Lessons Learned in Developing a Wind to Ammonia Pilot Plant

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Why Home Grown Energy?

Reason #1

- ***Economy –*** *Create jobs and wealth in Greater Minnesota with emerging technology and new industry*

Reason #2

- ***Energy Security –*** *Manage risk associated with volatile energy markets*

Reason #3

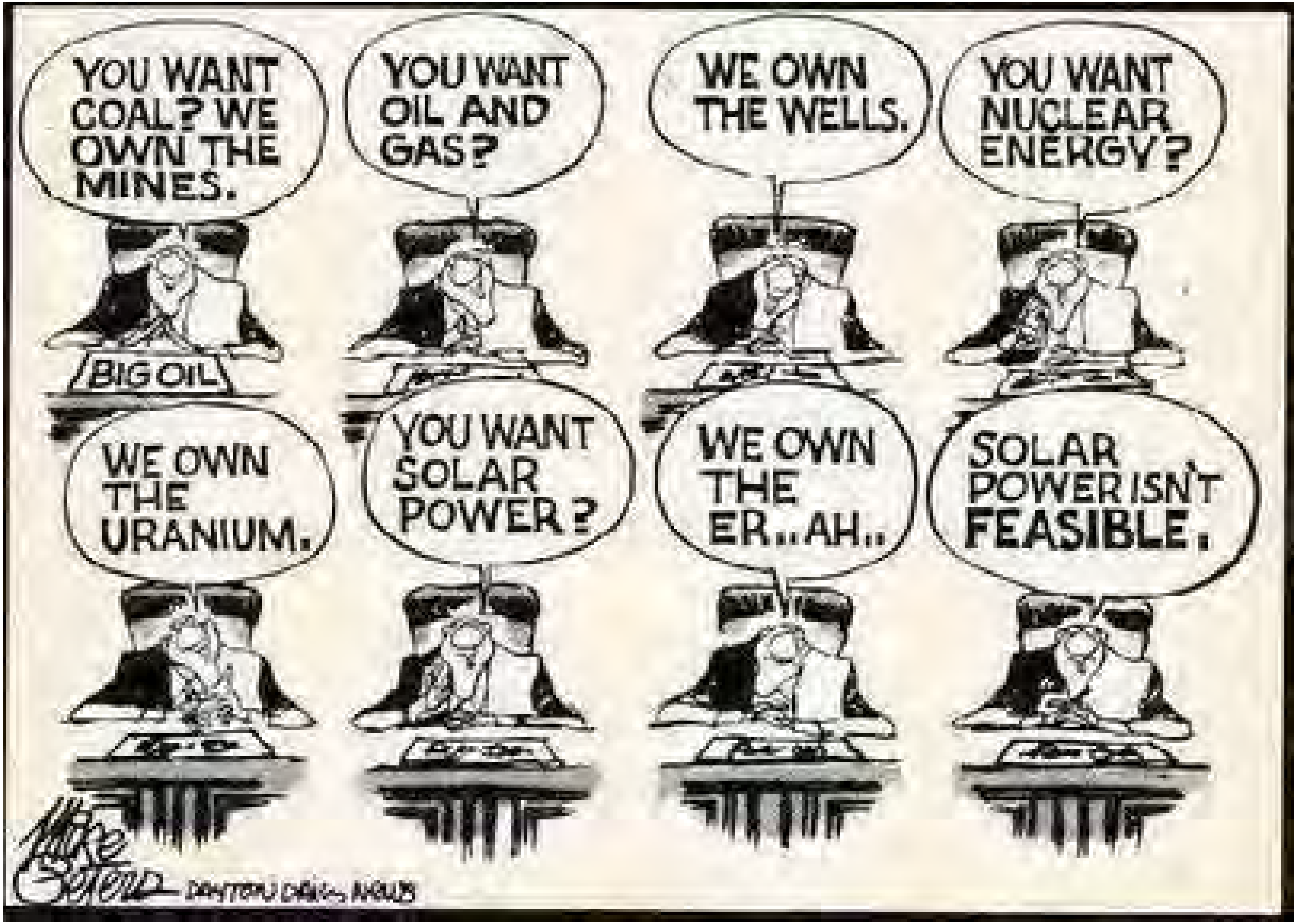
- ***Environment –*** *Can we afford to be wrong?*

Focus is to create jobs and wealth in rural Minnesota

2010 Census - Population Change from 2000 to 2010:

Minnesota Average	**+7.8%**	
Rochester	+24.4	**- High tech, dynamic economy**
Todd County	+1.9	
Wadena County	+0.9	
Pope County	-2.1%	
Stevens County	-3.3%	
Grant County	-4.3%	
Big Stone County	-9.5%	
Lac qui Parle County	-10.0%	
Traverse County	-13.9%	
Swift County	**-18.2%**	

We are losing the battle in rural Minnesota and need to do more!



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

UMM Biomass Gasification System

KMW Biomass Gasifier

English Boiler

UMM Biomass Gasification System

Wood Chips

Gasification in Progress

Feedstock Issues:

<u>**Field to Facility Supply**</u>
- Harvest
- Transport
- Storage

<u>**Utilization**</u>
- Flexibility

<u>**Sustainability**</u>
- Soil Carbon
- Soil Erosion
- Nutrient removal
- Emissions and ash

<u>**Eco-services**</u>
- Bird / wildlife habitat

<u>**Economics**</u>

Chippewa Valley Ethanol Coop Biomass Gasification System

Cob Harvest Demonstration and Evaluation

Vermeer CCX Cob Harvestor

District 45 Dairy 1.5 MW Anaerobic Digester

Fibrominn Biomass Generation Facility

Green Buildings & Small Renewable Energy Systems

- **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

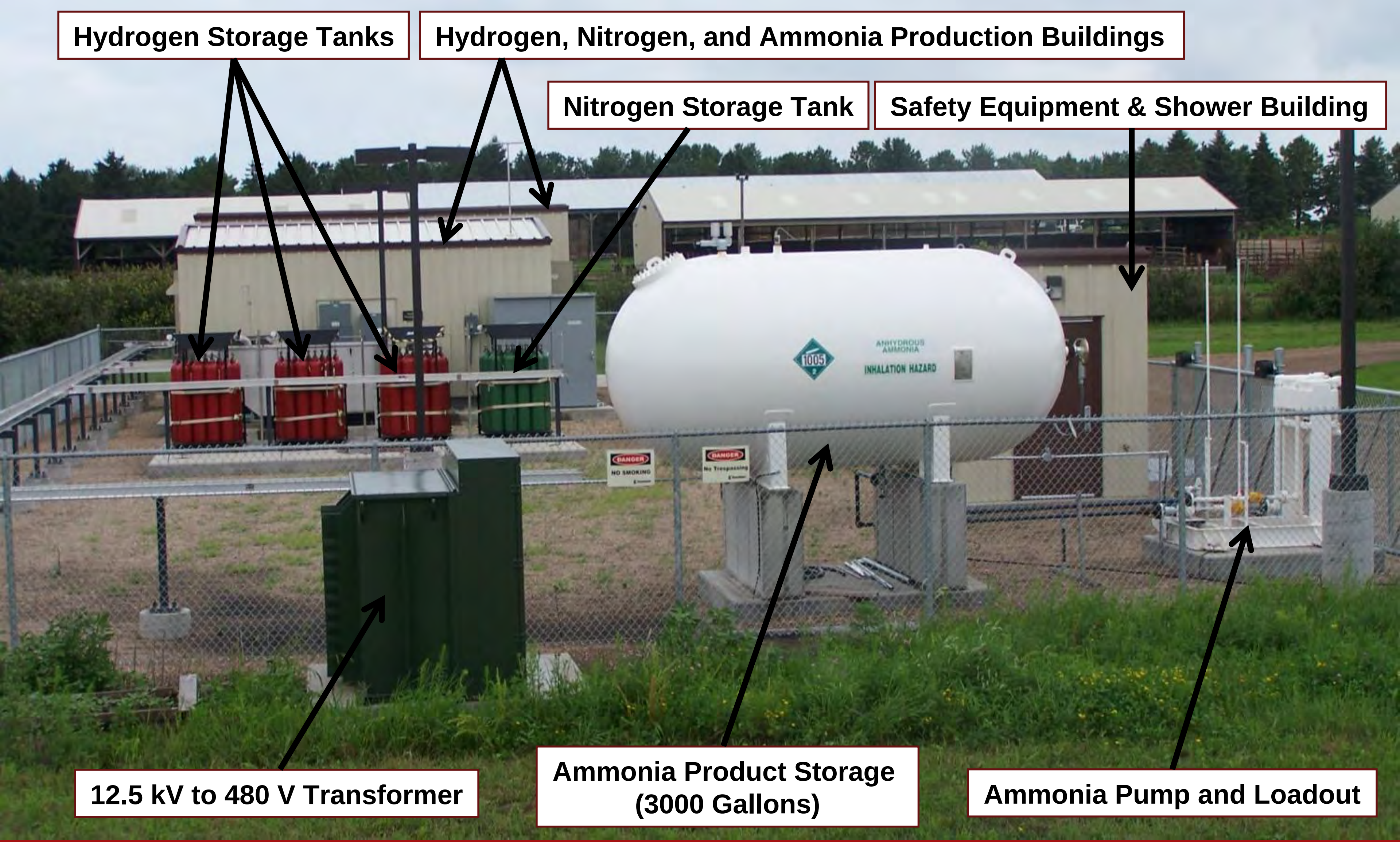
WCROC Wind Turbine:

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 60% of electrical energy needs
7. Approximately 10% power will be used for H2 and NH3 production
8. Second Turbine - UMM 80 M Tower

Elegant Concept

Wind Energy + Water + Air = Nitrogen Fertilizer

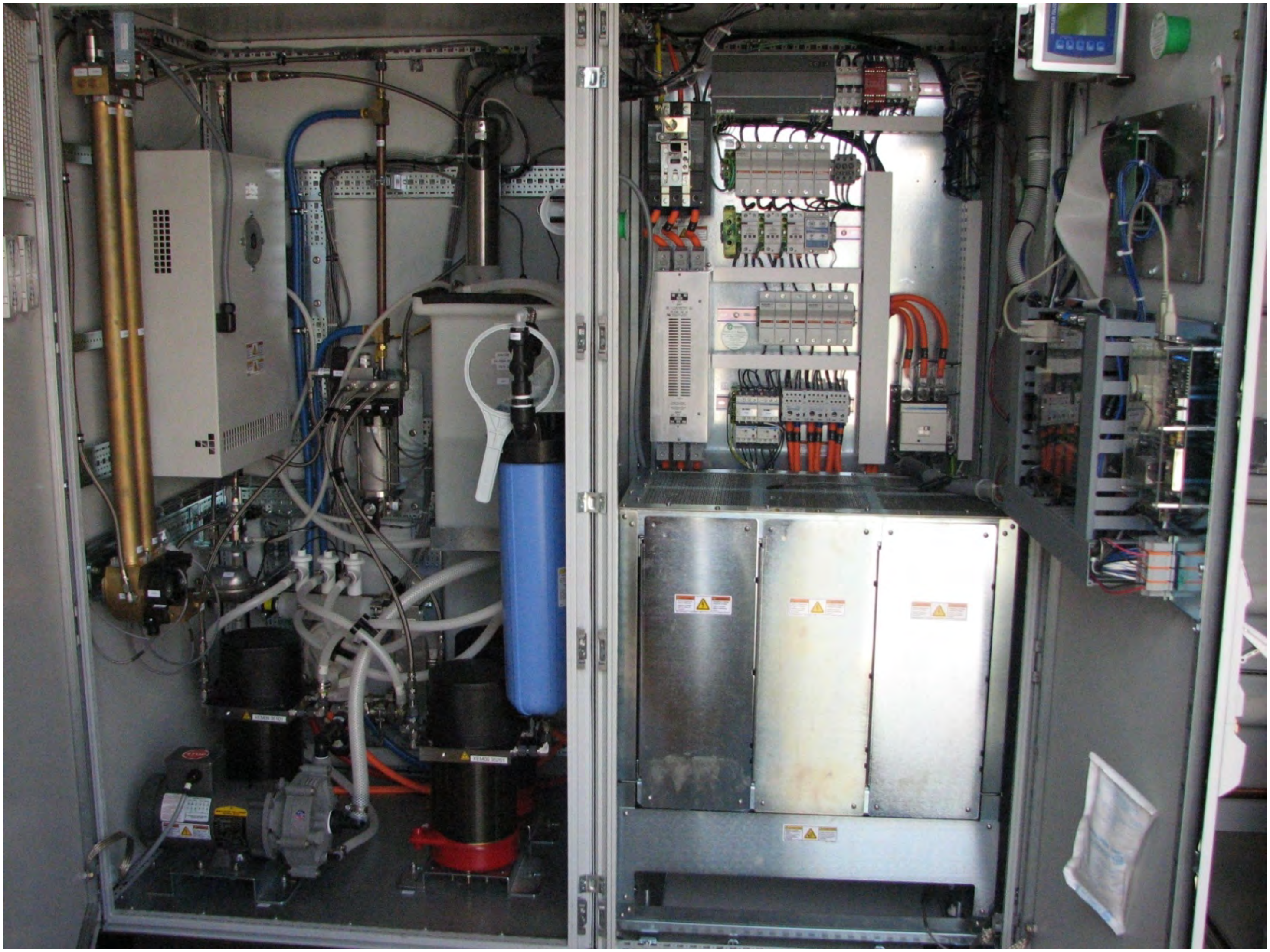
Renewable Hydrogen and Ammonia Pilot Plant



Water DI Unit and Safety Shower Pump

Hydrogen Electrolyzer (Proton Energy 10 kW)

Hydrogen Electrolyzer (Proton Energy 10 kW)



H2 Booster Diaphragm Compressor (220 to 2450 psi)

Air Compressor and Dryer

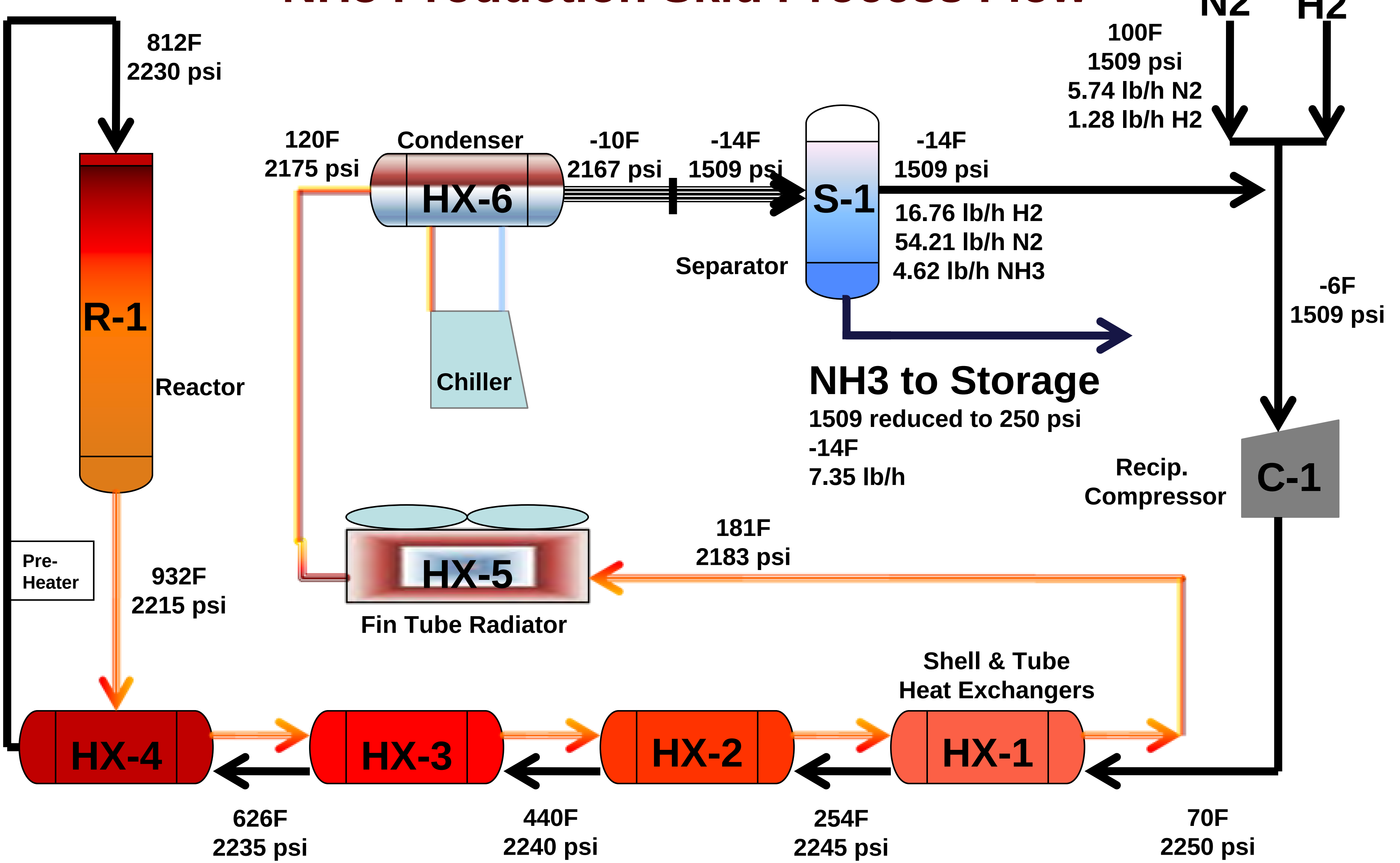
N2 Gas Generation

N2 Booster Compressor (50-120 to 2450 psi)

Interior of H2 and N2 Production Building

H2 and N2 Gas Storage Tanks (2450 psi)

NH3 Production Skid Process Flow

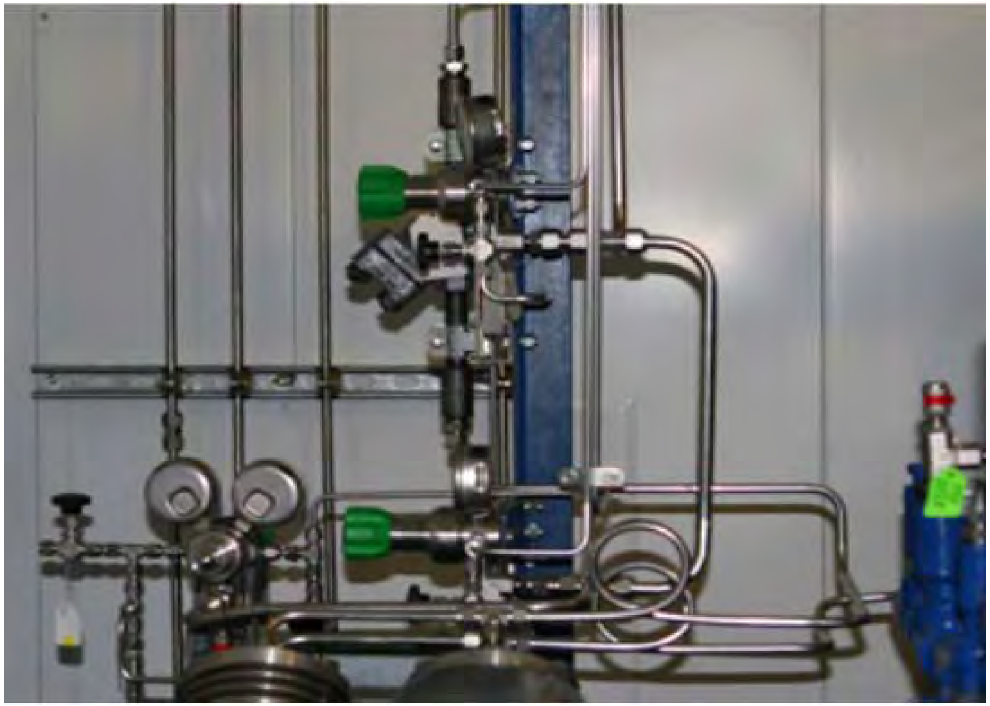


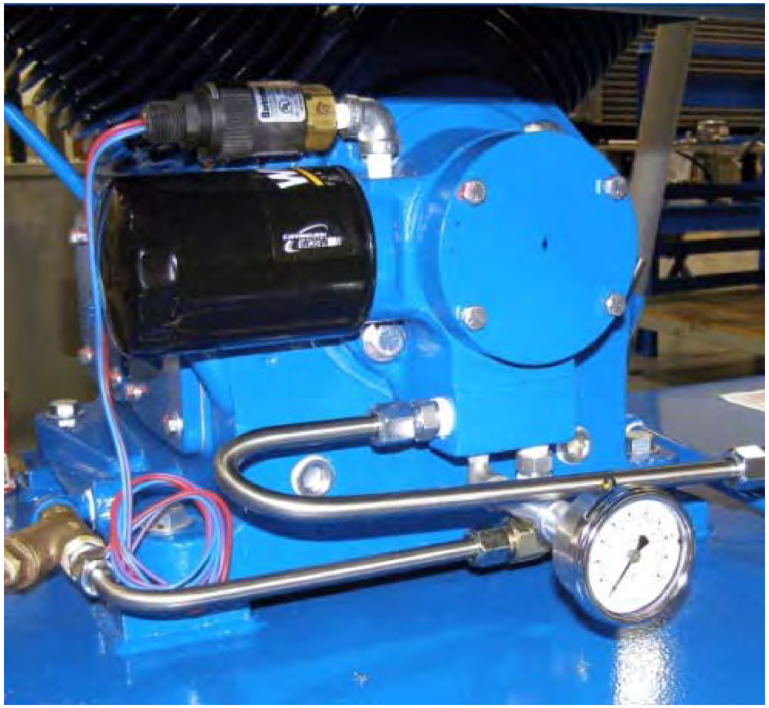
When skids fly…

Ammonia Reactor Skid

Ammonia Reactor & Chiller Skids

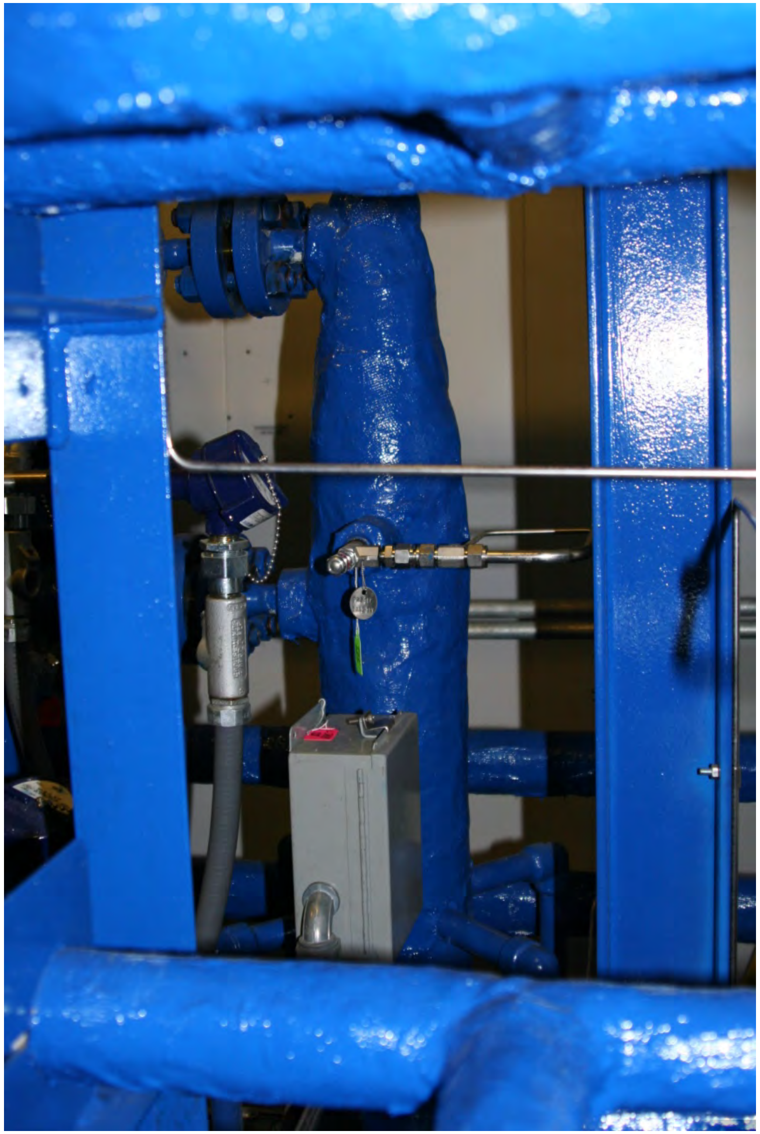
Ammonia Skid Make Up Gas Mixing Station and Compressor





Ammonia Skid Tube-in-Shell and Electric Heater

Ammonia Reactor and Low Temp Flash Drum Separator

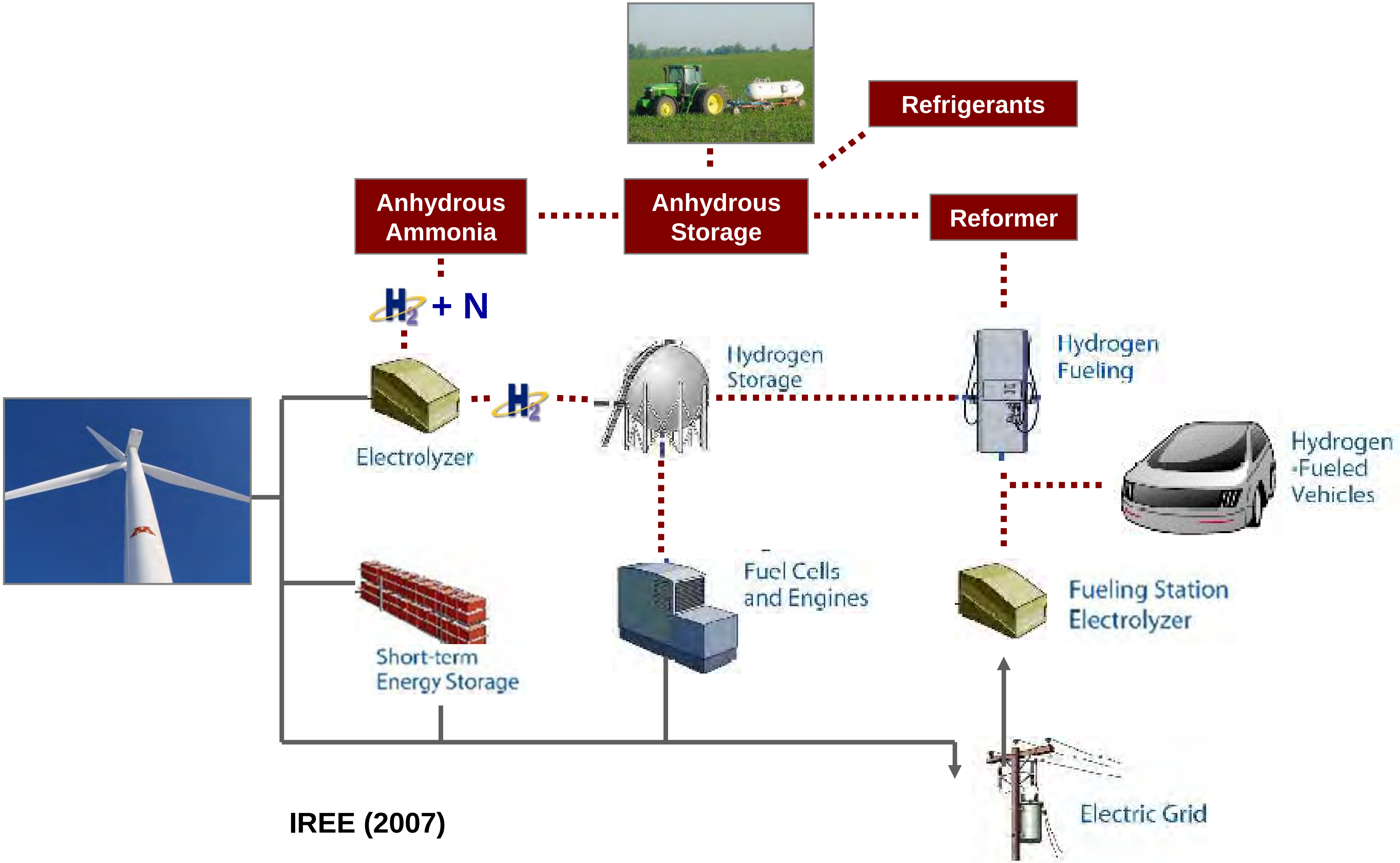


NH3 Load Out, Storage, Nurse Tanks, & Application

H2 and N2 Gas Dew Point Detectors and Power Meters

HEC Oxx Power 60 kW Hydrogen Engine Generator

Distributed "Smart" Micro Grid



IREE (2007)

“Green” Energy Consumed in Agriculture

1. **Reduce dependence of agricultural industry on fossil fuels**
2. **Increase local markets for renewable energy**
3. **Decrease economic and financial risk associated with fossil fuel based agricultural / rural economies**
4. **WCROC has comparison agricultural production systems**
   - Conventional Crop and Livestock Systems Paired with Organic Crop and Livestock Systems
   - Renewable Nitrogen Fertilizer and Renewable Energy Systems
   - “Energy-Optimized Crop and Livestock Production Systems”

Some Insights on the U of MN Experience

- Not meant to discourage anyone
- Not meant to make excuses
- Not meant to disparage any group

Provide a roadmap to avoid some of the potential risks that we experienced - May not be the only risks!

U of MN Renewable Hydrogen and Ammonia Pilot Plant has been a good investment, experience, and is a valued facility. You are all welcome to visit!

Regulatory

- **Environmental Protection Agency (EPA)**
  - Risk Management Plan (RMP) – Above 10,000 lbs NH_3
- **Minnesota Department of Agriculture (MDA)**
  - Oversee agricultural ammonia facilities
  - Regulatory role –large fines if found in violation
- **OSHA**
  - Right to Know employee training for hydrogen, ammonia, others
- **MN Department of Labor** - High pressure piping

➢ Different uses of same product (fertilizer or fuel) and size of plant will /may change jurisdiction

➢ There may be conflicting regulations and codes

Codes

- **Several Sections of Codes May Apply**
  - United State Building Codes
  - University Building Codes and Standards
  - State Building Codes for Agricultural Ammonia
  - State Building Codes for High Pressure

- **Custom Design and Build**
  - Difficult to identify all applicable codes
  - Ended up moving equipment, adding barriers, making modifications in the field
  - Keep a good working relationship with code officials and inspectors

Project Delivery / Management

- **No turnkey system was available**
- **Pre-design**
  - The actual design cost was much higher than pre-design estimate
- **Design and Engineering**
  - Full design documents are needed to get reliable costs
  - Once costs came in, apparent an entire redesign was necessary

Contractor-at-Risk

- **Issued a RFP for a Design to Build**
  - Negotiated for 18 months and firm then backed out
  - IP issues, funding issues with grants, and bond funds
- **Returned to Contractor-at-Risk and consulting engineering firm**
  - Contractor-at-Risk provides “guarantee” on total cost
  - Knutson Construction Services
  - Sebesta Blomberg Engineers and Architects
- **Contractor-at-Risk sourced all components and labor**

Supply

- **Hydrogen and Nitrogen Gas Production**
  - All H2 and N2 components were sourced from Proton Energy
  - Hydrogen Electrolyzer
  - PSA Unit
  - Compressors
  - All built and installed in portable building off-site
  - Excellent experience with Proton Energy and this process
  - Considered non-US companies
    - Challenges with cost / price, codes, and technical language barrier (even with a very large company)

Supply

- **Ammonia Production**
  - Sub-contract with a design firm in Texas
  - Small company
  - Design firm sub-contracted the fabrication to a custom fab firm in Texas
  - Controls were sub-contracted as well
  - Delivery was 20 months late (Oct 2010 to July 2012)
  - Very little leverage to speed up delivery
  - New customers and new designs take second or third place in production line

Supply

- **Ammonia Production**
  - Catalyst
    - Concern for HB reactor
      - Small amount required compared to large natural gas plants
      - How do you convince catalyst manufacturers to supply small amounts of proprietary material?
      - What are the benefits to the supplier?

Finance

- **State Bond, University Cash, and Grant**
  - Issues
    - Questions whether GO bonds could be legally used for system – 16 month delay
    - Questions whether IP license could be granted to or secured by design build firm - 12 month delay
    - University Capital Project folks do not like large capital “research” projects - prefer traditional construction – required several high level meetings for final approval

Delays

- **Delays were not just a loss of time**
  - People and experience moved in and out
    - Needed to re-educate
    - Both in project and outside (need to re-justify to superiors)
  - Contingency funds were used up
    - Increased time for all parties, multiple trips to site, additional meetings (and $$$)
  - Frustration enters the project at all levels

Recommendations and Considerations

1. Use experienced designers, contractors, and suppliers
2. Accurate initial cost estimates are important
3. Perform due diligence on project participants – request and check references – Is there redundancy and succession plans? Do firms stand behind their product and labor?
4. Budget a higher than normal contingency (15% plus)
5. Be engaged with all engineers, contractors, and suppliers to insure timeline and design specs are being met

Recommendations and Considerations

6. Remember HAZOP (hazardous operation) review
7. Training – Safety, Operation, Maintenance
8. Try to get written approval of designs from code officials
9. Clearly articulate the project goals and who is to benefit
10. Obtain a performance bond and attach milestones to payment terms

    – Maintain a reasonable retention at least until commercial operation

    - Consider rewards for meeting milestones / penalties for missing

Recommendations and Considerations

11. Pay attention to contract details and specifications

-Training? Is it provided or an extra? On-site or off-site?

-HAZOP participation?

-Commissioning? On-site or off-site

-Maintenance? On-site, maintenance kits, etc.

-Control package? What data? How is data obtained?

-Are the components meant to be housed inside or outside and (“outside” is different in Texas, Minnesota, and Alaska)

-Quality of components, workmanship, testing (x-ray, pressure, etc)

-Shipping – Are the skids secure, crating, dust, vibration, insurance

-Who loads catalyst? “What do you mean it can self-ignite?”

Recommendations and Considerations

12. Review the design – project team & third party, ask questions regarding codes, regulations, controls (and integration), and safety
13. Trained operations team with Standard Operating Procedures (SOPs)
14. Do you have an engaged, trusted team with a real commitment from all the project participants?
15. Practice three P's – Patience, Persistence, and Passion!

JULY 2013 – Renewable Fertilizer and Energy Conference and West Central MN Renewable Energy Road Tour

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