Hydrogen Facility


Wind To
Hydrogen
Hydrogen
HYDROGEN
CHEVROLET
HYDROGEN

North Side - Utilities

South & East Side

South End

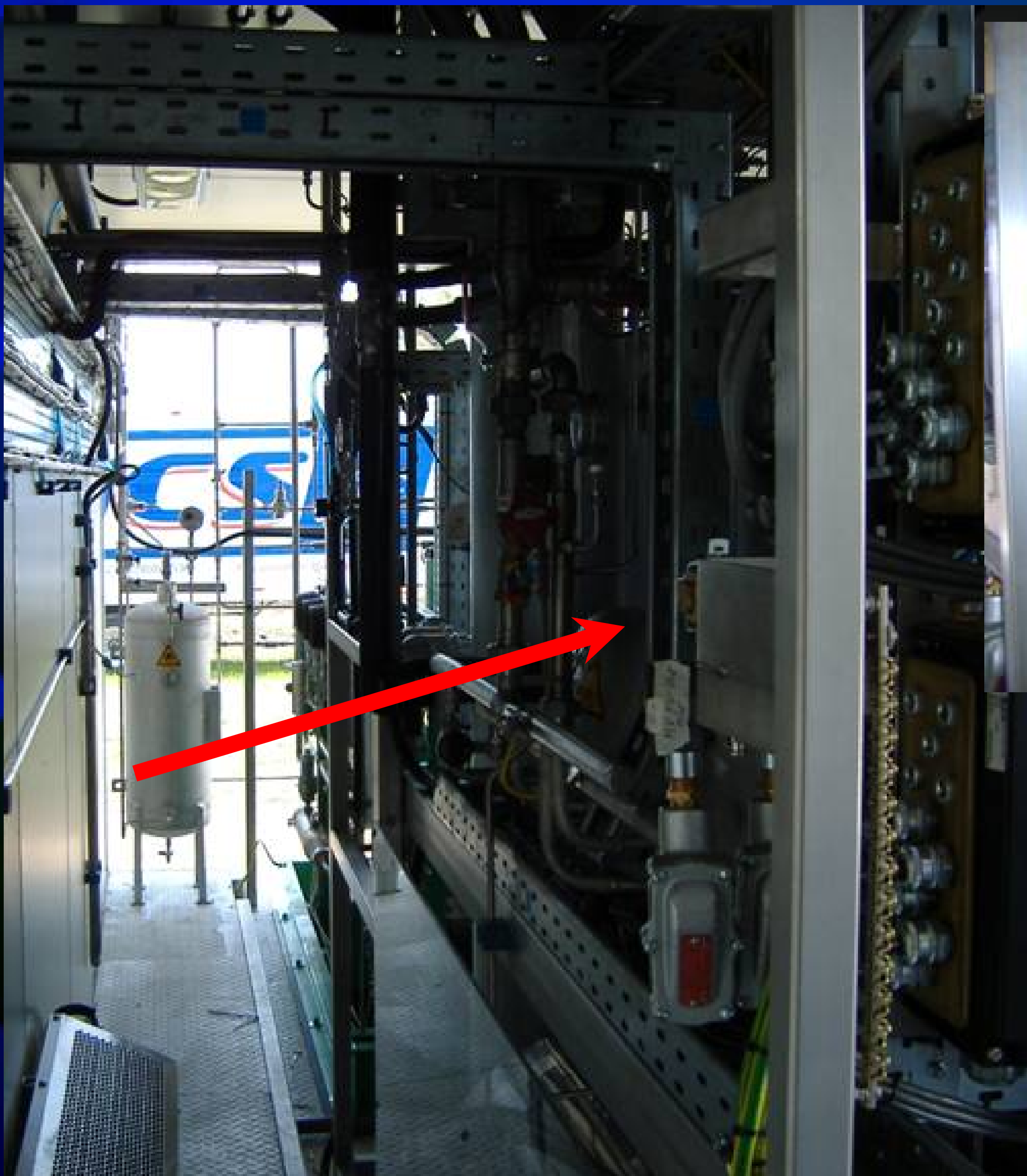

Electrical / Water Treatment / Electrolyzer & H2 Compressor
Hydrogen
Hydrogen
HYDROGEN
H2

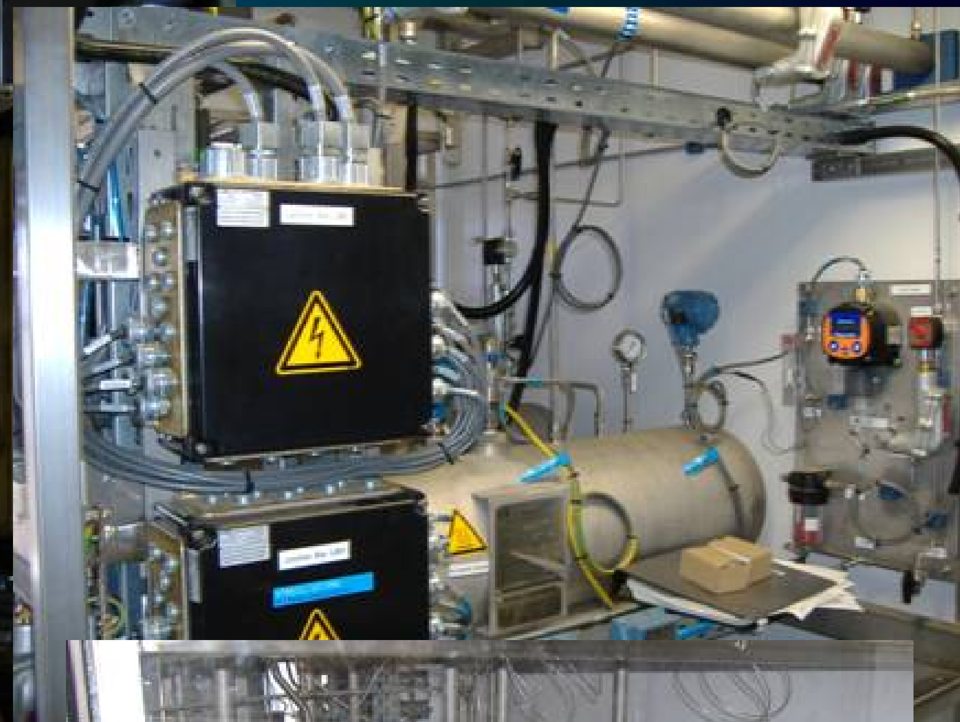
Electrical Room (Controls)

Water Treatment

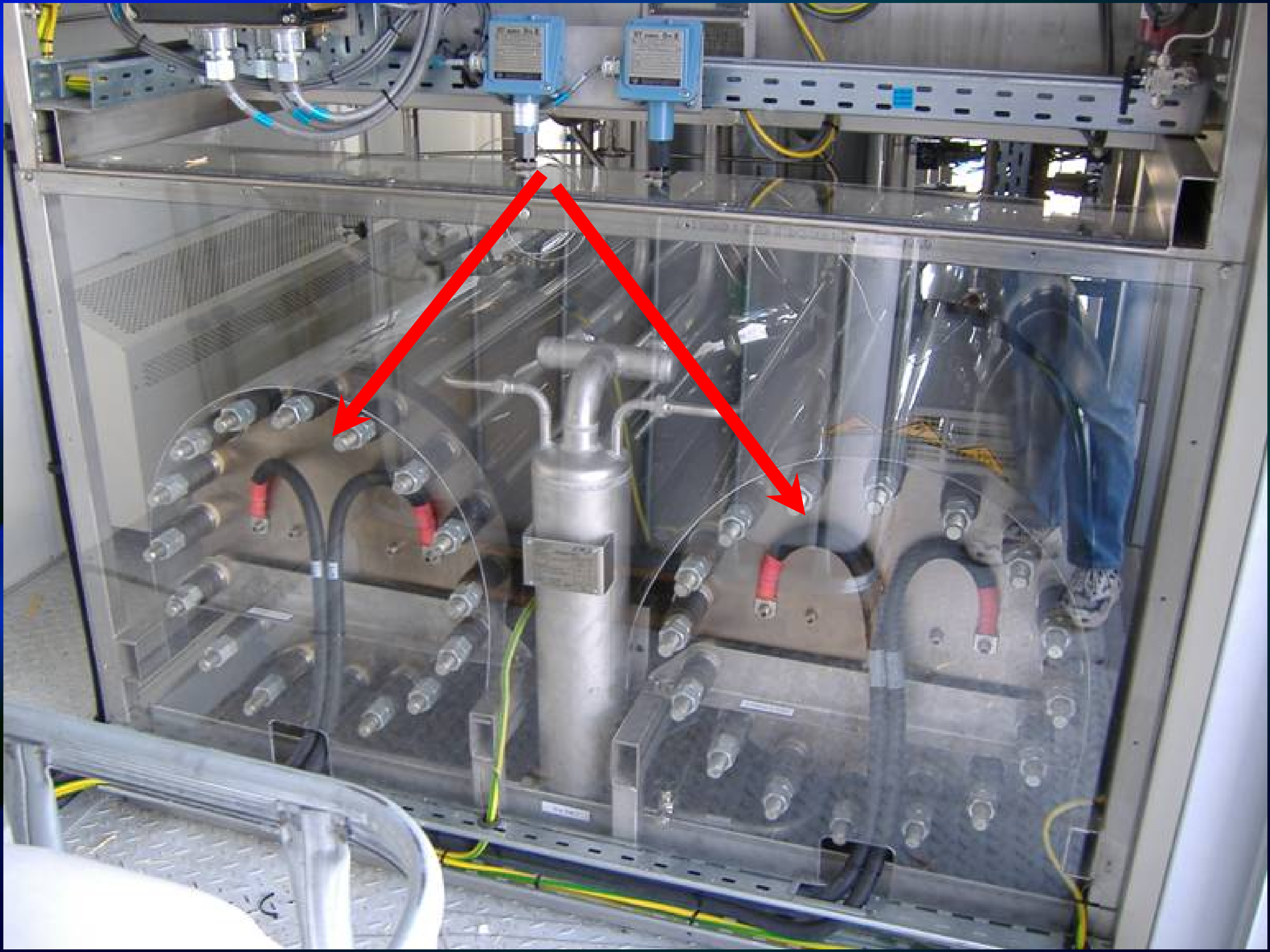
KOH Water

Electrolyzer





Cell Stacks (electrolyzer)



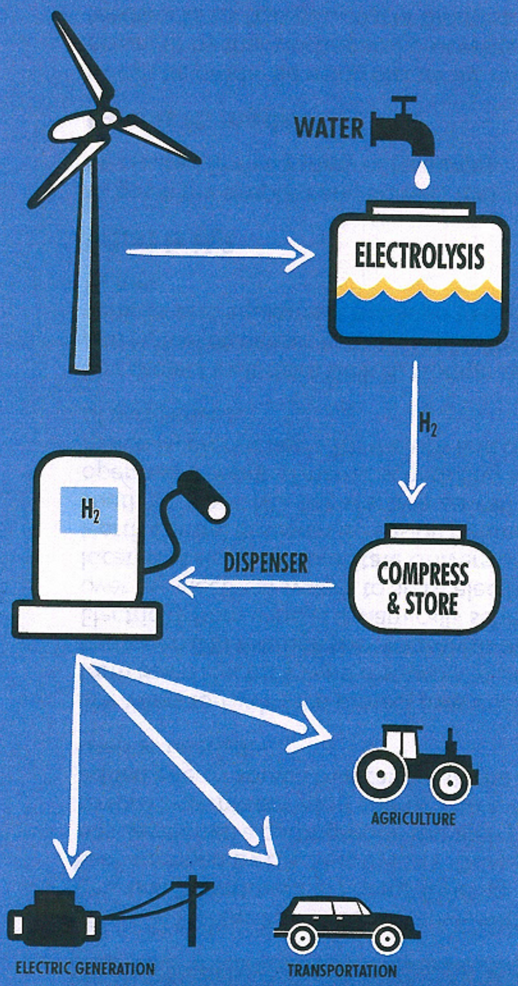
Compressor

Standby Generator

Gas & Flame Detection

(911/Basin Dispatch Emergency dial out)

HERE IS HOW IT WORKS



Project sponsors and participants:

Basin Electric Power Cooperative
U.S. Sen. Byron L. Dorgan
U.S. Department of Energy
Central Power Electric Cooperative
Verendrye Electric Cooperative
Cooperative Research Network
NDSU North Central Research Extension Center
Butler Machinery Company
Ryan Chevrolet
North Dakota State University
Energy & Environmental Research Center
AFVTech Inc.
Hydrogenics
Electric Utility Supply Company
Jim Ressler Trucking Inc.
N.D. Department of Commerce
N.D. Department of Transportation
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BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative

Wind To Hydrogen
A Basin Electric Project

Basin Electric Power Cooperative, with U.S. Department of Energy funding arranged by U.S. Sen. Byron L. Dorgan, has developed a cutting-edge research project to turn intermittent wind energy into a value-added energy source that can be stored and used as needed.

The Wind-to-Hydrogen project uses energy from Basin Electric's wind resources to produce hydrogen (H_2) through the electrolysis of water. Electricity from wind is dynamically scheduled over the electrical system to an H_2 electrolyzer located at North Dakota State University's North Central Research Extension Center south of Minot, ND. The electrolyzer will be operated through dynamic scheduling to match H_2 production with the ups and downs of wind energy.

The project includes a bulk H_2 storage system and H_2 fuel dispenser to allow for fueling of vehicles and equipment modified to burn H_2 fuel.

What is H_2?

H_2 gas is the simplest and lightest fuel. It can be created from a variety of resources.

How is H_2 made?

H_2 can be produced using electricity, nuclear power or by thermochemical processes from feedstocks such as gas, coal or biomass.

What is an electrolyzer?

An electrolyzer produces H_2 gas through the electrolysis of water using electricity to extract the H_2 molecules from water. The byproduct of this process is oxygen.

How will H_2 be used by this innovative project?

The H_2 fuel will be used to fuel three full-size pick-up trucks, a tractor, and a H_2-powered generator, which will generate electricity to the power grid during peak demand periods.

Electrolyzer facts:

- 1 kilogram of H_2 is equal to 1 gallon of gasoline
- Production of H_2 at full load: 64 kilograms per day
- Electrolyzer size: rated at 175 kilowatts
- Electricity needed to produce 1 kilogram of H_2: 60 kilowatt-hours
- Water needed to produce 1 kilogram of H_2: 5.8 gallons
- H_2 storage pressure: 6,200 psi

Wind to H_2 project cost:

Approximately $2 million

What are the benefits of H_2?

- Helps address concerns about energy security, global climate change and air quality
- Increases energy efficiency
- Fuels vehicles
- Has fuel cell applications

Is H_2 safe?

With proper knowledge and responsible handling, H_2 is no more or less hazardous than gasoline, propane or methane.

What about the Hindenburg fire?

The Hindenburg was coated with reactive chemicals, similar to solid rocket fuel, which was easily ignitable by an electrical charge. The outer cover, not H_2, is to blame for the fire.

Dynamic Scheduling of Wind Power to Produce Hydrogen by Electrolysis

A Basin Electric Power Cooperative Project

Wind to Hydrogen Project near Minot North Dakota

Introduction

As the number of wind turbine installations continues to expand and movement toward a hydrogen economy is initiated, interest in deriving fuel and/or energy from hydrogen created by electrolysis powered by wind energy has also increased. Because the location of the best wind resource may not be the ideal or most convenient location for a hydrogen generation/fueling facility, this research endeavor explores some of the challenges of placing the hydrogen facility apart from the wind farm.

Details of an existing project in Basin Electric Power Cooperative's control area involving a 175-kW, 30-Nm^3/hr capacity alkaline electrolyzer that can be powered by remote wind energy from several wind farm sites are given here. The dynamic scheduling process for matching electricity generated from wind with hydrogen production is coordinated using a small-scale SCADA system for control, communication, monitoring, and data logging.

Project Background

Three wind farm sites in North Dakota: Minot (2.6 MW), Edgeley (40.0 MW), and Wilton (49.5 MW).

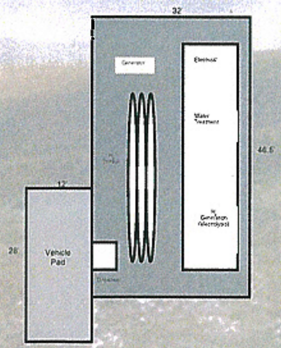
Electrolyzer: Hydrogenics HySTAT A-30, output 30 Nm^3/hr (2.7 kg/hr), 175 kW energy consumption (electrolyzer only) at full production.

Hydrogen storage and fuel dispenser located on site with electrolyzer.

Compression/storage: 80 kg of storage in three pairs of cascading cylinders (six total) at 6200 psi.

Dispenser: 5000 psi of dispensing pressure.

Hydrogen use: Three Chevy ½-ton internal combustion pickups capable of running on hydrogen, E85, and gasoline. A genset converted to run on H_2 may also utilize the created hydrogen.



Dynamic Scheduling

Four control modes, each representing a different approach for dynamic scheduling.

Programming allows for any combination and permutation of the three wind farm sites with the four modes, giving 24 possible control signals to the electrolyzer.

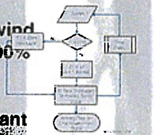
Electrolyzer must maintain a minimum of 7.5 Nm^3 (25%) H_2 production at all times for fast response time.

The minimum operating level requirement (when not available from wind) and the parasitic power (heating, lights, etc.) will be met by grid energy for this research project.

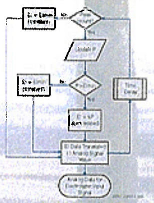
Mode 1:

Equivalent to adding electrolyzer load capacity equal to nameplate wind capacity.

Simulated by scaling: 100% wind farm output to be equal to 100% electrolyzer power capacity.



Least efficient due to significant underutilization of electrolyzer capacity. May also shorten electrolyzer life.



Mode 2:

Same as Mode 1 but with addition of low-cost, off-peak, non-wind electricity to supplement wind energy for full electrolyzer production from 11 p.m. to 7 a.m. daily and all day on weekends.

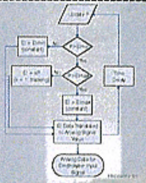
Non-wind electricity is only utilized when wind energy is not sufficient to run electrolyzer at full load.

Still an inefficient use of electrolyzer due to underutilization.

Mode 3

Added wind energy is greater than the electrolyzer electrical load.

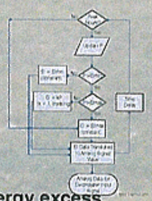
Requires the grid to utilize energy excess.



Improved utilization of the electrolyzer over Modes 1 and 2 makes it more efficient.

Mode 4

Same as Mode 3, but with the addition of low-cost off-peak non-wind electricity to supplement wind energy for full electrolyzer production from 11 p.m. to 7 a.m. daily and all day on weekends.



Requires the grid to utilize energy excess.

Most efficient of the modes—approximately 90% utilization of electrolyzer.

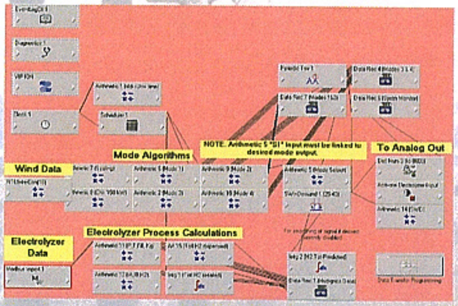
Software Implementation

Variables monitored/recorded:

1. (Near) Instantaneous production output from each of the three wind farms.
2. Dynamic value of hydrogen production by electrolyzer. DC stack current is measured and hydrogen output is determined by the relationship between current and hydrogen production.
3. Dynamic value of hydrogen in storage cylinders (PV = nRT: pressure and temperature are monitored, volume is known, n is calculated).
4. Amount of hydrogen dispensed at each fill.

Communications:

- SCADA system uses MODBUS format, electrolyzer uses Profibus format. Manufacturer has provided MODBUS format output for electrolyzer variables of interest to monitor.
- RTU (remote terminal unit) provides analog output signal to electrolyzer to set the dynamic hydrogen production level. Electrolyzer response time is approximately 10 seconds.



Future Research

Electrolyzer is expected to be installed and operational during summer 2007.

Operation and system data will be gathered and analyzed over a 1 to 2 years following installation.

Practical limitations of varying electrolyzer output as a result of dynamic scheduling will be monitored and investigated. System will initially be run in Mode 4 for minimal variation of hydrogen production level. Modes 3, 2, and 1 are expected to be progressively investigated, as output variation has potential to deteriorate electrolyzer.

Overall system could eventually be optimized for lowest hydrogen production cost.

Based on results of this investigation, the feasibility of purely renewable-based hydrogen production from dynamic scheduling of both grid-connected and stand-alone systems could be explored in the future.