

# An International Ammonia Fuel R&D Agenda/Wrap-Up

John Holbrook

*AmmPower* LLC

# Video Segment

## Ammonia Fuel— X-15 Rocket Plane

# Video Segment

## Utsira W2H—Norsk Hydro




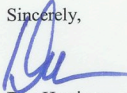
## Main components

Wind turbine	600 kW
Hydrogen engine	55 kW
Fuel cell	10 kW
Electrolyser	10 Nm <sup>3</sup> /h, 48 kW
Compressor	5,5 kW
Hydrogen storage	2400 Nm <sup>3</sup> , 200 bar
Flywheel	200 kW, 5 kWh
Battery	35 kWh
Master synchronous machine	100 kVA

# Ammonia Fuel Growth

- AF I (2004), Des Moines, ~20 attendees, 8 Presentations
- AF II (2005), Chicago/Argonne
  - 50 registrants/33 organizations/13 Presentations
  - ~10 from ANL (6 registered)
  - 1 federal employee
- AF III (2006), Denver/NREL
  - ~65 attendees/49 organizations/23 Presentations
  - 34 new organizations
  - No ANL attendees (?)
  - No federal employees

# Letter from Congressman

<small>DOC HASTINGS 4TH DISTRICT, WASHINGTON</small>		<small>WASHINGTON, DC 20515 (202) 225-5816 2715 SAINT ANDREWS LOOP, SUITE PASCO, WA 99301 (509) 543-9396 302 EAST CHESTNUT YAKIMA, WA 98901 (509) 452-3243</small>
<small>CHAIRMAN, COMMITTEE ON STANDARDS OF OFFICIAL CONDUCT</small>		
<small>COMMITTEE ON RULES CHAIRMAN, SUBCOMMITTEE ON RULES AND ORGANIZATION OF THE HOUSE</small>	<b>Congress of the United States</b> <b>House of Representatives</b>	
	September 26, 2006	
 Dr. John Holbrook 1161 Viewmoor Court Richland, WA 99352		
Dear John:		
<p>Thank you for taking the time to update me on the conference, <i>Ammonia, The key to U.S. energy independence</i>. I appreciate having the benefit of your views on this issue.</p> <p>I appreciate your updating me on the role that ammonia can play in our nation's alternative energy future. I believe that it is vital that our nation take steps now to reduce our dependence on foreign energy sources by investing in alternative energy. As you may be aware, this year I supported the House Energy and Water Appropriations Act that strengthens basic scientific research by \$4.132 billion. This funding will help support federal efforts to develop clean energy technologies, including biomass, hydrogen, solar, wind, and clean coal.</p> <p>Again, thank you for taking the time to contact me. Please do not hesitate to contact me if I may be of assistance.</p>		
<p>Sincerely,</p>  <p>Doc Hastings Member of Congress</p>		
DH:mc		

# Letter from Congressman

“...I appreciate your updating me on the role that ammonia can play in our nation’s energy future. I believe that it is vital that our nation take steps now to reduce our dependence on foreign energy sources by investing in alternative energy...”

Congressman Doc Hastings, 9/26/06

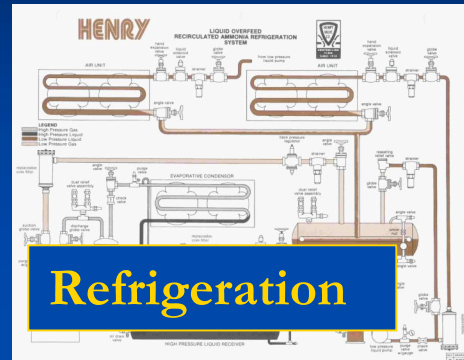


# Ammonia—All Around Us



Fertilizer

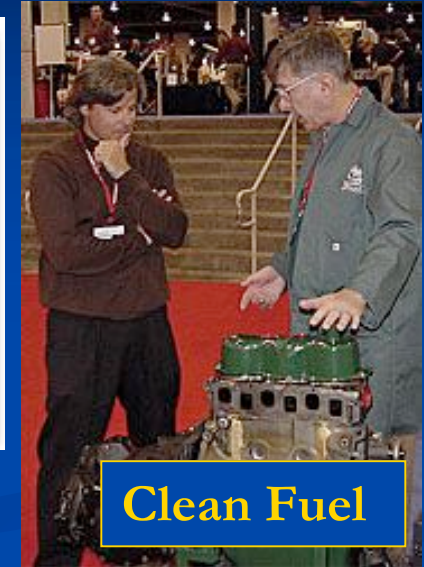
IOWA STATE UNIVERSITY



Refrigeration



Metal Heat Treatment



Clean Fuel



Baking

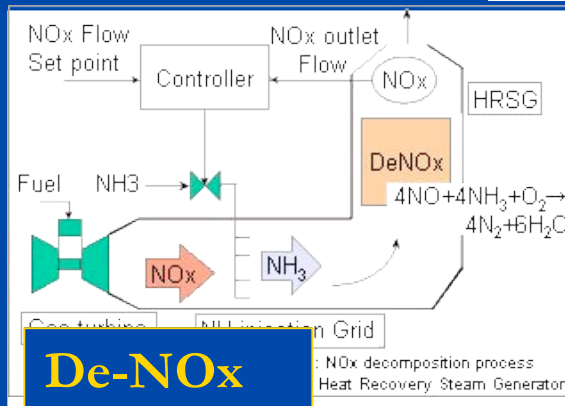
After Bite *The Itch Eraser*



First Aid

## Also

- Nitric acid production (Ostwald process)
- Soda ash production (Solvay process)
- Wastewater treatment—chloramine
- Semiconductor cleaning
- Plastics/cosmetics manufacture
- Smelling salts



De-NOx

: NOx decomposition process  
Heat Recovery Steam Generator



Cleaning





# Ammonia is a Friendly Fuel





# What Have We Heard?

- Ammonia is an energy-dense, clean-burning fuel and hydrogen carrier
- Toxicity/safety issues are prime focus, but are believed on par with other fuels, and manageable
- Production by NG, coal, nuclear, and renewables
- US (NG) domestic production down ~50%
- Commercial ammonia ICE availability in early 2007
- Storage and delivery infrastructure devoted to fertilizer

# Ammonia Fuel R&D Priorities

Priority	Name	Average Ranking	Range	Number of #1's
1	Safe Storage/Delivery	3.0	1 - 9	8
2	Safety Technology	3.3	1 - 9	11
3	Ammonia from Renewables	3.5	1 - 9	5
4	Internal Combustion Engines	4.1	1 - 9	4
5	Direct Ammonia Fuel Cells	4.3	1 - 9	4
6	Reforming Technology (on-board)	4.5	1 - 8	3
7	Innovative Ammonia Production (non Haber-Bosch)	4.6	1 - 9	4
8	(Clean) Ammonia Production from Coal	5.5	1 - 10	1
9	Reforming Technology (large scale)	6.2	2 - 10	- (3 #2's)

# The Write-In Winner

Priority	Name	Average Ranking	Range	Number of #1's
Top	Integrated Demonstrations	1.0	1 - 1	5

# Suggested Demonstrations

- Ammonia Highway
  - Fuel Cell (e.g. Apollo, FC Energy/Versa Power)
  - ICE (Iowa?)
- Zero-Emissions ICE
- Crash-Safe On-Board Storage
- Renewable To Ammonia (R2A)
- Energy Independent Farm (City? State?)
- Other...



# Current Significant Ammonia R&D Funding

Federal	State	Private Sector/ Associations / VC
• DOE ~\$100K	• Minn \$5300K	• Excel > 0
• DoD (ARO) 125K	• Iowa ~0	• HEC/Sawtelle > 0
• DOT -0-	• California -0-	• HEC other >> 0
• USDA -0-	• Oregon ?	• Hydra Fuel Cell > 0
• EPA -0-	• Other -0-	• U Minn 500K
• Labor/OSHA -0-		• Amminex >> 0?
• NSF 275K		• OSE ?
• Other -0-		

# The “Others”

- Priority = 9 → Anything but coal! Possibly combined production systems ie.) electricity, ammonia, and urea from renewables.
- Priority = 1 → EPA certification of engine emissions (or non-emissions as the case may be)
- Priority = 1 → Long term operation of any fuel cell with cracked ammonia
- Priority = 2 → Designation of ammonia as an Alternative Fuel by DOE!
- Priority = 5 → Nuclear ammonia production
- Priority = 2 → External combustion engines

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# Impediments

- Toxicity/Safety
- Public/Decision-maker Awareness/Support
- (Lack of) Infrastructure/Availability
- Oil Conspiracy
- Technological/Demonstrations

# Impediments—Toxicity/Safety (11)

- Releases in confined spaces
- Public perception of ammonia safety problems
- Perceived safety issues
- Toxicity
- Toxicity and lack of support by decision makers
- Toxicity
- Litigious society and acute toxicity
- Toxicity concerns that lead to a lack of support by decision or policy makers
- ...ammonia's toxicity...
- public concern over toxicity
- Need to convince people mentally. Pointing to the safe use of Ammonia in refrigerators and at ice-rings use on farms. Explaining that ammonia is opposed because it smells badly, which is a safety aspect

# Impediments—Public/Decision-maker Awareness/Support (11)

- Public acceptance
- Public's never heard of it, and virtually no demonstrations of its use in engines in recent history
- Lack of support by decision makers
- Ignorance on the part of the public and policymakers of the opportunities that ammonia holds
- Toxicity and lack of support by decision makers
- Toxicity concerns that lead to a lack of support by decision or policy makers
- Lack of knowledge by decision makers and the need of a constituency to promote ammonia agenda through the bureaucracy
- Ignorance of demonstrated viability and safe performance in an ICE or FC application
- Lack of support by decision or policy-makers
- Limited supplies and lack of support
- For Joe Average, ammonia is a well-kept secret. If Joe wanted to convert to ammonia tomorrow, Home Depot wouldn't be able to help him, and he wouldn't have a clue where to buy fuel, much less an ammonia "gas can" to take ammonia home to fill up his ammonia powered lawn mower. Of course none of these products and services will become available until Joe demands them (and policy makers and underwriter's laboratories approve)



# Impediments—Infrastructure/Availability (5)

- Lack of available vehicles and/or end users
- The major obstacles will be the cost of building the number of plants that would be required to supply just 20% of the US motor transportation fuel requirements and the distribution system required to get the product to the consumer. The existing petroleum product infrastructure will not be available for ammonia product movement
- Limited supplies and lack of support
- Infrastructure (availability)
- Nationwide availability and cost

# Impediments—Oil Conspiracy (3)

- The biggest problem is that without a floor on the price of oil, the mid east countries can render a capital investment in alternative fuels worthless
- Cheap diesel and gasoline
- Incumbent technology and fuels and momentum to accept hydrogen as a given pathway

# Impediments—Technological/Demonstrations (3)

- Demonstrations of integrated system(s) of renewables, transmission, firming storage, end use in cars and buses
- Ignorance of demonstrated viability and safe performance in an ICE or FC application
- (Need for) direct ammonia fuel cells

# A Bold Statement

“If I were to be rewarded for success and reprimanded for failure, I would pursue ammonia as the most promising hydrogen carrier to meet the 2015 FreedomCar goals.”

George Parks, ConocoPhillips, Calgary AB,  
9/25/2006

# Ammonia Network Decisions

- Do we want to continue to meet?
- Do we want to continue to meet annually?
- Do we want to “formalize” the network?
  - Web Site
  - Newsletter
  - Officials
  - Annual Dues
  - T-Shirts, coffee mugs...
- Do we want to seek official status for ammonia as an alternate fuel?
  - Volunteers?
  - Backers?

# EPAct Definition of “Alternate Fuel”

"alternative fuel" means methanol, denatured ethanol, and other alcohols; mixtures containing 85 percent or more ... by volume of methanol, denatured ethanol, and other alcohols with gasoline or other fuels; natural gas; liquefied petroleum gas; hydrogen; coal-derived liquid fuels; fuels (other than alcohol) derived from biological materials; electricity (including electricity from solar energy); and any other fuel the Secretary determines, by rule, is substantially not petroleum and would yield substantial energy security benefits and substantial environmental benefits



# Ammonia as “Alternate Fuel”--Steps

- Formal Petition
  - Well to Wheels Analysis
  - Greenhouse Gas Analysis
  - Energy Independence Analysis
  - Data
- Respond to inquiries
- Wait

# Benefits as “Alternate Fuel” Designation (preliminary)

- 40 % tax credit on additional cost of fleet vehicle usage
- Ammonia will be required to be listed in public documents as alternate fuel
- Could qualify for production subsidy, e.g. ethanol
- Would put ammonia on level playing field in fleet proposals to meet the federal requirement for alternative fuel fleet vehicles
- (Hopefully) R&D and Demonstrations would be encouraged and funding set aside

# Upcoming Events

- SBIR Season, Oct-Dec 2006
- National Hydrogen Association, March 2007, San Antonio (abstracts due Oct 19, 2006)
- Spring-summer 2007, HEC/S&RMS Irrigation Pumps
- Windpower07, June 2007, Los Angeles (deadline past, Holbrook/Leighty submission)
- Ammonia Fuel IV ?
  - Oct 2007
  - Where?

**Thank You!**