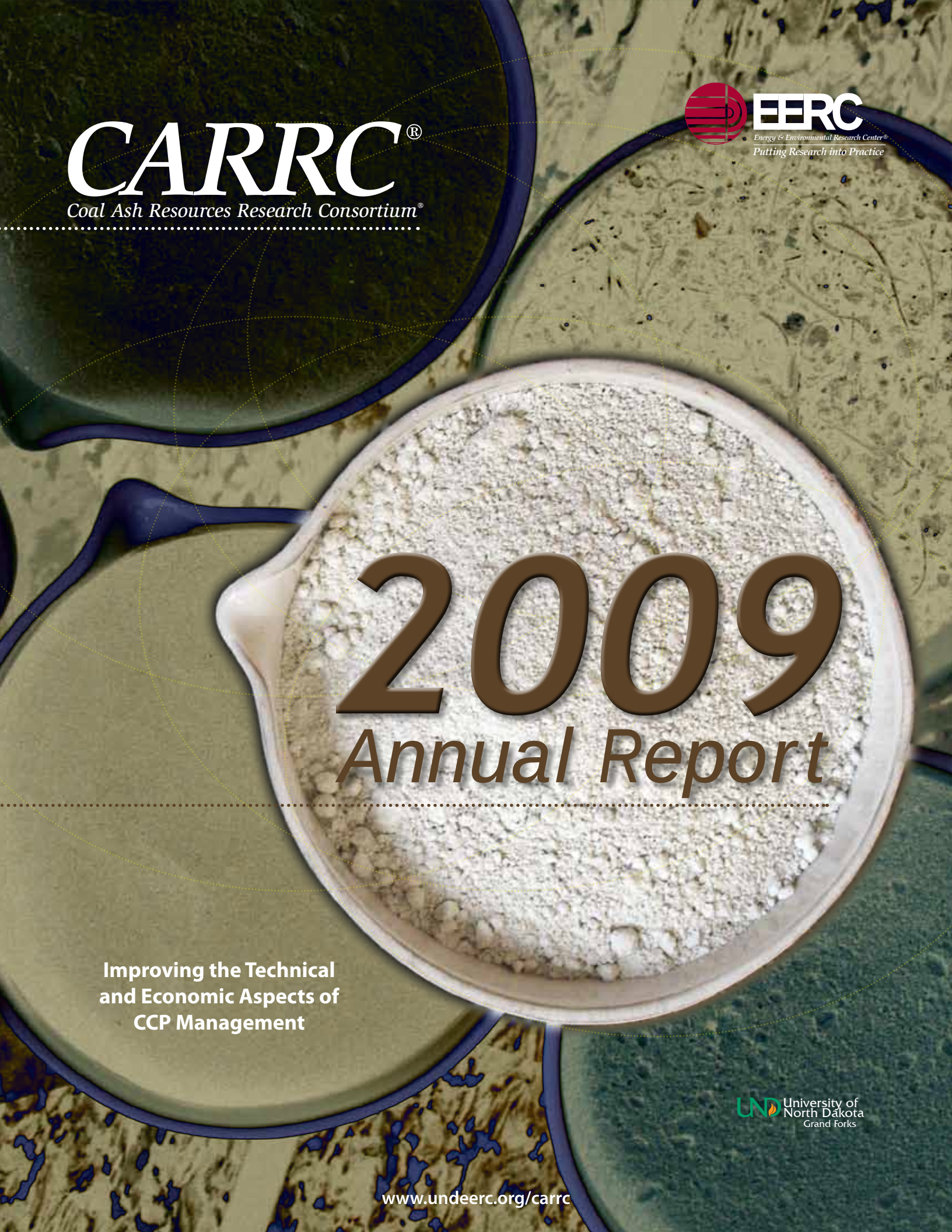


CARRC®

Coal Ash Resources Research Consortium®

EERC
Energy & Environmental Research Center®
Putting Research into Practice

2009 Annual Report

Improving the Technical and Economic Aspects of CCP Management

UND University of North Dakota Grand Forks

www.undeerc.org/carrc

CARRC® Coal Ash Resources Research Consortium®

2009 Annual Report

The Coal Ash Resources Research Consortium® (CARRC®, pronounced "cars") is the core coal combustion product (CCP) research group at the Energy & Environmental Research Center (EERC). CARRC focuses on performing fundamental and applied scientific and engineering research emphasizing the environmentally safe, economical use of CCPs. CARRC member organizations, which include utilities and marketers, are key to developing industry-driven research in the area of CCP utilization and ensuring its successful application.

The EERC's multidisciplinary approach to research is well demonstrated in CARRC research and related activities. CARRC has the opportunity to draw from the diverse research staff at the EERC while maintaining a core staff that focuses on CCP utilization and disposal research. Key to this approach is communication among numerous individuals and groups as well as the coordination of sample identification, collection, distribution, and data manipulation.

2009 CARRC Tasks

2009 CARRC tasks were designed to provide information on CCP performance, including environmental performance, engineering performance, favorable economics, and improved life cycle of products and projects. CARRC technical research tasks, developed with input from members focused on four key areas:

- Environmental Evaluations of CCPs
- Evaluation of Impacts on CCPs from Emission Controls
- Construction and Product-Related Activities
- Technology Transfer and Maintenance Tasks

2009 CARRC Accomplishments

- Determination of the interactions between fly ash leachate and mine spoil sediments through laboratory experiments.
- Development of characterization information on CCPs under mercury emission control demonstrations.
- Evaluation of the performance of Class C fly ash for mitigation of alkali–silica reactions (ASRs) in concrete.
- Demonstration of the use of CCPs in sustainable construction applications.
- Participation in industry events and communication with CCP stakeholders.

CARRC Research Objectives

The overall goal of CARRC is to promote the environmentally safe, technically sound, and economically viable management of CCPs. Supporting objectives are the following:

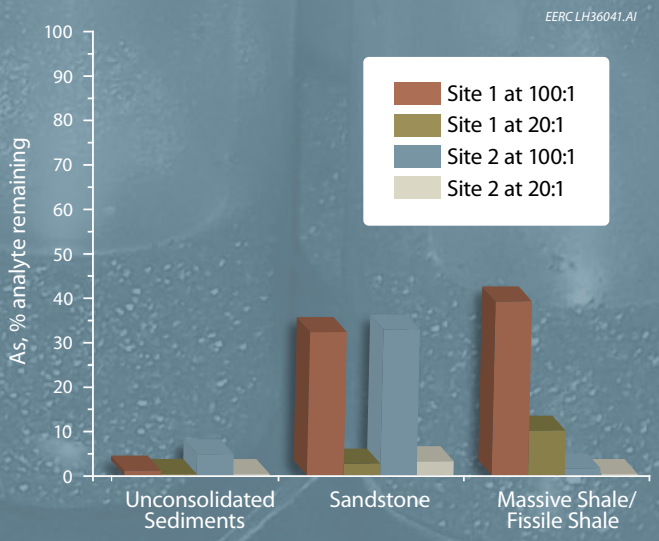
- To develop information on the environmental and engineering performance of CCPs in products and utilization applications.
- To develop scientifically valid characterization methods specific to CCPs as needed to support utilization of CCPs.
- To develop information on technologies impacting the production, collection, and management of CCPs and related materials generated by coal-based power generation facilities.
- To develop, test, and demonstrate products and processes for CCPs.
- To communicate with CCP industry stakeholders to disseminate information gained under CARRC and to educate students, educators, government officials, CCP users, CCP industry professionals, and the public.

Environmental Evaluations of CCPs

Evaluations of CCP–Soil/Sediment Interactions

Laboratory batch experiments were completed by CARRC researchers to evaluate the trace element attenuation of six mine site sediments exhibiting different characteristics collected from two mine sites (three from each site). The trace elements of interest were arsenic, boron, cadmium, chromium, lead, mercury, nickel, and selenium because these elements are found in CCPs and in leachate from CCPs.

All mine spoils and overburden samples evaluated provided high attenuation of analytes except boron. Analyte concentrations typically decreased by more than 85% (except for boron). The results from this effort were presented at the 2009 World of Coal Ash Conference.



Evaluation of Impacts on CCPs from Emission Controls

Impacts of CO_2 Capture on CCP Management

A review of existing CO_2 capture technologies that might be used by coal-based power plants was completed, and a topical report was submitted to CARRC members. The review indicated that these technologies generally are not expected to impact fly ash quality. Strategies that might have an impact on fly ash or other CCP production are oxycombustion, the use of biomass fuels, and the selection of gasification over combustion for new electric generating facilities.

Oxycombustion could impact coal conversion, ash formation, and resulting fly ash mineralogy. It is not likely that these changes would have a significant impact on fly ash quality or performance. Biomass may be used in electric generating units in small percentages. Laboratory data and experience with fly ash from full-scale systems burning low percentages of biomass (<10%) indicate that the resulting fly ash is similar to that produced with only coal.

Mercury Emission Controls on CCP Environmental and Engineering Performance

Nine fly ash samples collected during mercury emission control demonstrations using activated carbon (AC) injection and/or a sorbent-enhancing agent (SEA) were evaluated. Laboratory work focused on evaluations to determine suitability in concrete with ASTM International (ASTM) C618 physical tests and a foam index test.

Six of the nine samples met all ASTM C618 physical performance criteria. Foam index results indicate that seven of nine samples performed within the allowable range. Testing is needed to determine if a particular sample can be used in concrete applications. A topical report was submitted to CARRC members.

CARRC researchers performed tasks funded through other sources related to the mercury emission controls task. Two peer-reviewed journal articles resulted from the related work and were distributed to CARRC members.

Pflughoeft-Hassett, D.F.; Hassett, D.J.; Buckley, T.D.; Heebink, L.V.; Pavlish, J.H. Activated Carbon for Mercury Control: Implications for Fly Ash Management. *Fuel Process. Technol.* 2009, *90*, 1430–1434.

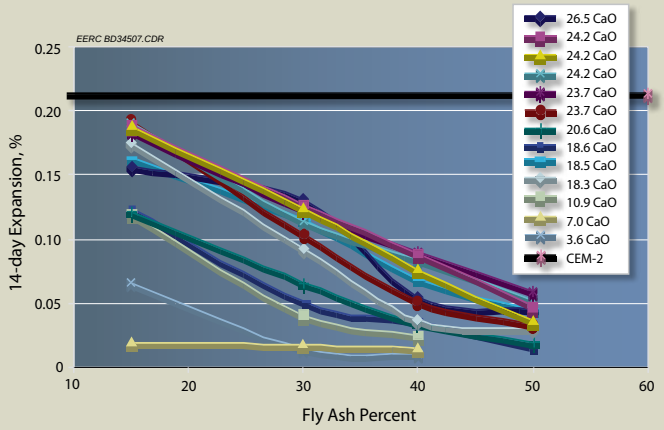
Heebink, L.V.; Pflughoeft-Hassett, D.F.; Hassett, D.J. Effects of Mercury Emission Control Technologies Using Halogens on Coal Combustion Product Chemical Properties. *J. Environ. Monit.* 2010, *12*, 608–613.

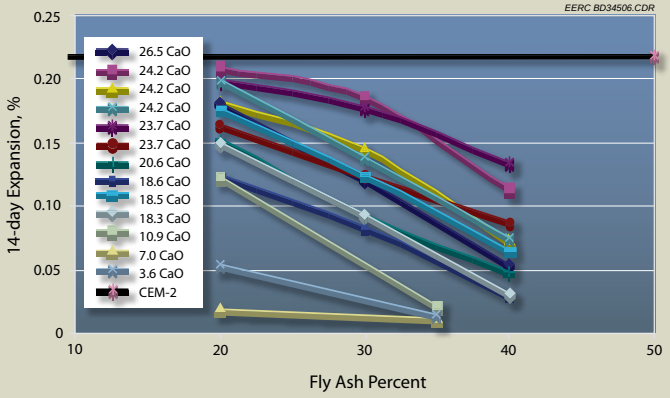
Construction and Product-Related Activities

Using Class C Fly Ash to Mitigate Alkali–Silica Reactions in Concrete

High-calcium fly ashes, classified as Class C by ASTM C618 definition, are often excluded as a means to mitigate ASR in concrete. It is generally true that low replacement levels (<15%) of Class C fly ash may not offer ASR mitigation; however, it has been demonstrated that Class C fly ashes can mitigate the effects of ASR at higher replacement levels than specified. In some cases, the amount of Class C fly ash needed to control ASR may exceed specification limits set by state departments of transportation. In these instances, combining Class C fly ash with silica fume, for example, can help to mitigate ASR and improve early strength gain.

CARRC researchers completed the second year of a 3-year series of investigations to evaluate the performance of several Class C fly ashes (>10% CaO) using existing predictive ASR test methods. Results indicate that all the Class C fly ashes submitted for this study helped reduce the expansion of the mortar mixtures, even at the lowest replacement level of 15%. This reduction in expansion continued as the fly ash content increased. The results have confirmed limited and unpublished work that indicates the effectiveness of using higher percentages of Class C fly ash to mitigate ASR when using moderately reactive aggregates. A poster detailing these results was presented at the 2009 World of Coal Ash Conference. Year 3 Concrete testing was initiated in early 2010.





CCPs in Green Roadbuilding

The use of fly ash in concrete is one key use of CCPs that has been identified as environmentally sustainable because the replacement of cement with fly ash results in a reduction of CO_2 emissions related to the concrete produced. Environmentally sustainable, or "green," construction technologies and products are currently being developed and demonstrated throughout the United States, including for roadbuilding.

CARRC researchers worked with the Theodore Roosevelt Medora Foundation, regional contractors, and CARRC member companies in Medora, North Dakota, to determine the impact of CCPs on the sustainability of road-building technologies. The CCP applications focused on high-volume fly ash concrete pavement in parking and pedestrian areas at the Theodore Roosevelt Medora Foundation Burning Hills Amphitheater in 2008.

In a second phase of the project, CARRC research staff worked with a commercial engineering firm to determine the best technologies for soil stabilization at a selected site.

Preliminary cost estimates of standard base and subgrade treatments, fly ash–soil stabilization, and fly ash–recycled asphalt recycling were made, and results indicated that costs would be very similar for all types of base and subgrade preparation. The CO_2 emission values calculated for these techniques reinforced the point that the location of the CCP source is frequently a limiting factor for utilization. In this project, both cost and sustainability were similar, but continued monitoring of the project site will indicate sustainability based on reduced maintenance and replacement schedules.

Technology Transfer and Maintenance Tasks

ASTM Standards Development

The goal of the standards development activity was to enhance and promote the technically sound utilization of coal ash through development of technical standard guides or practices for technically proven ash utilization applications. Industry and government identified the development of standards such as this as a key component of efforts to advance the beneficial use of CCPs in the United States.

Under a special project funded by the Utility Solid Waste Activities Group, CARRC researchers worked to modify or develop the following standards within the ASTM E50 Committee on Sustainable Development and Pollution Prevention:

- Draft Standard Guide for the Use of Coal Combustion Products for Underground Mine Fill
- Draft Standard Guide for Selection of Appropriate Leaching Procedures for Coal Combustion Products
- Standard Guide for Use of Coal Combustion Products for Surface Mine Reclamation: Revegetation and Mitigation of Acid Mine Drainage
- Standard Terminology for Coal Combustion Products

Under a special project funded by Energy Efficient Combustion Technology, CARRC researchers continued work on the ASTM C9.24 Subcommittee on Supplementary Cementitious Materials to modify the definition of fly ash in ASTM C618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

Research Exchange

CARRC Topical Reports

The following CARRC topical reports were prepared for CARRC members:

- Impact of Carbon Dioxide Capture on Coal Combustion Products (CCPs)
- Technical Review – Imported Drywall Causes Consumer Complaints
- Evaluation of Mercury Emission Controls on Coal Combustion Product (CCP) Engineering Performance

Technology Transfer

The following is a list of technical papers and presentations related to CARRC work.

Heebink, L.V. The Characteristics and Utilization of Spray Dryer Absorber Material. Presented at the Science of Ash Utilization – World of Coal Ash 2009 Short Course, Lexington, KY, May 4, 2009.

Dockter, B.A. Using Class C Fly Ash to Mitigate Alkali–Silica Reactions in Concrete. Poster presented at the World of Coal Ash Conference; Lexington, KY, May 4–7, 2009.

Hassett, D.J.; Meier, D.; Heebink, L.V.; Hoffarth, J.J.; Pflughoeft-Hassett, D.F. Evaluation of CCP Leachate Interactions with Mine Overburden. In *Proceedings of the World of Coal Ash Conference*; Lexington, KY, May 4–7, 2009.

Pflughoeft-Hassett, D.F.; Heebink, L.V.; Hassett, D.J.; Dockter, B.A.; Eylands, K.E.; Buckley, T.D.; Zacher, E.J. JV *Task 120 – Coal Ash Resources Research Consortium Research*; Final Report (Jan 1, 2007 – March 31, 2009) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-98FT40321; EERC Publication 2009-EERC-06-15; Energy & Environmental Research Center: Grand Forks, ND, June 2009.

Pflughoeft-Hassett, D.F.; Dockter, B.A.; Naasz, D.E. *Demonstration of Coal Combustion Products for Green Road-building in Medora, North Dakota*; Final Report (Feb 1, 2008 – March 31, 2009) for North Dakota Industrial Commission, Great River Energy, Theodore Roosevelt Medora Foundation, and Lignite Energy Council; Energy & Environmental Research Center: Grand Forks, ND, June 2009.

2009 CARRC Industry Partners

- Duke Energy
- Great River Energy
- Indianapolis Power and Light
- Otter Tail Power Company
- Tennessee Valley Authority
- TransAlta
- Xcel Energy

2009 CARRC Special Project Sponsors

- Ash Grove Resources
- Boral Materials Technologies, Inc.
- Great River Energy
- Holcim (US), Inc.
- Lafarge North America, Inc.
- Lignite Energy Council
- Mineral Resource Technologies, Inc.
- Nebraska Ash Company
- North Dakota Industrial Commission Lignite Research Council
- Theodore Roosevelt Medora Foundation
- WE Energies
- Western Region Ash Group

CARRC also gratefully acknowledges the CARRC industry advisors Mr. David Goss, consultant, and Mr. Ken Ladwig, Program Manager, Electric Power Research Institute.

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Coal Ash Resources Research Consortium

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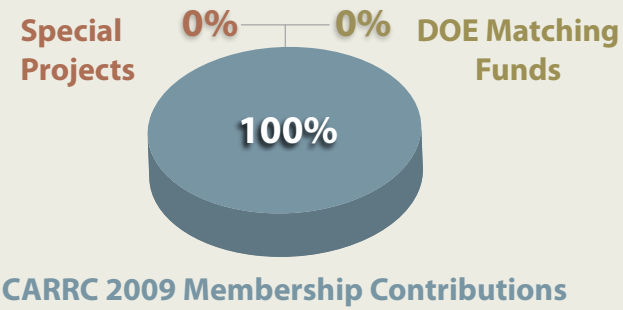
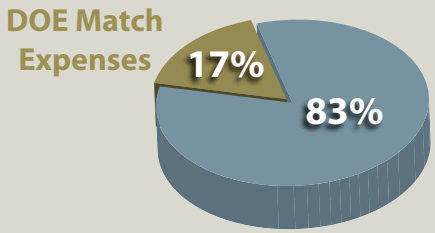
CARRC Summary of Funds Received



CARRC 2009 Membership Contributions

DOE Matching Funds	$0
CARRC Membership Contributions	$70,000
Special Projects	$0
Total	**$70,000**

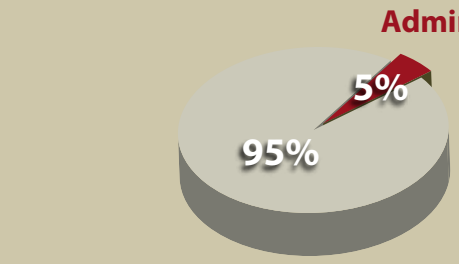
CARRC Summary of Membership Expenditures



Membership Expenses

Membership Expenses	$83,022
DOE Match Expenses	$17,170
Total	**$100,192**

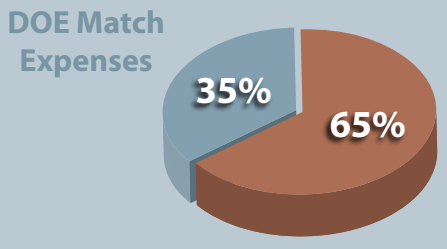
CARRC Summary of Expenditures



Technical Management and Task Performance

Administration	$17,420
Technical Management and Task Performance	$309,875
Total	**$327,295**

CARRC Summary of Special Project Expenditures



Special Project Expenses

Special Project Expenses	$147,325
DOE Match Expenses	$79,777
Total	**$227,103**

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