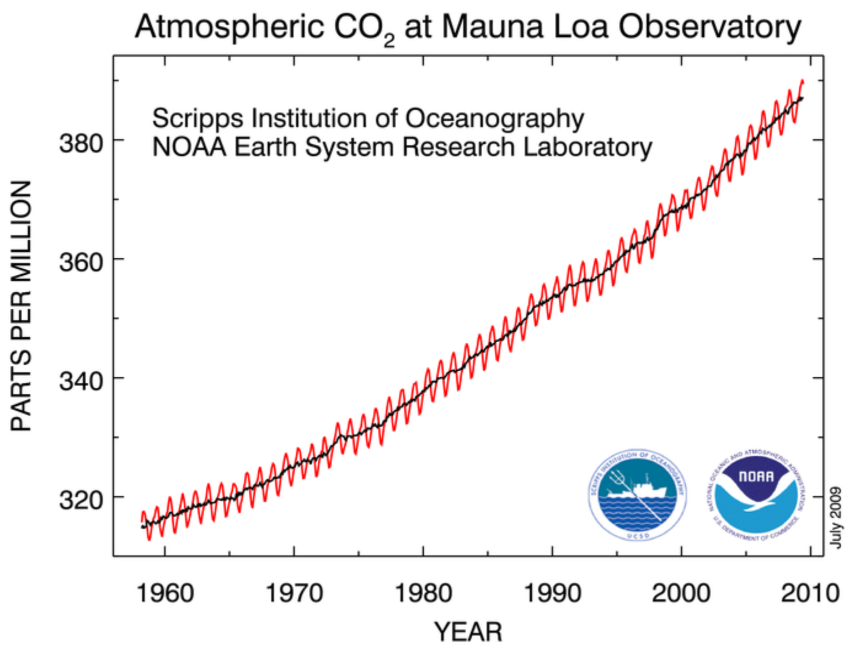
Alternative energy through hydrogen production

A Viable Consideration for the Future of the Northern Plains

Dr. Hal Campbell, Professor Emeritus
California State University – Humboldt
College of Natural Resources and Sciences

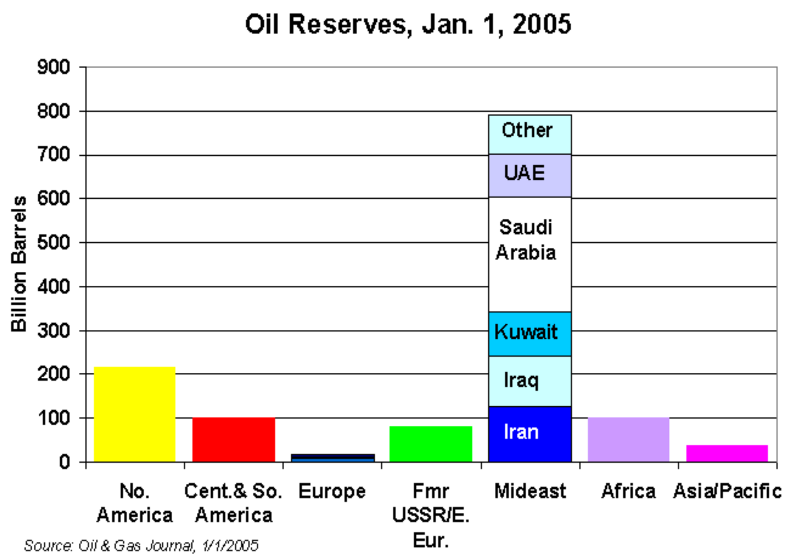
A Presentation Made to the Montana-Dakota Energy Alliance, August 20, 2009, Williston, ND

The contemporary debate over environmental pollution, as well as the discourse regarding our nation's dependency on Arab oil and the impact it has on strategic policy decisions, has fueled continual demands for a viable solution. Despite the impassioned arguments presented by a variety of special interest groups on both sides of the environmental issue, repeated scientific measurement has confirmed that Carbon Dioxide levels have experienced a curvilinear increase from 290 PPM (1000bc) to more than 380 PPM (2008).



In the 1970's automobile manufacturers scrambled to find an effective solution to the rising air pollution and smog levels caused by carbon monoxide automobile emissions. To meet this challenge, they adopted the Catalytic Converter as standard equipment on all automobiles manufactured within the United States in response to the Clean Air Act legislation enacted in 1975. Such an approach became the worldwide standard. Catalytic converters are (functionally) nothing more than complex incinerators that use a three-way catalyst process to superheat unburned fuel and carbon monoxide traveling through the car's exhaust.

For the most part, catalytic converters do a good job of incinerating pollutants harmful to humans before they can escape into the atmosphere, but recent studies confirm that this benefit comes at a significant cost to the environment. What few realized in the 1970's was that even though catalytic converters offered a short term solution to the air pollution crisis, the incineration process that these devices used to deal with unburned gasoline and diesel fuel, would dramatically intensify green house gas emissions. The principle reason for this dramatic rise in CO_2 can be largely attributed to the adoption of catalytic converters, which as a byproduct of incinerating carbon monoxide, converts this gas to Carbon Dioxide. This is exacerbated by a steady increase in the number of vehicles produced each year, which adds to the volume of CO_2 produced annually worldwide. In addition to the adverse effects caused by the use of fossil fuel to power the world's transportation industry, rising gasoline prices have also ignited the fire for dramatic change among consumers. This situation is further accentuated by recognition on the part of the American government that oil has become a strategic weapon, used by unfriendly nations to affect concessions in policy, which places our nation in an untenable position. This issue has been even further intensified by the world's sustained dependency upon foreign oil, which is controlled by a cartel, and the impact that this has on artificial price controls through manipulated changes in supply, along with diminishing reserves, and volatile market speculation by aggressive investors (who neither drill, produce, transport, nor distribute this critical commodity). Consumer demands upon the automobile industry for development of vehicles that operate on alternative fuels, combined with more stringent pollution guidelines has also had a dramatic influence in the rethinking of our future energy needs. No matter whose numbers you choose to believe the future of oil as a primary source of fuel for transportation is finite. The U.S. consumes about 20 million barrels of oil every day. World consumption is estimated at 87 million barrels daily and the majority of oil reserves are controlled by Middle Eastern nations.



As we've seen in recent years a significant push is underway to develop vehicles that operate on alternative energy. General Motors, Ford Motor Company, and several of the leading foreign automobile manufacturers have made significant strides over the past three years in developing hydrogen fuel cell and hydrogen powered vehicles.

The GM Hydrogen4 uses a 440-cell fuel cell stack, 73 Kw electric motor and has three carbon fiber hydrogen tanks that help propel the vehicle to a range of around 200 miles. The GM Hydrogen4 has a top speed of around 100 mph. General Motor's HydroGen3 vehicle is the last general fuel cell vehicle that marked yet another milestone for GM in regards to pursuing a lineup of greener vehicles. The GM HydroGen3 is an environmentally friendly fuel cell minivan that has been used by FedEx as a delivery vehicle for real world testing trials

Ford designers have introduced a new supercharged v-10 engine with a tri-flex fueling system that allows users to enjoy a choice of three different fuels including gasoline, E85 ethanol or hydrogen. The tri-flex fueling system on the Ford F-250 Super Chief allows operators to go 500 miles between total refueling with the supercharger activated only when using the hydrogen fueling system. The hydrogen system also provides 400 lb.-ft. of torque. The transfer between fueling options is performed through a switching system onboard and can be accomplished while the vehicle is running. The hydrogen based fuel alternative boasts 12-percent greater fuel efficiency when compared to either of the remaining fueling options. Using hydrogen also provides 99-percent less CO_2 emissions than the gasoline-only option.

The BMW Hydrogen 7 also generates 260 hp, accelerates from 0 - 60 mph in just 9.4 seconds and runs on liquid hydrogen fuel instead of compressed hydrogen as is typical for fuel cell vehicles. Unlike other hydrogen cars, which are powered by fuel cells, the Hydrogen 7 is powered by a 12-cylinder internal combustion engine (ICE). The vehicle's top speed is electronically limited to 143 mph. The BMW Hydrogen 7 is a dual-fuel vehicle capable of running on either hydrogen or gasoline with just the press of a button on the steering wheel. Engine torque and performance remain the same when switching between the two modes. If either tank on the BMW Hydrogen 7 runs out of fuel the onboard controller automatically switches the vehicle to the other tank.

Although no viable distribution infrastructure yet exists, the technology has been developed to make this a reality and it is likely that this shortcoming will be remedied either through entrepreneurial venture or government mandate within the near term. The question then becomes, which region/s of the country will step forward to serve as the major providers of hydrogen fuel and what technologies will they employ to mass produce this abundant commodity.

As applied to eastern Montana and western North Dakota, transition away from fossil fuels to hydrogen could have long term devastating effects on the economy. An example of such devastation can be seen simply by looking at the Glendive experience and recognizing the consequences of failing to plan for the future and diversifying the region's economy. Fortunately, our area of the country is rich in hydrogen with a virtually limitless supply flowing past most of our major cities. The Yellowstone River maintains an average flow of *10,270* Cubic Feet per Second of water. The Missouri River maintains an equal average flow of *12,250* Cubic Feet per Second 22,520 CFS of water translates to 10,111,480 Gallons per Minute / 41 gallons per Barrel = 246,621 Barrels of water per MINUTE. Since water is 2/3 hydrogen and 1/3 oxygen, this translates to 164,414 barrels of hydrogen fuel (per Minute) moving past the confluence of these two rivers every day. This quantity of potential fuel can be used to not only support the transportation industry, but can also serve as source of fuel for clean electrical power generation.

To put this into perspective the water (or hydrogen) resources that are available in our area and which are located at the surface dwarfs the quantity of oil that is contained in our area and which is located 10,000 feet below the ground. As we know, the Bakken oil reserve stretches across Montana, North Dakota and into Southeastern Saskatchewan. The amount of oil in place has been estimated between 271 billion and 503 billion barrels of oil. A recent U.S. Geological Survey (USGS) field report however released on April 10, 2008, estimated there are only 4.3 billion barrels of technically recoverable oil on the U.S. side of the Bakken. 4.3 billion barrels of total Bakken oil reserves sounds like allot, but when you compare it against the potential reserves of hydrogen you quickly discover that, when compared to the 246,621 Barrels of water per MINUTE of "average" flow of river water, this translates into an interesting comparison. The mathematics of the equation indicate that enough water flows past the confluence of the two rivers (which is easily accessible on the surface) in just 12 days to equal the total oil reserves available deep below ground within the Bakken. The average drilling cost for just one well is between 5 and 7 million dollars. That translates to $700 dollars per foot in drilling costs and break-even point well out in the time line.

Obviously total diversion of water resources isn't feasible, but these computations should provide a sense of the differential between water and oil reserves.

4,300,000,000bbl / 246,621bpm = 17435 minutes

17435 / 60 minutes per hour = 290 hours

290/24 hours a day = 12 days of river flow to equal all the potential oil available within the Bakkan.

An extremely promising option for hydrogen production from water is electrolysis, in which electricity is used to dissociate water into hydrogen and oxygen. Electrolysis is the process of using electricity to split water into hydrogen and oxygen. This reaction takes place in a unit called an electrolyzer. Popular Mechanics magazine awarded GE Global Research (of the General Electric Company) its 2006 Breakthrough Award for development of a leading edge electrolyzer that makes hydrogen production on an industrial scale not only possible, but cost effective. The Electrolyzer has the potential to lower the cost of producing hydrogen energy through the water electrolysis process. High-tech plastic parts are used in place of metal parts to lower the cost of producing high performance electrodes, which improves the technology's market competitiveness. The U.S. Department of Energy has identified electrolyzer capital costs as a major barrier to the competitiveness of hydrogen fuel for transportation. GE's electrolyzer has the potential to bring the cost of producing hydrogen down to a level that is competitive with the current price of gasoline. GE's electrolyzer represents a profound breakthrough in hydrogen energy that has the potential to greatly expand the possibilities in realizing cleaner, more affordable energy solutions, said James Meigs, Editor-in-Chief, Popular Mechanics magazine. "We were impressed as much with the technology's potential impact as we were with the creativity of design that enabled the breakthrough itself. We applaud GE for this extraordinary achievement."

Based on data provided by GE Research regarding the capacity of their industrial electrolyzer the following computations are provided.

Base = 50 Kilowatt hours required to produce 1 Liter of hydrogen production, 50 unencumbered Megawatt hours are available for hydrogen production at MDU Sidney/50kwh per liter = 1000 liters of hydrogen production per hour X 2.79 (current price per gallon of gasoline) = 2,790 dollars per hour X 24 hours = $66,960 per day in retail revenue. Annual retail value in hydrogen fuel from this single source would equal $24,105,600

(Considerations wholesale value of hydrogen, capital outlay for construction and operation, transportation, and utility costs)

Conclusions and Future Directions as presented in a recent paper by the GE scientist that headed the team that invented the electrolyzer stated; "The work performed in FY 2007 brings us confidence that low capital cost electrolyzers can be produced at industrial scales and meet all necessary performance targets. Our market research shows that such an electrolyzer, especially when paired with low-cost electric power, can compete in the existing industrial hydrogen market. Our work for the remainder of the year and in 2008 will focus on demonstrating the prototype pressurized electrolysis stack and completing reference designs for distributed industrial and large scale commercial applications", (Richard Bourgeois, P.E.GE Global Research, 1 Research Circle, Niskayuna, NY 12309, Phone: (518) 387-4550, E-mail: richard.bourgeois@research.ge.com). The new hydrogen electrolyzer was recently turned over by the research team to the marketing team at General Electric. And is now available.

Clearly, there are many considerations and feasibility equations that still need to be reviewed before committing to such a venture, but given the inevitable conversion from fossil fuels to hydrogen it's worth a look over the horizon into this possible source of alternative energy to assure the economic vitality of our region.

A compelling argument can be made for pursuing hydrogen production in the northern plains by the MonDak Energy Alliance under an LLC arrangement that is inclusive of all major energy producers in the region. Given the abundant water resources in the northern plains, combined with the fact that this region possesses a substantial railroad infrastructure that can be used for transporting hydrogen, plus the absence of political and sociological barriers, and in further consideration that the Montana Dakota Utilities power generation plant in Sidney, Montana presently operates at only one half capacity (50MW), it's not difficult to envisage the potential that exists for this region to step forward on to the national stage as one of the premiere leaders in hydrogen fuel production.

The most prudent course of action to further explore and pursue the development of a regional hydrogen production facility would be through the formation of a MonDak Hydrogen Enterprise LLC consisting of;

Scientific Innovators
State, County, and City Governments
Petroleum and Oil Industry Companies
Railroads and Commodity Distribution Companies
Montana Dakota Utilities

If established, the LLC feasibility task force should begin by determining;

1. Total cost/time assessment for constructing a regional hydrogen generation facility.
2. Identification of funding and capital resources.
3. Break-even analysis (that considers relevant variables such as construction costs, increased power generation requirements, transportation, average daily hydrogen production capacity as an offset to cost, and ancillary costs, as well as current and forecasted price per unit of hydrogen.)
4. Forecasted demand for hydrogen and competition sources.
5. Assessment to determine whether a modular or phased approach be used to allow for increased production capacity, as demand increases.
6. Determination of water resources available for hydrogen production and the consequence to agriculture and residential communities.
7. Economic impact study that addresses the consequence of inaction (not taking steps now) should a major hydrogen facility be built in western Montana combined with a decline in oil production in our area.