombouctou
- Hydrogen field approximately 50 miles north of Bamako, a city of about 1.8 million
- No electrical power grid nearby
- Enough hydrogen for 100 Megawatts of Electrical power generation

Mali

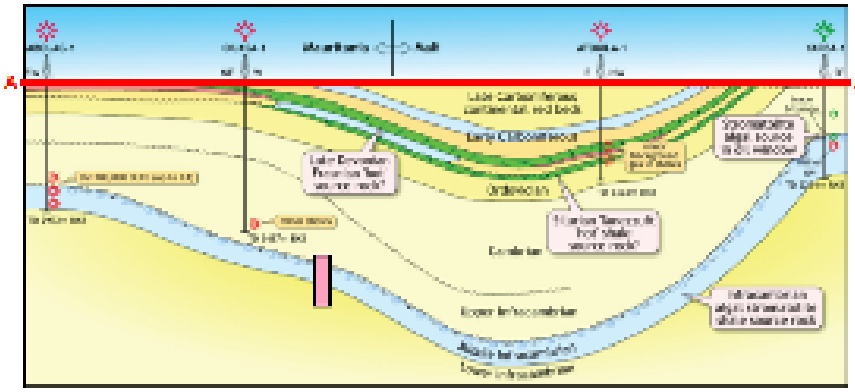
- Landlocked
- No oil

Timbuktu, aka Tombouctou

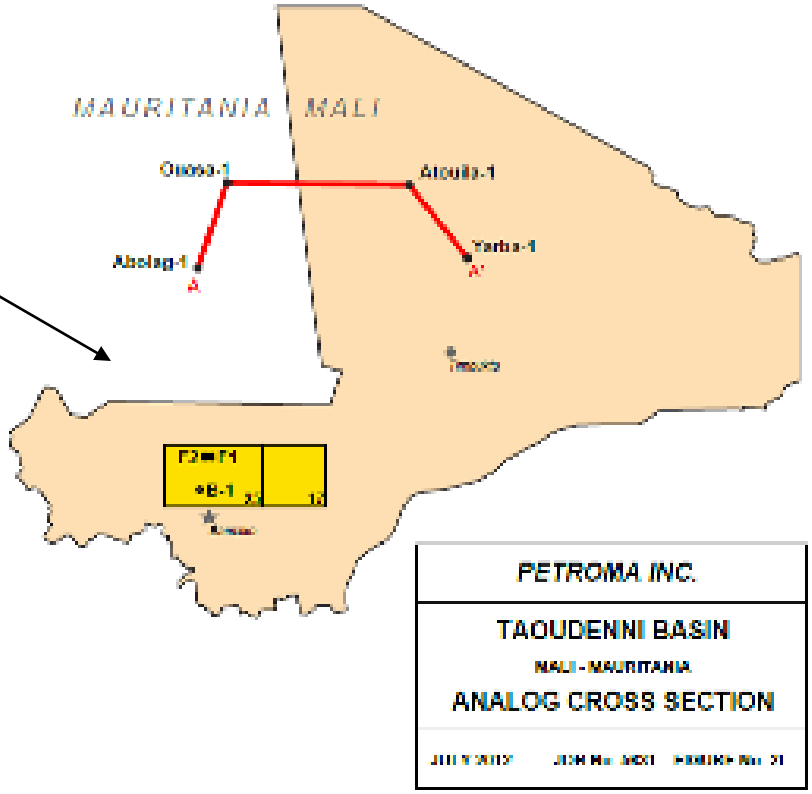
Now you know

Hydrogen gas field

See Denis for details

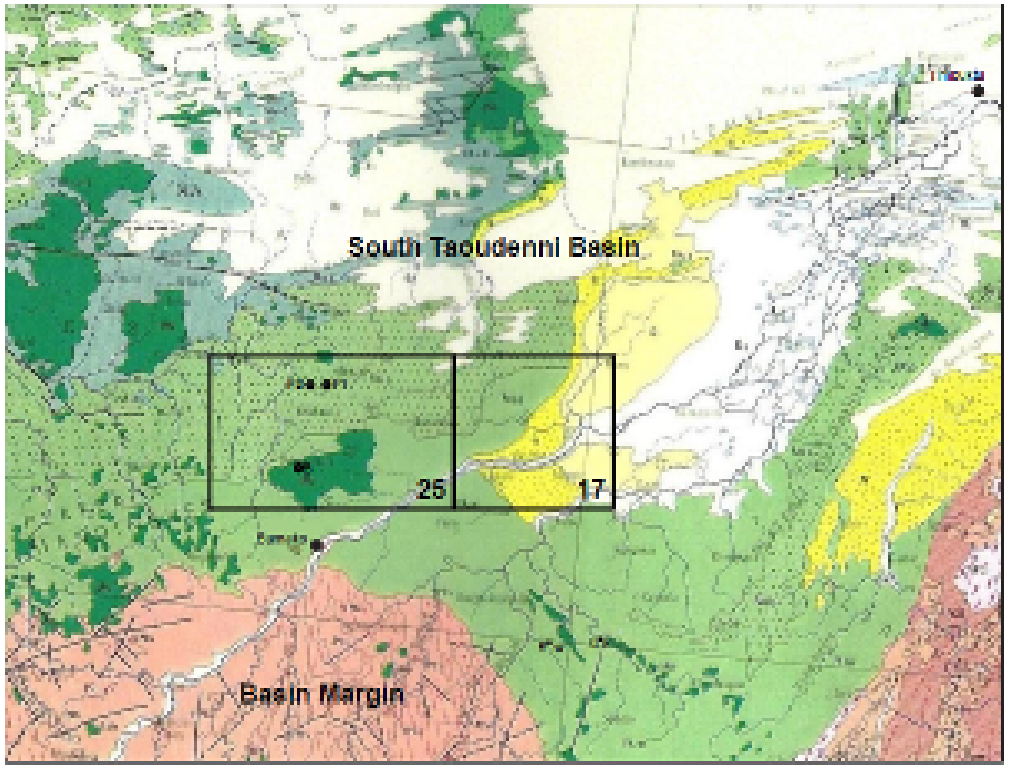


Stratigraphic Interval Covered by Block 25



Hydrogen gas field

Denis can explain



Hydrogen well gas analysis

- Hydrogen 99.37%
- Nitrogen .20%
- Methane .42%
- Ethane .01%

- Total Volume in cubic feet >1.4×10^{11}

That's a lot of hydrogen and very pure

Hydrogen from a hydrogen well

- Unit shipped to Mali, Black Mamba proofed

note the yellow and blue wire covers, **Not Black**

note the fine screening, **Snake proof**

Black Mamba proof genset in Mali

Picture before building was put up

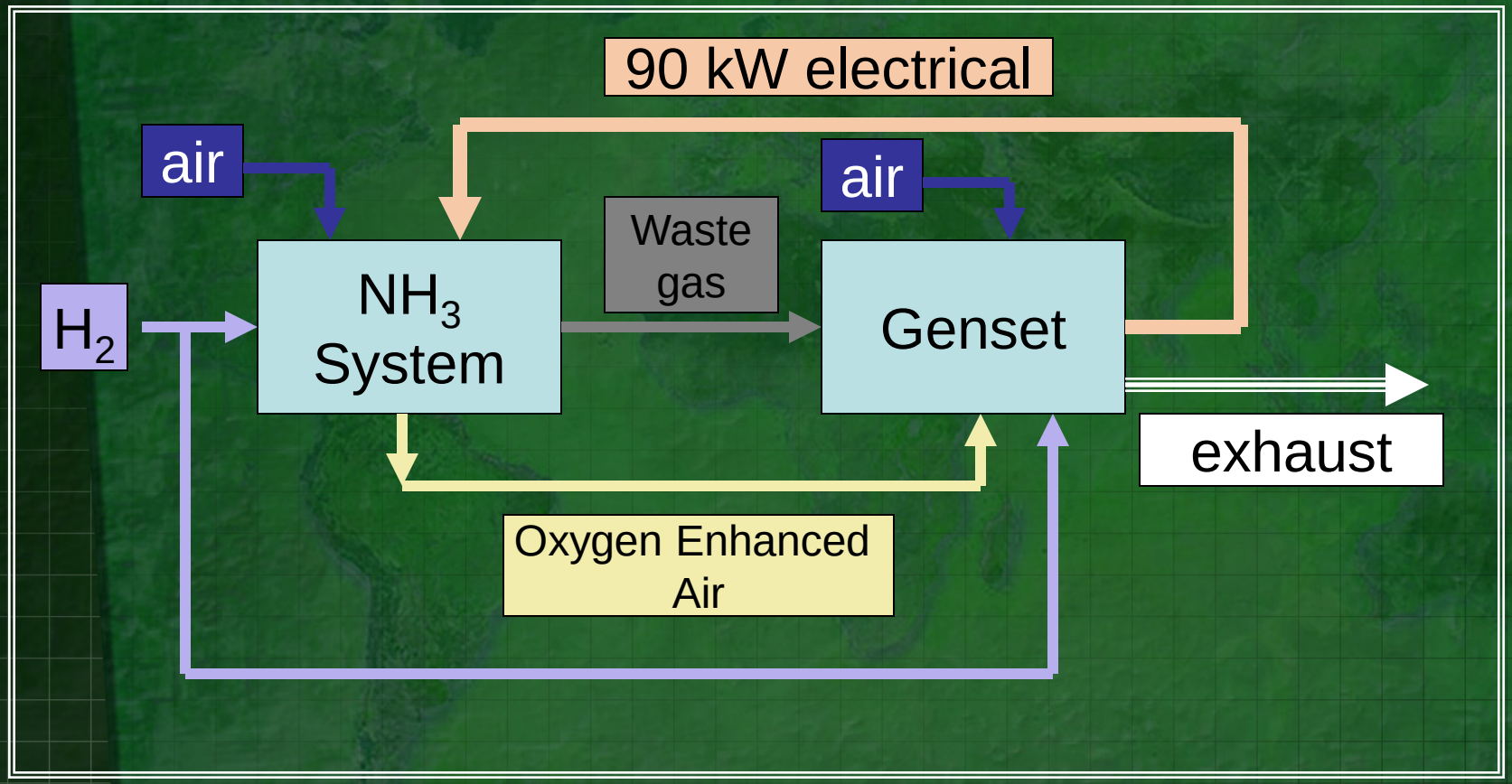
Ammonia waste gas recovery for fuel

- The NH_3 system has a waste gas stream that contains 15 to 20% hydrogen and 5 to 10% ammonia. The remaining gas is nitrogen.

- The pressure swing absorption unit has a waste stream that is about 75% oxygen and the rest nitrogen.

System performance

Block diagram of system



Waste gas plus hydrogen fuel

- Set waste gas to 7.5% ammonia and 17.5% hydrogen (leaves 75% nitrogen)
- Add hydrogen and Oxygen Enhanced Air (OEA) to system to achieve .5 EQR
- Waste hydrogen adds to the fuel
- Waste ammonia adds to the fuel, but slows flame velocity, so timing changes are required
- Waste nitrogen leans dilutes the fuel

Waste gas plus hydrogen fuel

- Waste nitrogen dilution is over come by adding OEA
- Additional oxygen is added to eliminate the need for a turbo-charger.
  - The oxygen added has the same effect as boosting the intake pressure, i.e.; doubling the amount of oxygen will allow you to approximately double the amount of power
  - The additional oxygen requires retuning of the engine
- Exhaust gas from ICE is water and nitrogen
  - Very low NOx

*Patent Pending system design

Summary

- Hydrogen to make ammonia exists
- Systems exist to make ammonia
- Ammonia is the best way to store hydrogen
- Nitrogen is needed to help feed the world and ammonia is the best source
- Ammonia can be used as a fuel and be used to generate power
- HEC can provide the electrical power to operate anywhere in the world.

Thank You!

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