



Ohio Coal Development Office  
**2014 Coal Agenda**



Development  
Services Agency

John R. Kasich, Governor

David Goodman, Director



**Governor Kasich, Members of the General Assembly and fellow Ohioans:**

We are pleased to present to you the Ohio Coal Development Agenda for Fiscal Year 2012-2013. The Agenda is the biannual report for the Ohio Coal Development Office. Created by the General Assembly in 1984, the Ohio Coal Development Office supports the discovery of new technologies and applications for Ohio coal as fuel or chemical feedstock, while reducing the impact on the environment.

The Ohio Development Services Agency houses the Ohio Coal Development Office within its Office of Energy and Redevelopment. The Office of Energy and Redevelopment is the U.S. Department of Energy's designated state energy office and is responsible for administering federally allocated funds in Ohio and works to support Governor Kasich's comprehensive energy strategy. Governor Kasich's strategy has identified 10 pillars that are focused on Ohio's strengths and builds on the state's natural resources. The coal industry has a long and rich history in Ohio and is addressed specifically in Pillar 8 of the strategy, *Coal: New Opportunities for a Critical Resource*. The Ohio Coal Development Office works to identify new uses for this resource and new ways to reduce its environmental impact by providing \$30 million in project funding for coal research and technology projects.

Ohio is a leader in the support and development of coal technologies. The Ohio Coal Development Office continues to fund a range of projects from applied research to deployment of full-scale demonstration projects that enhance the viability of Ohio coal while reducing environmental impact and maintaining affordability. The Ohio Coal Development Office also supports the Ohio Coal Technical Advisory Committee, comprised of industry and environmental professionals, academics and legislators. This committee provides recommendations for project funding to the Director of the Ohio Development Services Agency.

The Ohio Coal Development Office currently administers \$30 million in funding over the biennium (Fiscal Year 2013-2014) through the Ohio Coal Research and Development Program which consists of two initiatives: the Ohio Coal Demonstration and Pilot grants and the Ohio Coal Research Consortium. This agenda provides descriptions of funded projects and a fiscal report, as required by the Ohio Revised Code Section 1551.34.

The Ohio Coal Development Office will continue to identify and support new technologies and applications for Ohio coal that benefit the state's economy. This report demonstrates our continued focus on greater accountability of public funds, transparency in use of these funds and our commitment to exceptional customer service.

Sincerely,

David Goodman  
Director  
Ohio Development Services Agency



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## What Does Coal Mean to Ohio?

### Characterization

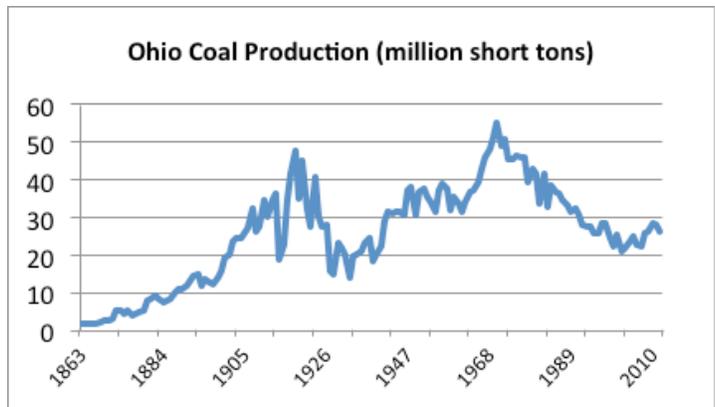
#### Ohio Coal Creates Jobs

- The coal industry in Ohio employed 2,918 employees in 2012: of these 2,189 were in production, down from a peak of 50,267 miners in 1908.
- The average salary of a production employee in 2012 was \$70,854<sup>1</sup>.



#### Ohio Coal Production

- Ohio ranked 11<sup>th</sup> in the nation for total production of coal in 2012, producing 26,328,000 short tons<sup>2</sup>.
- In 2012, 22 companies were operating 61 mines in 13 Ohio counties: Belmont, Carroll, Columbiana, Guernsey, Harrison, Jackson, Jefferson, Mahoning, Noble, Perry, Stark, Tuscarawas and Vinton<sup>3</sup>.
- In 2012, 42.17 million tons of coal were consumed in Ohio.
- It is estimated that Ohio has 11.5 billion tons of economically recoverable coal reserves<sup>4</sup>. Based on 2012 consumption levels, Ohio has a 250+ year supply of coal.

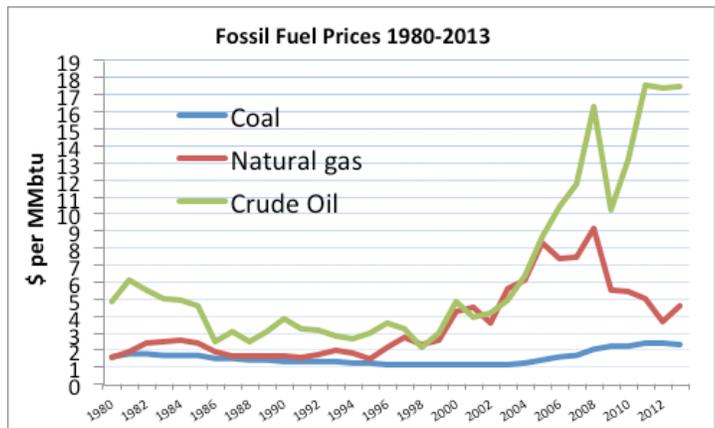


#### Ohio Coal has Economic Value

- 25,508,364 tons of Ohio coal was sold in 2012, valued at \$1,182,184,498, a per ton average price of \$46.38<sup>5</sup>.

#### Coal is a Dependable and Affordable Energy Source

- Coal prices have remained stable and remain vital to ensure low-cost electricity for Ohio's manufacturing and agriculture sectors<sup>6</sup>.
- Ohio has the 2<sup>nd</sup> largest operable fleet of coal-fired electricity generation units in the U.S. with a combined nameplate capacity of more than 20,835 megawatts<sup>7</sup>.



## Ohio Coal Continues to be Constrained by its High Sulfur Content

- Ohio coal production peaked in 1970 at 55,351,000 tons, nearly twice the amount produced in 2012<sup>8</sup>.
- U.S. Clean Air laws enacted in 1963, 1967 and amended in 1970, 1977 and 1990 required new coal power plants built after 1979 to scrub sulfur, and reduce sulfur emissions from existing units, to an output rate of 1.2 pounds of sulfur per million Btu of heating value.
- Ohio coal typically has one of the highest sulfur contents of any U.S. coal at 3.5 percent which, when burned, produces six pounds of sulfur dioxide per million Btu of heat input, or five times higher than allowable levels for combustion<sup>9</sup>. This has reduced Ohio coal sales over the years.



*General James M. Gavin Powerplant – Cheshire, Ohio  
Photo by: Analogue Kid*

## Electricity Generated from Coal

- Ohio generated 66 percent of its electricity from coal in 2012, down from a peak of 92 percent in 2003<sup>10</sup>.
- 88 percent of the coal consumed in Ohio was used for electric power generation in 2012<sup>11</sup>.
- 55 percent of the coal produced in Ohio in 2012 was sold to Ohio electric generation units. These 14 million tons of Ohio coal satisfied 40.5 percent of electric generation needs. The remaining 59.5 percent came from out of state sources, mostly low-sulfur coal<sup>12</sup>.
- Ohio utilities have built and invested in maintaining a large fleet of coal power plants, most of which were initially installed 20-60+ years ago<sup>13</sup>. Regulations like the U.S. EPA Mercury and Air Toxics Standards have led units that burn Ohio coal to shut down, or plan to shut down, operations<sup>14</sup>.

## Constraints and Market Opportunities

### So what constrains burning more Ohio coal?

When coal is burned it releases by-products, which impact human health and the environment, including: 1) mercury, which can impact brain development of unborn children 2) sulfur dioxide and nitrogen oxides, which can cause acid rain, regional haze 3) particulate matter, which can aggravate asthma and other respiratory symptoms and 4) carbon dioxide, which impacts climate change.

### What opportunities are available to reduce these impacts?

- Install technologies that capture these emissions
- Burn coal with lower mercury or sulfur content, so less is emitted
- Find new ways to use coal or coal by-products that have a benefit

### Which opportunities make the most sense for Ohio?

Innovative technologies that balance today's energy needs with the economic and environmental health of future generations.

### What does the Ohio Coal Development Office do as part of the equation?

The Office invests in technologies that provide affordable solutions to capturing and reducing pollutants. By meeting these standards power plants can operate longer, and electricity can be less expensive, more diversified and more stable.

Environmental regulations have placed constraints on Ohio coal, but they have also spurred innovation. The U.S. generated 33 percent more electricity in 2012 compared to 1990, but the electric power industry emitted 76 percent less tons of sulfur dioxide, and 73 percent less tons of nitrous oxides (NOx) over that same period<sup>15</sup>. This decline in emissions is due primarily to an increasing number of coal-fired units being retrofitted with flu-gas desulfurization units, or scrubbers, and to the increased installation of selective catalytic reduction units, or low NOx burners<sup>16</sup>.



Coal mine near Salineville, Ohio  
Associated Press

## Ohio Coal Development Office: Programs and Purposes

The Coal Development Office was first created in 1984 to address the environmental impediments to Ohio's coal utilization. Section 8.15 of the Ohio Constitution authorizes the state to issue bonds and other obligations to support coal research and industry development. Additionally, the state may take an equity position and accept royalty payments for funded technology that reaches commercialization. In 2011, the Office moved from the Ohio Air Quality Development Authority to the Development Services Agency.

Funding priority is given to projects that provide:

- Improvements or reconstruction of existing facilities and equipment;
- Construction and operation of commercial-scale clean coal demonstration facilities; and
- Technologies, equipment and other techniques that maximize the use of Ohio coal in an environmentally-acceptable and cost-effective manner.

The Coal Development Office awarded \$15.25 million over the previous biennium (Fiscal Year 2012-2013) to projects as part of Governor Kasich's Ohio's 21<sup>st</sup> Century Energy Policy to help create and preserve jobs. Ohio's economy depends on access to reliable, diverse and low-cost energy. *(Please see appendix for additional details)*

Governor Kasich's 21<sup>st</sup> Century Energy Policy reads in part:

*Ohio is rich with coal, and it's a critical resource for our state's energy needs. However it's important that we pursue new technologies that reduce coal's impact on the environment. The energy policy proposes:*

- \$30M for coal research projects on carbon capture, sequestration, enhanced oil recovery, and new technologies

**BOTTOM LINE:** *In order to ensure economic stability and move toward energy independence, Ohio's energy policy includes a diverse mix of sources available at a low cost. By utilizing partnerships between the government, industry leaders, the education system and environmental advocates, as well as by developing new technologies and applying appropriate regulatory oversight to ensure public safety, Ohio can lead the nation with a complete energy policy while maintaining Ohioans' historical common sense stewardship of the environment.*



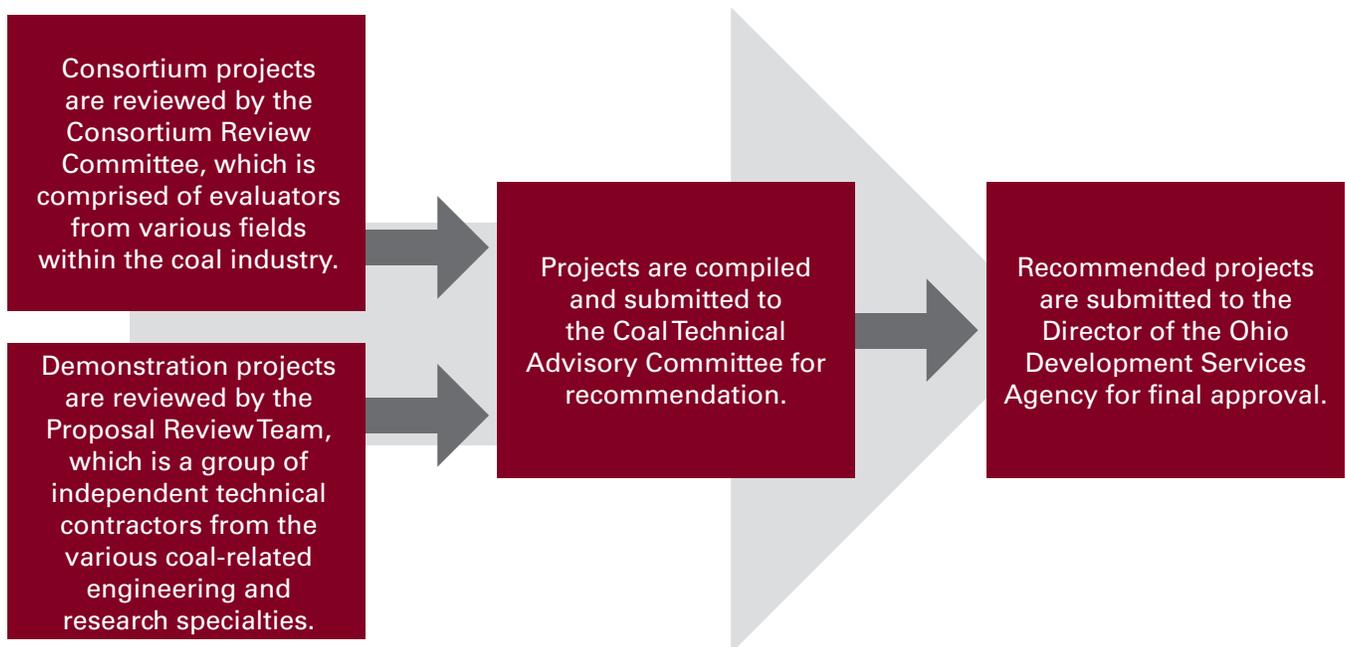
## Programs

The Coal Development Office implements this policy initiative through the Ohio Coal Research and Development Program, which provides funds for research and development of technology that result in the maximum conversion or use of Ohio coal as a fuel or chemical feedstock in a cost-effective and environmentally-friendly manner. Funding for this program is available to awardees on a cost-sharing basis and is divided into two initiatives: 1) Ohio Coal Demonstration and Pilot grants and 2) Ohio Coal Research Consortium grants.

The **Ohio Coal Demonstration and Pilot Program** issues grants to utility power producers, clean coal technology developers, research and development firms and universities directed toward the discovery and implementation of new technologies. Funding can be applied toward groundbreaking research or the demonstration of existing technologies that enables better, cost-effective utilization of Ohio coal under current, and anticipated, environmental regulations.

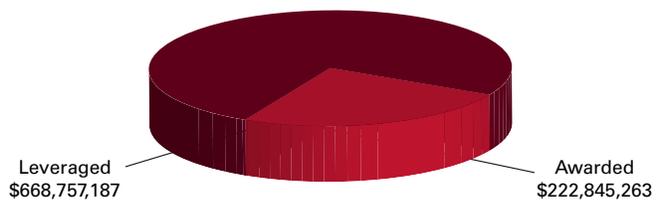
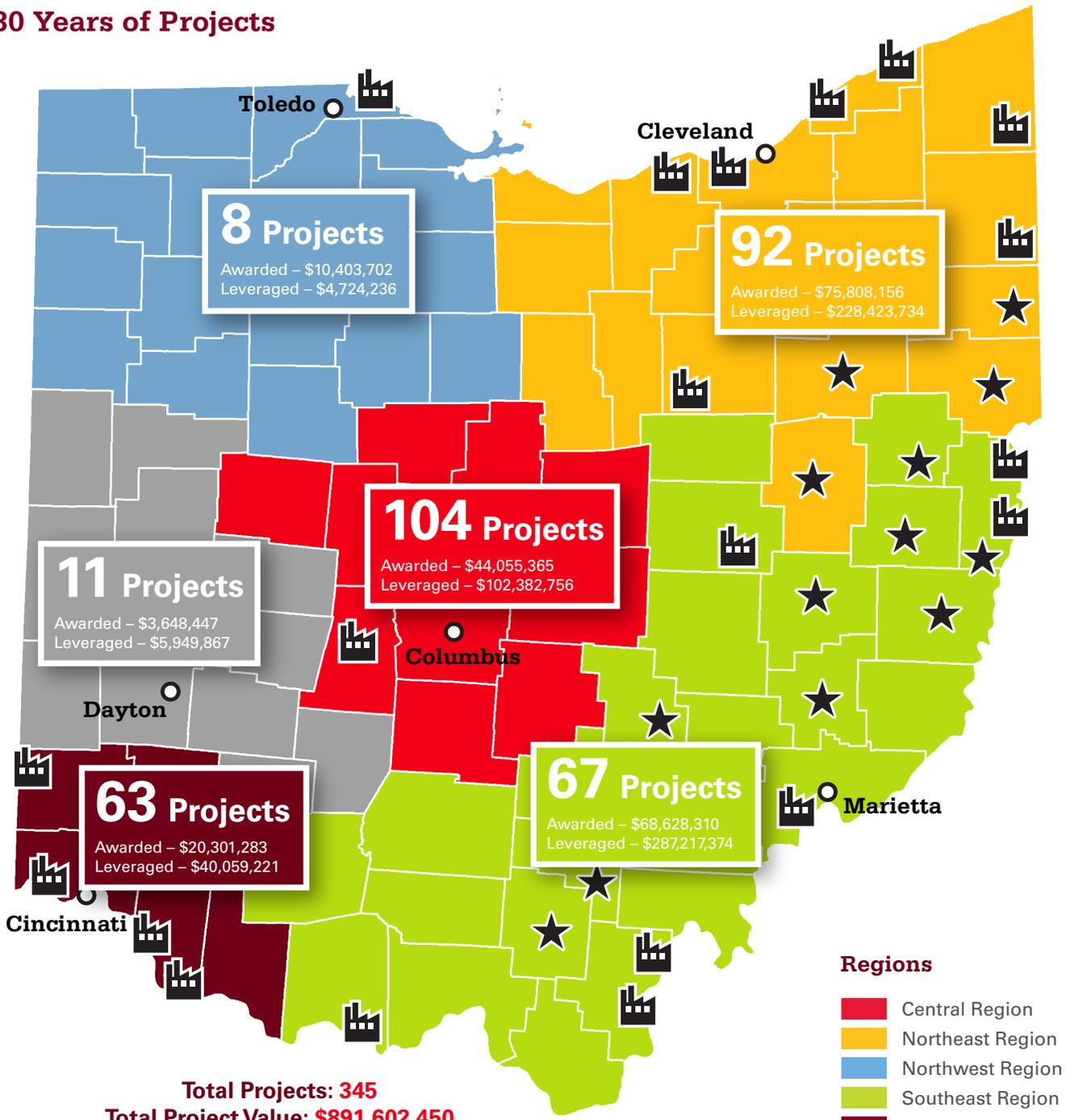
The **Ohio Coal Research Consortium** provides grants to Ohio colleges and universities to study mechanisms critical to emissions formation and methods of control. Additionally, funding can be used for researching feasible uses of coal as a feedstock or for other processes.

Projects for both initiatives are received through public outreach and Request for Proposals.



# Ohio Coal Development Office

## 30 Years of Projects



### Regions

- Central Region
- Northeast Region
- Northwest Region
- Southeast Region
- Southwest Region
- Western Region
- Counties with Active Coal Mines (as of 2012)
- Coal-Fired Power Plants



Development Services Agency

## Purposes

The commercialization of technologies, enhancement of markets and ultimate adoption by the market are the results of the programs. The time scale for these outcomes varies and is vulnerable to disruptive technologies/regulations, impacted by global energy/commodity prices and can sometimes take decades to mature or for the right market/regulatory conditions to emerge.

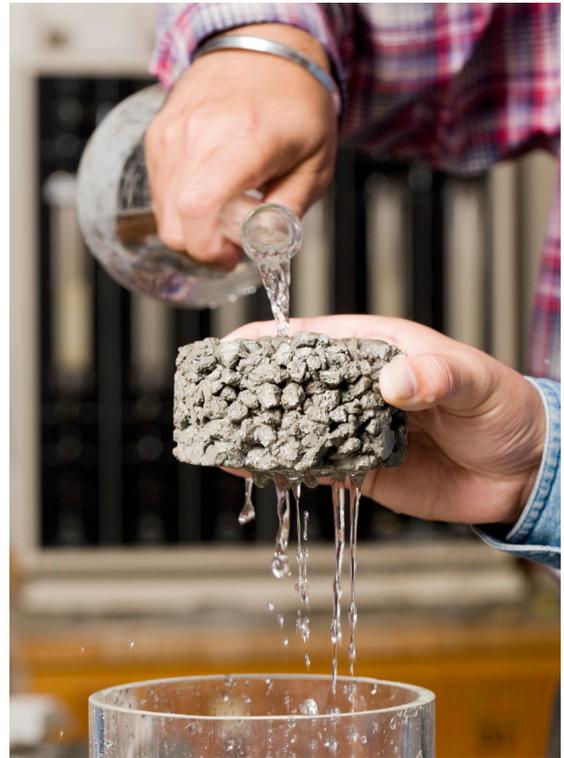
The Coal Development Office takes a short-term and long-term approach to the development of technologies and processes that help to ensure coal's continued utilization as a low-cost fuel source in Ohio or as a chemical feedstock for materials production. This requires evaluating, anticipating and planning for current and future impediments by strategically addressing these obstacles.

## Coal By-product Utilization

The coal-combustion products program at The Ohio State University takes by-products which would typically be disposed in a landfill and puts them to use. Waste products like slag and bottom ash from coal-combustion can be used for road and highway construction. Flue gas desulphurization gypsum can be used in manufacturing wallboard. Coal-combustion products are being used as aggregate for asphalt, additives for cement-making, amendments for soil enhancement and ingredients of special metal composites. The Coal Development Office support of this program encourages technology transfer by sharing technical information, providing expert opinion to both the end-user and the regulatory communities on various ways to use coal by-products.

## Advanced Materials

The Energy Industries of Ohio (EIO) develops technology teams to aid Ohio's energy providers and energy-intensive user industries. EIO is currently leading a team to develop and commercialize Advanced Ultra Super Critical (AUSC) materials for coal-fired power plants. These next generation power plants will more efficiently convert coal to electricity by burning coal at higher temperatures and at higher pressures, which will produce less CO<sub>2</sub> per each unit of electricity generated. To operate under these conditions, AUSC power plants will require new materials that can withstand these conditions. Partnering with the Electric Power Research Institute (EPRI), the U.S. Department of Energy and a consortium of boiler and turbine manufacturers, EIO has identified and developed these materials and fabrication techniques. EIO is required to use Ohio's high-sulfur coal when these materials are tested for boiler pressure code certifications, which are required for the commercialization of this technology. EIO has numerous partners on this project, including The Ohio State University, the University of Cincinnati and the Edison Welding Institute. They are currently in discussions with electric generation companies in the U.S. and abroad to deploy this technology at the full demonstration level. The Coal Development Office encourages all of its grantees to leverage resources with other Ohio organizations, share the lessons learned with the public and with academia and seek pathways to commercialization.





## Advanced Power Generation

The Coal Development Office is committed to technology advancement through multiple stages of development. The Ohio State University Professor L.S. Fan's chemical looping process is the only technology being developed today that is able to directly perform both combustion and gasification of coal. Coal combustion typically occurs in the presence of air, which contains nitrogen and oxygen. During typical combustion, carbon from coal and oxygen from air bond together to produce carbon dioxide and nitrogen from air bonds with oxygen to

produce nitrogen oxides. Separating out these and other pollutants that are formed during combustion is difficult and expensive. Chemical looping simplifies this process by combusting coal in the presence of pure oxygen so nitrogen oxides are not formed<sup>17</sup>. The chemical looping process simplifies and reduces the cost of commercial production of electricity and hydrogen gas. This process has the potential to achieve one of the lowest costs and most efficient technologies to produce affordable, pure hydrogen from coal, while attaining nearly 100 percent CO<sub>2</sub> control and complying with all current and proposed environmental regulations. This research was started with an \$80,000 Research Consortium award from the Coal Development Office in 2003. This technology has been supported and scaled up as it has progressed and its potential has been demonstrated. Consortium projects are urged to seek patents for their projects, to publish in academic articles and to participate in technical conferences to share their results. The Coal Development Office has invested more than \$7.3 million in this process, most recently awarding \$1.8 million in 2013. Shell Oil Company, Air Products and Chemicals, Inc., Babcock and Wilcox Company and CONSOL Energy Inc. all have teamed up with Professor Fan to test his chemical looping technologies for synthetic liquid fuels, hydrogen and electricity production at his lab and at a larger-scale test facility.

Professor Fan won The Ohio State University Innovator of the Year award in 2012. A panel of experts assembled by the U.S. Department of Energy considers his technologies to be "transformational." The Ohio State University is working with a venture capitalist to license this technology, which will lead to it being deployed at a commercialized full-scale level. The Coal Development Office holds royalty agreements with its grantees so that up to five percent of the gross revenues from the sale or lease of a technology is returned to the office. Royalty payments are capped at three times the grant amount. Royalty payments are used to either award new projects or to pay down the bonds that were issued for the purpose of making the original grants.

## Identifying and Connecting Advanced Power Generation

Energy Industries of Ohio issued Ohio's "2013 Baseload Energy Manufacturing Source Directory"<sup>18</sup>, which was prepared under a grant from the Ohio Development Services Agency. This resource/directory of Ohio manufactured products and services lists providers of critical components needed by the advanced energy coal sector. The directory was developed through meetings with key stakeholders to define the critical needs for constructing and upgrading coal-fired power plants. Many of the key items were found to be mainstay Ohio industries such as castings, foundries and extrusions along with special fabricators and service providers including carbon control technologies. The directory is a useful resource of Ohio-produced items, providing the power generation industry with a reference to a base-hub of suppliers and manufacturers of energy components. This publication helps to connect these industries and supports not only utilities and industries using Ohio coal, but also the economic expansion of Ohio equipment and technology suppliers for customers in Ohio and around the world.

## Ohio Coal Development Technical Advisory Committee

The Ohio Coal Development Technical Advisory Committee was established under Section 1551.35 of the Ohio Revised Code. It is a 13 member group that reviews and makes recommendations concerning Ohio coal development project proposals, governance matters and other topics related to Ohio's coal development. Eight of the members are appointed by, and serve indefinitely, at the pleasure of the director of the Ohio Development Services Agency, four members are appointed by the General Assembly and serve for the duration of the term in office and one ex officio member is from the Ohio Environmental Protection Agency.

The members of the Ohio Coal Development Technical Advisory Committee (as of January 31, 2014) are:

Members	Representing
Babe Erdos	United Mine Workers of America
Commissioner Lynn Slaby	Public Utilities Commission
James J. Reuther	Non-university Research & Development
John McManus	Electric utilities
Joseph Shields	State University Research & Development
Michael Carey	Coal production company
Vacant	Environmental organization
Representative Al Landis	Ohio House of Representatives
Representative Jack Cera	Ohio House of Representatives
Craig Butler	EPA, Ex Officio
Senator Lou Gentile	Ohio Senate
Senator Troy Balderson	Ohio Senate
Vacant	Manufacturers that use Ohio coal

## Types of Projects to be Funded in the Future

The types of projects that will be targeted under the Demonstration and Pilot Program will include the clean coal related technology priorities listed below. Persons (individuals and businesses) doing business in Ohio or educational or scientific institutions in Ohio are eligible to receive funding through this program. The types of projects the Ohio Coal Research Consortium will target will include the technical issues facing Ohio coal producers and end users and are listed below. These projects must improve or lower the cost of technologies and/or expand the use of Ohio coal. Copies of the Fiscal Year 2014 Request for Proposals (RFP) for both programs can be found on the Development Services Agency website ([http://development.ohio.gov/bs/bs\\_ohiocoaldev.htm](http://development.ohio.gov/bs/bs_ohiocoaldev.htm)). These program priorities take into consideration the long-term and short-term needs of the Ohio industry in the face of existing and proposed environmental regulations, including the market realities of competing fuel sources, with input from Technical Advisory Committee members and industry stakeholders.

### Demonstration and Pilot Program RFP Priorities:

1. Development/deployment of advanced coal-based power and fuel producing systems (e.g., integrated gasification combined cycle, oxy-combustion systems, ultra-supercritical systems, chemical looping systems, etc.);
2. Improved retrofit technologies applicable to existing coal-fired generating units: to increase generating efficiency in order to significantly reduce CO<sub>2</sub> emissions; to reduce parasitic loads of pollution control technologies; to reduce emissions of conventional pollutants, including hazardous air pollutants (HAPs); and to develop methods for capture and sequestration of CO<sub>2</sub>;
3. Improved technologies/processes that enable the more efficient conversion of Ohio coal to a chemical feedstock, liquid or gas;
4. Cost effective CO<sub>2</sub> capture and sequestration through improving capture technology and development of CO<sub>2</sub> transport mechanisms that can meet the proposed U.S. EPA CO<sub>2</sub> emission caps of 1,100 pounds per MWh of power produced, on a gross output basis;
5. Coal technologies/processes that lower the cost of supplying the energy needs of Ohio's industrial complex;
6. By-product utilization: high volume fly ash and flue gas desulfurization by-product utilization in mine remediation/reclamation, captured CO<sub>2</sub> from coal combustion or a chemical reaction for Enhanced Oil Recovery (EOR) that provides a benefit/revenue stream to the Ohio coal industry or that reduces by-product liability/disposal costs;
7. Economic and effective mercury capture technologies; and
8. Analysis of the costs of retrofitting existing power plants with CO<sub>2</sub> capture technologies compared to the costs of retrofitting new facilities that have constructed "CO<sub>2</sub> capture ready" units.

Ohio Coal Research Consortium Priorities:

1. Projects that address technical problems experienced today by Ohio coal producers and end-users and to improve and/or that lower the cost of technologies and/or emission controls that enable continued or expanded use of Ohio coal;
2. Improve the environmental performance of coal-based technologies and/or lower their cost of operation;
3. Generate innovative research in the field of coal use;
4. Train a future supply of Ohio-based scientists and technologists in clean coal and emission control technologies;
5. Find novel and more economical ways to convert Ohio coal to a liquid, gas or chemical feedstock;
6. Benefit Ohio coal by improving the efficiency of the coal to electricity conversion process; and
7. Projects that will contribute toward accelerating development and supporting early-stage deployment of processes or technologies that can enhance or improve the use of Ohio coal in an environmentally acceptable manner.

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- \* The Ohio Department of Natural Resources provided photos for this report.

## Appendix A

### Demonstration and Pilot Program Project Descriptions & Research Consortium Project Descriptions

Grantee	Title	Grant Amount
<b>Advanced Coal-based Power Generation</b>		
Energy Industries of Ohio	A Supplier Development Program for Clean Coal Energy Components	\$330,661
Energy Industries of Ohio	Materials for A-USC Boilers	\$1,743,574
The Ohio State University	Calcium Looping Process (CLP) for Clean Coal Conversion to Hydrogen and Electricity; Fate of Sulfur	\$100,000
The Ohio State University	Pilot Scale Testing of the Carbon Negative, Product-flexible Syngas Chemical Looping Process	\$1,799,997
<b>By-product Utilization</b>		
The Ohio State University	Beneficial Uses of FGD Gypsum in Ohio: Agricultural and Environmental Applications	\$406,181
The Ohio State University	Reclamation of Ohio Coal Mine Sites Using FGD Byproducts: Phase III: Demonstration Projects	\$1,643,820
<b>Carbon Management/Coal Advancement</b>		
Battelle Memorial Institute	CO <sub>2</sub> Utilization for Enhanced Oil Recovery and Geologic Storage in Ohio	\$1,739,660
Battelle Memorial Institute	Defining CO <sub>2</sub> Storage Options in Upper Ohio Valley Region – Advanced Characterization of Geologic Reservoirs and Caprocks	\$4,986,629
Battelle Memorial Institute	Simplified Predictive Models for CO <sub>2</sub> Sequestration Performance Assessment	\$150,000
Battelle Memorial Institute	Systematic Assessment of Wellbore Integrity for Geologic Carbon Storage Projects Using Regulatory and Industry Information	\$199,999
Ohio Department of Natural Resources	A Resource Evaluation of the Pittsburgh (No. 8) and the Lower Freeport (No. 6a) Coal Seams of Ohio	\$300,000
The Ohio State University	Affordable CO <sub>2</sub> -selective Membranes for Post-Combustion Capture	\$100,000
The Ohio State University	Electro-catalytic Separation of Oxygen from Air	\$100,000
The Ohio State University	Nano-composite Supported Membranes for Cost Effective O <sub>2</sub> Separation	\$100,000
The Ohio State University	Novel Inorganic/Polymer Composite Membranes for CO <sub>2</sub> Capture	\$500,000
The Ohio State University	Study of Physical & Chemical Interactions between Coal and Oxygen Carrier Particles in OSU's Coal Direct Looping Process	\$100,000
University of Akron	Novel NOx and SOx Resistant Polyethylene Glycol-Amine Sorbents for Post-combustions CO <sub>2</sub> Capture	\$100,000
University of Cincinnati	Metal-organic Framework Based Membranes for Highly Selective Gas Separation	\$100,000
<b>Coal as a Chemical Feedstock</b>		
Ohio University	Ohio Coal Conversion to High Value Graphene	\$249,991
The Ohio State University	Production of Functionalized Carbon Nano-structures from Coal Gas	\$100,000
The Ohio State University	Thin Film Solid Oxide Fuel Cell for Coal Syngas	\$100,000
University of Cincinnati	Multi-scale Catalytic Membrane Reactors for Hydrogen Production in Coal Gasification Systems	\$100,000
University of Cincinnati	Novel Catalysts for Direct Conversion of Ohio Coals Derived SYNGAS into Ethanol	\$100,000
<b>Mercury Capture</b>		
University of Cincinnati	Novel Regenerable Absorbents for Waste Water Treatment from Wet Flue Gas Scrubbers to Remove Heavy Metals	\$99,998
		<b>\$15,250,510</b>

## Appendix B

### Fiscal Report

	Budget	Total Obligated	Balance
Fiscal Year 2012 Administrative Expenses*	\$260,983	\$161,464	\$99,519
Fiscal Year 2012 Coal Projects*	\$46,651,011	\$16,338,474	\$30,312,538
Fiscal Year 2013 Administrative Expenses#	\$261,205	\$239,107	\$22,098
Fiscal Year 2013 Coal Projects#	\$30,312,538	\$3,247,794	\$27,064,744

\*As of June 28th, 2012

#As of June 30, 2013