

# EERC

**EERC Technology... Putting Research into Practice**


**Overview of the Energy & Environmental Research Center  
Energy and Environmental Programs and Global, National, and  
Regional Perspectives, Challenges, and Opportunities**

Dr. Gerald H. Groenewold  
Director


North Dakota Legislative Council Interim Energy Development and  
Transmission Committee  
October 24, 2007

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## What Does the EERC Do?



- The EERC is recognized as one of the world's leading developers of:
  - Cleaner, more efficient, and innovative energy technologies to guarantee clean, reliable energy supplies for the United States and the world.
  - Environmental technologies to protect and clean our air, water, and soil.
- The EERC is a research, development, demonstration, and commercialization center.
- The EERC vigorously maintains a nonadvocacy position.
- The EERC enhances any guarantee.




## EERC Research, Development, Demonstration, and Commercialization



"... the road to energy independence runs right through Grand Forks and up to the front doors of the EERC."

—U.S. Senator Byron Dorgan



## EERC Facilities





## Providing Strategic Solutions to Real-World Problems

The EERC provides practical, cost-effective solutions to today's most critical energy and environmental issues and challenges.

**Our research portfolio includes the following:**


- Clean coal technologies
- Coalbed methane
- Underground coal gasification
- Emission control
  - SO<sub>x</sub>, NO<sub>x</sub>, air toxics, fine particulate, and CO<sub>2</sub>
- Mercury measurement and control
- CO<sub>2</sub> sequestration
- Global climate change
- Energy and water sustainability
- Energy-efficient technologies
- Distributed power generation – various fuels
- Hydrogen technologies
- Alternative fuels
  - Ethanol, biodiesel, biojet, and strategic fuels for the military
- Biomass
- Wind energy
- Water management
- Flood prevention
- Waste utilization
- Contaminant cleanup
- Advanced analytical technologies/extraction technologies
- Pesticides and neurological diseases



## Invention vs. Innovation

**"Don't invent something that nobody wants!"**

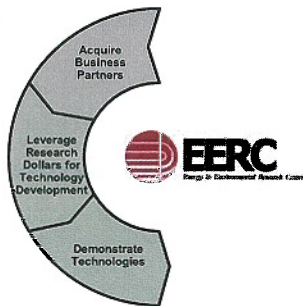
— Thomas Edison



## The EERC Has Pioneered a Market-Driven Approach to RDD&C

The energy industry is focused on the growing demand for more efficient and economical techniques for a variety of fuels.

The environmental field is challenged with the growing demand for the cleanup and control of pollutants and environmental hazards.



## The Culture of the EERC

### Cornerstone: Freedom, Not Security

- At the EERC, we have the freedom to pursue our dreams—but they must be practical, entrepreneurial, and market-driven dreams.
- A culture of partnerships.



## The Culture of the EERC

- The EERC is led by multidisciplinary teams of people, not organizational charts.
- A commitment to nurture leadership throughout the organization.



The EERC receives no state-appropriated funding for RDD&C that is not competitive.



## Willingness to Assume Risk




## The Culture of the EERC

**Relationships are the currency of life.**




## Worldwide Clients




Since 1987, the EERC has had nearly 1000 clients in 49 countries and 50 states.

**Client Specs:**


- Governmental clients: 87
- Academia: 49
- International market: 122
- Private corporations: 731



## EERC Keys to Success




- A unique culture.
- A practical market-driven, problem-solving approach that consistently meets client needs.
- A willingness to assume risk.
- A commitment to commercialize innovative technologies.
- A working environment that provides the freedom to pursue promising opportunities.
- A dedication to building partnerships with the private sector, government, and the research community.
- A talented and diverse group of researchers whose work attracts business from around the world.
- A commitment to excellence.



## EERC Quick Facts

- Total value of current EERC contract portfolio is over \$150 million.
- The EERC had 442 active contracts in FY07.
- In FY07, over 80% of contracts were with private sector partners.
- Total employment of over 300 highly skilled scientists, engineers, and support personnel, with about 20 new open positions.
- Total expenditures for FY07 were more than \$27 million, with an estimated regional economic impact of \$94.5 million.



## EERC Quick Facts


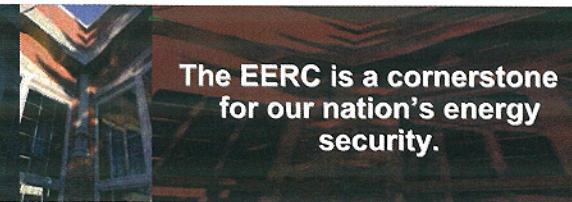
### National News Coverage

- In 2006, the EERC received more than 9 million hits on its Web site.
- In FY07, the EERC was covered in over 520 news articles nationwide.


Coverage included the following:

- 441 newspaper, magazine, and other print articles
- 45 stories aired on broadcast media
- 38 press releases

- The EERC received coverage in the following national publications:
  - USA Today
  - Wall Street Journal
  - The Boston Globe
  - ABC News, FOX News, CBS News, and CNN International
  - Forbes
  - Business Week
  - MSN Money
  - Renewable Energy World Magazine
  - Electric Light & Power Magazine
  - POWER Engineering

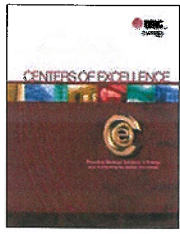

## The EERC is a cornerstone for our nation's energy security.



## EERC Centers of Excellence

The EERC's Centers of Excellence are leading the world in providing expertise in scientifically advanced energy systems and the prevention and cleanup of air, water, and soil pollution.

- Coal Utilization Technologies Center
- Emission Control Technologies Center
- The National Center for Hydrogen Technology
- Center for Climate Change and CO<sub>2</sub> Sequestration
- Center for Air Toxic Metals® (CATM®)
- Centers for Renewable Energy and Biomass Utilization
- Water Management Center
- National Alternative Fuels Laboratory® (NAFL®)
- Supercritical and Subcritical Extraction Technologies Center
- Coal Ash Research Center

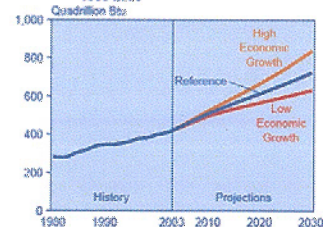
## Ten Key Challenges/Issues Facing the Global Community

1. Population growth
2. Population growth
3. Population growth
4. Population growth
5. Population growth
6. Population growth
7. Population growth
8. Population growth
9. Population growth
10. Energy and environment



## World Energy Consumption Is Expected to Grow 50%–100% in 25 years

Figure 14. World Marketed Energy Consumption in Three Economic Growth Cases, 1980–2030

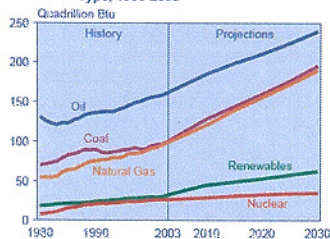


Sources: History: Energy Information Administration (EIA), *International Energy Annual 2003* (May–July 2005), web site [www.eia.doe.gov/iea/](http://www.eia.doe.gov/iea/); Projections: EIA, *System for the Analysis of Global Energy Markets* (2006).



## Renewables Have a Big Growth Percentage, But Fossil Fuels Have to Grow the Most

Figure 10. World Marketed Energy Use by Fuel Type, 1980–2030



Sources: History: Energy Information Administration (EIA), *International Energy Annual 2003* (May–July 2005), web site [www.eia.doe.gov/iea/](http://www.eia.doe.gov/iea/); Projections: EIA, *System for the Analysis of Global Energy Markets* (2006).



**“Predictions are hard,  
especially about the future.”**

**— Yogi Berra**



**Carbon management (CO<sub>2</sub>) is the gatekeeper for long-term fossil energy use:**

- Oil
- Coal
- Natural gas



## U.S. Energy Consumption by Fuel Type 2005

(Source: U.S. Department of Energy Energy Information Administration)

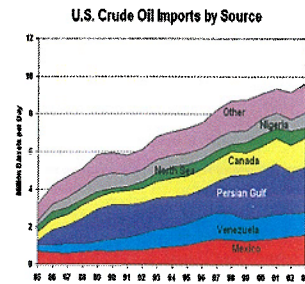
Fuel Type	Energy (quad. Btu)	Percent
Coal	23	23
Natural Gas	18.5 domestic 3.5 imported 22 total	18.5 domestic 3.5 imported 22 total
Oil	16 domestic 24 imported 40 total	16 domestic 24 imported 40 total
TOTAL FOSSIL ENERGY	86	86
Nuclear (no new facilities in 30 years)	8	8
Renewables (largely hydroelectric and wood burning)	6	6
	100	100 total



# Oil



## U.S. Oil Imports by Source



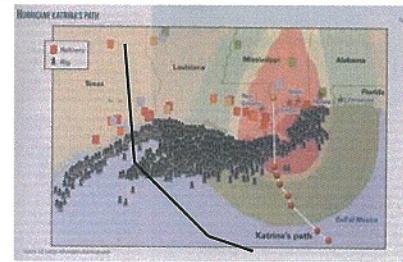
Source: DOE EIA Country Analysis Brief 2003



Two-thirds of the increase in world petroleum production during 2000–2005 came from the former Soviet Union, not OPEC.



## The Strategic Oil-Related Resources and Vulnerability of the Gulf Coast Region



- 35% of U.S. oil and natural gas production (4000 platforms)
- 45% of U.S. refining capacity, 70% of VLCC ports, Henry Hub natural gas and gasoline pipelines (33,000 miles), SPR
- \$25 billion in damage and \$16 billion in lost revenue



# Coal



## New Electrical Demand in the United States

- The United States currently has 500 coal-fired power sites with 1250 units.
- DOE NETL (May 2007) analyzed 151 new and proposed coal-fired power plants representing 90 GW of power: enough energy to power 90 million homes.
- Corresponding increase in need for cooling water.
- Total investment in these projects was estimated at \$145 billion.



## Coal Gasification The Power Plant of the Future

- Current coal gasification systems are acknowledged to cost more than conventional coal-fired plants (EPRI, 2006).
- **Carbon capture and sequestration**, if required, may make coal gasification the least-cost option for new coal-fired power generation.
- **NEAR-ZERO TO ZERO EMISSIONS.**

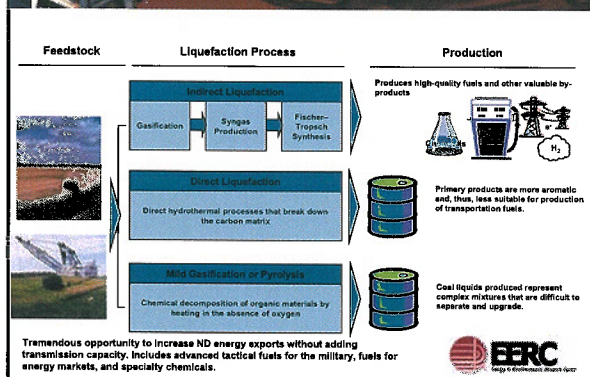
Transient Gasifier



## Coal to Liquids (CTL)



## Liquefaction of Coal and Biomass



## Liquefaction of Coal and Biomass

- Indirect liquefaction is currently the only economical technology for producing liquid fuels from coal or biomass, cost-effective at approximately \$40–\$50/barrel.
  - The process is similar to the existing Great Plains Synfuels facility except instead of producing a synthetic natural gas, the facility would produce a liquid fuel via Fischer–Tropsch synthesis.
  - Future coal gasification systems could be built to produce three energy sources: electricity, liquid fuel, and hydrogen.
  - There are no commercial plants in the United States; however, Sasol has been doing this for many years in South Africa, and other countries are currently building facilities.
- 

## Liquid Fuels from Coal

- The U.S. military has set out to rid itself of dependence on foreign oil. The Army has announced its intent to build up to seven coal-to-liquid facilities.
- Coal to liquids is competitive with oil at \$40–\$50/barrel. However, it could take 8–10 years to build a facility.



## Natural Gas



## Natural Gas Usage in the United States

- The use of natural gas for electrical generation has grown more than 50% since 1994.
- 25% of natural gas usage in 2004 was for electrical generation (5.5 quads).
- 19% of natural gas usage in 2004 was from imported natural gas (4.3 quads).
- Nonfuel uses
  - Hydrogen production
  - Fertilizer production (ammonia)
  - Plastic feedstock
  - Chemical feedstock (methanol)
- In 2004, about 50% of the U.S. methanol, 45% of the ammonia, and 15% of the ethylene capacity were shut down because of high natural gas prices.
- U.S. chemical industry accounts for about 10% of all U.S. gas consumption.



## Natural Gas

Should be considered a chemical feedstock, not a feedstock for electrical generation.



## Natural Gas & Climate Change

Action now will shape the future

While scientists hammer out a better understanding of climate change, significant and widespread actions are being taken now to reduce the amount of carbon dioxide released into the atmosphere. As public opinion and government shape environmental policies and laws to address global warming, winners and losers are emerging.

Increased natural gas use should be championed as an immediate, genuine and compelling strategy to mitigate climate change. The more natural gas we use today, the cleaner the environment and the more efficient the economy tomorrow. But misconceptions about natural gas supply availability, costs, and the impacts of exploration and production are blurring decision makers' ability to recognize natural gas as a powerful "wedge" against increasing levels of CO<sub>2</sub>. With half the CO<sub>2</sub> emissions of its principal fossil-fuel competitor, secure increasing domestic supply, and innovative production technologies and sound environmental practices in place today — the natural gas industry must make its case strongly in the public arena and take a seat at the table.

The consequences of acting now (or not) will be critical for the Rockies, the U.S. economy and the world's environment.



## CO<sub>2</sub> Sequestration

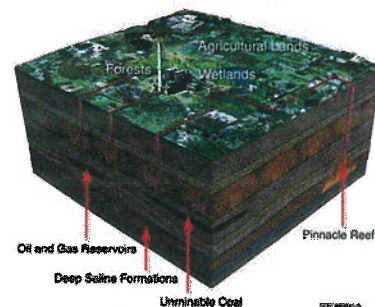


## Major Opportunity

- CO<sub>2</sub> is a resource, not a pollutant.
- The use of sequestered CO<sub>2</sub> can enhance oil and gas production.
- CO<sub>2</sub> is also a versatile solvent for many industrial applications.



## CO<sub>2</sub> Sequestration



## Oil from the Bakken Formation

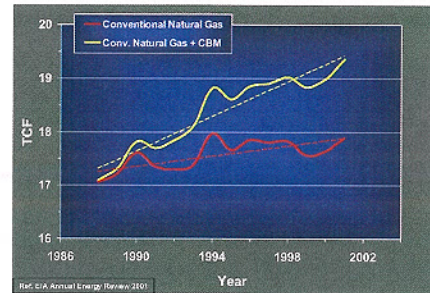
- 200,000-mi<sup>2</sup> formation of oil-rich shale.
- Estimated oil in place ranges from 200 to 500 billion barrels.
- With only 10% recovery, it would eclipse Prudhoe Bay as largest U.S. find.
- Translates to about 30 years of all U.S. oil consumption at current rates.
- Its recovery is technologically challenged.



"Easy to Find, Difficult to Produce"



## Coalbed Methane or Other Unconventional Natural Gas Resources Could Impact U.S. Natural Gas Production



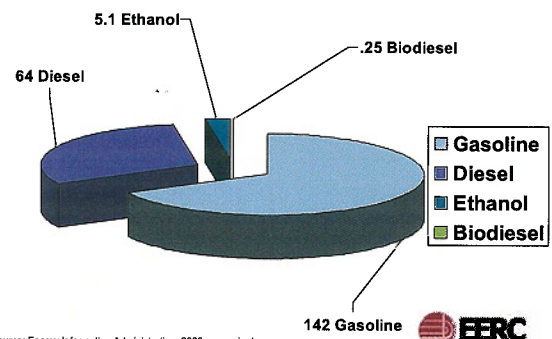
Coalbed methane has continued to show significant growth. North Dakota lignite potential needs to be explored.



## Ethanol and Biodiesel



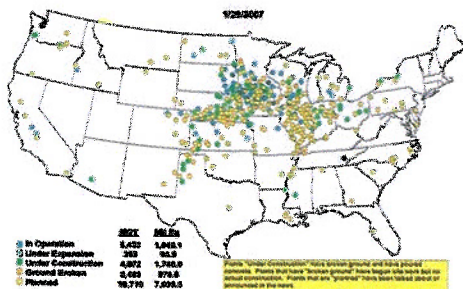
## Transportation Fuels in the United States 2006 Estimates in Billions of Gallons



Source: Energy Information Administration, 2006, [www.eia.doe.gov](http://www.eia.doe.gov).



## U.S. Ethanol Plants



Sources: 2007 Renewable-Ag.com, [www.renewable-ag.com](http://www.renewable-ag.com).



## Today's Ethanol Industry

- 115 grain ethanol biorefineries are producing about 5.6 billion gallons of ethanol.
- Over 80 construction projects are under way that will add at least another 5 billion gallons within 3 years.
- 10 million metric tons of livestock/poultry feed.
- Current land and agricultural methods can sustain about 15 billion gallons of corn ethanol.
- Beyond 15 billion gallons, genetic breakthroughs or cellulosic ethanol will be required.



## Today's Ethanol Industry

- Enough ethanol is produced yearly for 8 days of U.S. transportation. This market is growing rapidly.
- Ethanol (E85) gasoline is more expensive today than petroleum gasoline when you account for mileage differences.
- Ethanol subsidies (51 cents per gallon) will need to be diminished in the future if it becomes a larger part of the fuel mix (nearly \$1 billion in lost revenues to the Highway Trust Fund as a result of ethanol in 2005). Who will pay for the roads?
- Key question: food vs. fuel



## Estimated Land Requirements for Renewable Transportation Fuels

(100% replacement of gasoline and diesel with ethanol and biodiesel by 2015)



Cropland requirement to replace 140 billion gallons of gasoline and 60 billion gallons of diesel:

- Ethanol = 450 million acres (corn ethanol)
- Biodiesel = 500 million acres (soybean biodiesel)

The total acreage available for U.S. crop production is 455 million acres.



## Lignocellulosic Ethanol Production

**"But the fuel (ethanol) will not make a dent in U.S. gasoline consumption unless it can be made from cellulosic stocks."**  
 – U.S. Energy Secretary Samuel Bodman.

- Lignocellulosic ethanol can be produced from nontraditional sources (woody biomass, forest by-products, recycled wood,...) and from agricultural residues (wheat straw, corn stover,...), thus helping to reduce the acreage limitations of ethanol.
- Lignocellulosic ethanol is currently twice the cost to produce compared to corn-based ethanol (\$2.20/gallon).



## Today's Biodiesel Industry

- ~900 MM gallons of production capacity in the United States by the end of 2007.
- 105 plants.
- Largest plant of 85 MM gallons being built in North Dakota by Archer Daniels Midland.
- Biodiesel requires less energy to produce than ethanol; however, significantly less is produced per acre.
- Issues – cold-weather performance and long-term storage.



## The Future of Renewable Energy



## What Are the Primary Drivers for Renewable Energy?

- Energy security
- Economics
- CO<sub>2</sub> concerns
- Rural economic development
- Technical needs (biodiesel as a lubricity enhancer in ultralow-sulfur diesel)
- Public opinion



## Renewable Energy Challenge

- It is impossible at this time (and in the foreseeable future) to assume that we can satisfy all (or even most) of these drivers.
- We do not want to repeat the mistakes of the 1970s.
  - Increasing production capacity in the absence of fiscal responsibility (irrational exuberance).
- We must understand the drivers and how technologies respond to those drivers.



## Wind



## Wind Challenges

- Current technology produces electricity from wind an average of only 40% of design capacity (requires 100% backup system to maintain reliability).
- Lack of transmission infrastructure.
- Not portable (unusable for transportation).
  - H<sub>2</sub> from wind via electrolysis may change this?
- Wind farms impact the environment and wildlife.
  - 6970 towers (at 10 acres each = 109 square miles) would be needed to replace the current eight North Dakota coal-fired power plants.
- Requires 1.9 cents per kWh tax credit to be economic.



## Wind Resource in the United States

Wind Resource Rank*	Wind Energy Potential, MW	Installed Capacity at the End of 2005, MW
1. North Dakota	138,400	179
2. Texas	136,000	2768
3. Kansas	121,900	364
4. South Dakota	117,200	44
5. Montana	116,000	145
6. Nebraska	99,100	73
7. Wyoming	85,000	288
8. Oklahoma	82,763	535
9. Minnesota	75,000	895
10. Iowa	62,900	936
17. California	6779	2361

\*American Wind Energy Association.

North Dakota is number one for wind energy potential.



## Current Federal Incentives/Subsidies for Wind, Ethanol, and Biomass – Uncertainty

- Wind energy production tax credit until December 31, 2008.
- Tax credit for the production of electricity from biomass – until December 31, 2008. Biomass includes sawdust, tree trimmings, and agricultural by-products.
- Federal excise tax exemption of 51 cents per gallon of grain ethanol blended into gasoline. Incentives governed by the Volumetric Ethanol Excise Tax Credit (VEETC) legislation passed in 2004 and scheduled to expire in 2010.
- A new tax incentive to produce ethanol from cellulosic ethanol plants placed in service through December 31, 2012. Provision provides 50% bonus depreciation. Applies to cellulosic ethanol derived from feedstocks such as switchgrass, wood fibers, shell hulls, agricultural residue, and other organic sources.
- 54-cent-per-gallon tariff on imported ethanol through January 1, 2009.

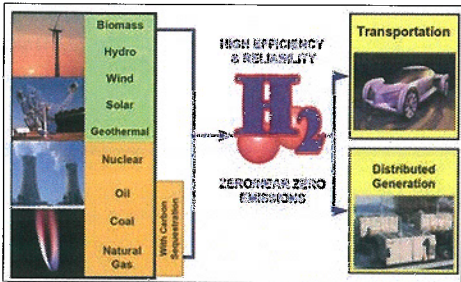


## Hydrogen



## Hydrogen Production

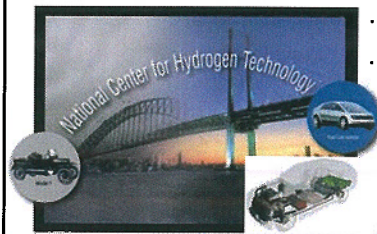
It can be obtained from many domestic resources and can be clean and efficient.



Source: U.S. Department of Energy



## The Western United States Is Poised to Support a Hydrogen Economy



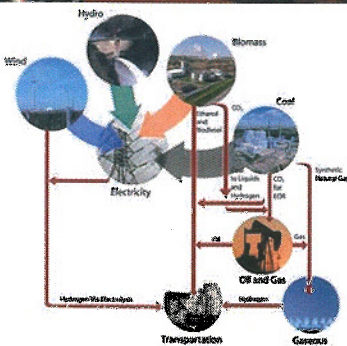
- The hydrogen economy will rely on a diverse mix for supply of hydrogen.
- Coal is a likely cornerstone for that mix, with integration of hydrogen production into coproduction of power and synthetic fuels.

The National Center for Hydrogen Technology at the EERC comprises a range of development activities, including:

- Coal-to-hydrogen production and purification.
- Hydrogen storage, transport, and end uses.
- Hydrogen from renewable sources.



## Opportunities for Energy Synergy



## Bottom Line

- Enormous and growing global competition for energy supplies.
- United States vulnerable to disruption of petroleum supply.
- Much of our domestic oil and gas resources and associated infrastructure are on the Gulf Coast.
- U.S. electrical demand is increasing significantly—corresponding increase in demand for water.
- Natural gas is better used as chemical feedstock.
- Renewables can play a significant role.
- Fossil energy remains the key to U.S. energy security—CO<sub>2</sub> capture and sequestration are essential.
- Enhanced efficiencies must be achieved.
- Energy and water sustainability issues are critical.



## THE EERC's ROLE...



## Select Program Highlights

- Zero-emission power plants
- National Center for Hydrogen Technology
- Plains CO<sub>2</sub> Reduction Partnership
- Oil and gas
- Distributed energy
- Crop oil to jet fuel
- Water



## Zero-Emission Power Plant Becomes a Reality



- The EERC is working with numerous corporate partners to make zero-emission coal-fired power generation a reality.
- Such a facility would run more efficiently and exceed current air emission regulations.
- The technical hurdles are behind us; it is just a matter of time before the system economically becomes a reality.
- Design consists of an entire family of technologies that, when working together, will address all major and minor environmental challenges, offer greatly enhanced efficiency and reduced emissions, and contribute to a cleaner, healthier environment.



## Zero-Emission Power Plant Becomes a Reality



- Key components of the system include:
- Advanced coal utilization technologies to improve energy efficiency and reduce fuel use.
  - Advanced emission control devices to reduce sulfur oxide (SO<sub>x</sub>), sulfur trioxide (SO<sub>3</sub>), and nitrogen oxide (NO<sub>x</sub>).
  - The EERC's *Advanced Hybrid*™ filter to capture 99.99% of fine particulates.
  - State-of-the-art mercury control technologies.
  - Devices to capture and sequester carbon dioxide.
  - Technology to recover water from the power plant and conserve scarce water resources.



## The National Center for Hydrogen Technology (NCHT)

The EERC was designated by the U.S. Department of Energy in November 2004 as the National Center for Hydrogen Technology.

The EERC has more than 50 years of experience with hydrogen production and fuel cell technologies.



## The National Center for Hydrogen Technology (NCHT)

Current and pending contracts in the NCHT include nearly \$45 million in funding for the following projects:

- Hydrogen from coal
- Hydrogen on demand
- Battlefield hydrogen (JP-8)
- Biomass-to-hydrogen program
- Integrated hydrogen and ethanol production
- Wind-to-hydrogen
- Hydrogen fuel cell-powered vehicles



## The National Center for Hydrogen Technology (NCHT) Facility



The EERC's new 15,000-square-foot facility for the NCHT will augment hydrogen-related programmatic growth, resulting in 50 to 100 new high-paying technical jobs at the EERC and facilitating at least 50 to 100 new private sector jobs in the Grand Forks region.




## The National Center for Hydrogen Technology (NCHT)

### Partners



- |  |   |  |
|--|---|--|
| <ul style="list-style-type: none"> <li>• Agricultural Utilization Research Institute</li> <li>• Air Products and Chemicals, Inc.</li> <li>• Appareo Systems</li> <li>• Ballard</li> <li>• BMC Construction</li> <li>• BNI Coal</li> <li>• Basin Electric Power Cooperative</li> <li>• Bobcat Company</li> <li>• CEO Praxis Inc.</li> <li>• Chippewa Valley Ethanol Producers</li> <li>• City of Grand Forks</li> <li>• Coming</li> <li>• CRI-Criterion, Inc.</li> <li>• ePower Synergies, Inc.</li> <li>• Fisher Motors</li> <li>• Franklin Fuel Cells</li> <li>• General Hydrogen</li> <li>• Grand Forks Army National Guard</li> </ul> | <ul style="list-style-type: none"> <li>• Grand Forks Air Force Base</li> <li>• Great River Energy</li> <li>• H2Gen Innovations</li> <li>• Idatech</li> <li>• Kraus Global Inc.</li> <li>• Microbeam Technologies, Inc.</li> <li>• Minnesota Corn Growers Association</li> <li>• Minnesota Corn Research Council</li> <li>• Mind Area Chamber of Commerce</li> <li>• NexTech Materials</li> <li>• North American Coal Corporation</li> <li>• North Dakota Association of Rural Cooperatives</li> <li>• North Dakota Centers of Excellence</li> <li>• North Dakota Corn Utilization Council</li> <li>• North Dakota Department of Commerce</li> <li>• North Dakota Industrial Commission</li> </ul> | <ul style="list-style-type: none"> <li>• Nuvera</li> <li>• Prairie Public Broadcasting, Inc.</li> <li>• Pratt &amp; Whitney Rocketdyne, Inc.</li> <li>• Red River Valley Research Corridor</li> <li>• Resurface Corporation</li> <li>• Rio Tinto</li> <li>• SGL Carbon</li> <li>• Siemens Power Generation</li> <li>• Sud Chemie, Inc.</li> <li>• TXU Power</li> <li>• U.S. Air Force</li> <li>• U.S. Army</li> <li>• U.S. Department of Agriculture</li> <li>• U.S. Department of Energy</li> <li>• United Technologies Research Center</li> <li>• Verendrye Electric Cooperative</li> <li>• Xcel Energy</li> <li>• Xethanol</li> </ul> |
|--|---|--|



## Center for Climate Change and CO<sub>2</sub> Sequestration





- The EERC is one of the leading organizations selected by the U.S. Department of Energy (DOE) to determine the best ways to manage our country's CO<sub>2</sub> emissions.
- The EERC's Plains CO<sub>2</sub> Reduction (PCOR) Partnership is the largest and best of seven lead organizations around the nation heading up an effort to meet the President's Global Climate Change Initiative.
- The EERC was awarded \$25 million to advance commercialization of climate change technologies to capture and permanently store greenhouse gases. The PCOR Partnership award is the EERC's largest single award to date.

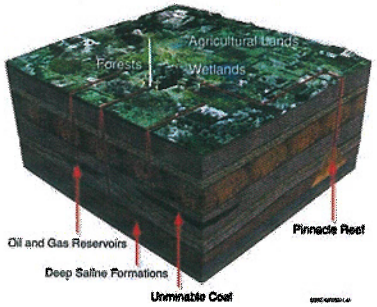




## PCOR Partnership Region

Nine states and four provinces  
1,362,089 square miles





## CO<sub>2</sub> Sequestration

## Center for Climate Change and CO<sub>2</sub> Sequestration

**Phase II Partners**



The PCOR Partnership currently has 72 partners representing public agencies, utilities, oil and gas companies, engineering firms, associations and nonprofit organizations, and universities.




## PCOR Partnership Sequestration Activities




## Major Opportunity

- CO<sub>2</sub> is a resource, not a pollutant.
- The use of sequestered CO<sub>2</sub> can enhance oil and gas production.
- CO<sub>2</sub> is also a versatile solvent for many industrial applications.



## Oil and Gas

Oil- and gas-related research programs at the EERC embrace an array of issues relevant to the industry. The EERC provides the following services and activities:



- Over three decades of practical field and laboratory experience
- Development of specialized value-added products from coal, plastic wastes, and other low-cost carbon sources
- Petroleum engineering
- Geological characterization
- Resource assessment
- Coalbed methane – soil and groundwater remediation
- Freeze-thaw/evaporation (FTE®) for produced water management



## Oil from the Bakken Formation

- 200,000-mi<sup>2</sup> formation of oil-rich shale.
- Estimated oil in place ranges from 200 to 500 billion barrels.
- With only 10% recovery, it would eclipse Prudhoe Bay as largest U.S. find.
- Translates to about 30 years of all U.S. oil consumption at current rates.
- Its recovery is technologically challenged.



*"Easy to Find, Difficult to Produce"*



## Distributed Generation – Gas Microturbines

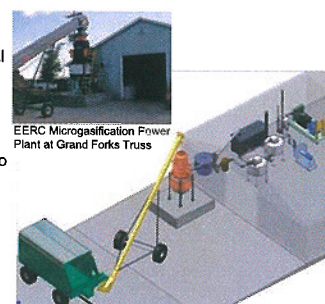
### EERC Powers Microturbines with Oil Field Gas

- Turn by-product gas into a valuable fuel resource.
- Supply electrical power to oil field operations in remote locations for ongoing enhanced oil recovery efforts.
- Cedar Creek Red River Oil Field, south of Marmarth, North Dakota, operated by Encore Acquisition Company, Fort Worth, Texas.
- 12 well sites in operation.
- 70% emission reduction can be achieved.



## Distributed Generation – Biomass Power

- Small gasification systems (nonutility scale)
- Low capital with economical power generation
- Simplified operation
- Waste utilization
- Market-driven
- Future syngas conversion to liquids potential



## Alternative Fuels Development and Commercialization Center – ND Jobs (manufacturing)

- The EERC focuses first on local manufacturing, even for systems that will be deployed elsewhere.
  - Anticipate spending over \$1.5 million in local manufacturing over the next 12 months in support of demonstration and commercialization activities

North Dakota-manufactured biomass gasification for heat and power systems going to

- Fond du Lac Reservation, Minnesota
- Thief River Falls, Minnesota
- Ashcroft, British Columbia

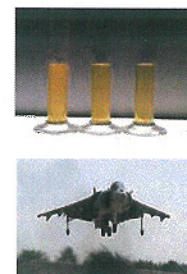
North Dakota-manufactured mercury control systems going to

- Kansas City, Kansas
- Fergus Falls, Minnesota
- Regina, Saskatchewan

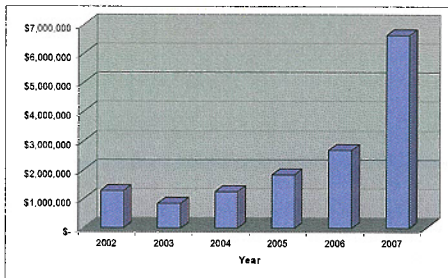


## Oil Crop-Derived Alternatives to Petroleum-Based Diesel and Jet Fuel

- EERC partnership with Wright-Patterson Air Force Base (WPAFB) and oil crop producers.
- Develop vegetable oil-derived fuels with cold-flow, energy density, and other critical properties that comply with commercial diesel and jet fuel specifications.
- New EERC technology using vegetable oil to produce synthetic JP-8 fuel funded by the Defense Advanced Research Projects Agency (DARPA) and the U.S. military.



## EERC Research Contracts in Alternative Fuels



## Water Management Center

**“Whiskey is for drinking, water is for fighting.”**

**– Mark Twain**



## Water Management Center

The EERC is a leader in addressing critical water issues including:

- Flood and drought mitigation (Waffle®).
- Climate reconstruction for forecasting.
- Hydraulic/hydrologic modeling.
- Technology assessment and demonstration.
- Storm water management.
- Groundwater resource investigation.
- Water/wastewater treatment.
- Contaminant cleanup.
- Animal-feeding operation assessment.
- Watershed stewardship.
- Water resource monitoring.
- Riparian restoration.
- Public information dissemination.



## Energy and Water

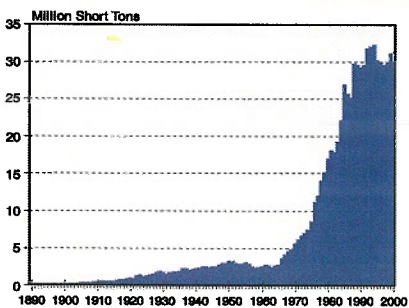
- Conventional coal power generation is second only to agriculture as the largest user of water in the United States:
  - 39% of all freshwater withdrawals in the United States
- 131,900 million gal/day of water is used.
- All regions of the United States are vulnerable to water shortages.
- Recent technology developments:
  - Flue gas water extraction
  - Dry and hybrid cooling systems



Continued availability and efficient use of water resources are critical to the future growth of the energy industry.



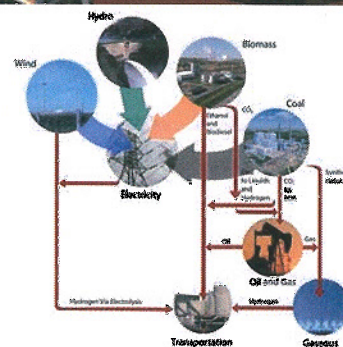
## Annual History of North Dakota Coal Mined – Energy and Water Sustainability



ND state statistics publicly available at [www.oilgas.nd.gov/stats/statistics.asp](http://www.oilgas.nd.gov/stats/statistics.asp)



## Opportunities for Energy Synergy



# A UNIQUE BUSINESS MODEL TO COMMERCIALIZE TECHNOLOGIES



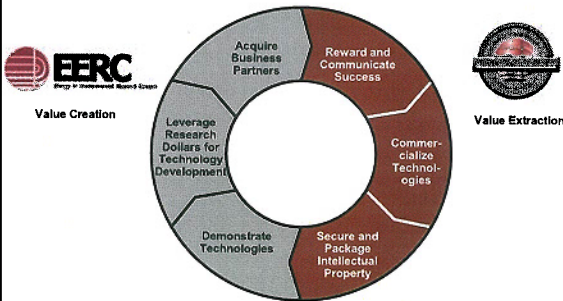
## EERC Foundation Complements the EERC Business Model by Commercializing Technologies



- Commercialization is facilitated through the EERC Foundation, a nonprofit corporation formed in 1992.
- The EERC excels through partnerships with clients in industry and government to develop, refine, demonstrate, and commercialize marketable technologies that provide practical solutions to real-world problems.
- The EERC specializes in jointly sponsored research projects and multiclient consortia between government and industry.
- Facilitating confidentiality agreements is a cornerstone of the EERC's commercialization activities.

## This Integrated Approach to Technology Management Creates and Extracts Value

### A Seamless Transition...



## Invention vs. Innovation

### Invention:

"An act of finding or of finding out"

### Innovation:

"The introduction of something new"



## Invention vs. Innovation

The history of **INVENTION** is the story of litigation.


The history of successful marketplace **INNOVATION** is the story of relentless business focus.




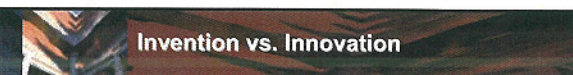
"The role of invention in innovation is vastly overblown. There is no correlation between a successful act of invention and a successful marketplace innovation. None."

— Michael Schrage







**"Patent productivity is a lousy measure for innovation that matters."**  
— *Michael Schrage*

### Invention vs. Innovation

The key is not invention; the key is the ability to cost-effectively translate breakthrough inventions into marketable products.

### Invention vs. Innovation

University-derived technology championed by innovative private sector partners is key to success in the marketplace.




The market must **pull** technology.

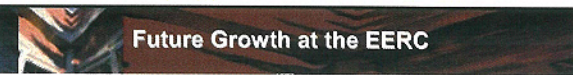



### EERC — A Culture for Commercialization

We put **research** into practice, focusing on innovation, not invention.

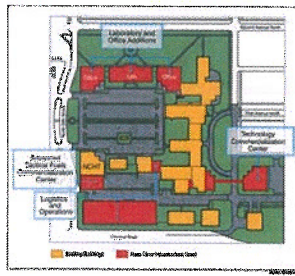
We value our partners, providing them with strategic, timely, and professional service.

We seek to inspire enterprising and imaginative people—in our clientele and our staff—and reward our innovators.


### Future Growth at the EERC

**The EERC's 5- to 7-year Strategic Infrastructure Plan**



As a result of continuing growth at the EERC and new program opportunities, there is an urgent need for additional facilities dedicated to the development and commercialization of environmental technologies. The plan includes:

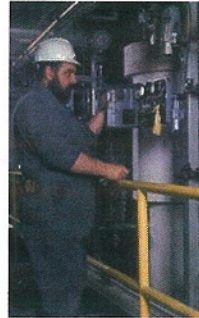
- Total employment goal of 550–600 employees within the next 5–7 years
- The National Center for Hydrogen Technology (NCHT) facility
- The Technology Commercialization Center
- Two office buildings
- One laboratory building
- One storage facility



### The Challenge

**"Human history more and more  
becomes a race between  
education and catastrophe."**

**—H.G. Wells**



**"Opportunity is missed  
by most people  
because it comes  
dressed in overalls and  
looks like work."**

**—Thomas Edison**



### Contact Information

**Energy & Environmental Research Center**  
University of North Dakota  
15 North 23rd Street, Stop 9018  
Grand Forks, North Dakota 58202-9018

World Wide Web: **[www.undeerc.org](http://www.undeerc.org)**  
Telephone No. (701) 777-5131  
Fax No. (701) 777-5181

**Gerald H. Groenewold, Director**

