HYDROGEN

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The hydrogen economy has the ability to significantly decrease our dependence on foreign oil while at the same time decreasing the environmental impact of energy technologies. A true hydrogen economy requires both inexpensive, plentiful sources of hydrogen as well as advanced technologies for using the hydrogen. The state of North Dakota is leading the way in developing and demonstrating both hydrogen production and hydrogen utilization technologies. These technology advances are providing real hydrogen utilization opportunities today that will pave the way for the hydrogen economy.

Hydrogen Production

Engineering practical technologies to extract hydrogen from North Dakota's plentiful natural resources and agricultural products

Hydrogen is the most abundant element on Earth; however, it does not exist in a pure form. Hydrogen is produced from a variety of energy resources including coal, oil, natural gas, agricultural products (biomass), water, wind, and solar energy. With North Dakota's incredible resources of coal, oil, agricultural products, and wind energy, it is poised to be a significant provider of hydrogen. North Dakota already has numerous hydrogen production activities under way.

Producing Hydrogen from Coal

The Energy & Environmental Research Center (EERC) National Center for Hydrogen Technology (NCHT) is working with numerous industry partners to develop coal gasification systems to produce inexpensive, hydrogen-rich gas. The Great Plains Synfuels Plant in Beulah, North Dakota, is a national example of coal gasification today.

Hydrogen from Military Fuels

The EERC NCHT has partnered with the U.S. Army Corps of Engineers Construction Engineering Research Laboratory, ePower Synergies, Inc., and the U.S. Air Force, to develop specialized techniques to produce hydrogen from military fuel (JP8) for on-demand hydrogen on the battlefield. This will be demonstrated at the Grand Forks Army National Guard Base and the Grand Forks Air Force Base.

Hydrogen from Biomass

The EERC's trailer-mounted portable biomass gasification power plant is designed to convert a variety of plant materials to a hydrogen-rich gas similar to natural gas. This gas can be fed into turbines, piston engines, and boilers for low-cost power, or it can be used as a source of hydrogen. This mobile unit is designed for remote power generation where traditional fuel is unavailable or expensive. This technology is quickly advancing to commercial demonstrations.

Coproduction of Hydrogen and Ethanol

There is a growing number of ethanol production facilities in the upper Great Plains. A new technology being developed at the EERC could expand the use of ethanol from corn, with a process that produces clean hydrogen as part of the ethanol production process.

Wind-to-Hydrogen

The U.S. Department of Energy, in partnership with Basin Electric Power Cooperative, the EERC, and many others, is demonstrating the production of hydrogen from water using renewable wind energy near Minot, North Dakota. State-of-the-art wind turbines change wind into electrical energy. Electricity is used to split water into hydrogen and oxygen in an electrolyzer. The hydrogen is pressurized and stored to fuel hydrogen-powered vehicles.

Hydrogen Utilization

Putting clean hydrogen to work for transportation, electrical generation, and heating/cooling applications . . .

When hydrogen is utilized in a fuel cell, it produces electricity, heat, and water with no harmful emissions. Hydrogen can also be used in modified internal combustion engines (ICEs) with significantly reduced emissions. Although wide utilization of hydrogen is still in the future, there are many uses of hydrogen that are practical today, such as off-road vehicles (forklifts, ice refinishers, commercial all terrain vehicles), backup generators, and more. The state of North Dakota has numerous hydrogen utilization technologies in development and demonstration including the following:

- **Internal Combustion Engines**

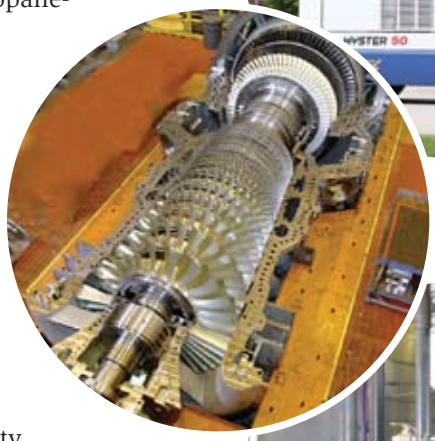
  With some modifications and a certified hydrogen fuel tank, today's vehicles can be converted to use hydrogen. The EERC has partnered with AFVTECH to convert a standard gasoline engine from a Chevrolet Silverado 4x4 half-ton pickup to operate on hydrogen, gasoline, or E85, making it a tri-fuel vehicle.

- **Fuel Cell Ice Refinishers**

  The NCHT, along with key partners including ePower Synergies, Inc., and Olympia, has developed the first commercially available fuel cell-powered ice resurfacer called the **eP-Ice Bear,** which is available for use on ice rinks worldwide today. The fuel cell exhaust contains only water vapor. All harmful gases are eliminated.

- **The Hyster Fuel Cell-Powered Forklift**

  A 4000-pound-capacity lift truck system is currently being tested by the North Dakota Army National Guard. The NCHT has partnered with the U.S. Army Engineer Research and Development Center; ePower Synergies, Inc.; and the U.S. Air Force to develop a dependable hydrogen-powered fuel cell system that replaces the batteries on a conventional electric forklift or standard engine in typical propane- or diesel-powered forklifts.



- **Hydrogen Turbines to Produce Electricity**

  The NCHT is involved in enhancing engine, turbine, and fuel cell development to efficiently use hydrogen. The NCHT is teaming with Siemens Power Generation to help develop the next generation of turbines, which will use hydrogen fuel and advanced combustion systems to reduce emissions while producing electricity.

- **Advanced Fuel Cell Energy Systems**

  To work well, fuel cells need high-purity hydrogen fuel. The NCHT is developing new systems that will produce high-purity hydrogen for use in solid oxide fuel cells. One new system produces hydrogen-rich gas from biomass, which can go directly to a fuel cell with no need for gas cleaning.

"When you look at the future of energy in this country, one of the most promising technologies on the horizon is hydrogen."

– U.S. Senator Byron Dorgan

Hydrogen . . . *Did you know?*

Hydrogen is the most abundant element on Earth . . . Hydrogen (H_2) is combined with oxygen (O) to make water (H_2O). Hydrogen also exists with carbon (C) in plants and fossil fuels like coal, oil, and natural gas. Hydrogen is obtained by processing these plentiful hydrogen sources and separating the hydrogen.

In 1959, Allis-Chalmers created one of the first fuel cell vehicles . . . a farm tractor. With 15,000 watts of power, the tractor generated enough power to pull weight of about 3000 pounds.

The EERC, located in Grand Forks, North Dakota, was designated the National Center for Hydrogen Technology (NCHT) in 2004 . . . The EERC received that designation from the U.S. Department of Energy in recognition of over 50 years of expertise in hydrogen and gasification technologies.

Hydrogen is a safe fuel . . . When hydrogen escapes from a vessel, it rapidly floats upward, thus eliminating the safety risk of the fuel igniting and fire engulfing the vehicle.

Hydrogen is a clean fuel . . . When hydrogen is used in a fuel cell, only heat, water vapor, and electricity are produced, greatly reducing air pollution. When hydrogen is burned with air in a conventional internal combustion engine, only water vapor, nitrogen compounds, and heat are emitted.

How does a fuel cell work? A fuel cell operates like a "rechargeable" battery. However, it does not run down or require charging. It uses hydrogen and oxygen in an electrochemical process that generates continous electricity and heat.

North Dakota is a leading energy producer in the United States . . . Per capita, North Dakota is the fifth largest producer of energy and has the largest wind resource available (commonly referred to as the Saudi Arabia of wind).

"Hydrogen technology is now, not tomorrow. Specialty vehicle applications are just the first wave—the EERC and its corporate partners are involved in the development of a variety of specialty hydrogen fuel cell vehicles, which are providing a cornerstone for deployment of hydrogen fuel cell-powered highway vehicles."

– EERC Director Gerald Groenewold

"The EERC is a model for our Centers of Excellence concept, illustrating a successful partnership between business and research that results in high-paying jobs and career opportunities for our citizens. The new hydrogen technology Center of Excellence facility will generate those jobs and career opportunities by developing the products of the future."

– The Honorable John Hoeven, North Dakota Governor

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