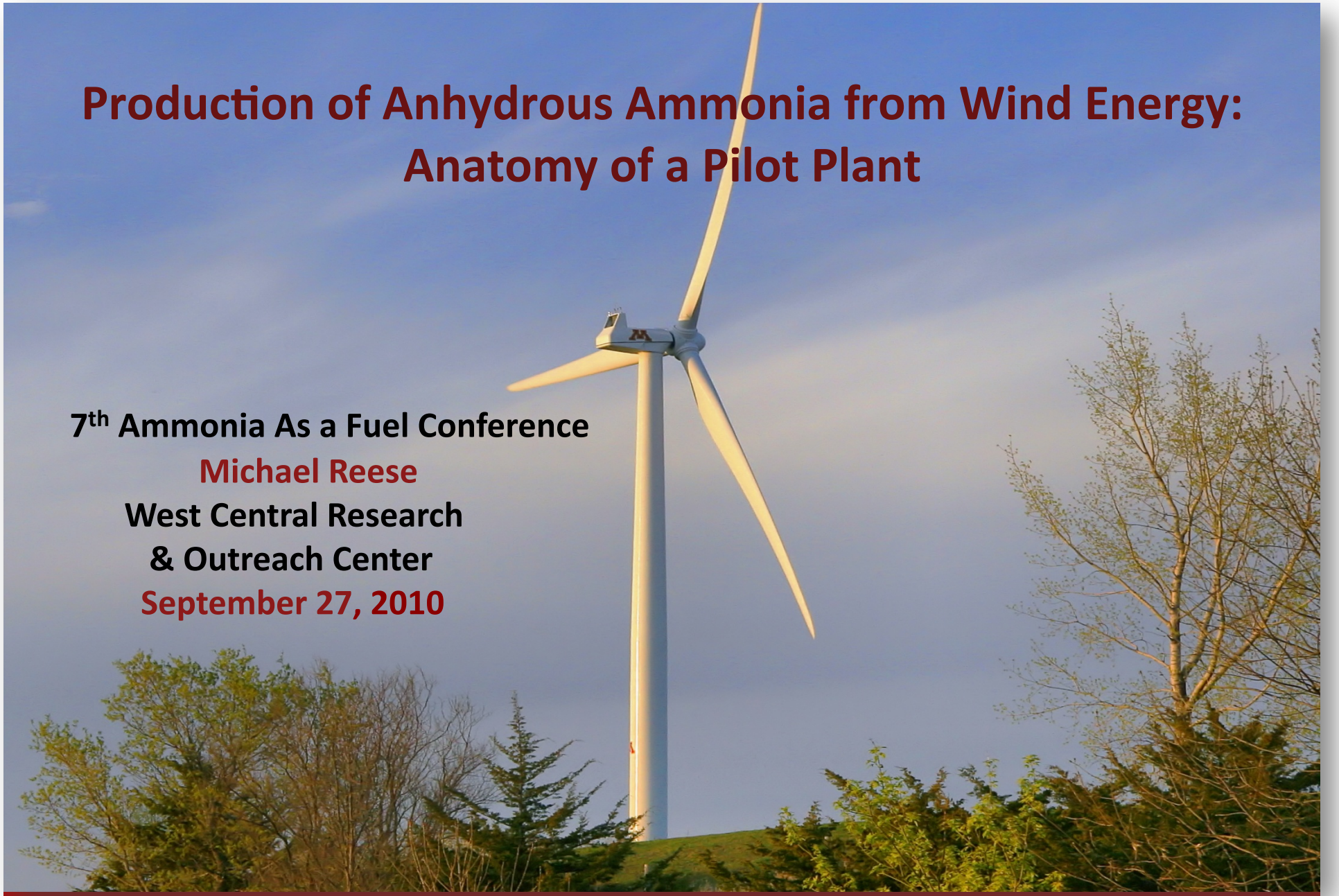
Production of Anhydrous Ammonia from Wind Energy: Anatomy of a Pilot Plant



7th Ammonia As a Fuel Conference

Michael Reese
West Central Research
& Outreach Center

September 27, 2010

University of Minnesota
Driven to Discover℠

University of Minnesota

Community-Scale Renewable Energy Systems:

- Hybrid Wind System - WCROC
- Biomass Gasification System - UMM
- Renewable and Efficient Energy Systems for Farms, Homes, and Business - WCROC

- Focus on local or community ownership to foster economic growth
- Practical production systems with research and demonstration platforms
- "Destination Renewable Energy Research & Demonstration Systems"
- Identify opportunities and conduct research to overcome barriers

WCROC Solar Thermal Evacuated Tube System

WCROC Solar Thermal Flat Plate System – Solar Skies

USFW 20 kW Solar PV System

UMM Biomass Gasification System Biomass Receiving

UMM Biomass Gasification System

KMW Biomass Gasifier

English Boiler

Feedstock Issues:

Field to Facility Supply
- Harvest
- Transport
- Storage

Utilization
- Flexibility

Sustainability
- Soil Carbon
- Soil Erosion
- Nutrient removal
- Emissions and ash

Eco-services
- Bird / wildlife habitat

Economics

Chippewa Valley Ethanol Coop Biomass Gasification System

Cob Harvest Demonstration and Evaluation

Vermeer CCX Cob Harvestor

Cob Harvest Demonstration and Evaluation

Ceres Cob Harvestor

West River Dairy 1.5 MW Anaerobic Digester

Green Buildings

- **Buildings in the US account for ~40% of the nation's energy use**

Features:

Building Durability / Longevity

Passive Solar / Day lighting

Renewable Energy

Efficient Lighting – CFs & LEDs

High Quality Windows & Glazing

Insulation

Water Conservation

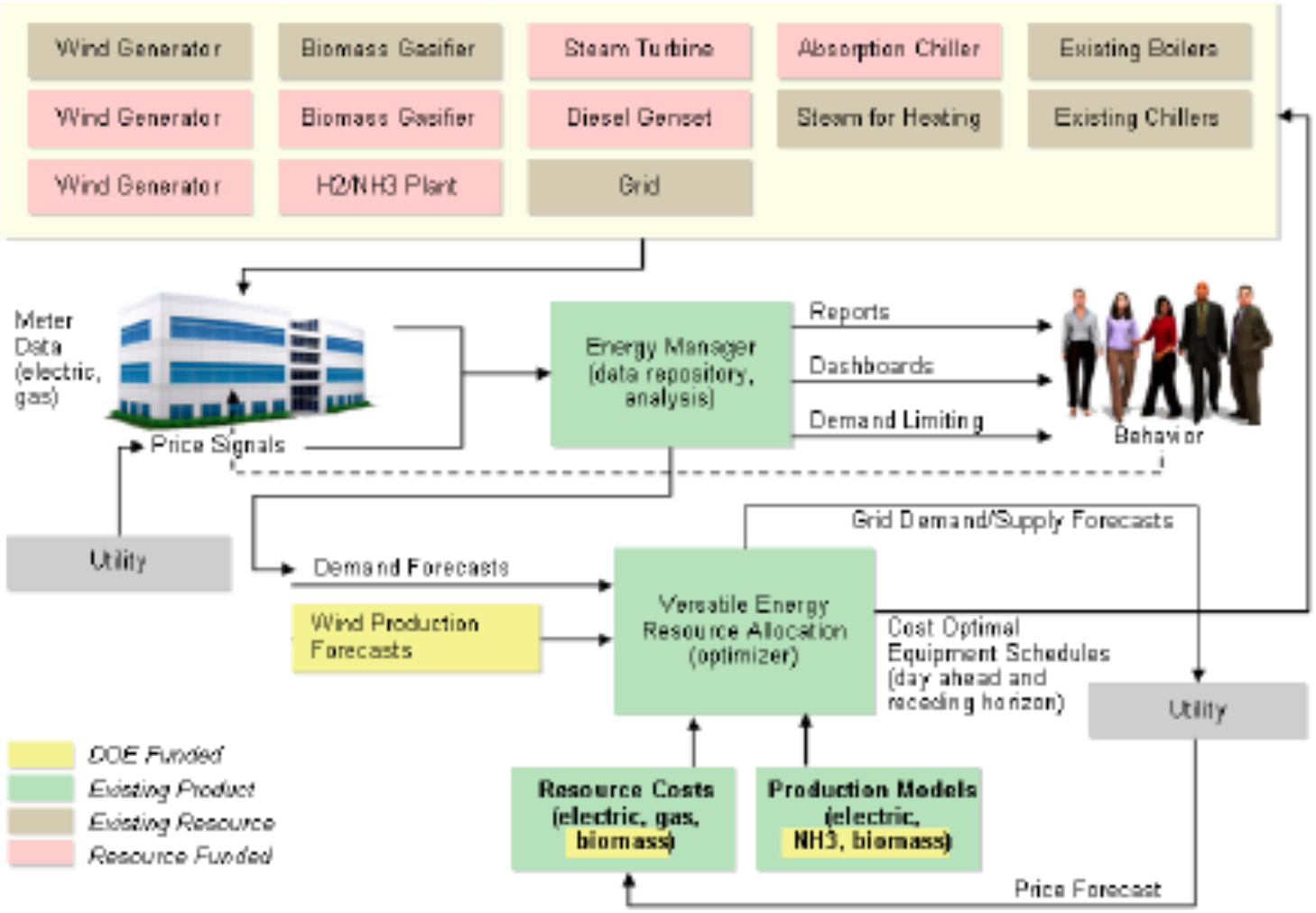
Recycling

Healthy environment

WCROC 1.65 MW Wind Turbine

Grant County Wind, LLC – 20 MW

Renewable Energy Integration – Smart Microgrid



Courtesy Honeywell Automation, Inc., 2009

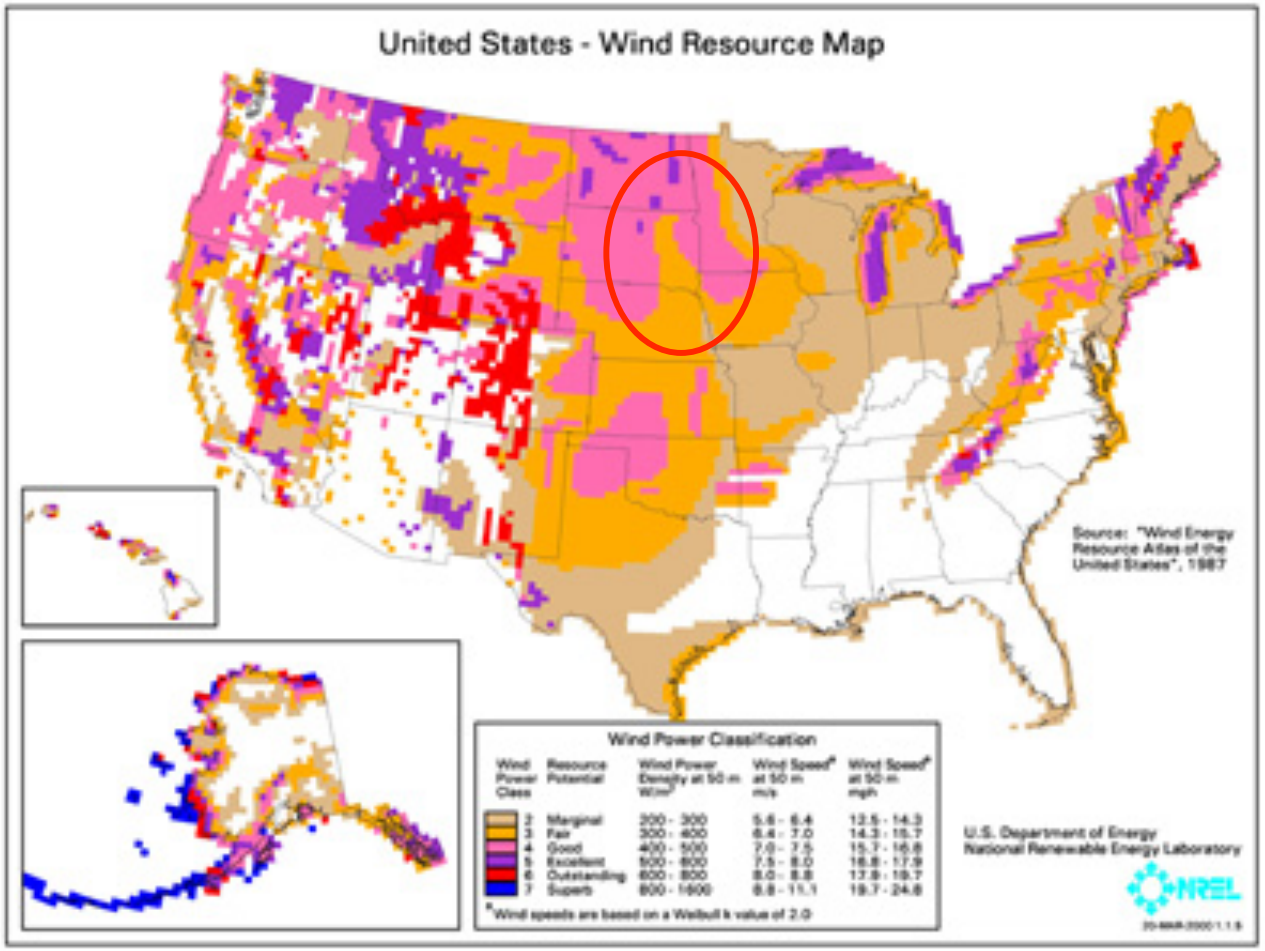
Hybrid Wind System

Elegant Concept~

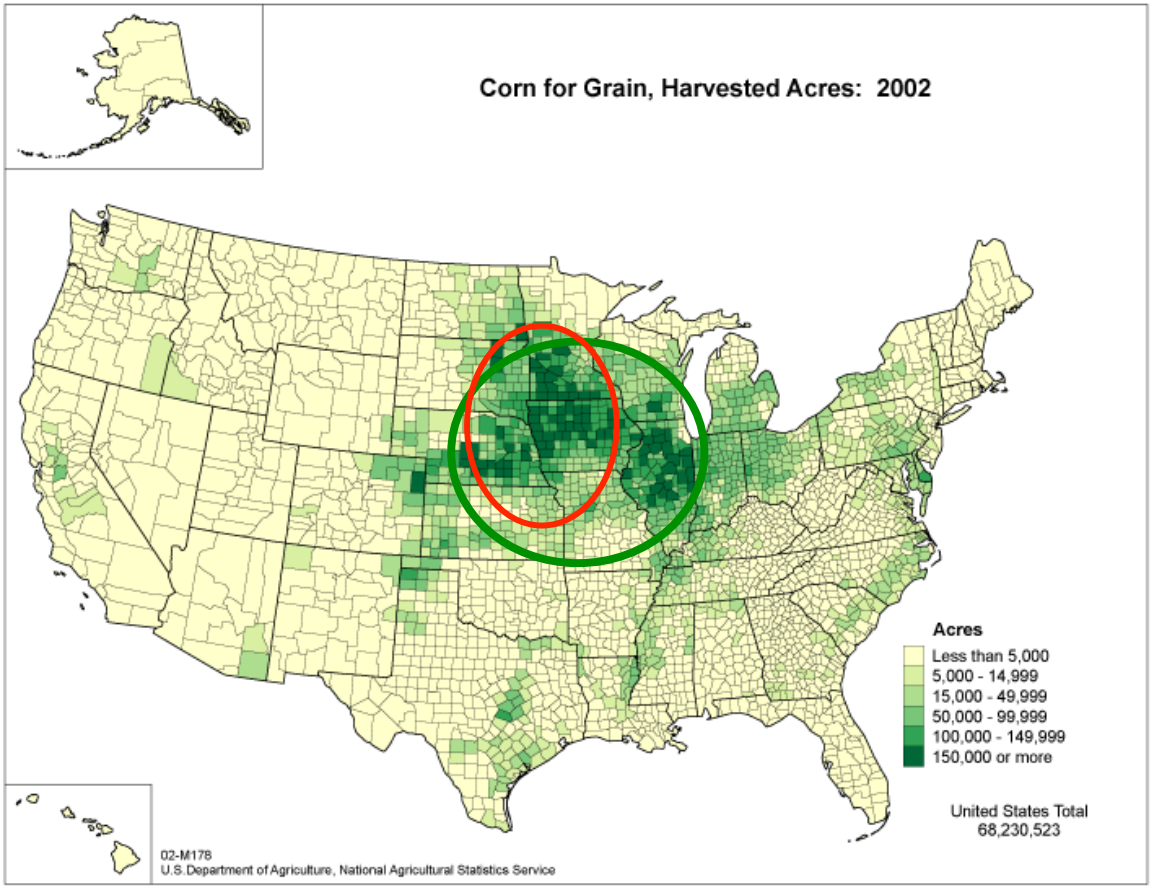
Wind + Water + Air

= Electricity, Hydrogen, and Nitrogen Fertilizer

Excellent Wind Resource



High Demand for Ammonia



& Excellent Wind Resource

Wind Energy to Ammonia Drivers

1. Declining domestic ammonia production
2. Stranded wind resource due to low transmission capacity
3. Nitrogen fertilizer price / cost currently tethered to fossil fuels
4. High ammonia / nitrogen demand and robust infrastructure
5. Security for domestic food, feed, and bio-fuel production
6. Supports rural economic development
7. Helps achieve greenhouse gas emission reduction targets
8. Hydrogen economy transition bridge

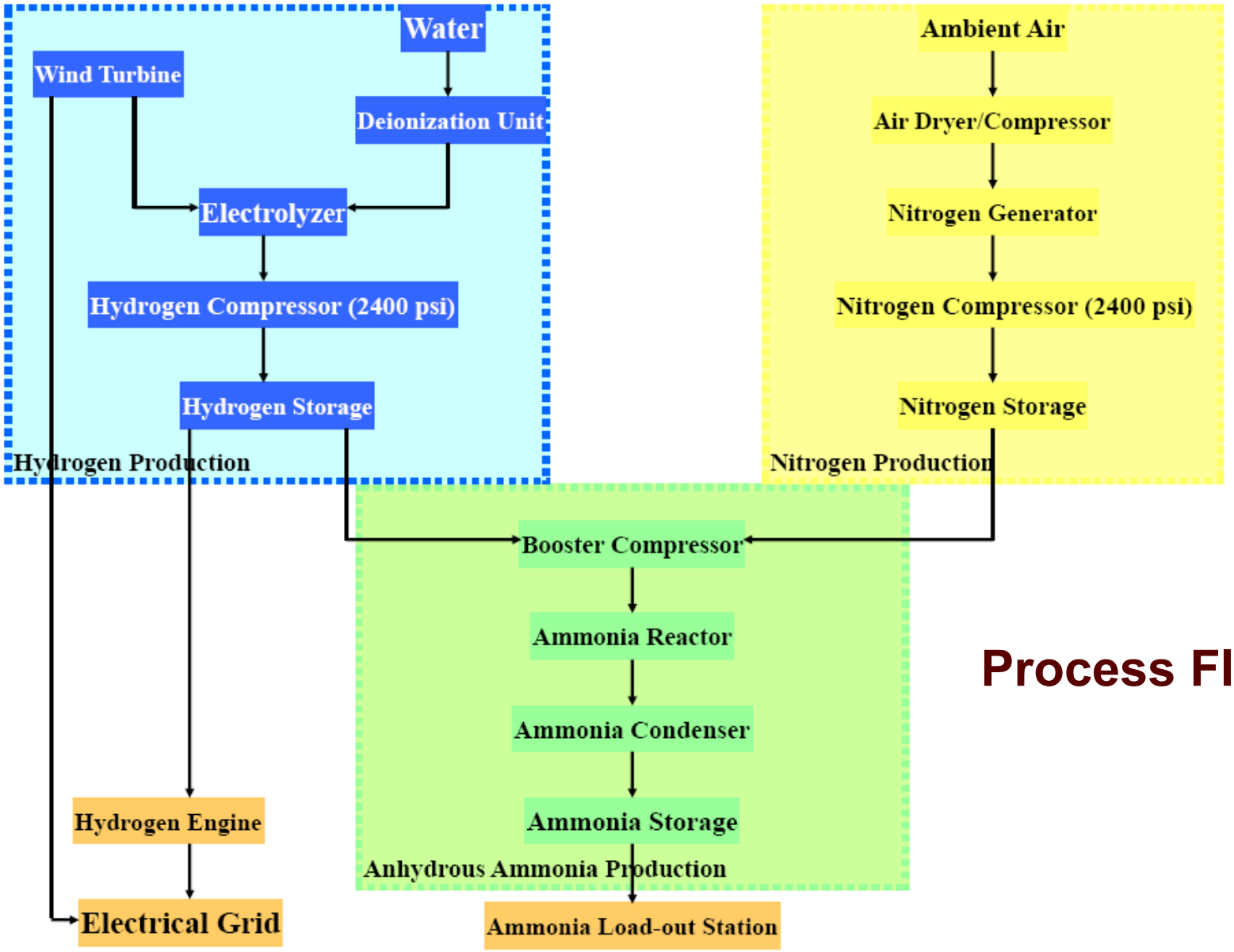
Under Construction - Finally!

Washington Post
The Associated Press
By Dirk Lammers
Wednesday, June 9, 2010

“Minnesota researchers have designed a $3.75 million carbon-free system that uses wind power from a towering turbine to produce anhydrous ammonia, a common nitrogen-based fertilizer.”

“Construction on the Morris plant began this week, and it should be produce fertilizer by the end of the year.”

“’You’ve already got one arm tied behind you because those [electrolyzers] are very expensive and pretty inefficient,’ Holbrook said.”



Process Flow

WCROC Wind Turbine:

1. 1.65 MW Vestas V-82
2. Installed March 2005
3. Produces 5.4 mil kWh / yr
4. Energy first used for research
5. Excess sold via direct line to UMM
6. Provides UMM with over 50% of electrical energy needs

Transformer (12.5 kV to 480 V)

Renewable Hydrogen and Ammonia Pilot Plant

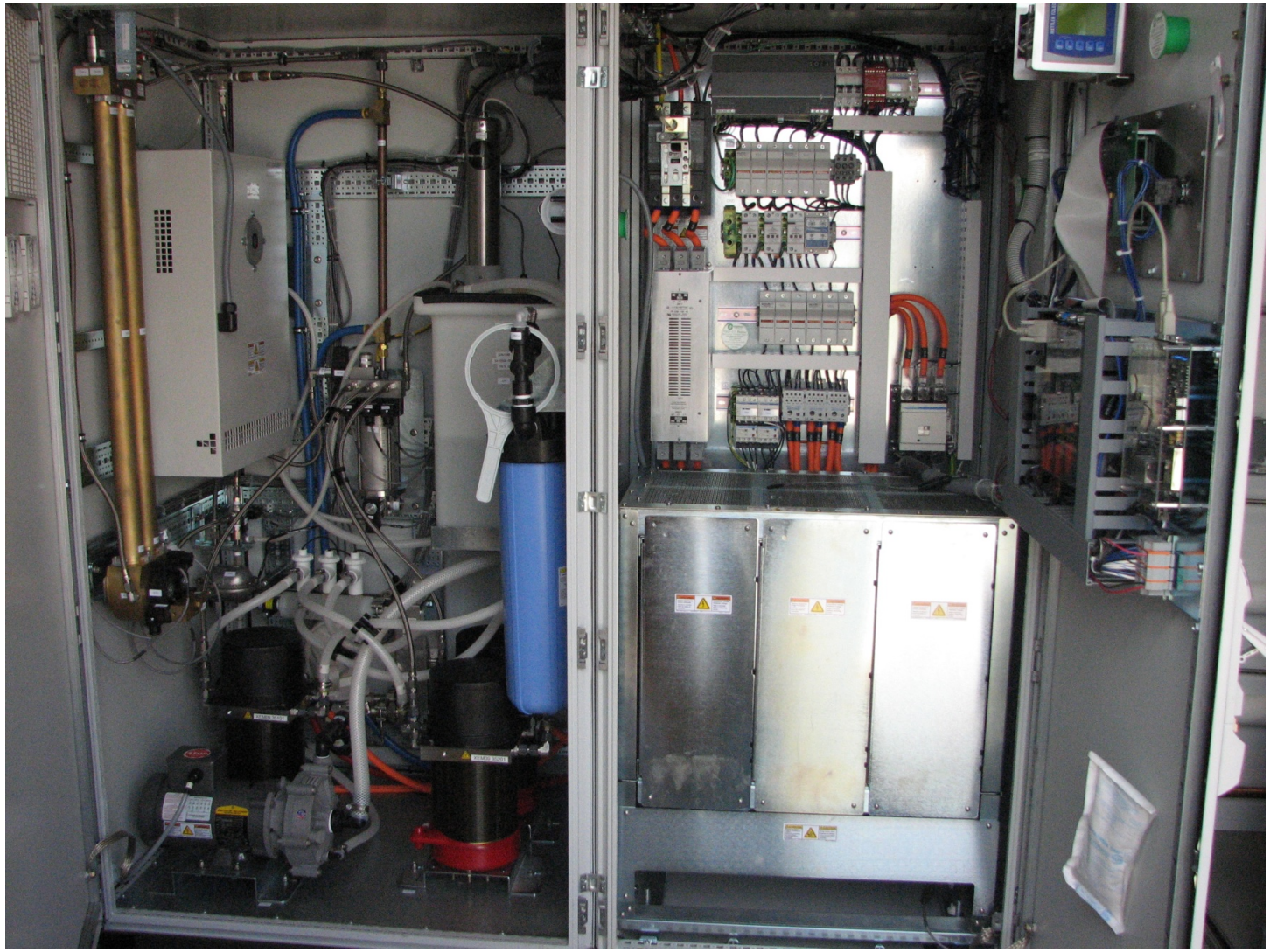
H2 and N2 Production Building

H2 and N2 Building – HVAC System

Water DI Unit and Safety Shower Pump

Hydrogen Electrolyzer (Proton Energy 10 kW)

Hydrogen Electrolyzer (Proton Energy 10 kW)



Chiller for Electrolyzer

Building H2 Gas and Smoke Detectors

H2 Booster Diaphragm Compressor (220 to 2450 psi)

H2 and N2 Gas Storage Tanks (2450 psi)

Air Compressor and Dryer

N2 Gas Generation

Buffer Tanks and Nitrogen Generator / PSA

N2 Booster Compressor (50-120 to 2450 psi)

H2 and N2 Gas Dew Point Detectors and Power Meters

External Safety Features

Interior of H2 and N2 Production Building

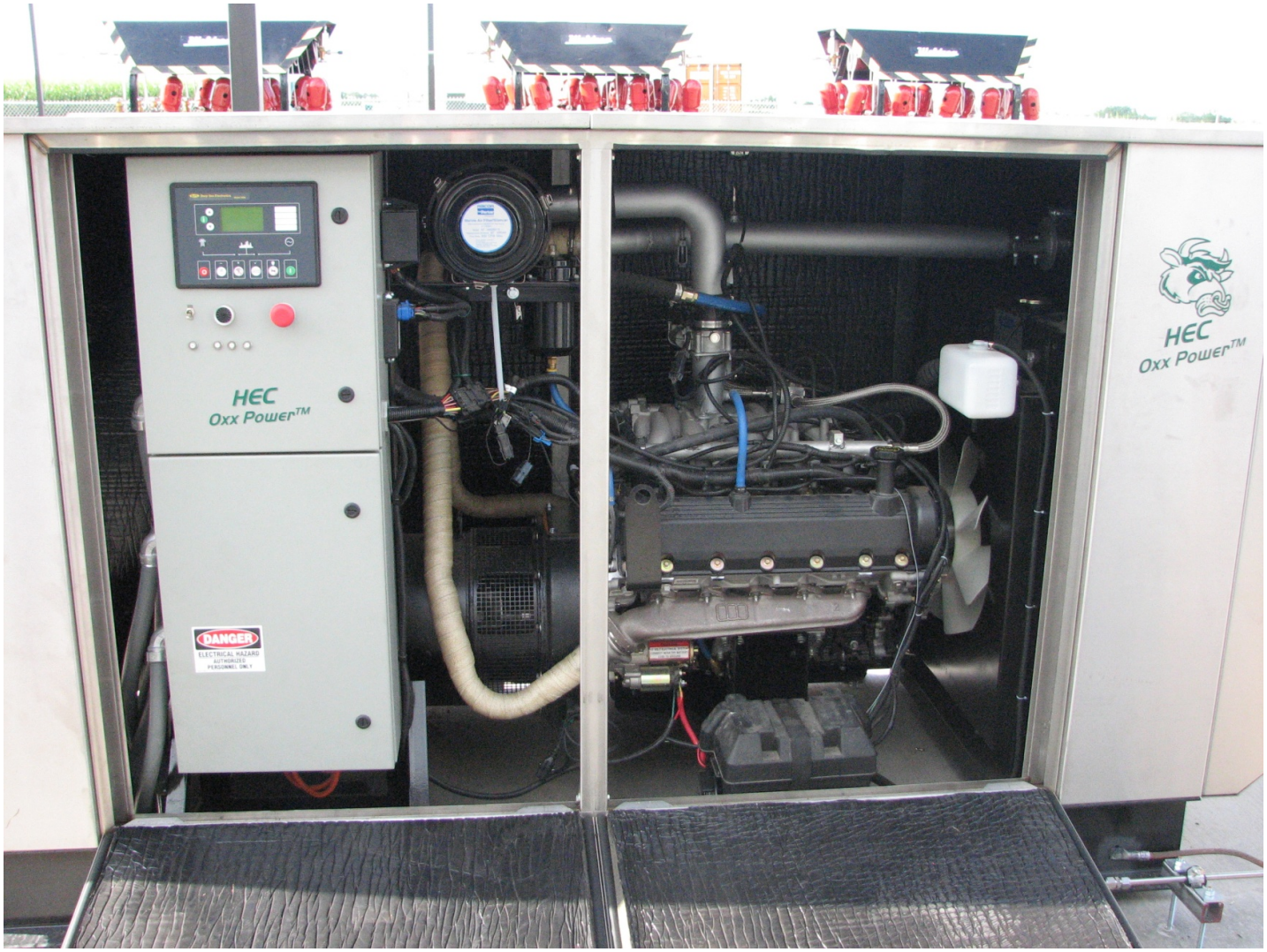
N2, H2, and NH3 Pipe Tray

Hydrogen and Nitrogen Gas Storage (2450 PSI)

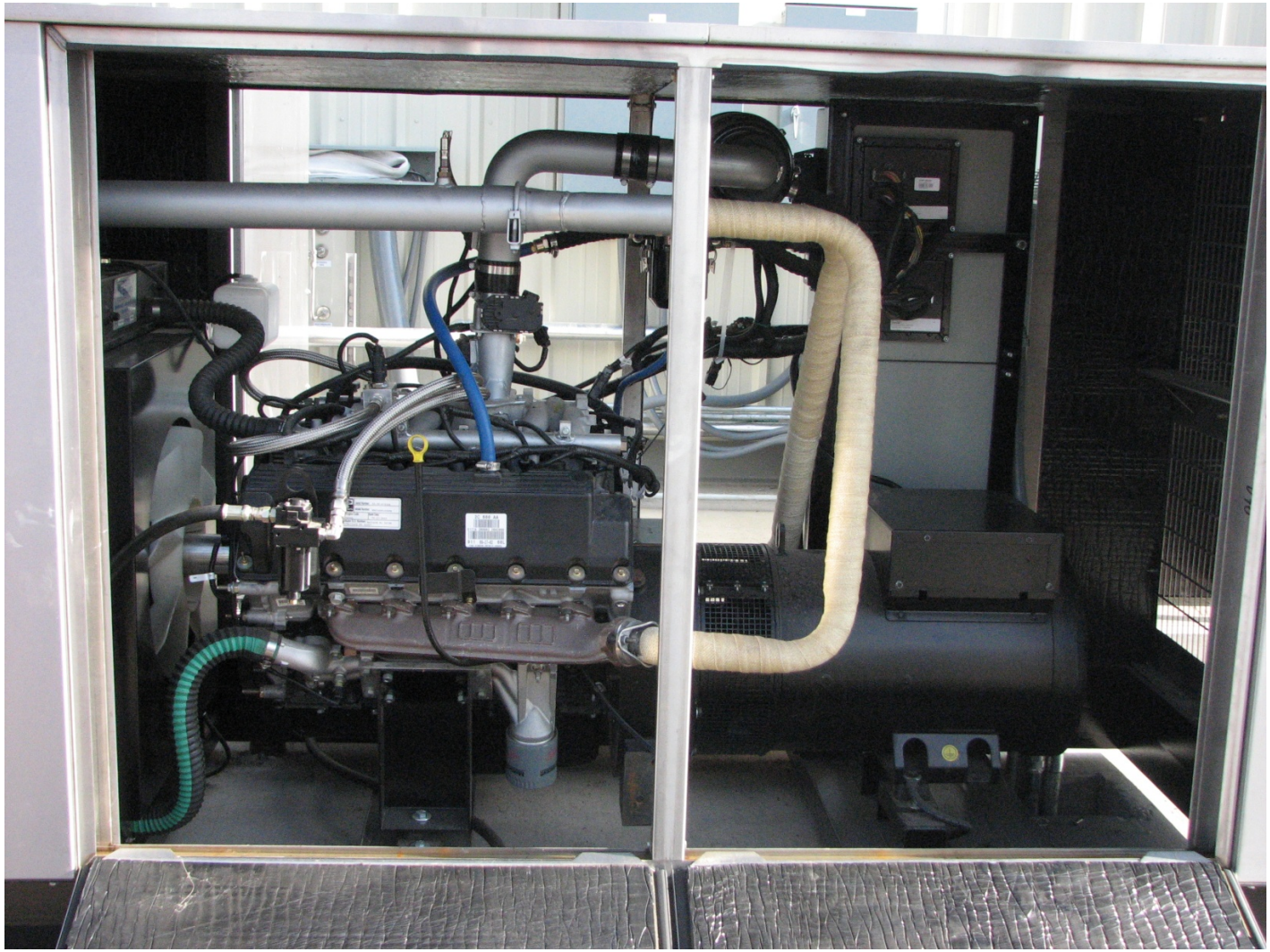
H2 Storage Tank Manifold

N2 and H2 Storage Manifold

HEC Oxx Power 60 kW Hydrogen Engine Generator



HEC Oxx Power 60 kW Hydrogen Engine Generator



Generator Switch Gear for Grid Connection

H2 / N2 Building, Piping Tray, and Wind Turbine

N2 & H2 Gas to NH3 Building – NH3 to Storage

NH3 Production Building Foundation

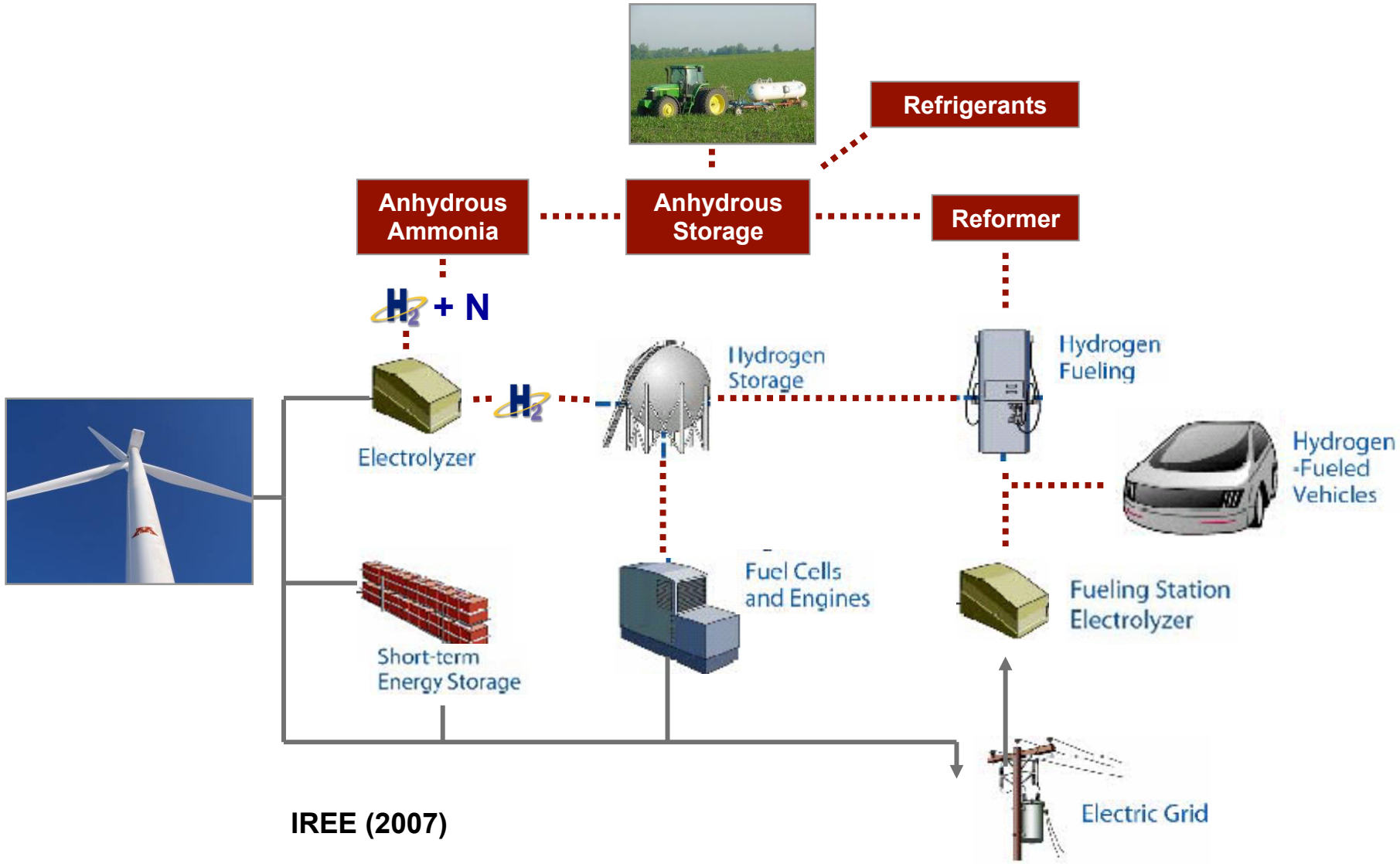
NH3 Storage, Load Out, and Safety Building / Shower

NH3 Safety Building- Emergency Shower & Equipment

NH3 Load Out, Storage, Nurse Tanks, & Application

Wind Turbine and Pilot Plant

Hybrid Wind Research and Demonstration



IREE (2007)

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