



EERC

EERC Technology... Putting Research into Practice

**Global, National, and Regional
Perspectives on Energy Development**

**Presentation to the
Energy Development and Transmission Committee
Energy & Environmental Research Center
September 16, 2009**

**Dr. Gerald H. Groenewold
Director**



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 (RDD&C) center.
- The EERC vigorously maintains a nonadvocacy position.
- The EERC enhances any guarantee.
- The EERC is NOT an academic enterprise.

THE INTERNATIONAL CENTER FOR APPLIED ENERGY TECHNOLOGY



EERC Research, Development, Demonstration, and Commercialization

EERC ES31650.CDR

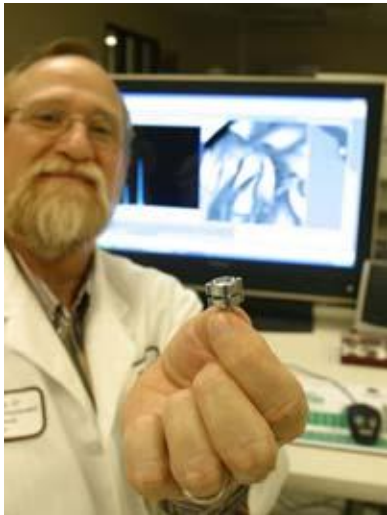


Over 245,000 square feet of state-of-the-art facilities.

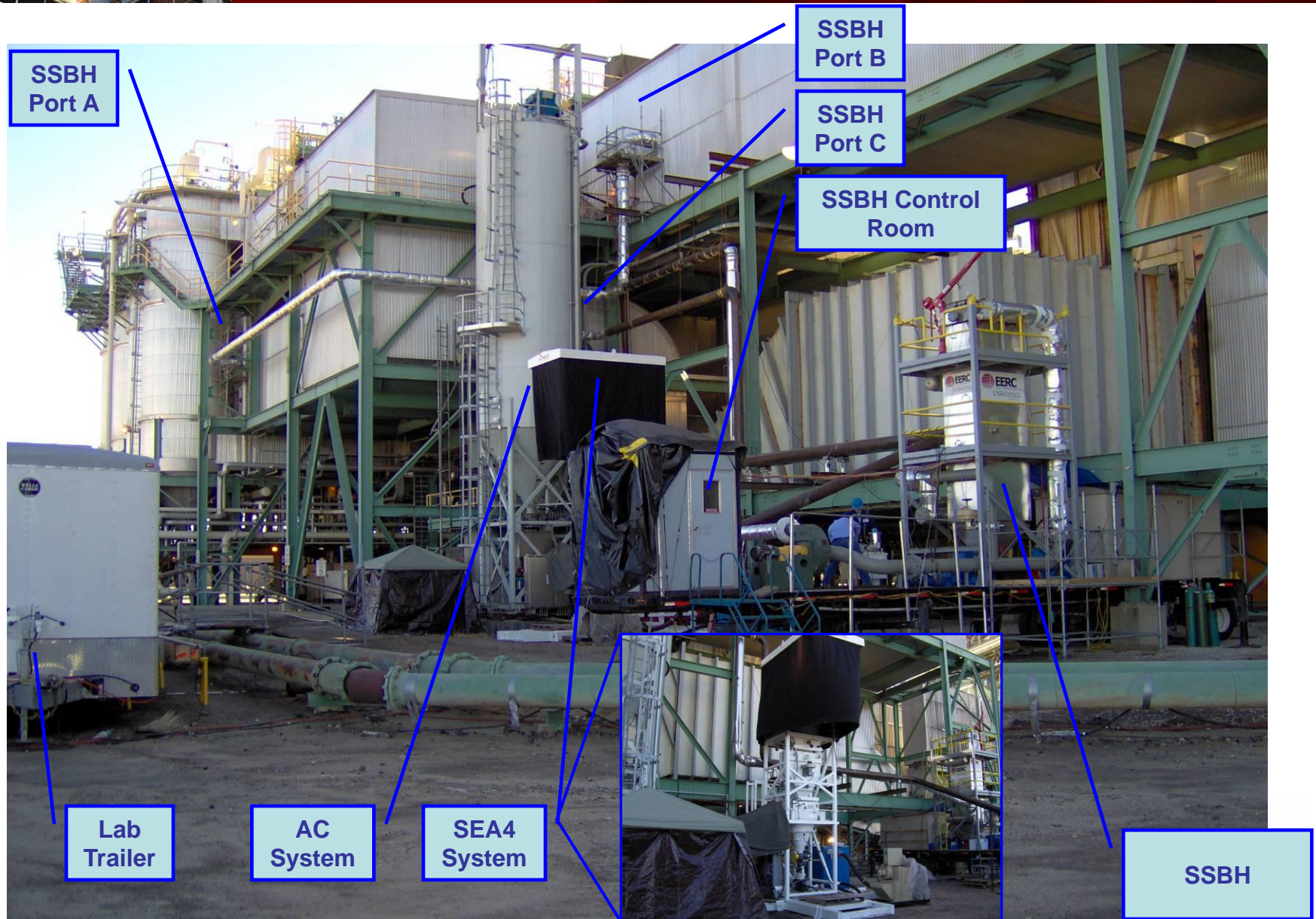
“... the road to energy independence runs right through Grand Forks and up to the front doors of the EERC.”

–U.S. Senator Byron Dorgan

EERC Facilities



Mobile Test Equipment – Big Brown in Texas
Features: Slipstream Baghouse (SSBH), Laboratory Trailer, Activated Carbon (AC) System, and Small-Scale Sorbent Injection System



Air Jig



Used in the field to reduce ash and moisture in coals such as lignite.



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:

- Clean coal technologies
- Coalbed methane
- Underground coal gasification
- Emission control
 - SO_x , NO_x , air toxics, fine particulate, and CO_2
- Mercury measurement and control
- CO_2 sequestration
- Global climate change
- Energy and water sustainability
- Energy-efficient technologies
- Distributed power generation – various fuels
- Hydrogen technologies
- Alternative fuels
 - Ethanol, biodiesel, 100% renewable diesel, and jet, including 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



The Culture of the EERC

**“Don’t invent something
that nobody wants!”**

– *Thomas Edison*



The market must
pull
technology.



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.



**By Choice, the EERC Receives
No State-Appropriated
Funding for RDD&C That Is
Not Competitive**



Willingness to Assume Risk



Worldwide Clients

Since 1987, the EERC has had nearly 1100 clients in all 50 states and 51 countries.

Client Specs:

- Government: 93
- Academia: 52
- International market: 142
- Private enterprise: 787

EVERY CONTRACT IS A COMMERCIALIZATION ACTIVITY



EERC Quick Facts

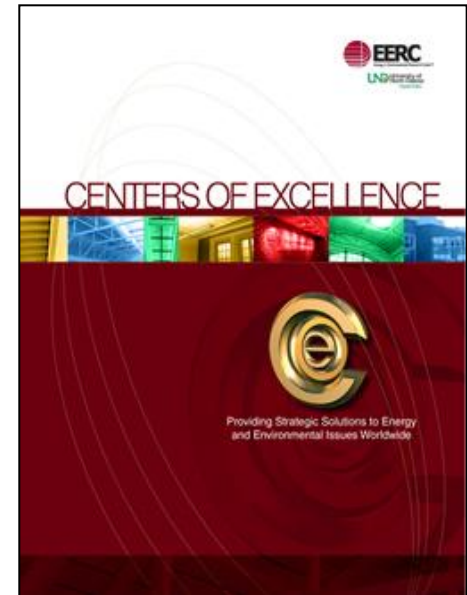
- The EERC had 434 active contracts in FY08.
- In FY08, 87% of contracts were with private sector partners.
- Total employment of over 330 highly skilled scientists, engineers, and support personnel, with about 20 new open positions.
- Total value of current EERC contract portfolio is \$227 million.



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.

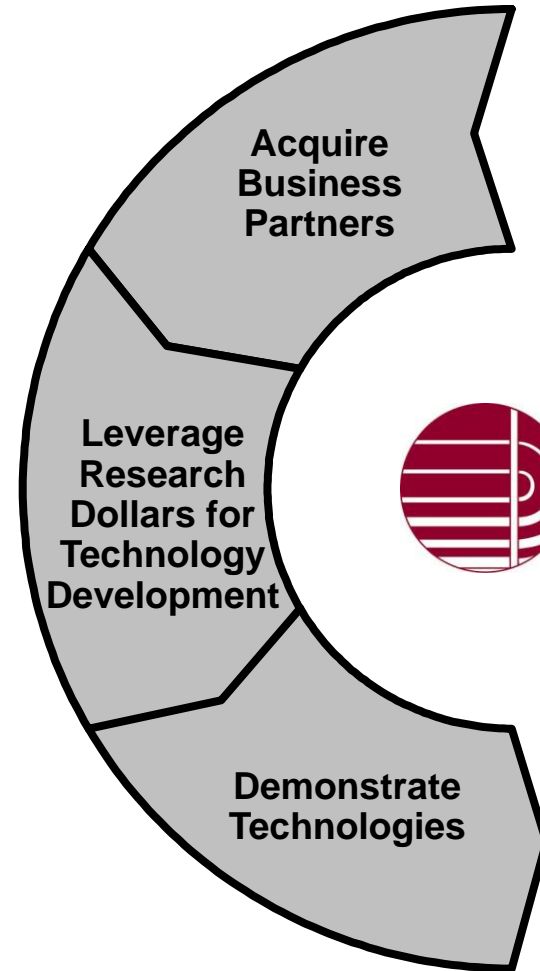
- Coal Utilization Technologies Center
- Emission Control Technologies Center
- The National Center for Hydrogen Technology
- Center for Climate Change and CO₂ Sequestration
- Center for Air Toxic Metals® (CATM®)
- Centers for Renewable Energy and Biomass Utilization
- Water Management Center
- National Alternative Fuels Laboratory® (NAFL®)
- Supercritical and Subcritical Extraction Technologies Center
- Coal Ash Research Center



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.

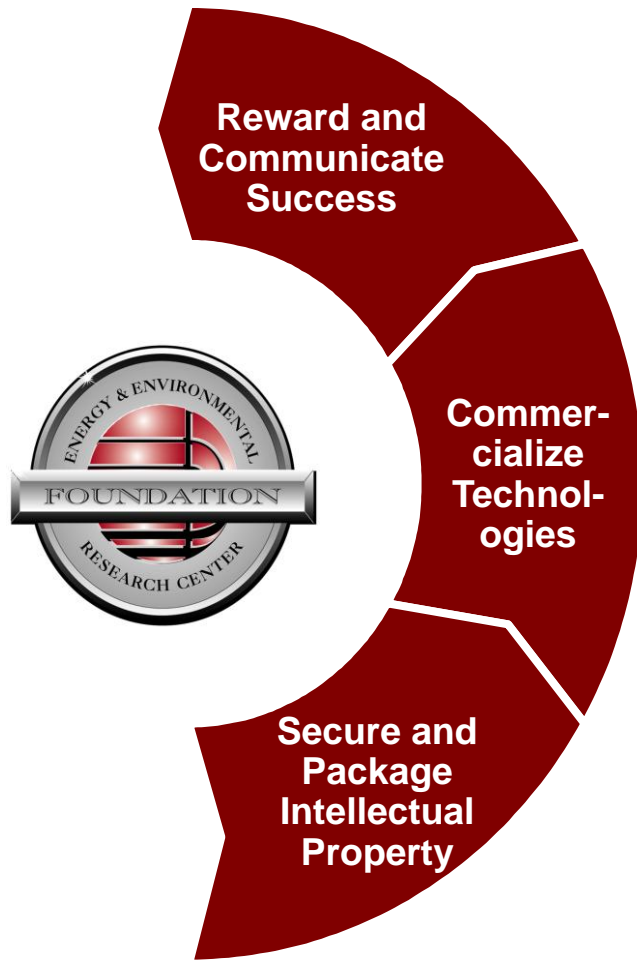
The environmental field is challenged with the growing demand for the cleanup and control of pollutants and environmental hazards.



EERC

Energy & Environmental Research Center®

EERC Foundation Complements the EERC Business Model by Commercializing Technologies



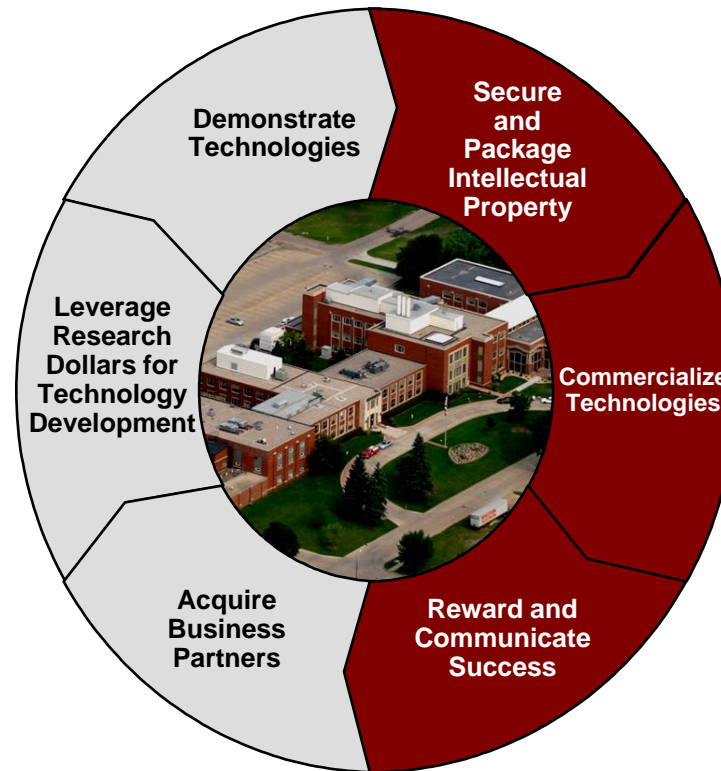
- Commercialization is facilitated through the EERC Foundation, a nonprofit corporation formed in 1992.
- The EERC excels through partnerships with clients in industry and government to develop, refine, demonstrate, and commercialize marketable technologies that provide practical solutions to real-world 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.

The EERC Has Pioneered a Market-Driven Approach to Energy and Environmental RDD&C

A Seamless Transition...



Value Creation

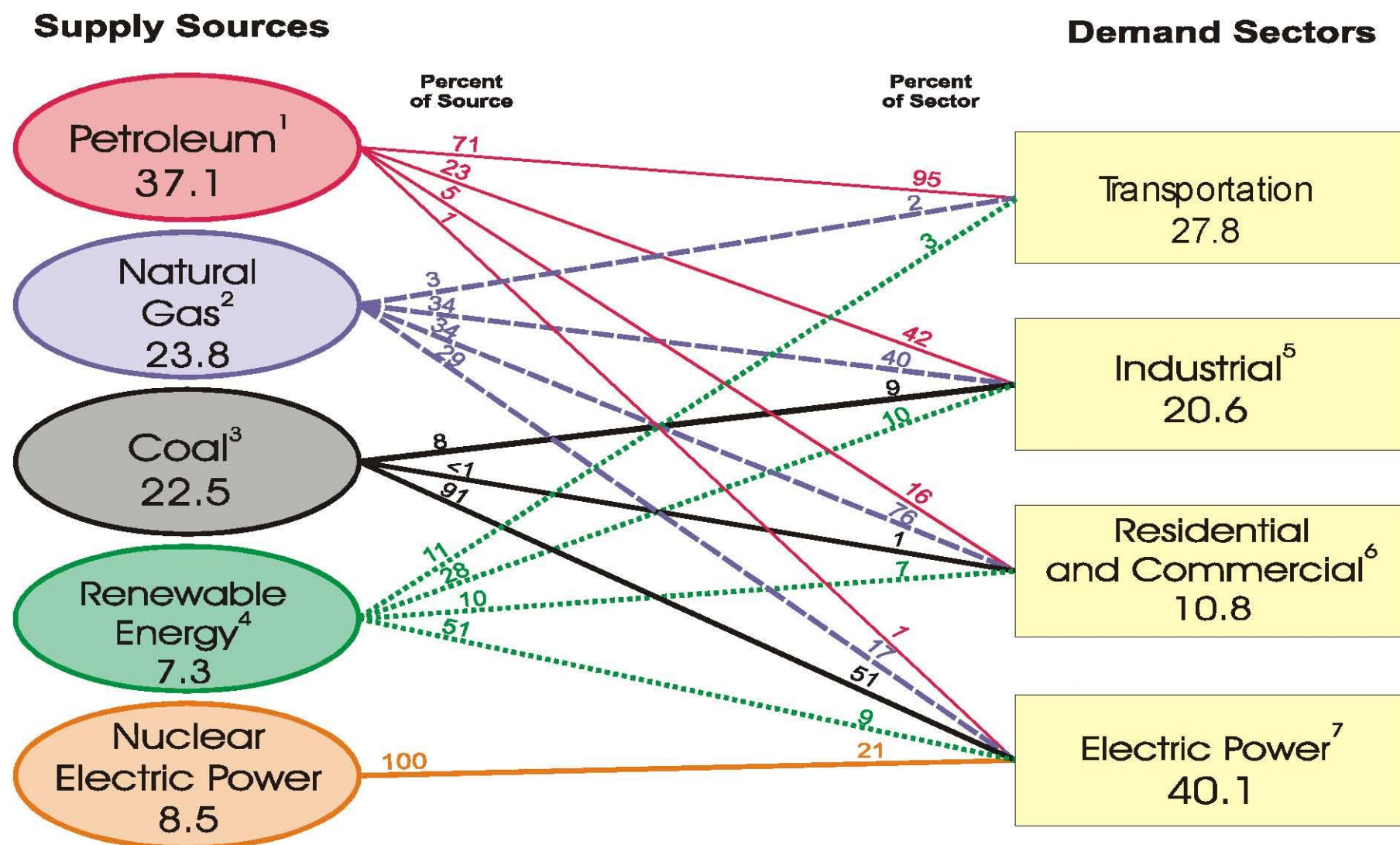


Value Extraction



The market must
pull
technology.

Figure 2.0 Primary Energy Consumption by Source and Sector, 2008
(Quadrillion Btu)



¹ Does not include the fuel ethanol portion of motor gasoline—fuel ethanol is included in "Renewable Energy."

² Excludes supplemental gaseous fuels.

³ Includes less than 0.1 quadrillion Btu of coal coke net imports.

⁴ Conventional hydroelectric power, geothermal, solar/PV, wind, and biomass.

⁵ Includes industrial combined-heat-and-power (CHP) and industrial electricity-only plants.

⁶ Includes commercial combined-heat-and-power (CHP) and commercial electricity-only plants.

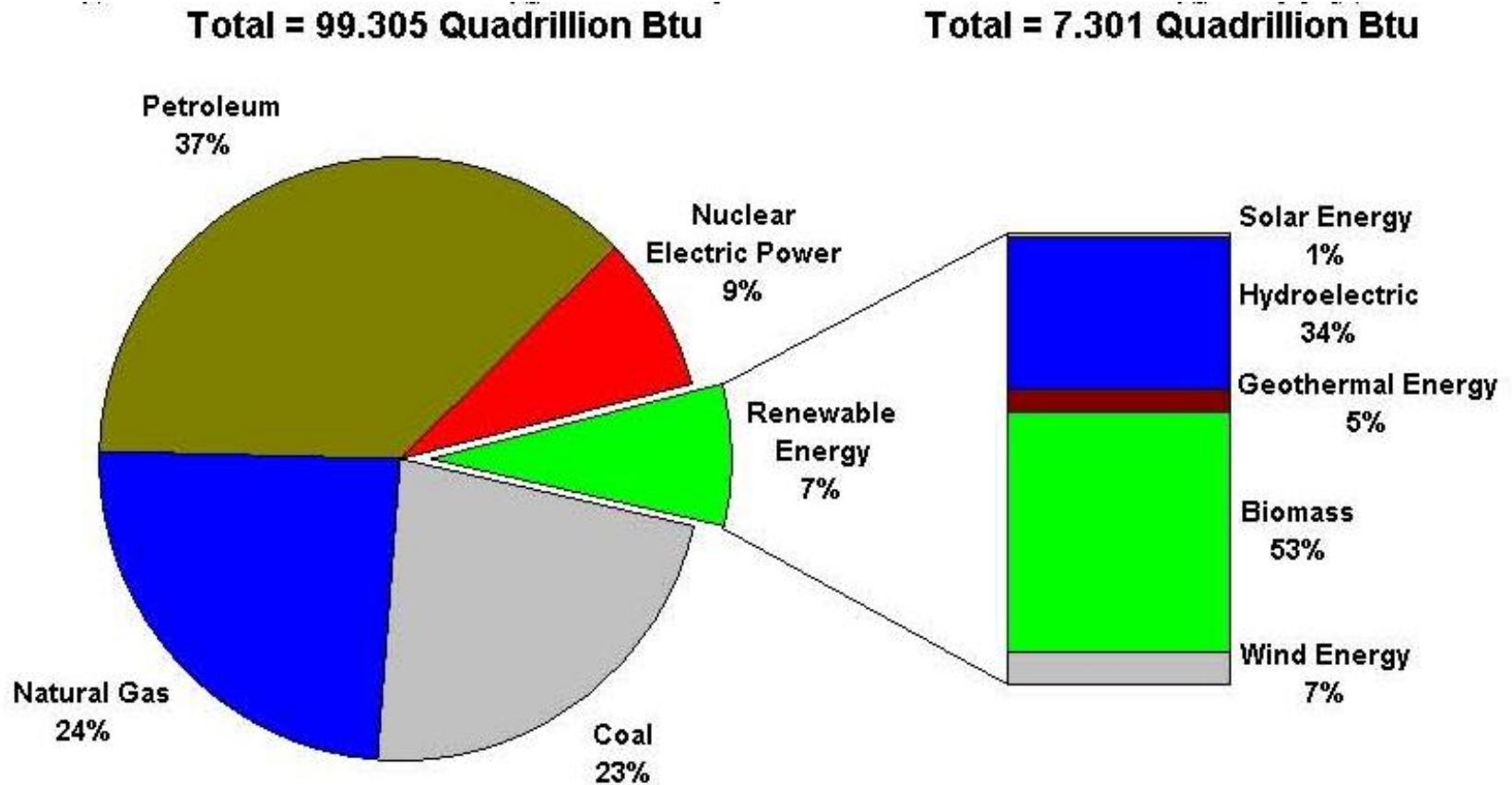
⁷ Electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public.

Note: Sum of components may not equal 100 percent due to independent rounding.

Sources: Energy Information Administration, *Annual Energy Review 2008*, Tables 1.3, 2.1b-2.1f, 10.3, and 10.4.

Renewables

Renewable Energy Consumption in the Nation's Energy Supply, 2008





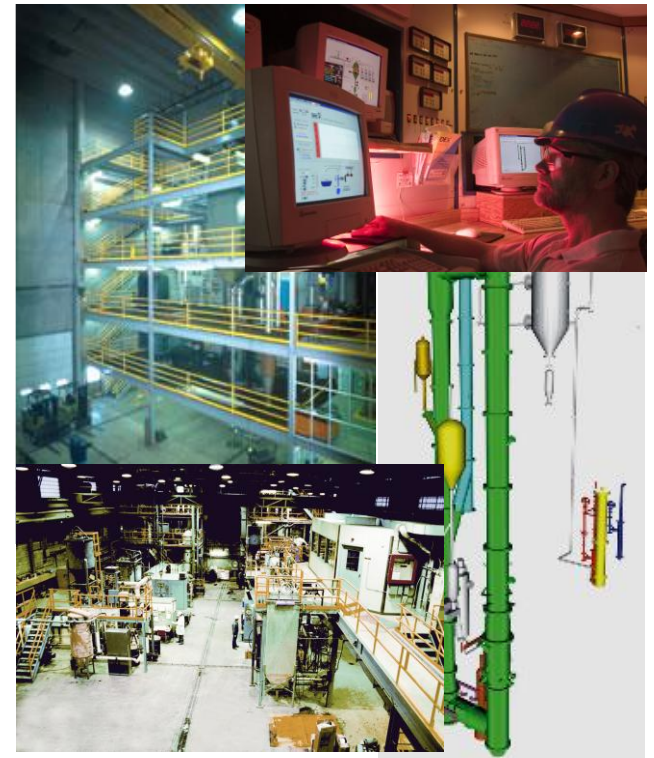
Coal Utilization Technologies Center

The EERC, and its federal predecessor organization, has been involved in research and development of clean coal technologies for over 50 years and is the world's leading research, development, demonstration, and commercialization center for cutting-edge coal utilization technologies emphasizing high efficiency and zero emissions.



International Leader in Coal Combustion and Gasification Technology Development

- The EERC has seven coal combustion demonstration systems on-site to develop new combustion technologies, test the effects of switching coals, and evaluate new environmental performance technologies.
- The EERC has supported virtually every major coal gasification company throughout the world.
- The EERC houses the transport reactor (advanced gasification) scale-up facility.
- The EERC developed, along with our corporate partners, a suite of technologies capable of creating a truly zero-emission power plant.
- The EERC is capable of conducting a wide range of full-scale and slipstream technology demonstrations and testing at full-scale facilities.





Emission Control Center



The EERC is internationally recognized for groundbreaking work in understanding the formation of air pollutants and in the development of technologies to control their emission, including:

- Air toxics
- Particulate matter
- SO₂
- SO₃
- NO_x
- CO₂
- H₂O



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.



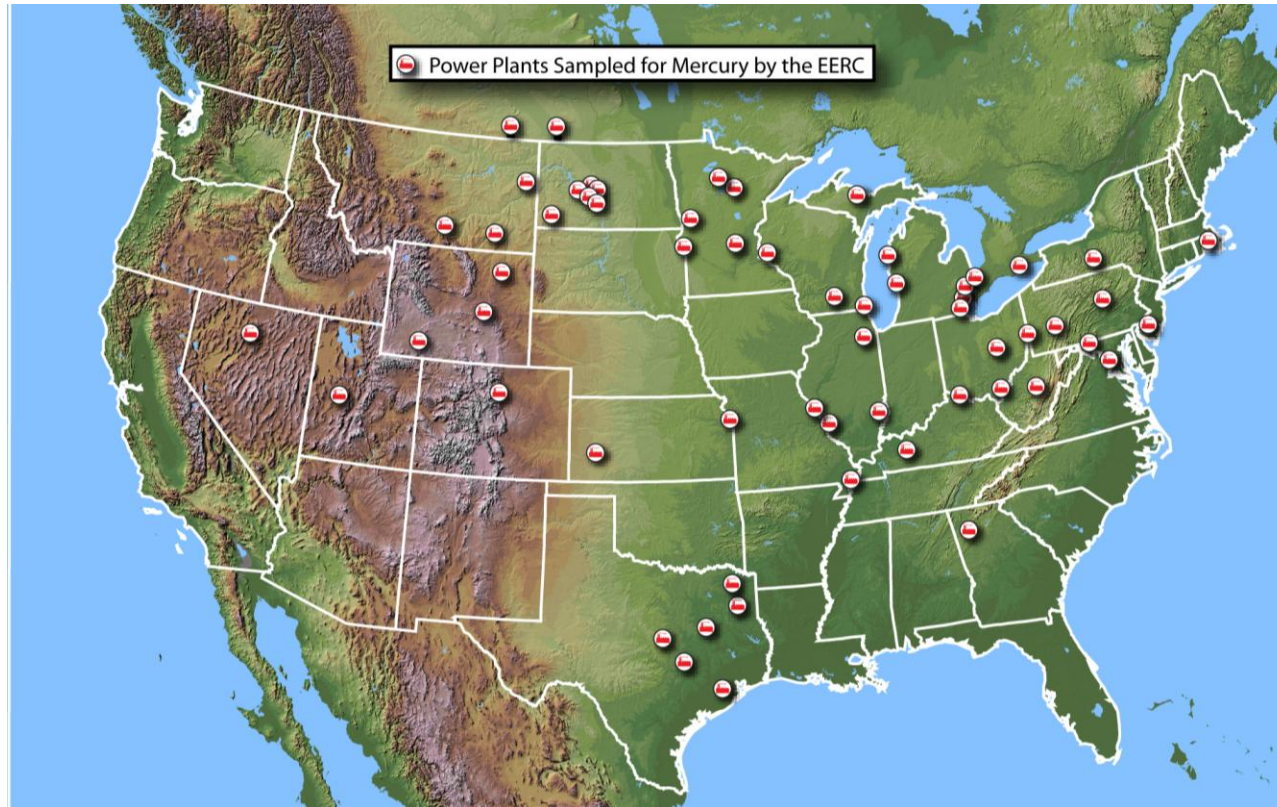
Center for Air Toxic Metals®



The EERC Center for Air Toxic Metals (CATM®) was designated by the U.S. Environmental Protection Agency (EPA) in 1993.

CATM is the national leader in developing effective strategies to understand and control mercury and other air toxic metal emissions.

The World's Leader in Mercury Measurement and Control



In response to regulatory mandates and industry needs, the EERC has conducted over 80 mercury field tests at more than 60 power plants in North America over the past decade.



EERC Technology Spin-Off

RLP Energy – Mercury Control

RLP Energy is a privately held firm, incorporated in 2008, commercializing EERC-developed technology.

- RLP in the United States owns the mercury control business and acquired an exclusive technology license from the EERC Foundation.

RLP Energy is currently transitioning from the commercial demonstration phase to market launch.

- It provides consulting and technology solutions to electric utilities.
- Full technology implementation is expected in 2010.

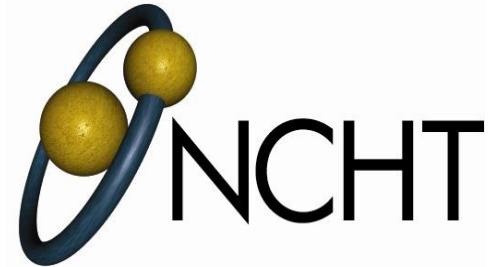
MAIN OFFICE IN THE UNITED STATES ON-SITE AT THE EERC.



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.

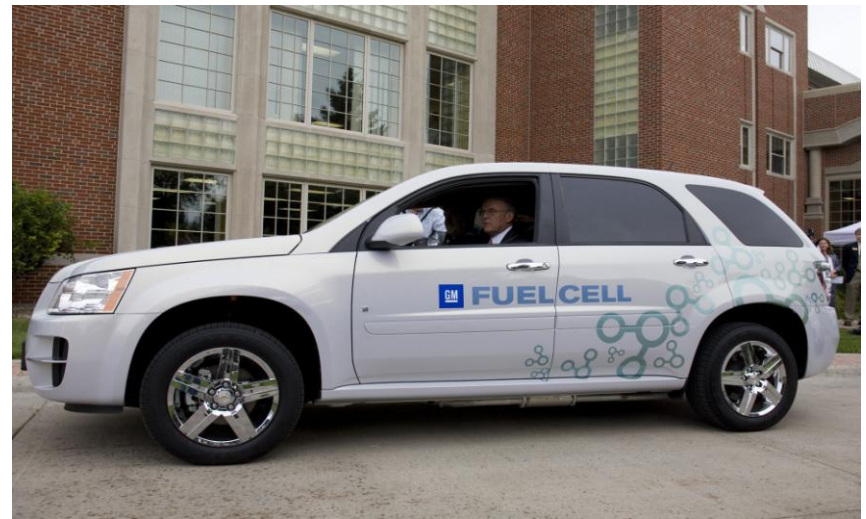
The EERC has more than 50 years of experience with hydrogen production and fuel cell technologies.



The National Center for Hydrogen Technology (NCHT)

Current and pending contracts in the NCHT include nearly \$58 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





Hydrogen Program Partners

- ◆ Aboriginal Cogeneration Company
- ◆ Advanced Biomass Gasification Technologies
- ◆ Agricultural Utilization Research Institute
- ◆ Air Products and Chemicals, Inc.
- ◆ Appareo Systems
- ◆ Ballard Power Systems
- ◆ BMC Construction
- ◆ BNI Coal Company
- ◆ Basin Electric Power Cooperative
- ◆ Bobcat Company
- ◆ CEO Praxis Inc.
- ◆ Chippewa Valley Ethanol Producers
- ◆ City of Grand Forks
- ◆ Conoco Phillips Company
- ◆ Corning
- ◆ CRI-Criterion, Inc.
- ◆ Dakota Gasification Company
- ◆ Dakota Westmoreland Corporation
- ◆ Diversified Energy
- ◆ Dynetek
- ◆ Enersis
- ◆ ePower Synergies, Inc.
- ◆ Fisher Motors
- ◆ General Hydrogen
- ◆ G F Truss Inc.
- ◆ Grand Forks Army National Guard
- ◆ Grand Forks Air Force Base
- ◆ Great River Energy
- ◆ H₂Gen Innovations
- ◆ HT Veramix
- ◆ Hydrovolt Energy Systems, Inc.
- ◆ Hyster Company
- ◆ Idatech
- ◆ Kraus Global Inc.
- ◆ Lorzig Ceramics
- ◆ Microbeam Technologies, Inc.
- ◆ Minnesota Corn Growers Association
- ◆ Minnesota Corn Research Council
- ◆ Minot Area Chamber of Commerce
- ◆ Minnesota Power Company
- ◆ Minnkota Power Cooperative
- ◆ Montana-Dakota Utilities
- ◆ Nextech Materials
- ◆ North American Coal Corporation
- ◆ North Dakota Army National Guard
- ◆ North Dakota Association of Rural Cooperatives
- ◆ North Dakota Centers of Excellence
- ◆ North Dakota Corn Utilization Council
- ◆ North Dakota Department of Commerce
- ◆ North Dakota Industrial Commission
- ◆ Nuvera Fuel Cells
- ◆ Porvair Filtration Group
- ◆ Prairie Public Broadcasting, Inc.
- ◆ Pratt & Whitney Rocketdyne, Inc.
- ◆ Red River Valley Research Corridor
- ◆ Resurface Corporation
- ◆ Rio Tinto
- ◆ SGL Carbon
- ◆ Siemens Power Generation
- ◆ Sud Chemie, Inc.
- ◆ TXU Power
- ◆ ThermoChem Recovery International, Inc..
- ◆ U.S. Air Force
- ◆ U.S. Army
- ◆ U.S. Army Corps of Engineers Construction Engineering Research Laboratory
- ◆ U.S. Department of Agriculture
- ◆ U.S. Department of Defense
- ◆ U.S. Department of Energy
- ◆ United Technologies Research Center
- ◆ Verendrye Electric Cooperative
- ◆ Worldwide Environmental Energy Systems, Inc.
- ◆ Xcel Energy



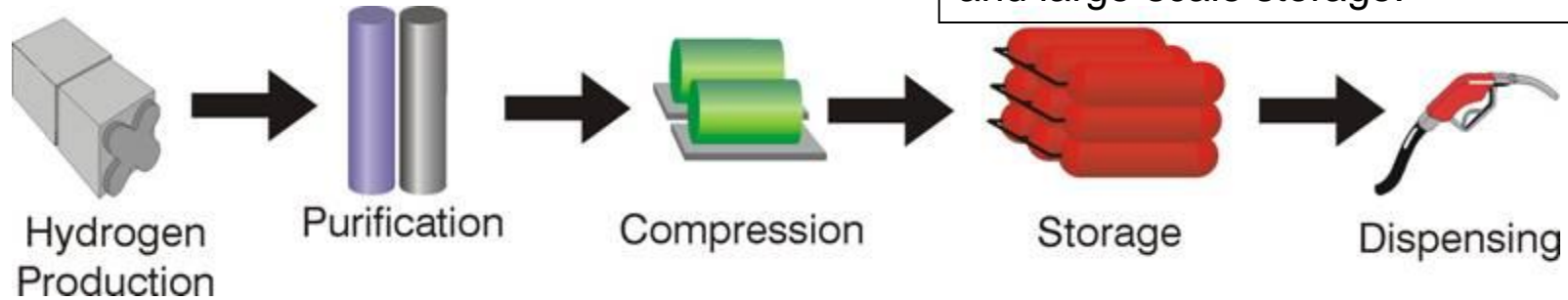
Evolution of the Hydrogen Economy

The evolution of the hydrogen economy is a fuel transition—analogous to the evolution to natural gas.

Distributed Production

Liquid Fuels to Hydrogen

“Traditional” Concept



Significantly reducing costs by removing the need for H₂ compression and large-scale storage.

On-Demand High-Pressure Reforming Concept



This technology is currently moving toward commercial deployment.



JOHN DEERE



Construction Engineering
Research Laboratory (CERL)

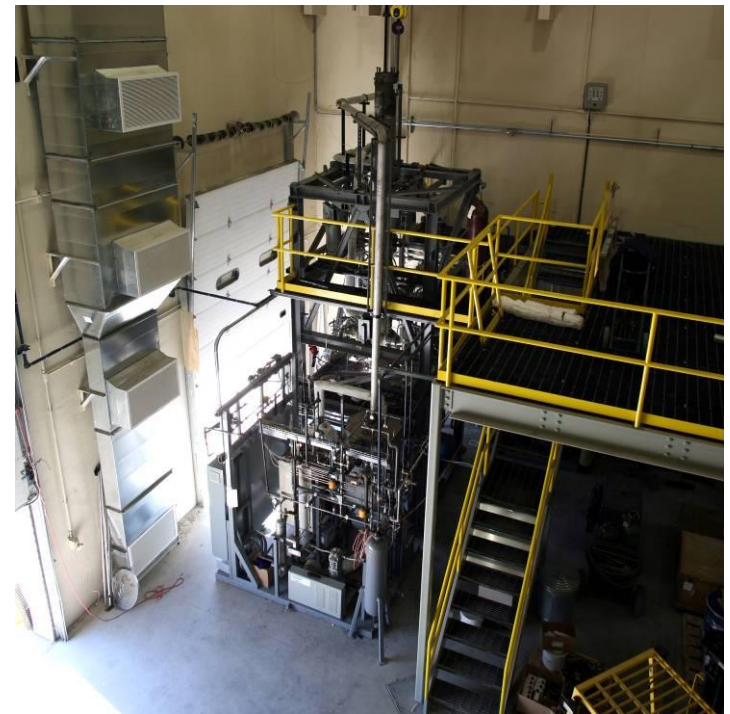
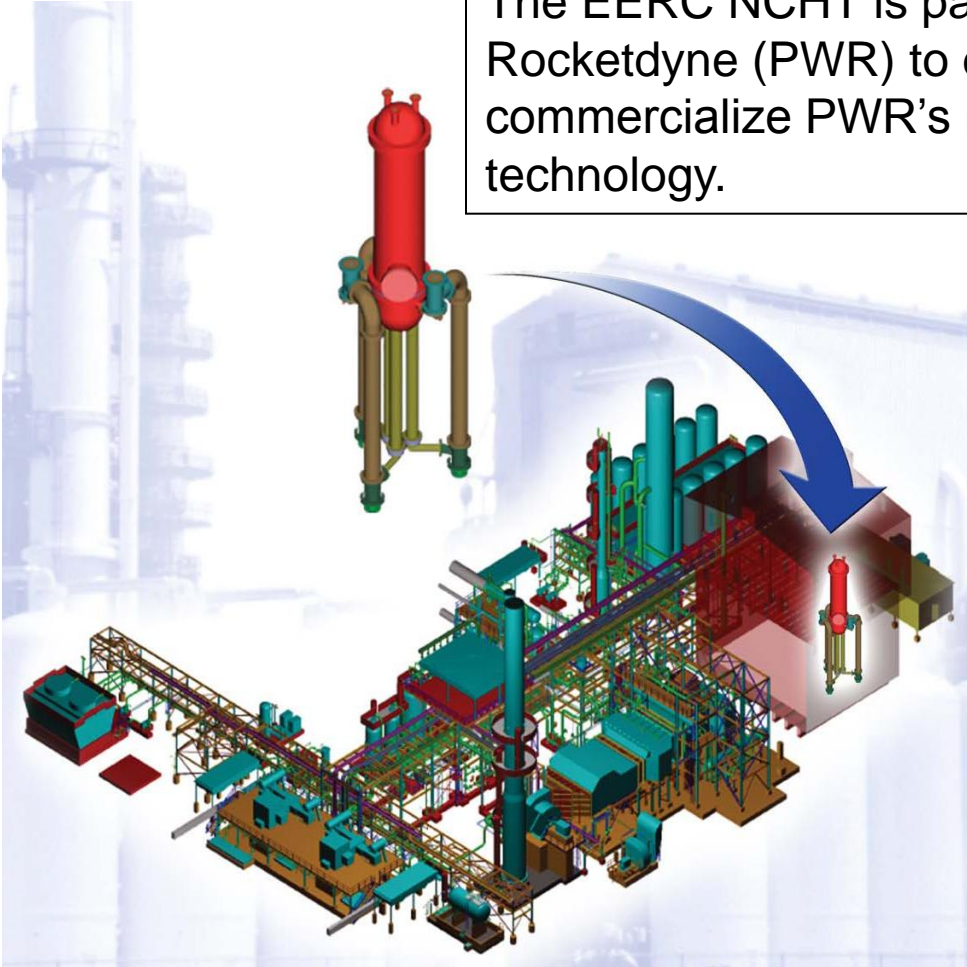
Paradigm Change

EERC Hydrogen-on-Demand Fueling System



Compact Reformer for Hydrogen Production

The EERC NCHT is partnered with Pratt & Whitney Rocketdyne (PWR) to develop, demonstrate, and commercialize PWR's new, compact hydrogen production technology.

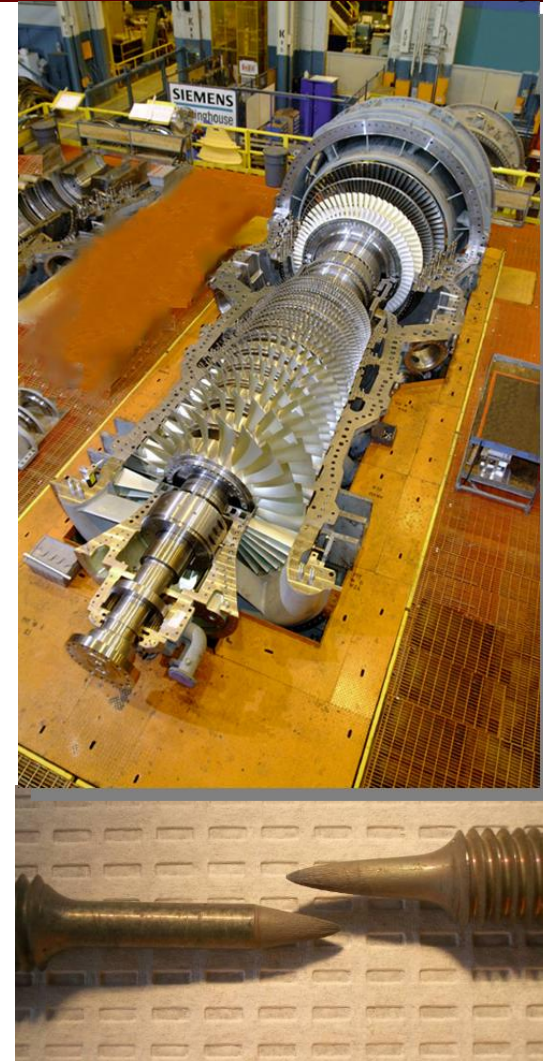


* Courtesy of Pratt & Whitney Rocketdyne

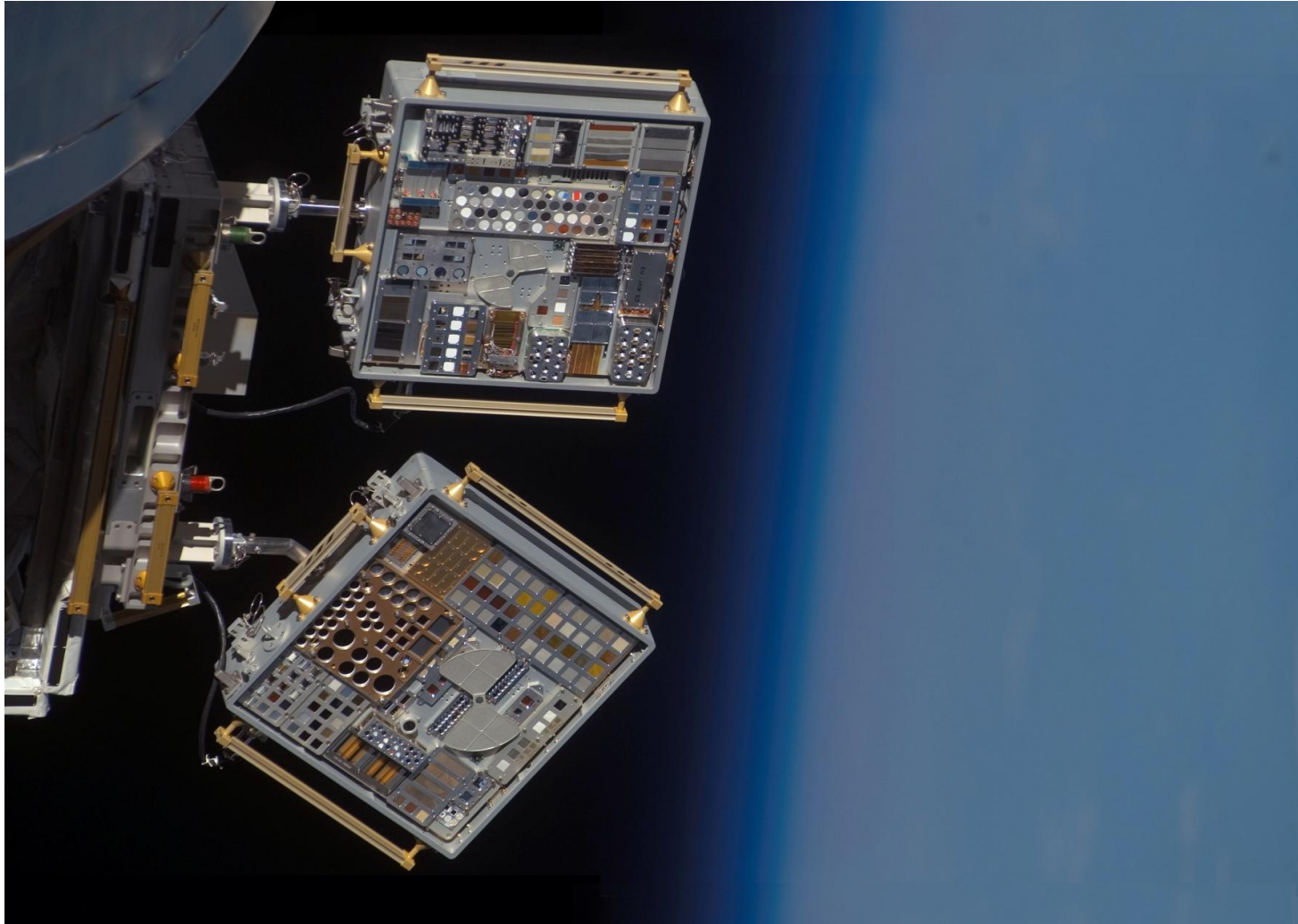
Materials Development for Hydrogen Applications

The EERC NCHT is working with Siemens Power Generation to develop and apply new joining techniques for specialty materials for hydrogen applications.

- Many hydrogen applications require advanced materials that provide high-temperature tolerance, increased strength, and improved corrosion resistance.
- Traditional welding cannot be used to join this family of alloys.
- Initial joints have outperformed base materials.



MISSE-6



The Partnership for CO₂ Capture



Industrial-Scale Monoethanolamine (MEA)
CO₂ Scrubber

Advancing the state of CO₂ capture by evaluating and developing those technologies that are nearest to commercial viability for utility applications.

- The Partnership for CO₂ Capture includes \$3,785,000 of funding from private sector sponsors (15), the North Dakota Industrial Commission, and the U.S. Department of Energy National Energy Technology Laboratory.
- Construction of oxyfiring and industrial-scale postcombustion platforms.
- Identification of technology challenges and opportunities for improvement.
- Development of strategies for cost-effective and efficient implementation at the power utility scale.

Sponsors – CO₂ Capture

- Black & Veatch
- C-Quest
- Midwest Generation
- Hitachi
- Huntsman
- Minnesota Power
- PPL
- SaskPower
- TransAlta
- ATCO Power
- Metso Power
- Constellation Energy
- Basin Electric Power Cooperative
- North Dakota Industrial Commission
- U.S. Department of Energy
- Baker Petrolite
- Nebraska Public Power District



BAKER PETROLITE

HITACHI
Inspire the Next



Center for Climate Change and CO₂ Sequestration



- The EERC is one of the leading organizations selected by DOE to determine the best ways to manage our country's CO₂ emissions.
- The EERC's Plains CO₂ Reduction (PCOR) Partnership is the largest of seven lead organizations around the nation heading up an effort to meet the President's Global Climate Change Initiative.
- The PCOR Partnership award is the EERC's largest single program to date. The total value of the demonstration projects exceeds \$500 million.



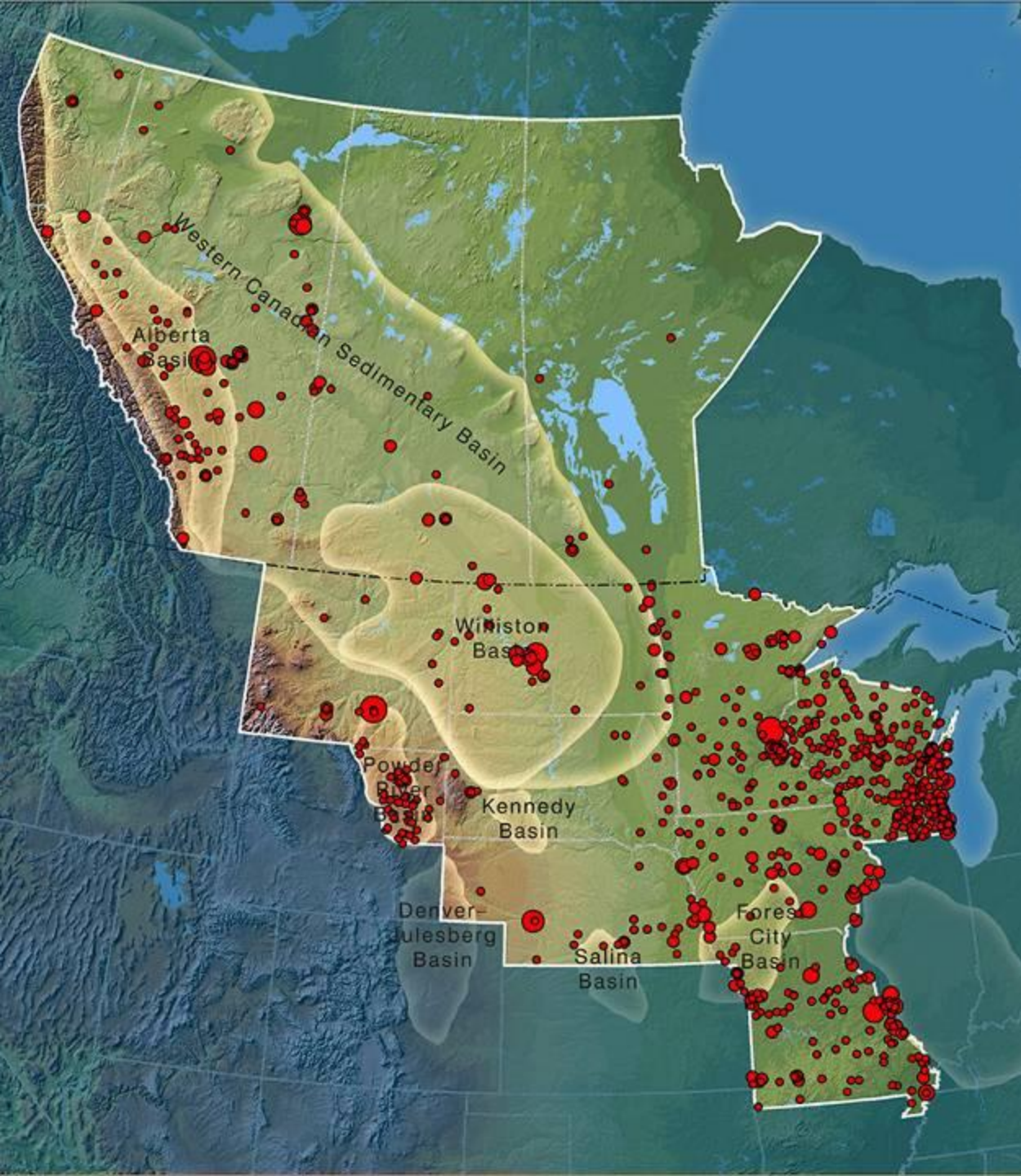
PCOR Partnership Region

- Nine states
- Four provinces
- 1,382,089 square miles



PCOR Partnership Members

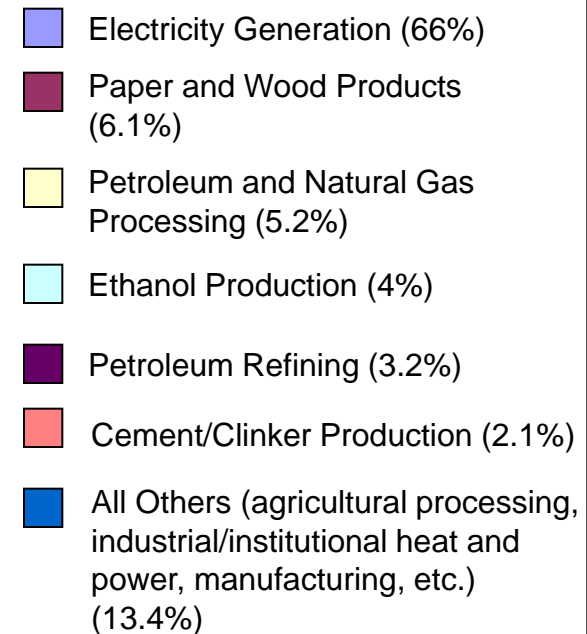
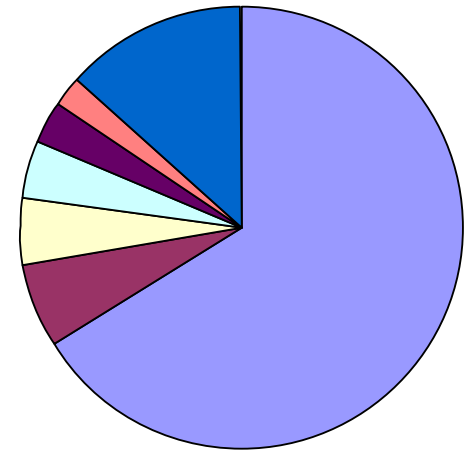




Sources

1225 stationary sources

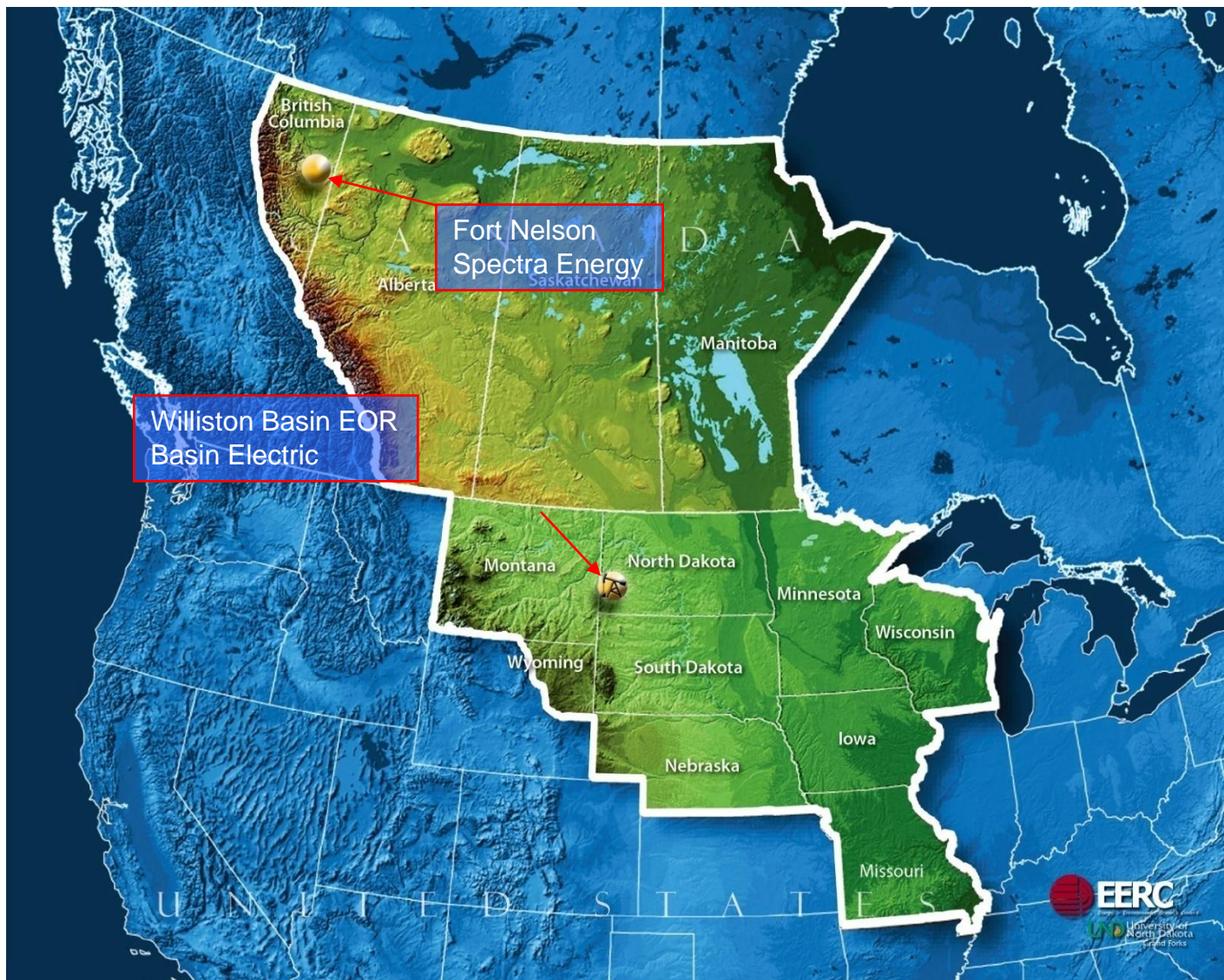
Total CO₂ emissions:
≈ 559 million tons/yr



Phase II Demonstration Sites



Phase III Demonstration Sites



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
- Reservoir simulations
- Petroleum engineering
- Geological characterization
- Resource assessment
- Coal bed methane
- Freeze–thaw/evaporation (FTE[®]) for produced water management



EERC Technology Spin-Off Blaise Energy – Stranded Gas Utilization

- Turn stranded gas into a valuable fuel resource.
- Supply electrical power to oil field operations in remote locations.
- 70% emission reduction can be achieved.
- Demonstrations in:
 - Cedar Creek Field (Encore)
 - Newburg Field (Hess)
- **NEW NORTH DAKOTA ENTERPRISE, BLAISE ENERGY, IS ADVANCING THIS CONCEPT COMMERCIALY.**



Centers for Renewable Energy and Biomass Utilization

The EERC's Centers for Renewable Energy and Biomass Utilization are worldwide leaders in developing technologies for, and promoting the use of, biomass, and alternative fuels.



Hydrogen, Liquid Fuels, and Power Production from Biomass

Multiple Projects

- Multifuel gasification system
- Integrate for:
 - Power production
 - Hydrogen production
 - Methanol production
 - Demonstration system operation at G F Truss Plant
 - Next-generation system in design stage

Demonstration of a reliable, simple, economical method of converting solid fuels into hydrogen, liquid fuels, and power.



Downdraft Gasifier



EERC Technology Spin-Off

Aboriginal Cogeneration Corporation – Biomass to Energy



- Aboriginal Cogeneration Corporation (ACC) is a Native corporation in Winnipeg, Manitoba, Canada, commercializing the EERC's proprietary biomass gasification technology for the production of electricity and heat.
- ACC has two 1-MW biomass gasification systems scheduled for installation in Kamloops, British Columbia, Canada, in 2010 for operation on used railroad ties.
- ACC is currently under contract with the Canadian Pacific Railroad to acquire railroad ties at the Kamloops site.
- Tri-Steel in Grand Forks has been the primary manufacturer of EERC biomass gasification systems to date.
- **THE GRAND FORKS OFFICE OF ACC IS OPENING SOON AT THE EERC.**

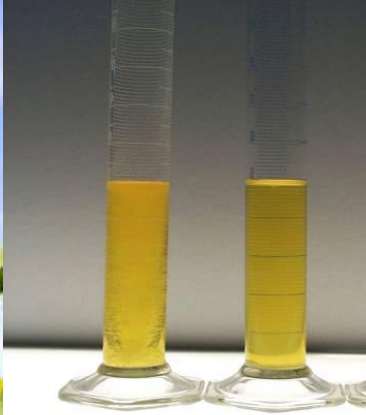
National Alternative Fuels Laboratory[®] (NAFL[®])



Through NAFL, the EERC finds scientifically based answers to critical technical questions related to alternative fuels in order to assist in bringing new products to market, including:

- Ethanol-blended gasoline and diesel fuels.
- Biodiesel.
- Ethanol-based aviation fuel.
- Advanced tactical fuels for the military.
- Lignocellulosic ethanol.
- Opportunity fuels and chemicals from engineered agricultural systems and processing facilities.

Natural Oil-Derived Alternatives to Petroleum-Based Diesel and Jet Fuel

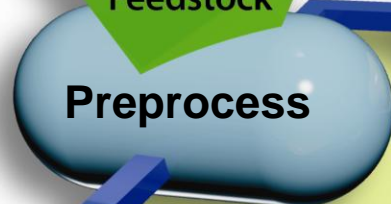
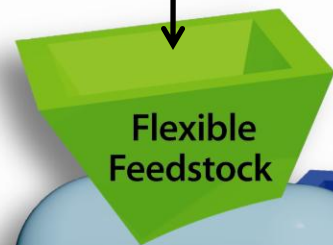
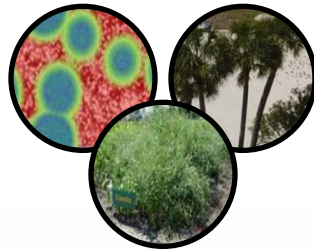


National Alternative Fuels Laboratory® (NAFL®)

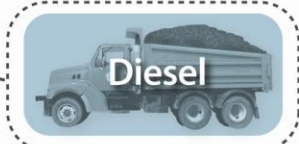
- New EERC technology using vegetable and algae oil to produce petroleum-analogous fuels funded by the Defense Advanced Research Projects Agency (DARPA) and the U.S. military.
- These renewable fuels comply with commercial diesel and jet fuel specifications as tested by Wright–Patterson Air Force Base such as cold-flow, energy density, and other critical properties.

EERC Process Produces Spec-Compliant Fuel from Renewables

Crop Oils
Algae Oils



Suite of Fuels





EERC Technology Spin-Off

Accelergy – Renewable Fuel

- Accelergy is an alternative fuels company with a broad suite of strategic partners and technologies for producing liquid fuels from coal and biomass.
- Combining the **ExxonMobil** coal-to-liquid technology with the EERC's renewable fuel technology to produce domestic, drop-in-compatible jet fuel (Jet-A, JP-8), diesel, and gasoline with a low CO₂ footprint.
- The Accelergy scale-up coal-to-liquid demonstration facility will be located at the EERC.
- A commercial demonstration design of the EERC renewable fuel production technology is currently being conducted for future placement at the **Tesoro** Mandan facility.
- **THE GRAND FORKS OFFICE OF ACCELERGY IS OPENING SOON AT THE EERC.**



Why Use Algae for Biofuels?

- Greenhouse gas reduction
 - Renewable feedstock
- Does not compete with food
- Does not compete with high-value agricultural land
- Higher-energy-density oil with more potential fuel products
- Stimulates rural economies
- Provides energy security
- Technology being developed



Unwanted algae in bay off of Qingdao, on an east China coast



Projected Oil Production Yields

Feedstock	Gallons of Oil per Acre per Year
Soybean	48
Sunflower	102
Rapeseed	127
Castor Bean	151
Jatropha	200
Kukui	237
Coconut	287
Palm Oil	635
Microalgae	5000–15,000

Path to Algae Utilization



Example of System Integration

DARPA selected one team to develop complete algal systems for the production of military fuel (although the economics not solely driven by this).

- The team is required to have numerous participants to cover all aspects of production through to utilization.
- The team is led by SAIC. The EERC is a partner on the team.

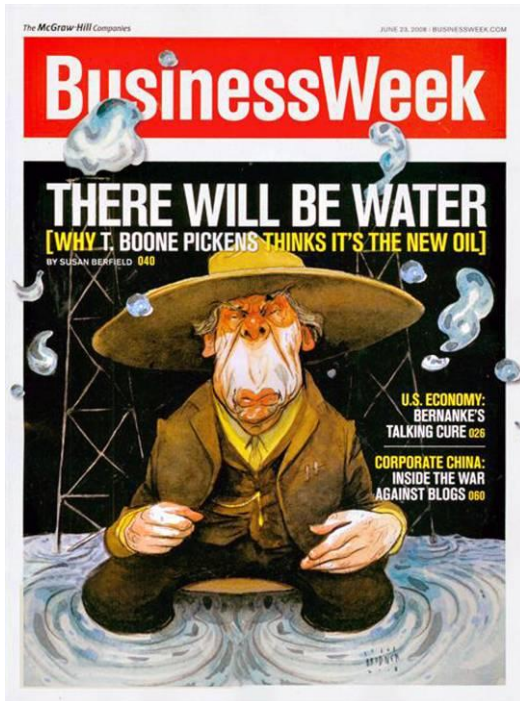




Water Management Center

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

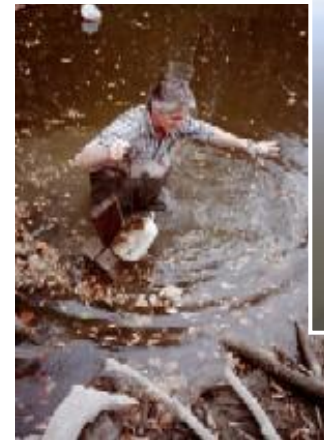
— *Mark Twain*



Water Management Center

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

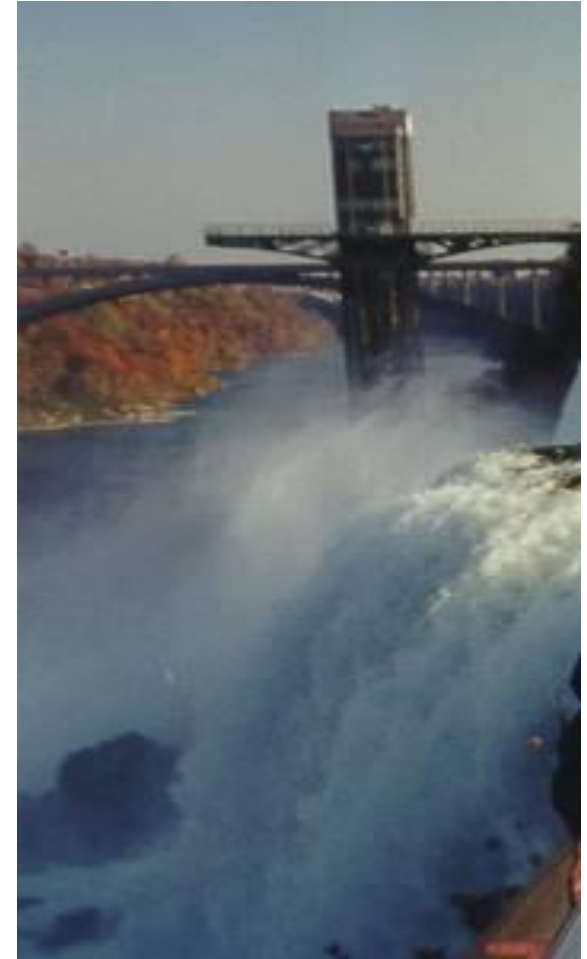
- Flood and drought mitigation (Waffle®)
- Climate reconstruction for forecasting
- Hydraulic/hydrologic modeling
- Technology assessment and demonstration
- Storm water management
- Groundwater resource investigation
- Water/wastewater treatment
- Contaminant cleanup
- Animal-feeding operation assessment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

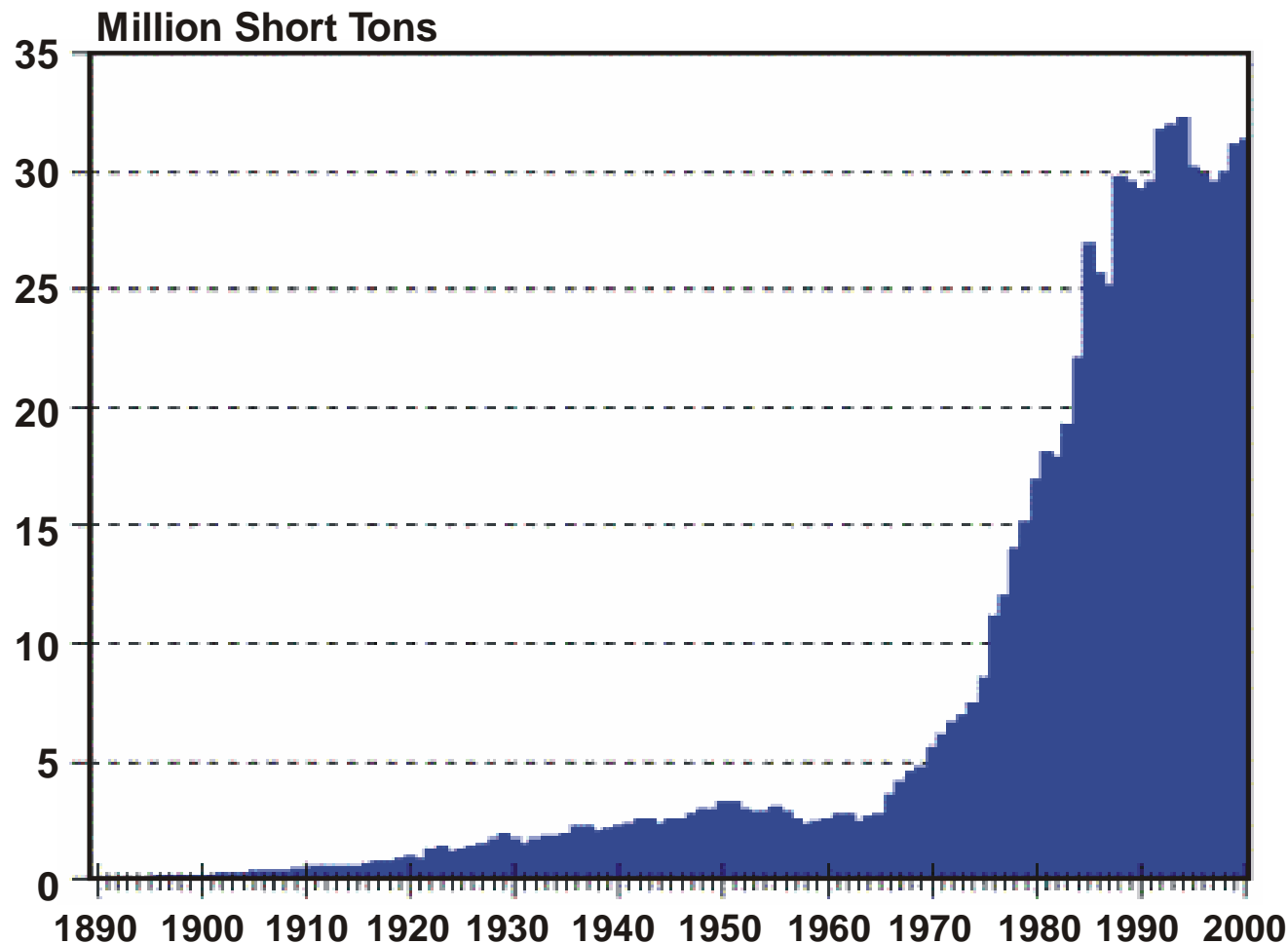


Continued availability and efficient use of water resources are critical to the future growth of the energy industry.



Annual History of North Dakota

Coal Mined – Energy and Water Sustainability

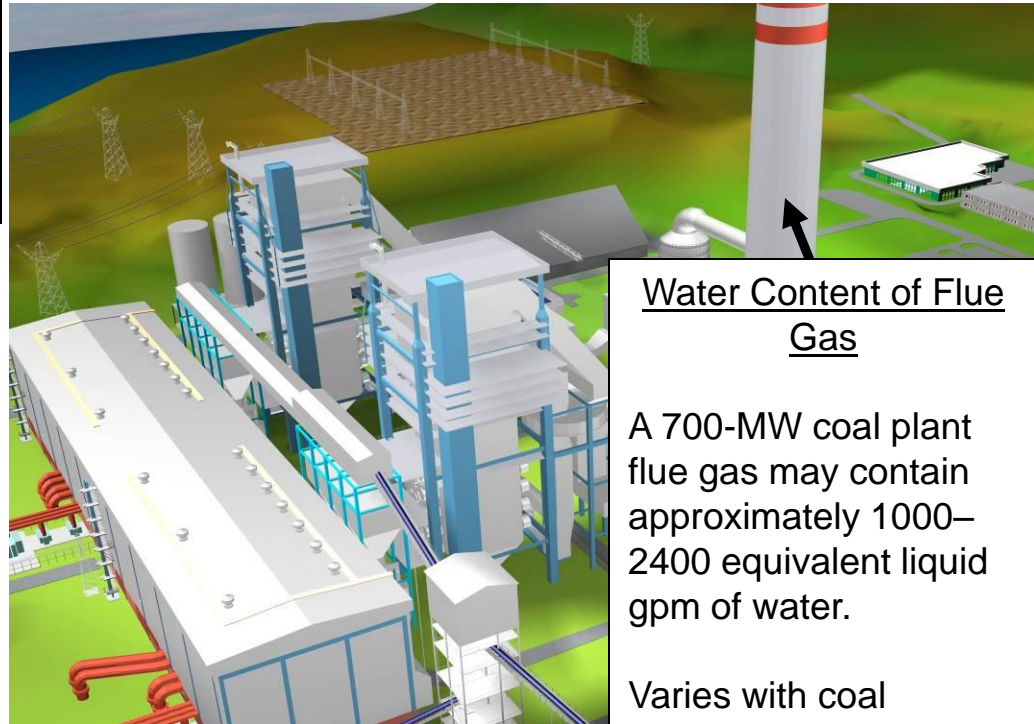


EERC Water Activities

The EERC works with industry and technology developers to evaluate and commercialize water solutions.

EERC projects focused on water issues related to energy:

- Power plant water capture and minimization
- Northern Great Plains Water Consortium
- CO₂ Water Consortium (dealing with water issues tied to CO₂ capture and sequestration)



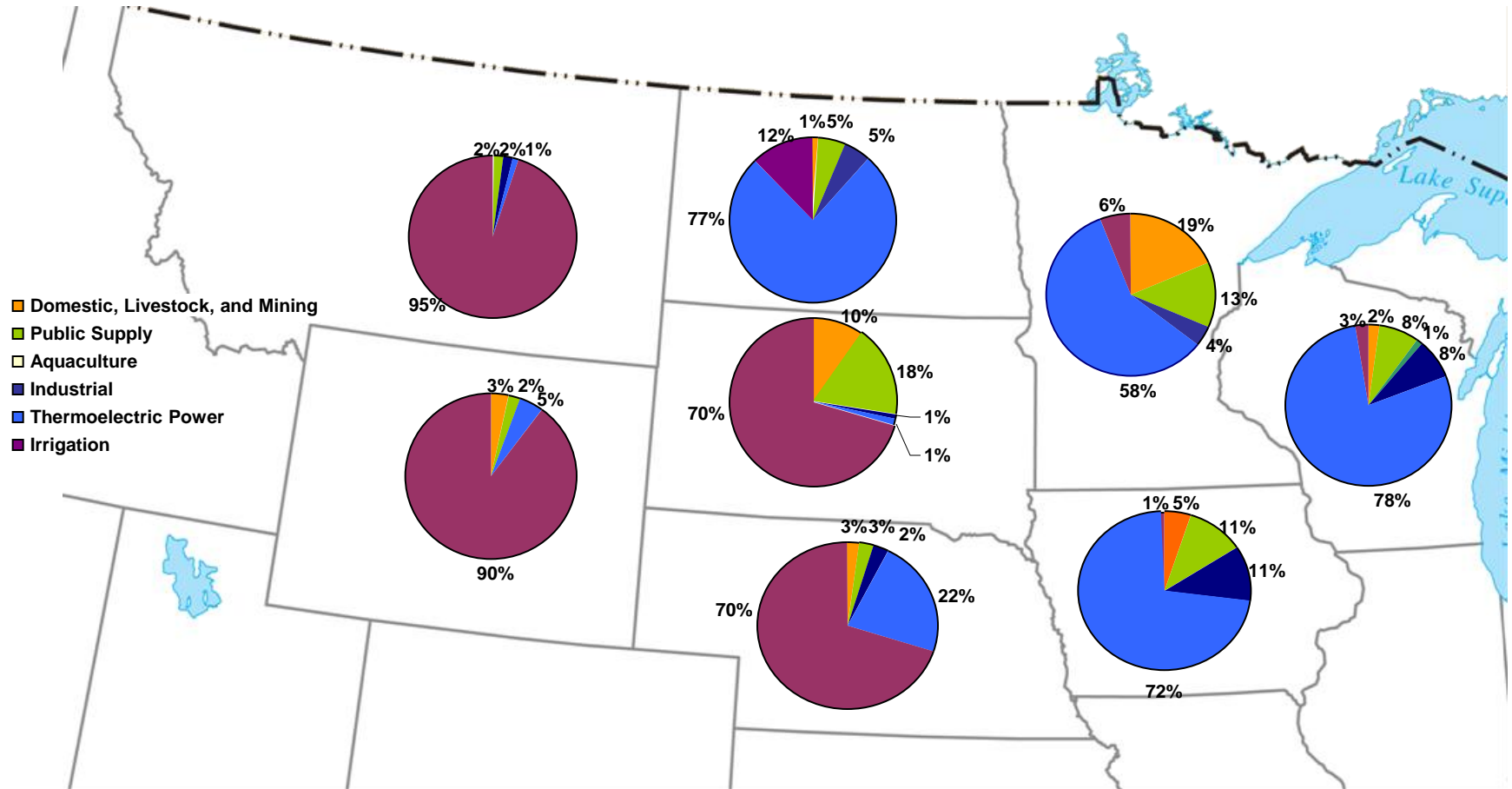
Water Content of Flue Gas

A 700-MW coal plant flue gas may contain approximately 1000–2400 equivalent liquid gpm of water.

Varies with coal moisture.

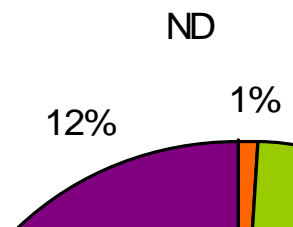
Varies with treatment.

Regional Water Withdrawal Comparison



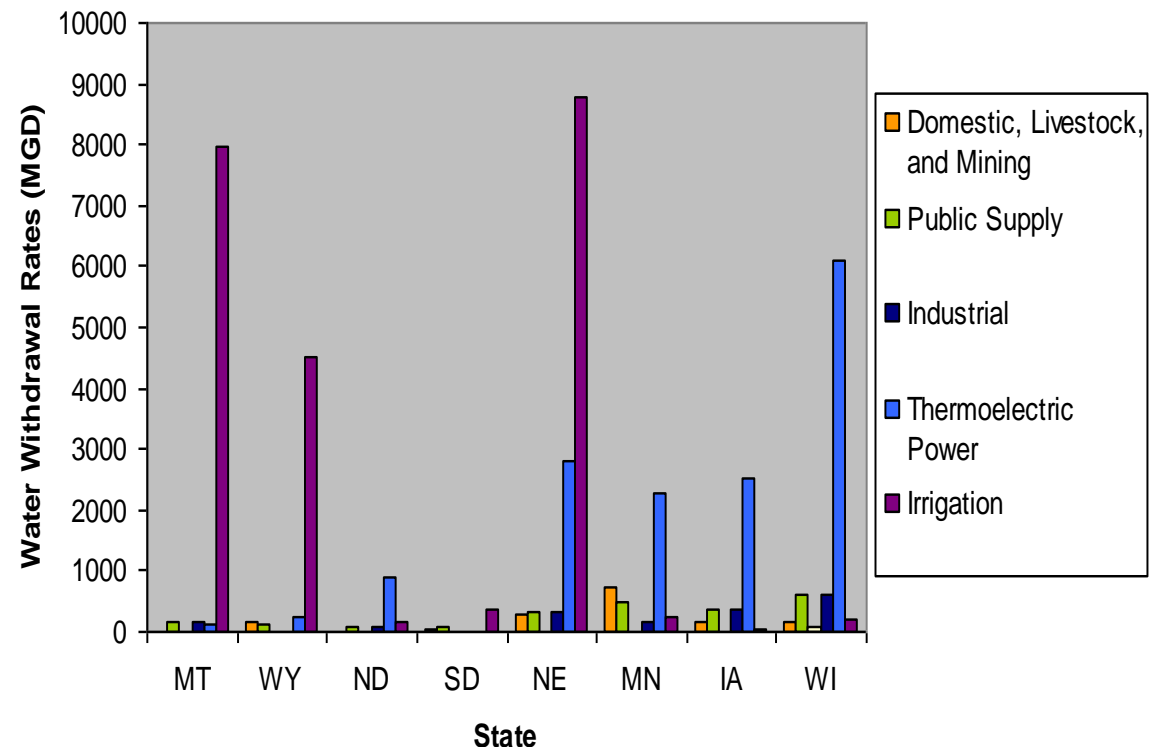


North Dakota Water Withdrawals

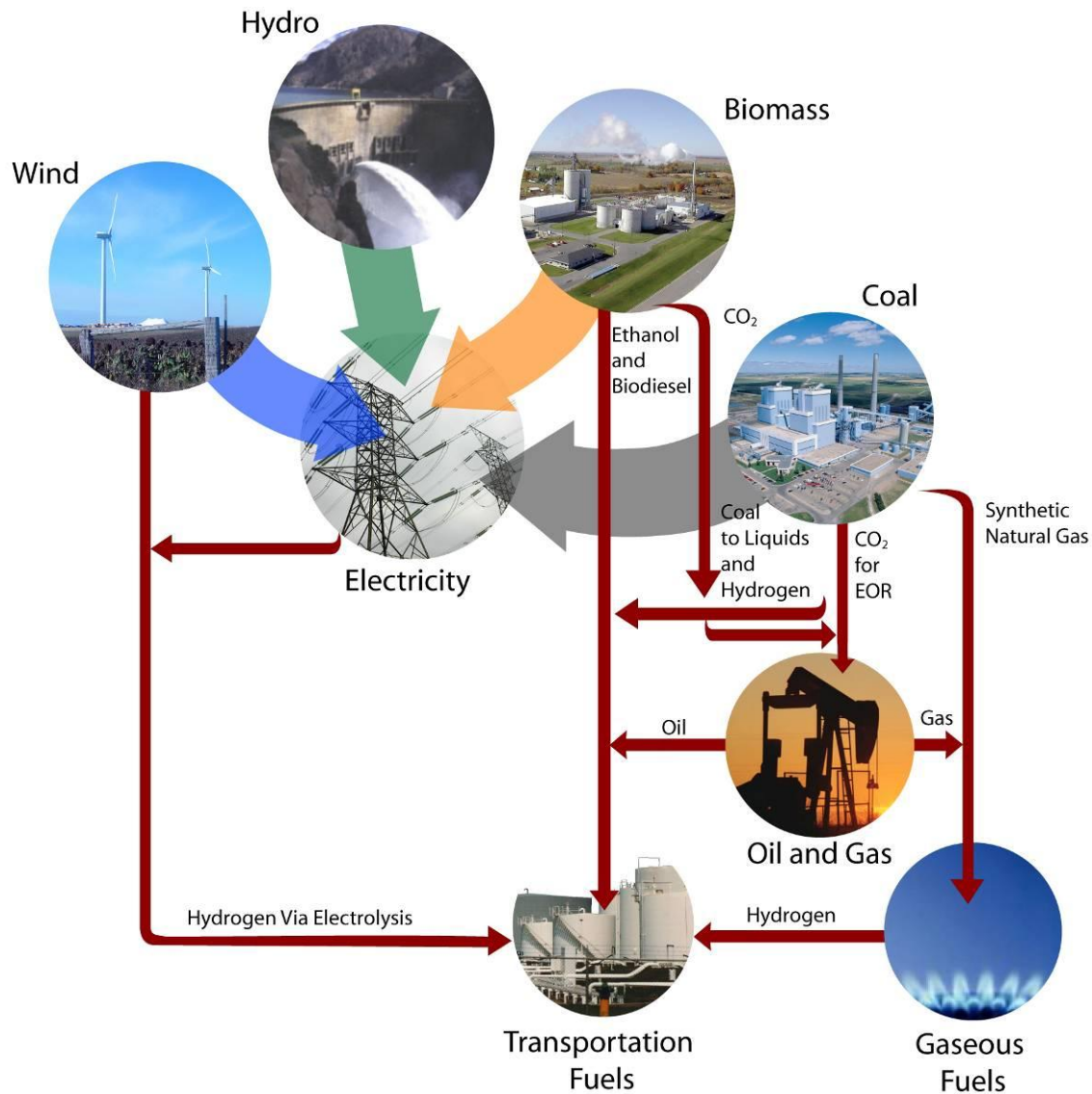


(USGS Circular 1268, 2004)

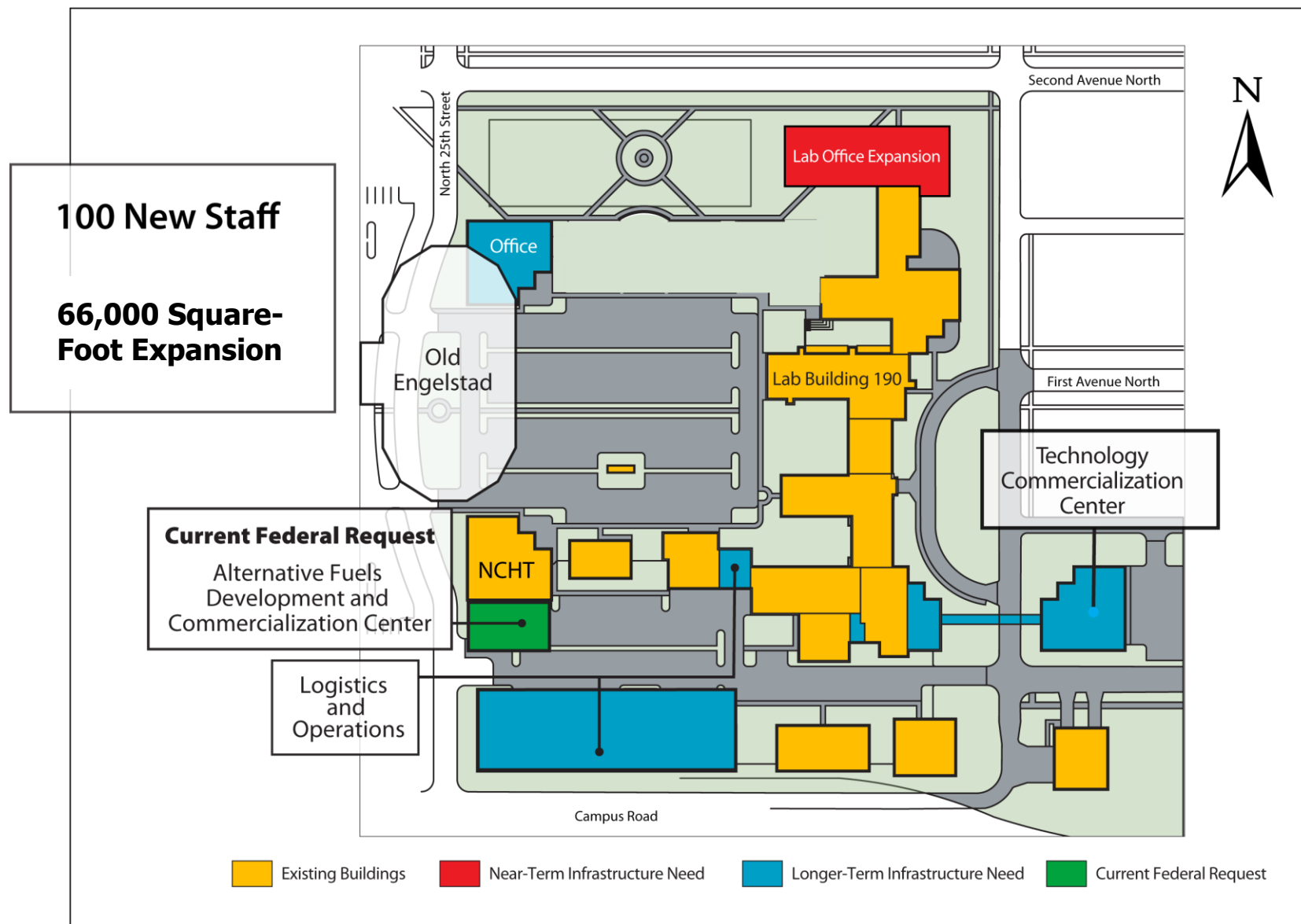
Withdrawal Rate Comparison



Opportunities for Energy Synergy



EERC Growth and Facilities Expansion





The Challenge

“Human history more and more becomes a race between education and catastrophe.”

– *H.G. Wells*



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